Topock Project Executive Abstract

Document Title:

Final Groundwater Corrective Measures Study/Feasibility Study Report for SWMU 1/AOC 1 and AOC 10, PG&E Topock Compressor Station, Needles, California

Submitting Agency: PG&E

Final Document? ☒ Yes ☐ No

Date of Document: December 16, 2009

Who Created this Document?: (i.e. PG&E, DTSC, DOI, Other)

PG&E

Priority Status: ☒ **HIGH** ☐ **MED** ☐ **LOW**

Is this time critical? ☒ Yes ☐ No

Type of Document:

☐ Draft ☒ Report ☐ Letter ☐ Memo

☐ Other / Explain:

Action Required:

☒ Information Only ☐ Review & Comment

Return to: N/A

By Date:

☐ Other / Explain:

What does this information pertain to?

☐ Resource Conservation and Recovery Act (RCRA) Facility Assessment (RFA)/Preliminary Assessment (PA)
☐ RCRA Facility Investigation (RFI)/Remedial Investigation (RI) (including Risk Assessment)
☒ Corrective Measures Study (CMS)/Feasibility Study (FS)
☐ Corrective Measures Implementation (CMI)/Remedial Action
☐ California Environmental Quality Act (CEQA)/Environmental Impact Report (EIR)
☐ Interim Measures
☐ Other / Explain:

Is this a Regulatory Requirement?

☒ Yes
☐ No

If no, why is the document needed?

What is the consequence of NOT doing this item? What is the consequence of DOING this item?

The CMS/FS is a step in the site cleanup process that evaluates various remedial strategies to remediate impacted groundwater. Without this step, remedial strategies either may not be implemented or may be implemented without evaluating the most beneficial options.

Other Justification/s:

☐ Permit ☐ Other / Explain:

Brief Summary of attached document:

The Final CMS/FS Report has been prepared pursuant to the requirements in Section IV.C of the RCRA Corrective Action Consent Agreement, Section 9.3 of the CERCLA Administrative Consent Agreement, and the approved CMS/FS Work Plan. The Final CMS/FS Report has been modified in response to agency and stakeholder comments on the Draft CMS/FS Report.

The CMS/FS report presents the identification and evaluation of various remedial alternatives to address the remedial action goals for groundwater contamination associated with the historic discharges to Bat Cave Wash (SWMU 1/AOC1) and within AOC 10 (East Ravine) at the PG&E Topock Compressor Station. The CMS/FS includes a description of current conditions, remedial action objectives, identification and screening of remedial technologies, and development and evaluation of remedial action alternatives.

Nine alternatives were identified:

- Alternative A - No Action

- Alternative B - Monitored Natural Attenuation
- Alternative C - High Volume *In Situ* Treatment
- Alternative D - Sequential *In Situ* Treatment
- Alternative E - *In Situ* Treatment with Fresh Water Flushing
- Alternative F - Pump and Treat
- Alternative G - Combined Floodplain *In Situ* / Pump and Treat
- Alternative H - Combined Upland *In Situ* / Pump and Treat
- Alternative I - Continued Operation of Interim Measure

The alternatives above were defined to a sufficient level of detail to develop remedial cost estimates, in accordance with USEPA guidance for feasibility studies. The alternatives are evaluated against the threshold and balancing criteria of RCRA and CERCLA.

Written by: PG&E

Recommendations:

DTSC and DOI review and provide approval.

How is this information related to the Final Remedy or Regulatory Requirements:

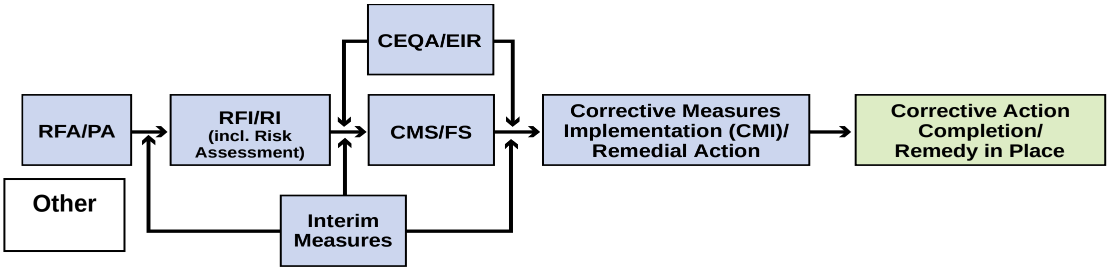
CMS/FS is a step in the site cleanup process that evaluates various remedial strategies to be used in the final remedy.

Other requirements of this information?

The CMS/FS incorporates remedy evaluation requirements of both RCRA and CERCLA.

Related Reports and Documents:

Click any boxes in the Regulatory Road Map (below) to be linked to the Documents Library on the DTSC Topock Web Site (www.dtsc-topock.com).



Legend
RFA/PA – RCRA Facility Assessment/Preliminary Assessment
RFI/RI – RCRA Facility Investigation/CERCLA Remedial Investigation (including Risk Assessment)
CMS/FS – RCRA Corrective Measure Study/CERCLA Feasibility Study
CEQA/EIR – California Environmental Quality Act/Environmental Impact Report

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December 16, 2009

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Denver, CO 80225-0007

Subject: Final Groundwater Corrective Measures Study/Feasibility Study Report for SWMU 1/AOC 1 and AOC 10, PG&E Topock Compressor Station, Needles, California

Dear Mr. Yue and Ms. Innis:

This letter transmits the *Final Groundwater Corrective Measures Study/Feasibility Study Report for SWMU 1/AOC 1 and AOC 10 at the Pacific Gas and Electric Company (PG&E), Topock Compressor Station* (Final CMS/FS Report). This final report incorporates the results of over six months of discussions between PG&E, the California Department of Toxic Substances Control (DTSC), and the Department of the Interior (DOI) to resolve more than 500 comments received from stakeholders and agencies on the January 2009 draft report and the November 2009 redline final report. The comment resolutions are memorialized in Appendix C of this report.

PG&E looks forward to receiving the agencies' approval of this Final CMS/FS Report, as this is an important milestone that enables the project to move forward towards final remedy selection and implementation.

Please do not hesitate to contact me at (805) 234-2257 with any questions or comments regarding this submittal.

Sincerely,

Yvonne Meeks

Yvonne Meeks
Topock Project Manager

c: Karen Baker, DTSC
Christopher Guerre, DTSC
Rick Newill, DOI
Laura Kaweski, DTSC
Addie Farrell, AECOM

Final Report

Groundwater Corrective Measures Study/ Feasibility Study Report for SWMU 1/AOC 1 and AOC 10

PG&E Topock Compressor Station Needles, California

Prepared for

Pacific Gas and Electric Company

December 2009

Prepared by

CH2MHILL

155 Grand Avenue, Suite 100
Oakland, California 94612

Certification

Final Groundwater Corrective Measure Study/Feasibility Study Report for SWMU 1/AOC 1 and AOC 10

PG&E Topock Compressor Station
Needles, California

Prepared for
California Department of Toxic Substances Control and
United States Department of the Interior

on behalf of
Pacific Gas and Electric Company

December 2009

This report was prepared under supervision of a California Professional Engineer

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Acronyms and Abbreviations

μg/L	micrograms per liter
°F	degrees Fahrenheit
AOC	Area of Concern
APE	Area of Potential Effect
ARAR	applicable or relevant and appropriate requirement
bgs	below ground surface
BLM	United States Bureau of Land Management
BOR	United States Bureau of Reclamation
CACA	Corrective Action Consent Agreement
CCR	California Code of Regulations
CEQA	California Environmental Quality Act
CERCLA	Comprehensive Environmental Response, Compensation, and Liability Act of 1980
CFR	Code of Federal Regulations
CMS/FS	corrective measures study/feasibility study
COC	constituent of concern
COPC	constituent of potential concern
Cr(III)	trivalent chromium
Cr(T)	total chromium
Cr(VI)	hexavalent chromium
DOI	United States Department of Interior
DTSC	California Environmental Protection Agency, Department of Toxic Substances Control
E&E	Ecology and Environment, Inc.
EIR	environmental impact report
gpm	gallons per minute
GWRA	groundwater human health and ecological risk assessment

HI	health index
HNWR	Havasu National Wildlife Refuge
IM	Interim Measure
IRZ	*in-situ* reactive zone
MCL	maximum contaminant level
mg/L	milligrams per liter
MNA	monitored natural attenuation
NCP	National Contingency Plan
O&M	operation and maintenance
OWS	oil/water separator
PG&E	Pacific Gas and Electric Company
POTW	publicly owned treatment works
RAO	remedial action objective
RCRA	Resource Conservation and Recovery Act
RFI/RI	Resource Conservation and Recovery Act facility investigation/remedial investigation
SWFL	southwestern willow flycatcher
SWMU	Solid Waste Management Unit
TDS	total dissolved solids
USC	United States Code
USEPA	United States Environmental Protection Agency
USFWS	United States Fish and Wildlife Service
UTL	upper tolerance limit
VOC	volatile organic compound
Water Board	California Regional Water Quality Control Board

1.0 Introduction

This corrective measures study/feasibility study (CMS/FS) addresses chromium in groundwater at the Pacific Gas and Electric Company (PG&E) Topock Compressor Station. The purpose of this document is to identify and evaluate remedial alternatives and to provide the basis for the selection of a recommended alternative to address the defined objectives for this remedial action. The existing chromium contamination in groundwater near the compressor station is largely attributable to the historical wastewater discharge from compressor station operations to Bat Cave Wash, designated as Solid Waste Management Unit (SWMU) 1/Area of Concern (AOC) 1, and within the East Ravine, designated as AOC 10. Other cleanup actions at the Topock Compressor Station that may be required due to other historical operations at the compressor station are not within the scope of this document and will be addressed in subsequent documents as appropriate.

Figure 1-1 illustrates the site cleanup process. The CMS/FS is a crucial step in this process. As is shown in Figure 1-1, the step prior to the CMS/FS is the Resource Conservation and Recovery Act (RCRA) facility investigation/remedial investigation (RFI/RI). This step includes a risk assessment and characterizes the nature of and threat posed by hazardous substance releases. The CMS/FS step then identifies and evaluates remedial alternatives and allows for selection of a remedial alternative, and the corrective measures implementation/ remedial action step implements the selected remedial alternative.

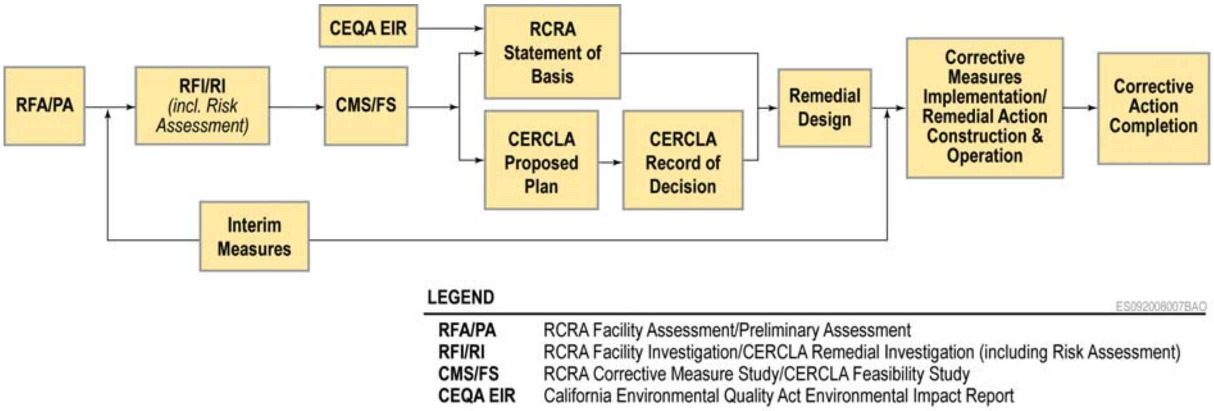

FIGURE 1-1
Site Cleanup Process
Groundwater Corrective Measures Study/Feasibility Study Report for SWMU 1/AOC 1 and AOC 10, PG&E Topock Compressor Station, Needles, California

The action being taken to address chromium in groundwater near the compressor station is referred to in this CMS/FS as the "remedial action," which is intended to be equivalent to RCRA Corrective Action and Comprehensive Environmental Response, Compensation and Liability Act of 1980 (CERCLA) terminology of "corrective measure," "corrective action," or "response action." The remainder of this section provides project background information, project objectives, and the content and organization of this CMS/FS.

1.1 History of Investigative and Remedial Activities at the Topock Compressor Station

The California Environmental Protection Agency, Department of Toxic Substances Control (DTSC) is the state lead agency overseeing corrective actions at the compressor station in accordance with RCRA Corrective Action. The United States Department of the Interior (DOI) is the lead federal agency overseeing response actions addressing the release of hazardous substances on or from land under its jurisdiction, custody, or control near the compressor station pursuant to CERCLA.

The investigative and remedial activities at the Topock Compressor Station are being performed in accordance with a Corrective Action Consent Agreement (CACA) between PG&E and DTSC, dated February 1996 (DTSC, 1996), as well as an Administrative Consent Agreement between PG&E and DOI, the United States Bureau of Land Management (BLM), United States Fish and Wildlife Service (USFWS), and United States Bureau of Reclamation (BOR) (collectively, the "federal agencies"), dated July 2005 (DOI, 2005).

Investigative and remedial activities at the Topock Compressor Station date back to the 1980s with the identification of SWMUs through a RCRA facility assessment. Closure activities of former hazardous waste management facilities at the compressor station were performed from 1988 to 1993. The RFI began in 1996 with the signing of the CACA, and numerous phases of data collection and evaluation have been performed as of the date of this CMS/FS. Since 2005, investigative and remedial activities have been performed in accordance with the requirements of both RCRA Corrective Action and CERCLA.[1]

1.1.1 RCRA Facility Investigation/Remedial Investigation

The *Revised Final RCRA Facility Investigation and Remedial Investigation Report, Volume 1 – Site Background and History* (CH2M HILL, 2007a) was completed in August 2007 and was subsequently approved by DTSC (2007) and DOI (2007a). The RFI/RI Volume 1 Report contains information on compressor station operations; history; and descriptions of SWMUs, AOCs, and other undesignated areas. The RFI/RI Volume 1 Report identifies the SWMUs, AOCs, and other undesignated areas at the Topock Compressor Station to be carried forward in the RFI/RI characterization phase, as shown in Figure 1-2. An addendum to RFI/RI Volume 1 will be prepared in the future.

The *Revised Final RCRA Facility Investigation and Remedial Investigation Report, Volume 2 - Hydrogeological Characterization and Results of Groundwater and Surface Water Investigations* (CH2M HILL, 2009a) was completed in February 2009 and was approved by DTSC (2009a) and DOI (2009a). The RFI/RI Volume 2 report contains information on the hydrogeologic characterization and results of groundwater, surface water, pore water, and river sediment

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[1] Pursuant to the Administrative Consent Agreement between PG&E and the federal agencies, remedial actions at the site must comply with the requirements of CERCLA and the National Oil and Hazardous Substances Pollution Contingency Plan in Title 40 of the Code of Federal Regulations Part 300.

investigations to evaluate and characterize the historic discharge of wastewater from the PG&E Topock Compressor Station to the former percolation bed in Bat Cave Wash (SWMU 1/AOC 1) and injection well PGE-8 (SWMU 2). Based on site history and characterization data, the RFI/RI Volume 2 report recommends that SWMU 1/AOC 1 (the former percolation bed in Bat Cave Wash and area around the former percolation bed) be carried forward from the RFI/RI into the CMS/FS (CH2M HILL, 2009a). Based on site history and site characterization data, SWMU 2 (Inactive Injection Well PGE-8) will not be carried forward into this CMS/FS An addendum to the RFI/RI Volume 2 report confirmed the conclusions of the RFI/RI Volume 2 Report (CH2M HILL, 2009b); the addendum was completed in June 2009 and was approved by DTSC (2009b) and DOI (2009b).

In November 2009, PG&E completed the *Final Human Health and Ecological Risk Assessment of Groundwater Impacted by Activities at Solid Waste Management Unit (SWMU) 1/Area of Concern (AOC) 1 and SWMU 2, Topock Compressor Station, Needles, California* (ARCADIS, 2009) that evaluated potential risks to human health and ecological receptors associated with groundwater and surface water affected by historical discharges to SWMU 1/AOC 1 and SWMU 2 to supplement the RFI/RI Volume 2 Report. The risk assessment provides information to assist risk management decision making about the constituents of concern in groundwater and surface water and risk-based concentrations of those constituents. DTSC and DOI approved the risk assessment in December 2009 (DTSC 2009c, DOI 2009c).

Subsequent to the RFI/RI Volume 2 and Volume 2 Addendum, PG&E completed additional hydrogeologic and groundwater characterization activities in the East Ravine (AOC 10). The additional hydrogeologic and groundwater characterization in the East Ravine has been incorporated into the conceptual site model for this remedial action. The results of the East Ravine groundwater investigation are provided as Appendix A to this report and additional investigation is planned for this area as outlined in the last section of Appendix A.

Following completion of additional investigations at the site, PG&E will prepare RFI/RI Volume 3. RFI/RI Volume 3 will include final characterization data to complete the RFI/RI requirements for remaining Topock Compressor Station operations, including the results of investigations of the other SWMUs, AOCs and undesignated areas. To supplement RFI/RI Volume 3, PG&E will also prepare a risk assessment that evaluates potential risks to human and ecological receptors that could be exposed to constituents at the other AOCs and undesignated areas at the Topock Compressor Station. A separate CMS/FS and/or an addendum to this CMS/FS will be prepared for additional media and SWMUs/AOCs at the Topock Compressor Station, if appropriate, based on the conclusions and recommendations in RFI/RI Volume 3 and associated risk assessment.

Applicable or relevant and appropriate requirements (ARARs) for the Topock site have been identified through an iterative process. A preliminary list of ARARs was issued by DOI in December 2007 (DOI, 2007b), updated in June 2008 (DOI, 2008a) and updated again to reflect comments submitted on the Draft CMS/FS (DOI, 2009d). The ARARs for the Topock site are listed in Appendix B of this CMS/FS.

This document addresses groundwater contamination resulting from the historic discharge of wastewater to the percolation beds in Bat Cave Wash, as well as groundwater contamination within the East Ravine. The area of the chromium plume is approximately 175 acres. Concentrations of total chromium (Cr[T]) in groundwater are greater than federal and

California regulatory standards, and concentrations of hexavalent chromium (Cr[VI]) in groundwater exceed background levels (there are no federal or California regulatory standards for Cr(VI) in groundwater). The groundwater risk assessment has concluded that Cr(VI) is present in groundwater at concentrations that could pose a potential hazard to the future hypothetical groundwater user, if the groundwater were to be used in the future as a potable source of water. The RFI/RI Volume 2 Report and Volume 2 Addendum concluded that, in addition to Cr(VI), three constituents in groundwater—namely molybdenum, selenium, and nitrate—may be associated with SWMU 1/AOC 1; however, the groundwater risk assessment concluded that these three constituents were not present in groundwater at levels of potential concern to future human health or the environment (ARCADIS, 2009).

DTSC and DOI, however, concluded that although the noncancer hazards associated with these constituents are much lower than those associated with Cr(VI), these constituents do have risks above a hazard index (HI) of 1 and they do contribute to a hazard quotient greater than 1 at localized areas within the plume. The agencies directed that molybdenum, selenium, and nitrate be monitored in the groundwater monitoring program and their associated impacts be considered in future soil and soil to groundwater risk evaluations (DTSC 2009c, DOI 2009c).

1.1.2 Interim Measures, Treatability Studies, and Other Relevant Studies

PG&E has been implementing an Interim Measure (IM) at the site since March 2004. Implementation of the IM is expected to continue until a final corrective action/remedial action for the site is operating properly and successfully and the regulatory agencies terminate the requirement for IM. The Interim Measure at the Topock site has held various designations since 2004 as IM No. 1, IM No. 2, and IM No. 3, which are collectively referred to in this report as the Interim Measure or IM. The IM currently consists of (1) groundwater extraction for hydraulic control of the groundwater plume in the Colorado River floodplain, (2) treatment of extracted groundwater in a groundwater treatment plant, and (3) reinjection of treated water through groundwater injection wells.

Concurrent with the RFI/RI, risk assessment, ARARs development, and IM implementation, PG&E has collected data and has implemented several studies to assist in the identification, screening, and evaluation of remedial technologies. These studies include:

- Extensive data collection as part of the IM to evaluate groundwater extraction, *ex-situ* groundwater treatment, and groundwater injection.
- Groundwater-level measurements, hydraulic testing, and groundwater modeling to determine the direction and rate of groundwater movement to support design and operation of extraction and injection wells.
- Anaerobic core testing of floodplain (fluvial) sediments to evaluate the capacity of anaerobic zone materials to chemically and biochemically reduce Cr(VI) to trivalent chromium (Cr[III]).
- Aerobic core testing to evaluate the degree of sorption or other interactions between Cr(VI) in groundwater and the aquifer material in the aerobic zone.
- Soil borings and seismic surveys to determine depth to bedrock.

- Groundwater model calibration updates to estimate cleanup times for various scenarios and to model simulations to predict effects of *in-situ,* pump/inject, and barrier wall technologies.
- *In-situ* pilot testing to evaluate site-specific effectiveness of *in-situ* treatment, longevity of reactants, ability to distribute reactants in the subsurface, and to assess potential effects of injected reagents on aboveground treatment systems. The effectiveness of *in-situ* reduction is being evaluated through pilot testing in both the fluvial aquifer in the floodplain and the Alluvial Aquifer in the upland portion of the site.
- A chromium isotope study to evaluate whether isotopic signatures of chromium could be used to distinguish anthropogenic from naturally occurring Cr(VI) in groundwater.

Data and information collected for the RFI/RI and during implementation of the IM, as well as the data and information collected from the above studies, are used in this document to identify and evaluate remedial alternatives.

1.2 Description and History of SWMU 1/AOC 1 and AOC 10

This document addresses the substances released into the environment from past discharges of wastewater into the Former Percolation Bed (SWMU 1) and the area around the Former Percolation Bed (AOC 1) within Bat Cave Wash near the Topock Compressor Station. This document also addresses groundwater within East Ravine (AOC 10). The following presents a description and history of SWMU 1/AOC 1 and AOC 10, summarized from the RFI/RI Volume 1 (CH2M HILL, 2007a), and the *Revised Work Plan for the East Ravine Groundwater Investigation, Topock Compressor Station, Needles, California* (CH2M HILL, 2008a).

SWMU 1 was formerly the site of wastewater percolation within Bat Cave Wash. AOC 1 is defined as areas affected by flow of wastewater from the percolation bed, including the floor of Bat Cave Wash in the area surrounding the location of the discharge area (SWMU 1) and the floor of Bat Cave Wash downstream from the discharge area towards the Colorado River. From 1951 to 1970, facility wastewater was discharged to this area and was allowed to percolate into the ground and/or evaporate. In addition, there have been several incidental releases of facility wastewater, a few of which have resulted in wastewater released to Bat Cave Wash, as described in the RFI/RI Volume 1 Report (CH2M HILL, 2007a).

Wastewater discharged to Bat Cave Wash consisted primarily of cooling tower blowdown (about 95 percent) and a minor volume of effluent from an oil/water separator (OWS) and other facility maintenance operations (about 5 percent). From 1951 until 1964, cooling tower blowdown was not treated prior to being released to the wash. During that period, the cooling tower blowdown contained Cr(VI). From 1964 to 1969, the cooling tower blowdown was treated with a one-step system to reduce Cr(VI) in the wastewater to Cr(III) prior to discharge to the wash. Beginning in late 1969, cooling tower blowdown was treated with a two-step system to reduce Cr(VI) to Cr(III) and then to remove Cr(III) from the wastewater prior to discharge to Bat Cave Wash. The continuous discharge of wastewater to Bat Cave Wash ceased in May 1970 when injection well PGE-08 was brought online. From May 1970 to September 1971, however, some treated wastewater may have been temporarily discharged to the percolation bed in Bat Cave Wash when injection well PGE-08 was offline for repairs or maintenance. All wastewater discharges to the percolation bed in Bat Cave Wash stopped when the first of four single-lined evaporation ponds was installed in September 1971. Since 1989, industrial wastewater from the compressor station has been disposed at Class II (double-lined) evaporation ponds.

AOC 10 (East Ravine) is located southeast of the compressor station, and includes four subareas, designated as AOC 10a, 10b, 10c, and 10d. Subarea 10a is the location of the termination of a storm drain leading from the southeastern portion of the compressor station. The remaining subareas are locations within the East Ravine where water and sediment have collected within low areas or behind one of three earthen embankments. Two historical aerial photographs of this portion of the site show a low area within the AOC 10c subarea that apparently contained liquids behind the largest embankment. While the composition of such liquids is not known, it is noted that this is the location of some of the highest chromium concentrations detected in site soil sampling. Thin layers of white powdery material have also been identified in the East Ravine area that are visually similar to the white waste layers located in Bat Cave Wash and the Railroad Debris Site (DTSC, 2008a). Drainage to this ravine includes minor runoff from the access road to the facility, runoff from the mountains to the south, and some runoff from the compressor station.

1.3 CMS/FS Report Objectives and Organization

The *Final Corrective Measures/Feasibility Study Work Plan, Topock Compressor Station, Needles, California* (CMS/FS Work Plan) (CH2M HILL, 2008b) was completed in March 2008 and was approved by DTSC (2008b) and DOI (2008b). The CMS/FS Work Plan conceptually describes the planned activities and schedule to complete the CMS/FS at the PG&E Topock Compressor Station in accordance with the requirements of RCRA Corrective Action and CERCLA.

This document is the CMS/FS for the remedial action addressing groundwater contamination associated with SWMU 1/AOC 1 and AOC 10 at the PG&E Topock Compressor Station. The purpose of this document is to identify and evaluate remedial alternatives and to provide the basis for the selection of a recommended alternative to address the defined objectives for this remedial action. This document is based on the conclusions and recommendations in the RFI/RI Volume 2 Report and Addendum (CH2M HILL, 2009a-b), groundwater risk assessment (ARCADIS, 2009), and results of the East Ravine investigation (Appendix A). This document has been prepared pursuant to the requirements in Section IV.C of the CACA (DTSC, 1996); Section 9.3 of the Administrative Consent Agreement (DOI, 2005); and the approved CMS/FS Work Plan (DTSC, 2008b; DOI, 2008b).

The Draft CMS/FS Report was originally published in January 2009[2] (CH2M HILL 2009c). In letters dated March 20, 2009 and March 26, 2009, DOI and DTSC provided comments to the January 2009 CMS/FS Report, and also forwarded comment letters from five stakeholder entities (DOI, 2009e; DTSC, 2009d). On June 2, the BLM also forwarded comments from three Native American tribes (BLM, 2009). This Final CMS/FS Report has been modified in response to these comments; responses to agency and stakeholder comments on the Draft CMS/FS Report are provided in Appendix C-1. A revised CMS/FS Report was sent to DTSC

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[2] The Draft CMS/FS report included specified information as directed by DTSC in late 2008 (DTSC 2008c-d), as well as changes in response to letters from the Fort Mojave Indian Tribe dated January 12, 2009 and the Colorado River Indian Tribe dated January 9, 2009.

and DOI in November 2009 (CH2M HILL, 2009d), and additional agency review followed; this Final CMS/FS Report has been further modified in response to these additional comments, as outlined in Appendix C-2. Resolution of comments was a joint effort between PG&E and its contractors, including CH2M HILL; DTSC staff; DOI staff and its contractors; and the DOI Solicitor's office. As documented in Appendices C-1 and C-2, text in certain sections of this report were provided directly by agency or agency contractors, to be published herein.

To comply with the requirements of the CACA, the Administrative Consent Agreement, and the approved CMS/FS Work Plan,[3] this CMS/FS report contains:

- Description of current conditions (Section 2.0).
- Remedial action objectives (Section 3.0).
- Identification and screening of technologies (Section 4.0).
- Development and evaluation of remedial action alternatives (Section 5.0).
- Discussion of recommended remedial action alternative (Section 6.0).

Following approval of this Final CMS/FS by DOI and DTSC, DTSC will identify a preferred alternative through a RCRA Statement of Basis and DOI will identify a preferred alternative in a CERCLA Proposed Plan. The preferred alternative(s) will be based substantially on one of the alternatives evaluated in the CMS/FS Report and will be proposed for selection based upon the comparative evaluation of alternatives presented therein, but may deviate in certain respects from the alternative as specifically described in the CMS/FS Report.

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[3] USEPA guidance (1988a-b, 1990, 1995, 1996a-b, 1997a, 1999, 2000, 2004, 2007, 2008) was also consulted during preparation of this document.

Notes:

AOC 13 is not depicted on this figure. It consists of the unpaved areas within the compressor station.

AOC 20 is not depicted on this figure. It consists of industrial floor drains within the compressor station.

Boundaries of all SWMUs, AOCs, and Other Undesignated Areas are approximate.

RFI/RI = Resource Conservation and Recovery Act facility investigation/remedial investigation.

FIGURE 1-2
SOLID WASTE MANAGEMENT UNITS, AREAS OF CONCERN, AND OTHER UNDESIGNATED AREAS TO BE ADDRESSED IN RFI/RI

FINAL GROUNDWATER CORRECTIVE MEASURES STUDY/FEASIBILITY STUDY REPORT
FOR SWMU 1/AOC 1 AND AOC 10
PG&E TOPOCK COMPRESSOR STATION
NEEDLES, CALIFORNIA

CH2MHILL

\\ZINFANDEL\PROJ\PACIFICGASELECTRICCO\TOPOCKPROGRAM\GIS\MAPFILES\2009\CMS\SEPTEMBER\CMSFS_SWMU_D_ZOOM.MXD BKAHLER 12/14/2009 16:18:30

2.0 Description of Current Conditions

This section provides descriptive information about the Topock site, the nature and extent of impacted groundwater, land uses, and site constraints important for identifying and evaluating remedial alternatives. The purpose of this section is to provide context for site conditions that were considered during development of this CMS/FS. For additional detail on the topics discussed herein, refer to the RFI/RI Report and other referenced documents.

2.1 Site Location, Property Ownership, and Land Uses

The Topock Compressor Station is located in eastern San Bernardino County, California about 15 miles southeast of Needles, as shown in Figure 2-1. The compressor station is located approximately 1,500 feet west of the Colorado River and the California/Arizona state border. The Topock Compressor Station began operations in December 1951 to compress natural gas supplied from the southwestern United States for transport through pipelines to PG&E's service territory in central and northern California. The compressor station is still active and is anticipated to remain an active facility into the foreseeable future. As discussed in Section 1.2, the station has not released untreated blowdown water containing Cr(VI) since 1964, and there have been no wastewater discharges to the percolation bed in Bat Cave Wash since 1971.

The groundwater plume underlies an area of approximately 175 acres located to the north of the compressor station. For the purposes of this remedial action, the site is defined as the areal extent of contamination and areas in proximity to the contamination necessary for implementation of the remedial action, assumed to be the 1,800-acre Area of Potential Effect (APE).

2.1.1 Land Ownership/Management

Land ownership/management within the APE is shown in Figure 2-2. Property within the APE includes land owned and/or managed by a number of government agencies and private entities including the BLM, BOR, USFWS, San Bernardino County, Burlington Northern Santa Fe Railroad, PG&E, and the Southern California Metropolitan Water District. As shown in Figure 2-2, land within the 175-acre plume area is divided among multiple property owners/managers: PG&E, BOR (managed by BLM), Burlington Northern Santa Fe Railroad, and the USFWS (which manages the Havasu National Wildlife Refuge [HNWR]). PG&E transferred parcel 650-151-06i to the Fort Mojave Indian Tribe in late October 2009. Under the terms of the land transfer the Tribe will hold the land in fee and PG&E will maintain an easement on the property (including access) to construct, operate and maintain existing and future facilities as needed for remediation of the site. In addition, several other entities have easements and/or rights-of-way within the 175-acre plume area, including California Department of Transportation, San Bernardino County, Southern California Gas Company, Transwestern Pipeline Company, Mojave Pipeline Company, PG&E, City of Needles Electric, Southwest Gas Corporation, and Frontier Telephone.

2.1.2 Land Use and Nearby Communities and Development

The site is located in a sparsely-populated, rural area. Land uses near the site are predominantly open space, interspersed with industrial facilities, recreational uses, and transportation infrastructure. Open space near the uplands portion of the site is characterized primarily by sparse desert vegetation on elevated mesas and steep, rocky slopes. The area is bisected by several steep-sided ephemeral streambeds, including Bat Cave Wash and several unnamed washes oriented north/northeast to their confluences with the Colorado River. Open space on the Colorado River floodplain is characterized by shifting sand dunes and associated riparian vegetation, primarily arrowweed and non-native tamarisk (salt cedar).

The nearest communities are mobile home parks and private residences at Topock, Arizona and Moabi Regional Park, California. The Topock mobile home park is located at the Topock Marina on the Arizona (or eastern) side of the Colorado River about 0.5 mile east of the site. Moabi Regional Park is located on the California (or western) side of the Colorado River about 1.5 miles northwest of the site. The community of Golden Shores, the largest nearby community outside the APE, is located approximately 5 miles north of the compressor station on the east side of the Colorado River.

A major gas utility and transportation corridor is located within the APE. This corridor includes six natural gas transmission pipelines, the Burlington Northern Santa Fe Railway, and the Interstate 40 freeway. Other developed land uses and existing structures are shown in Figure 2-3 and include the Topock Compressor Station, National Trails Highway, former Route 66, overhead electric lines, county roads, and various unnamed access roads. In addition, an interim remedial measures groundwater treatment plant and numerous groundwater well clusters related to the ongoing groundwater investigation activities are located within the APE.

The HNWR encompasses approximately 37,515 acres along the Colorado River in Mohave and La Paz Counties, Arizona and in San Bernardino County, California. Most of the refuge extends from the upper end of Topock Marsh southward to the head of Lake Havasu on the Arizona side of the river. A portion of the refuge borders the compressor station. Recreational activities at the HNWR include sightseeing, bird watching, fishing, hunting, camping, and canoeing (USFWS, 1999).

2.1.3 Groundwater and Surface Water Uses

Groundwater beneath and in the immediate vicinity of the groundwater plume is not used as a water supply. The nearest groundwater supply wells in California are located approximately 1.3 miles west-northwest of the plume at the Park Moabi Marina. Additionally, groundwater supply wells are located at private residences south of the Topock Marina on the eastern side of the Colorado River approximately 0.3 mile east-southeast of the plume.

The Colorado River, located adjacent to and east of the plume, is a major source of water for irrigation, drinking, and other uses by humans and wildlife. The closest downstream supply intake is located approximately 21 river miles downstream of the railroad bridge over the Colorado River. The Colorado River also supports recreational uses of swimming, boating, and fishing. In addition, the Colorado River serves as an aquatic habitat that supports various plant and wildlife species, including threatened or endangered species. Additional information on biological resources is discussed in Section 2.2.7.

2.2 Physical Characteristics

This section describes the physical characteristics that are important for identifying and evaluating remedial alternatives. As discussed above, for the purposes of this remedial action, the site is defined as the approximately 175-acre areal extent of groundwater contamination and all suitable areas in very close proximity to the contamination necessary for implementation of the remedial action, assumed to be the 1,800-acre APE, which also equates to the approximate study area boundaries for the RFI/RI (CH2M HILL, 2009a).

2.2.1 Surface Features and Topography

Topography at the site is shown in Figure 2-4. The site is located in the southern portion of the Mohave Valley, north of the Chemehuevi Mountains, and south and west of the Colorado River floodplain. Overlying the plume, topography ranges from approximately 455 feet above mean sea level at the Colorado River floodplain to approximately 600 to 625 feet above mean sea level at the compressor station.

The site consists of a series of terraces divided by dry desert washes. The terraces are considerably eroded with very steep slopes. The compressor station is located on a prominent alluvial terrace. Incised drainage channels separate the alluvial terraces. Overlying the plume, the largest incised channel is Bat Cave Wash, a north-south dry wash that bisects the plume. Bat Cave Wash flows on the surface only intermittently (as an ephemeral stream) following intense rainfall events and extends to the Colorado River.

2.2.2 Meteorology

The climate is typical of low desert areas in the lower Colorado River basin, with hot summer and mild winter seasons. The average daily average maximum temperature ranges from 63.8 degrees Fahrenheit (°F) in January to 108.6°F in July. The average daily maximum temperature exceeds 100°F during June, July, August, and September (National Oceanic and Atmospheric Administration, 2000), and rarely does the temperature drop below freezing.

Based on the 30-year period of 1961 through 1990, average precipitation was 4.67 inches per year in Needles.[4] From 1950 through 1965, the maximum annual rainfall was 9.5 inches. Rain occurs primarily during summer thunderstorms from July through early September and during the winter rainy season from December through March. May and June are typically the driest months. Based on data from the Needles Airport, the predominant wind direction is south-southwest, with an average speed of 8.8 miles per hour. The second most predominant wind direction is north-northwest, with an average speed of 10.7 miles per hour. Wind direction and speed are more variable at the compressor station site due to the extreme topography and proximity to the river channel.

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[4] Data available from http://www.weather.com/activities/otther/weather/climo-monthly.html?locid_USCA0753.

2.2.3 Colorado River and Surface Water Features

Figure 2-5 depicts surface waters and wetlands within and near the site as determined by field surveys in 2005 (CH2M HILL, 2005a).

The primary surface water feature is the Colorado River. The Colorado River channel ranges from approximately 600 to 700 feet wide in the area upstream of the bridge crossing at Topock. In 2005, the river depths ranged from 4 to 12 feet on two cross-river transects measured at and north of the Interstate-40 bridge. On the river transect measured at the I-3 pipeline bridge, the channel depths ranged from 5 feet near the Arizona shoreline to a maximum of 22 feet near the California shoreline (CH2M HILL, 2006a). Additional historical information on Colorado River dredging, river morphology, and bridge crossing subsurface investigations were incorporated in the surface water characterization, as summarized in the Final RFI/RI Report, Volume 2 Addendum (CH2M HILL, 2009b).

The flow of the Colorado River is dynamic and fluctuates daily and seasonally as a result of BOR's power and water delivery schedule. The flow of the Colorado River at Topock is regulated by BOR, primarily by the controlled release of water from Davis Dam on Lake Mohave approximately 33 miles upstream. River levels at the site fluctuate by 2 to 3 feet per day, and flows vary anywhere from 4,000 to 25,000 cubic feet per second according to the dam releases (CH2M HILL, 2009a).

Based on data collected during the monitoring period of the RFI/RI, no site-related contamination of surface water in the Colorado River is observed. Over 700 surface water samples were collected from 43 locations in the Colorado River to determine the occurrence and extent of constituents of potential concern (COPCs) in surface water for the RFI/RI. None of the average concentrations for the samples from the shoreline, in-channel, and pore water study surface water locations exceeds the most stringent chemical-specific ARAR. There was no discernable difference between results in samples collected upstream or downstream of Bat Cave Wash in the Colorado River. None of the Cr(VI) and Cr(T) concentrations from the RFI/RI samples collected from the Colorado River exceeded the chemical-specific ARARs criteria of 11 and 50 micrograms per liter (µg/L), respectively. The one exception is the Cr(VI) shoreline samples collected in June 2002 that data quality review indicated were false positives, as discussed in the RFI/RI Volume 2 Report (CH2M HILL, 2009a).

As mentioned previously, Bat Cave Wash is a north-south incised channel bisecting the plume that flows only intermittently (as an ephemeral stream) following intense rainfall events and extends to the Colorado River. Other surface water features within the APE include the Park Moabi inlet/slough, the Topock Marsh inlet, other dry wash drainages, and the Colorado River floodplain and sand dune shoreline features.

2.2.4 Geology

The site is in the Basin and Range geomorphic province, characterized by roughly parallel north/south fault-block mountains separated by alluvial valleys. The oldest rocks in the surrounding area are exposed in the Chemehuevi Mountains and include Precambrian and Mesozoic-age metamorphic and igneous rocks. Miocene-age sedimentary and volcanic rocks, associated with the tectonic uplift and faulting in the region, were deposited on the metamorphic and plutonic bedrock complex. The bedrock basement formations are, in turn, overlain by younger Tertiary and Quaternary to Recent-age sedimentary deposits.

The most prominent geologic structural feature is the detachment fault that forms the northern boundary of the Chemehuevi Mountains. The Chemehuevi detachment fault, located near the southern boundary of the APE, is inferred to be a low-angle (15- to 20-degree), northeast-dipping normal fault that has displaced pre-Tertiary metamorphic bedrock and Miocene sedimentary rocks (upper plate) across underlying, lower plate crystalline bedrock. The surface trace of the Chemehuevi detachment fault is mapped in western Mohave County, Arizona, approximately 2 miles southeast of the site, indicating that this regional fault extends eastward from California into Arizona.

Figure 2-6 is a geologic map of the APE. Within the APE, the primary geologic mapped units are Quaternary Colorado River and recent floodplain deposits, Quaternary alluvium and surficial deposits, older Tertiary alluvium, and bedrock formations that include Miocene Conglomerate and pre-Tertiary metamorphic and igneous rocks. Additional description and details on the site geology are presented in the RFI/RI Volume 2 Report (CH2M HILL, 2009a).

2.2.5 Hydrogeologic Conditions

The hydrogeologic conditions of the site described below are summarized from the RFI/RI Volume 2 Report (CH2M HILL, 2009a), Volume 2 Addendum (CH2M HILL 2009b), and the East Ravine Groundwater Investigation (Appendix A). The site is located at the southern downstream end of the Mohave Valley groundwater basin. Groundwater in the Mohave Basin occurs in the Tertiary and younger alluvial fan and fluvial deposits. The unconsolidated alluvial and fluvial deposits are underlain by the Miocene Conglomerate and pre-Tertiary metamorphic and igneous bedrock. The bedrock typically has lower permeability; therefore groundwater movement occurs primarily in the overlying unconsolidated deposits. In the Mohave groundwater basin, water-bearing zones may occur locally where bedrock formations are weathered or fractured, although no areas have been identified where saturated bedrock formations are capable of yielding significant quantities of groundwater.

Groundwater occurs under unconfined to semi-confined conditions within the alluvial fan and fluvial sediments beneath most of the site. The alluvial sediments consist primarily of clayey/silty sand and clayey gravel deposits interfingered with more permeable sand and gravel deposits. The alluvial deposits exhibit considerable variability in hydraulic conductivity between fine- and coarse-grained sequences. The fluvial sediments similarly consist of interbedded sand, sandy gravel, and silt/clay. The fluvial deposits at the site include the older Pleistocene deposits as well as more recent fluvial deposits associated with the Colorado River. The saturated portion of the alluvial fan and fluvial sediments are collectively referred to as the Alluvial Aquifer.

Figure 2-7 presents a schematic cross-section to illustrate the hydrogeologic setting between the Topock Compressor Station and the Colorado River. In the floodplain area adjacent to the Colorado River, the fluvial deposits interfinger with, and are hydraulically connected to, the alluvial fan deposits. The interface between alluvial and fluvial units occurs near the western edge of the floodplain. The Topock Compressor Station is located on an upland alluvial terrace near the southern edge of the Alluvial Aquifer where the aquifer pinches out against the underlying, sloping bedrock.

As shown in Figure 2-7, the water table in the Alluvial Aquifer is flat and typically equilibrates to an elevation within 2 to 3 feet of the river level. On the basis of the variable topography, the depth to groundwater ranges from as shallow as 5 feet below ground surface (bgs) in floodplain wells next to the river to approximately 170 feet bgs at the upland alluvial terrace areas. The saturated thickness of the Alluvial Aquifer is about 100 feet in the floodplain and thins to the south, pinching out along the Miocene Conglomerate and bedrock outcrops. In the western portions west of the site, where the depth to bedrock increases, the saturated Alluvial Aquifer is over 200 feet thick.

Additional hydrogeologic data collected during February through July 2009 for the East Ravine groundwater investigation refined the site hydrogeologic conceptual model presented in the RFI/RI Volume 2, specifically mapping bedrock structure and the bedrock/Alluvial Aquifer contact, characterization of hydraulic properties, groundwater gradient and flow, and groundwater quality in bedrock. The hydrogeologic results and findings from the East Ravine investigation are described in Appendix A of this report.

Hydrogeologic and hydrogeochemical features of the site are summarized below:

- Under natural conditions, groundwater flows from west-southwest to east-northeast across the site. Localized areas of northward flow likely occur along the mountain front to the south of the compressor station. Gradients are very small due to the limited recharge, with a typical value of 0.0005 foot/foot in the alluvial area. Under average conditions, groundwater velocity ranges from about 25 to 46 feet/year, according to numerical model estimates. Gradients are upward between bedrock and the overlying Alluvial Aquifer and typically, but not universally, upward within the Alluvial Aquifer.

- Investigation and monitoring in the East Ravine area shows that the groundwater in fractured bedrock is in hydraulic communication with the Alluvial Aquifer and equilibrates to an approximate elevation similar to the water table in the Alluvial Aquifer. Compared to the Alluvial Aquifer, the fractured rock permeabilities are overall very low, consistent with the RFI/RI data.

- Under ambient conditions in the vicinity of the site, the river recharges groundwater during the higher-flow stages in the spring and summer months, and groundwater discharges to the river during the months of lower river stages in fall and winter. Since 2004, the IM groundwater extraction and treatment system has maintained a consistent, year-round landward gradient in the area where the plume is present in the floodplain.

- The total dissolved solids (TDS) of site groundwater varies considerably, ranging from as low as 300 milligrams per liter (mg/L) (at MW-1) to over 40,000 mg/L (MW-30-30 and MW-32-20). Most site monitoring wells are in the 1,000 to 10,000 mg/L range. In general, high TDS is associated with (1) bedrock wells, (2) deep alluvial/fluvial wells, and (3) a few shallow fluvial wells. Low TDS is found in shallow fluvial wells close to the river and in shallow alluvial wells in the western parts of the site. Distribution of TDS in groundwater at the site is provided in Figures 5-18a, b, c, and 5-19 of the RFI/RI Volume 2 Report (CH2M HILL, 2009a). In general, TDS typically increases with depth, with the highest TDS concentrations found in deepest alluvial and bedrock wells. The

TDS in fluvial groundwater increases with distance away from the river and with depth, becoming similar to alluvial groundwater quality in deeper fluvial wells west of the floodplain.

- Groundwater oxidation-reduction (redox) data show a distinction between alluvial and shallow fluvial zones of the Alluvial Aquifer. Field measurements of redox potential and other chemical data and field observations of collected core indicate that organic-rich sediments in the fluvial deposits result in naturally-reducing conditions. Reducing conditions are also found in the bedrock and in some deeper zones of the Alluvial Aquifer. The majority of the Alluvial Aquifer does not exhibit reduced conditions.

2.2.6 Cultural Resources

The following information is derived from reports on cultural resource surveys conducted in the project area between 2004 and 2007. These are summarized in the report *Archaeological and Historical Investigations, Third Addendum: Survey of the Original and Expanded APE for Topock Compressor Station Site Vicinity* (Applied Earthworks, 2007). Additional research, including field visits, archival research, and ongoing meetings and interviews with tribal representatives, has been conducted by DTSC and its consultants for use in evaluating potential environmental impacts according to the California Environmental Quality Act (CEQA) Guidelines. A programmatic environmental impact report (EIR) is currently under preparation to meet DTSC's responsibilities under CEQA. Current environmental conditions summarized here will be described in greater detail in the EIR, along with an analysis of the potential effects of implementing the proposed cleanup action. Nine federally-recognized Native American tribes have ancestral ties to the area and have expressed interest in the project to DTSC. These include the Chemehuevi Indian Tribe, Cocopah Tribe of Arizona, Colorado River Indian Tribes, Fort Mojave Indian Tribe, Havasupai Indian Tribe, Hualapai Indian Tribe, Quechan Tribe of the Fort Yuma Indian Reservation, Twenty-Nine Palms Band of Mission Indians, and Yavapai-Prescott Tribe. The project site lies within a larger area of traditional cultural importance and spiritual significance to some of these tribes.

Thousands of years of human history are evident in the area surrounding the Topock Compressor Station. Among the larger and better-known cultural resources on the site is an expansive desert geoglyph or intaglio known as the Topock Maze. Although the Maze is viewed as one contiguous element of a larger area having unique value to some tribes, archaeological documents refer to three geographically-distinct parts, two of which overlie the groundwater plume. Prominent historic-era features in the landscape, several of which intrude upon the Maze and also overlie the groundwater plume, include segments of historic United States Route 66, the National Old Trails Highway, and the right-of-way of the Atlantic and Pacific/Atchison, Topeka and Santa Fe Railroad. A broad spectrum of archaeological resources is also present within the project site and on adjacent lands. Properties on and near the project site that are listed on the National Register of Historic Places include Native American cultural resources and elements of the historic "built environment."

In carrying out their respective responsibilities under the National Historic Preservation Act, CEQA, and all ARARs for cultural resource protection, the DOI and DTSC have indicated that they will ensure that the projects' potential effects on significant historic properties are taken into account in the remedy selection process (DTSC, 2009e).

2.2.7 Biological Resources

A large portion of the site and surrounding area is the HNWR. The *Lower Colorado River National Wildlife Refuges Comprehensive Management Plan 1994-2014*, adopted in 1994, currently guides land management at the HNWR. The Comprehensive Management Plan emphasizes that the HNWR should be used in a manner that will facilitate protection of (1) the endangered and threatened species found at the refuge; (2) marsh and wetland habitat for both endangered and threatened species; and (3) habitat for migratory, wintering, and nongame avian species and their habitat.

The site and surrounding area is characterized by arid conditions and high temperatures. As mentioned previously, the site consists of a series of terraces divided by dry desert washes, with Bat Cave Wash the largest incised channel. Bat Cave Wash flows on the surface only briefly (as an ephemeral stream) following intense rainfall events and drains to the Colorado River. Terraces are composed of rocky soils with very sparse vegetation.

Terrestrial wildlife found at the site are those adapted to the interrelated stresses of drought, temperature extremes, and the sparse or unpredictable food supply of the desert habitats found at the site. Trees and patches of native vegetation near the Colorado River may provide habitat for avian species and other wildlife species. Additional information on biological resources at the site are described in the *Biological Resources Survey Report for the Area of Potential Effect (APE) Topock Compressor Station Expanded Groundwater Extraction and Treatment System, Needles, California* (CH2M HILL, 2005a) and the *Programmatic Biological Assessment for Pacific Gas and Electric Topock Compressor Station Remedial and Investigative Actions* (CH2M HILL, 2007b). The conclusions of these reports are briefly summarized below for ease of reference.

Figure 2-8 shows the 10 plant communities that have been identified within the APE, with the boundary between these communities characterized by a transitional zone in which representative species from each community are found. The dominant plant communities at the site consist of creosote bush scrub (generally west of National Trails Highway) and salt cedar (generally between National Trails Highway and the Colorado River and at the mouth of Bat Cave Wash). These plant communities support a variety of common wildlife species and have provided habitat for several species that are currently designated as threatened or endangered by state and federal endangered species acts. These dominant plant communities and associated threatened or endangered species include:

- **Creosote Bush Scrub.** The desert tortoise (*Gopherus agassizii*) is the only threatened (state and federal) wildlife species that may occur in the creosote bush scrub. Tortoise protocol surveys conducted in the APE from 2005 through 2009 detected one desert tortoise carcass and four sets of highly deteriorated bone shell fragments. The carcass and bone shell fragments were estimated to be more than 4 years old and may indicate historical use of the site by tortoises. Alternatively, the tortoise sign observed in the drainages may have washed in from outside the survey area during a rainstorm. However, no desert tortoise scats, tracks, or other evidence of live tortoises or recent tortoise use was observed within the survey area (Garcia and Associates, 2009a).

- **Salt Cedar.** This plant community is characterized by dense thickets of salt cedar (*Tamarix* sp.), sometimes with an understory of arrowweed (*Pluchea sericea*). Salt cedar is highly successful in arid climates with saline or alkaline soils and often occurs in monotypic stands in riparian areas. Considered a noxious weed, salt cedar is fire-, flood- and drought-tolerant and resprouts readily after cutting or burning. It spreads through growth of adventitious roots and by dispersal of large amounts of seed. Salt cedar also out-competes native plant species for water and can increase soil salinity as it sheds foliage where it accumulates excess salt, thereby making conditions less tolerable for other species. Although salt cedar provides habitat and nest sites for some wildlife, many biologists conclude that it provides low-quality habitat for most native amphibians, reptiles, birds, and mammals. However, some literature has documented the endangered (federal and state) southwestern willow flycatcher (SWFL) (*Empidonax traillii extimus*) as nesting in the tamarisk thickets near watercourses, including the Colorado River (McLeod et al., 2005). Designated critical habitat for the SWFL does not exist within the APE. Flycatcher protocol surveys conducted near the site from 2005 through 2009 did not positively detect this species nesting. However, SWFL were detected and confirmed in 2008 and 2009 surveys but were determined to be migrants passing through the area (Garcia and Associates, 2008, 2009b). Although tamarisk is not known to provide optimal wildlife habitat, the trees appear to provide the only significant roosting and nesting structure due to limited structural tree diversity in the area.

The primary aquatic habitat within the APE is the Colorado River. The Colorado River supports several fish species listed as endangered. Additionally, game fish species were introduced into the river. There are also a number of water-associated avian and mammalian species that use the river and its banks. The fish species that are federally listed as threatened or endangered that may occur within the Colorado River in the study area vicinity include the bonytail chub *(Gila elegans)*,[5] Colorado pikeminnow *(Ptychocheilus lucius)*, and the razorback sucker *(Xyrauchen texanus)*. Within the APE, designated critical habitat for the bonytail chub is the Colorado River and the 100-year floodplain.

2.3 Nature and Extent of Groundwater Impacted by Chromium

This subsection describes the nature and extent of impacted groundwater near the compressor station that is attributable to the historic wastewater discharge from compressor station operations to the Alluvial Aquifer in Bat Cave Wash (SWMU 1/AOC 1), and the bedrock formations in AOC 10. This subsection also includes a description of the chromium plume, chromium fate and mobility, and background groundwater concentrations.

The principal constituents of concern (COCs) in groundwater at the site are Cr(VI) and Cr(T), which are the result of past wastewater disposal practices in Bat Cave Wash as described in Section 1.2 and as identified in the East Ravine. Selenium, molybdenum, and nitrate were found to exceed an HI of 1 and contribute to a hazard quotient greater than 1 at localized areas within the plume. Due to limited sampling data and comparatively lower risks contributions at the site, these constituents will be monitored throughout the remediation process (DTSC 2009c, DOI 2009c). Aside from these constituents, other

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[5] This fish is also often referred to as the bonytail.

constituents detected in groundwater were determined to either not be associated with SWMU 1/AOC 1 and/or were not present in site groundwater at levels of potential concern to future human health or the environment (CH2M HILL, 2009a-b; ARCADIS, 2009; Appendix A). Nearly all of the Cr(VI) releases to alluvial groundwater at the site are believed to have occurred during the 1951 to 1964 period when untreated wastewater from the compressor station was discharged to Bat Cave Wash. The extent of Cr(T) and Cr(VI) is defined sufficiently well for the purpose of establishing remedial action objectives and for evaluating remedial alternatives.

A schematic diagram of the groundwater chromium plume and key site features are depicted in Figure 2-9. From the percolation area in Bat Cave Wash, the wastewater infiltrated into the coarse sand and gravel of the wash bed and percolated approximately 75 feet downward through the unsaturated zone to reach groundwater. Testing to characterize the extent of the chromium plume indicates that the plume extends from the former percolation bed in Bat Cave Wash approximately 3,000 feet north/northeast to the Colorado River floodplain, along the general direction of groundwater flow. As discussed above, groundwater gradients at the site are slight, on the order of 0.0005 foot per feet, and the hydraulic conductivity of the Alluvial Aquifer along the axis of the plume is moderate, averaging about 30 feet per day. Chromium is present at all depth intervals of the alluvial portion of the aquifer but is generally not present in shallow and middle-depth fluvial wells near the Colorado River where reducing conditions predominate. Elevated concentrations of chromium are also present in wells completed within the shallow portion of the bedrock formations in the East Ravine to the southeast of the compressor station.

2.3.1 Chromium Plume Description

The chromium plume is defined as that part of the aquifer where Cr(VI) concentrations exceed natural background levels. The calculated statistical upper tolerance limit (UTL) of natural background levels for Cr(VI) in alluvial groundwater, obtained from sampling monitoring and water supply wells surrounding the Topock site, is 31.8 µg/L (CH2M HILL, 2008c, 2009i). The calculated statistical UTL for Cr(VI) of 31.8 µg/L is rounded to 32 µg/L for discussion of the extent of impacted groundwater below. The majority of the plume is located in the Alluvial Aquifer.

Figures 2-10, 2-11, and 2-12 illustrate the extent of Cr(VI) contamination in the Alluvial Aquifer and bedrock formations based on recent groundwater sample results for 118 wells. These maps were prepared using primarily Cr(VI) data from the October 2008 sitewide groundwater monitoring event (74 wells) for alluvial wells and the July 2009 sampling event for alluvial and bedrock wells completed in or near the East Ravine (16 wells). Since not all site wells were sampled during these two events, additional data for November and December 2008 (27 wells) and 2007 (17 wells), were combined with the October 2008 and July 2009 Cr(VI) data for completeness. With the exception of data collected from alluvial and bedrock wells completed in or near the East Ravine, the data used to prepare these maps were previously reported in the RFI/RI Volume 2 (CH2M HILL, 2009a) and groundwater monitoring and compliance monitoring reports (CH2M HILL, 2008d and 2009e-f). Sample results for alluvial and bedrock wells completed in or near the East Ravine are presented in Appendix A of this report.

In each of the Alluvial Aquifer depth monitoring zones,[6] the location of Cr(VI) concentrations for groundwater greater than or equal to 32 µg/L follows Bat Cave Wash northward approximately 3,000 feet from the compressor station. For the shallow and mid-depth zones, the 32 µg/L concentration limit extends west of Bat Cave Wash and into the western portion of the floodplain. In the deep zone of the Alluvial Aquifer, the 32 µg/L concentration limit extends further west of Bat Cave Wash and further eastward into the floodplain in the area between monitoring wells MW-27 and MW-28. The variability in the vertical distribution and trends for chromium within the aquifer are believed to result from the combined effects of: (1) proximity to the source area, (2) heterogeneity and permeability variations (vertical and lateral) of the aquifer media, (3) long-term groundwater gradients within the aquifer, and (4) site-specific geochemical conditions affecting the stability of Cr(VI). Pumping at former facility supply wells PGE-1 and PGE-2, located adjacent to Bat Cave Wash at the present site of the Interstate-40 right of way, may have also created downward gradients that acted to distribute Cr(VI) over multiple depth intervals beneath the wash. Since startup of the IM groundwater extraction in 2004, concentration trends in floodplain wells have been generally stable or decreasing (CH2M HILL, 2009g).

During the 2009 East Ravine Groundwater Investigation, Cr(VI) was also found within the Miocene conglomerate and pre-tertiary metadiorite bedrock formations east and southeast of the Topock Compressor Station (Appendix A). Cr(VI) concentrations in bedrock groundwater appear to be limited in extent to shallow and to a much lesser extent, mid-depth intervals (using the same elevation intervals for the Alluvial Aquifer). Currently, investigation data suggest Cr(VI) greater than or equal to 32 µg/L in the shallow and mid-depth wells extends approximately 1,500 feet east southeast of the compressor station. However, the mass of Cr(VI) in bedrock likely represents less than one percent of the total plume mass due to the low porosity of these bedrock formations.

Based on the site characterization data, the existing dimensions of the plume exceeding natural background levels underlie an area that is approximately 175 acres, including alluvium and bedrock. The depth to groundwater in the area of the plume ranges from approximately 28 to over 135 feet bgs, and the thickness of the aquifer in the area of the plume ranges from less than 50 feet near the bedrock interface to over 150 feet near National Trails Highway. The volume of contaminated groundwater in the Alluvial Aquifer is currently estimated to be approximately 1.50 billion gallons (approximately 4,600 acre-feet).This estimate was calculated by interpolating the Cr(VI) concentration contours shown in Figures 2-10, 2-11, and 2-12 over the model grid, integrating the concentration intervals over the depth of each zone (shallow, middle, and deep), and applying a total porosity of 35 percent for the alluvial/fluvial portion of the plume (from measurements of site materials presented in Ecology and the Environment, Inc. (E&E), 2004). Because the volume of the plume within the East Ravine bedrock formations is believed to represent less than 1 percent of the total plume, and the effective porosity of the bedrock formations is uncertain, the plume volume in bedrock is not included in this volume estimate.

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[6] The depth zones are primarily defined based on the relative depth and position of screen intervals within the Alluvial Aquifer; however, there are no aquitards separating the zones.

2.3.2 Chromium Fate and Mobility

Cr(VI) is relatively stable under the non-reducing conditions of the Alluvial Aquifer beneath the uplands portions of the Topock site. It is in the form of the chromate anion (CrO_4^{2-}) in the pH range of site groundwater. The chromate anion is a relatively mobile ion that does not form insoluble precipitates nor does it adsorb strongly to mineral surfaces (Hering and Harmon, 2004). This stability is evidenced by the presence of Cr(VI) from the original discharge area in Bat Cave Wash throughout all the predicted flow paths in the non-reducing alluvial material.

Once Cr(VI) encounters a sufficiently reducing geochemical environment as found in portions of fluvial materials in the floodplain, it quickly reverts to Cr(III). Trivalent chromium is essentially immobile except either under highly acidic pH conditions or in the presence of strong complexing agents, neither of which is present at the Topock site. Strongly-reducing geochemical conditions are observed in groundwater in most of the fluvial deposits along the Colorado River floodplain. Reducing conditions in floodplain areas of the site are derived from organic carbon in the younger fluvial deposits. The high-TDS and low oxidation reduction potential water found in several site bedrock wells located out of and within the East Ravine (MW-24BR, MW-58-205, MW-62-190, PGE-7BR, and PGE-8) is presumed to be very old water given the low permeability of the bedrock at these wells. As a groundwater's residence time increases, the slow bacterial reactions that tend to lower the redox potential cause the water to become more reducing over time (Drever, 1997). Groundwater in the shallow bedrock of the East Ravine area is notably less reducing, presumably due to the stronger hydraulic communication with alluvial groundwater and/or surface runoff (Appendix A).

Wherever the natural reducing capacity of the fluvial material is present, chromium is converted to its stable form of Cr(III) and is essentially immobile. The reducing conditions in the fluvial sediments provide a natural geochemical barrier that would, at the very least, greatly limit the movement of Cr(VI) in groundwater through the fluvial sediments adjacent to and beneath the Colorado River. The reduction capacity and extent of the reducing zone are not precisely known, but the combinations of available core testing and groundwater data provide an approximate horizontal and vertical distribution of a predominantly reducing portion of the fluvial material, as described in the RFI/RI Volume 2 Report (CH2M HILL, 2009a).

The presence of the reducing material in the shallow and mid-depth fluvial deposits and beneath the river has been confirmed by laboratory testing. The capacity of the reducing fluvial material to reduce Cr(VI) has been investigated by conducting three phases of anaerobic core study (CH2M HILL, 2005b, 2008e and 2009h). Laboratory evidence confirms that the fluvial sediments in the anaerobic zone beneath the floodplain have the capacity to remove Cr(VI) from groundwater via a chemical reduction process. Chemical reduction of Cr(VI) to Cr(III) is effectively permanent and irreversible under site conditions. The only naturally-occurring oxidant that can accomplish reoxidation is solid manganese dioxide, MnO_2 (Fendorf, 1995). If this solid is present, the Cr^{3+} ion can adsorb to the MnO_2 surface, where a redox reaction can occur which causes the chromium to be oxidized and manganese to be reduced. However, under the reducing conditions present in the fluvial materials, MnO_2 is not stable, and manganese tends to exist as the dissolved cation Mn^{2+}, as shown by the detectable manganese concentrations in these wells (CH2M HILL 2009a).

Calculations suggest that there is sufficient capacity within the floodplain and beneath the river in the Alluvial Aquifer to reduce at least a significant portion of the Cr(VI) plume were the plume to come in contact with these sediments (CH2M HILL, 2008e, 2009h). The estimate of total plume Cr(VI) mass is approximately 30,800 pounds. Using this value and assuming a total porosity of 0.35 and soil particle density of 2.65 grams per cubic centimeter, the range of measured capacities from cores collected from the boring for well MW-56 indicates that from 2 to 65 million cubic feet of anaerobic aquifer would be needed to reduce all of the Cr(VI) in the plume. Using the assumptions described in the previous anaerobic core testing report (CH2M HILL, 2009h), the current data indicate that there is an existing capacity in the aquifer from 1.8 to 55 times the required capacity for plume reduction. These calculations, although only approximate, suggest that there is capacity within the floodplain and beneath the river to reduce at least a significant portion of the Cr(VI) plume were the plume to reach the anaerobic portions of the floodplain and beneath the river. What is not known or reflected in these calculations is the potential for imperfections or "windows" in the reducing zone where reducing conditions may be weak or absent. This calculation does not apply to the bedrock aquifer.

Movement of chromium by density-driven flow is not currently considered to be a significant transport mechanism at the site based on the observed profiles of groundwater density at the site. During the time that blowdown water was being discharged to Bat Cave Wash, differences in fluid density between brackish blowdown water and the fresher groundwater in the upper portion of the aquifer may have resulted in some density flow effects, at least during the initial discharge. When the salinity of the blowdown water was reduced after the first few years of facility operation, the density gradients would have diminished or disappeared. Density-driven flow would not be expected to be a significant process for groundwater transport given the relatively small range of groundwater density in the Alluvial Aquifer at Topock today (CH2M HILL, 2009a).

2.3.3 Background Study Results for Chromium

Natural background Cr(VI) concentrations exist in groundwater in the Alluvial Aquifer at Topock. The source of natural Cr(VI) is primarily from pyroxene and amphibole minerals in area rocks. The chromium contained in these minerals is mobilized by oxidation of Cr(III) to Cr(VI) on the surfaces of manganese oxide minerals. Because Cr(VI) is very soluble, the natural background concentration in an oxidizing environment is limited by: (1) the amount of chromium in the natural rock material, (2) the formation of dissolved Cr(III) from the natural rock material, and (3) the presence and availability of reactive manganese oxides. In order for Cr(III) to react with manganese oxides, it first must undergo dissolution. The groundwater pH at Topock limits the ability of Cr(III) to dissolve (Cr(III) is only very sparingly soluble at the slightly alkaline groundwater pH). In addition, not all of the Cr(III) present in the natural rock material is reactive, rather only a portion may be reactive due to weathering of the chromium minerals in the rock and the creation of labile forms of Cr(III). Aquifer materials derived from granitic rocks in the Mojave Desert to the west have shown natural Cr(VI) concentrations up to 36 µg/L (Ball and Izbicki, 2004). More mafic rocks, such as diorite, basalt, and serpentinite, would be expected to produce higher groundwater concentrations of Cr(VI) since these rocks contain a higher concentration of the chromium source minerals. The background value of 31.8 µg/L found in the Topock area is consistent with these observations, as the source rock for the alluvium is metadiorite.

As described in the Final Background Study Report (CH2M HILL, 2008c), depending on the interpretation criteria used, the background study data may be viewed as belonging to a single population or may be split into separate populations on the basis of multiple factors. General chemistry and oxygen/deuterium isotopic analysis indicate that many of the fluvial samples have different chemical characteristics compared to alluvial samples. This is due to the influence of the Colorado River for the shallow fluvial groundwater. In addition to the geographic/geologic criteria, separate populations may be defined on the basis of depth because the Topock Alluvial Aquifer is stratified. The highest mean concentrations of Cr(VI) and Cr(T) in the groundwater background study are found at the MW-18 well. This well is screened at or near the water table as are some of the other shallow (non-background study) monitoring wells in the general vicinity (such as OW-2S and OW-5S) that have similar concentrations. Deeper wells in the area have much lower concentrations, suggesting the naturally elevated background Cr(VI) concentrations are confined to shallow depth. DOI approved the Final Background Study Report in August 2008 (DOI, 2008c).

The Final Background Study Report was revised to incorporate DTSC’s comments received in October 2009. DOI and DTSC approved the Revised Final Background Study Report (CH2M HILL, 2009i) in December 2009 (DOI, 2009d and DTSC, 2009f).

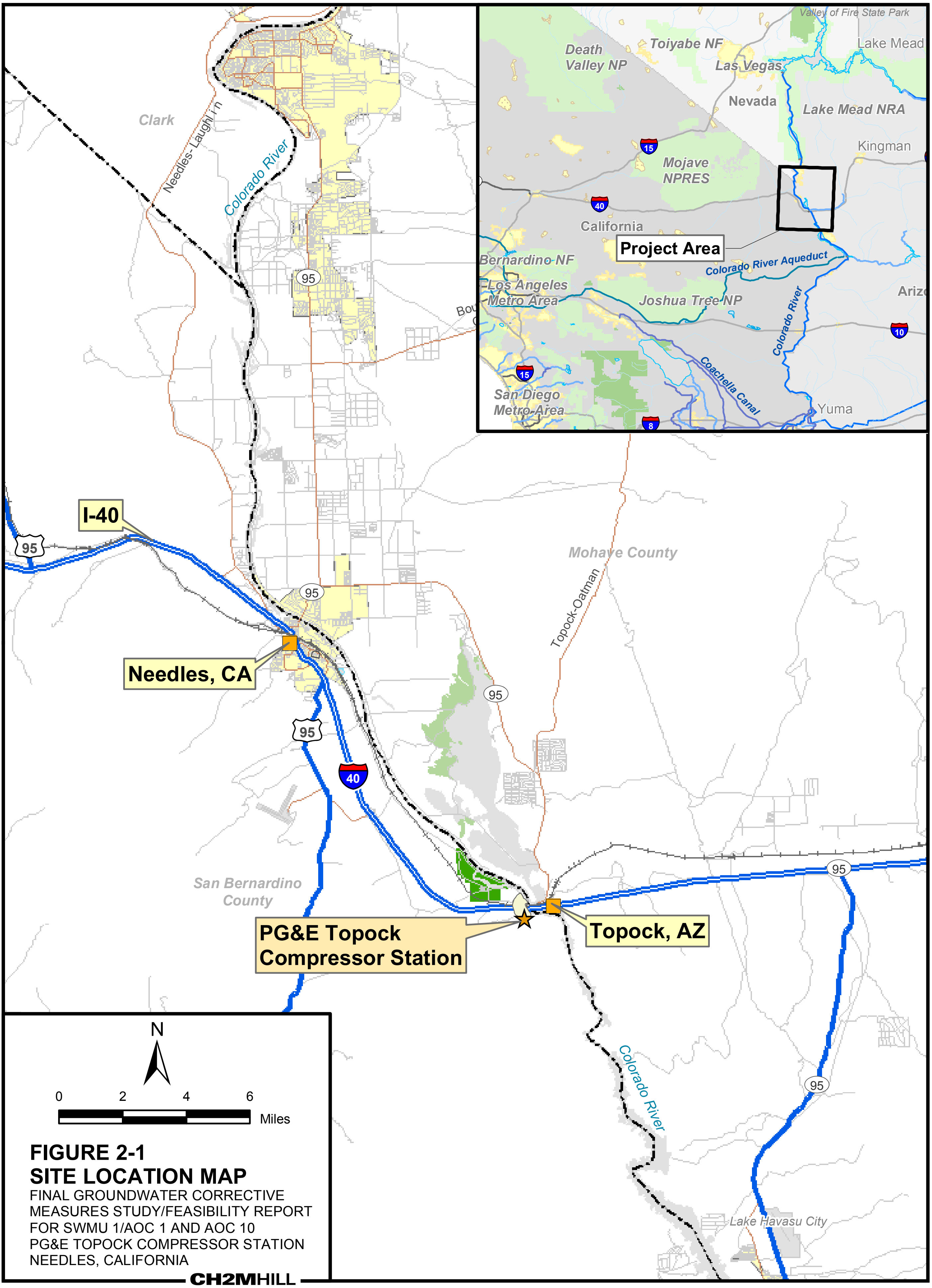

FIGURE 2-1
SITE LOCATION MAP

FINAL GROUNDWATER CORRECTIVE
MEASURES STUDY/FEASIBILITY REPORT
FOR SWMU 1/AOC 1 AND AOC 10
PG&E TOPOCK COMPRESSOR STATION
NEEDLES, CALIFORNIA

CH2MHILL

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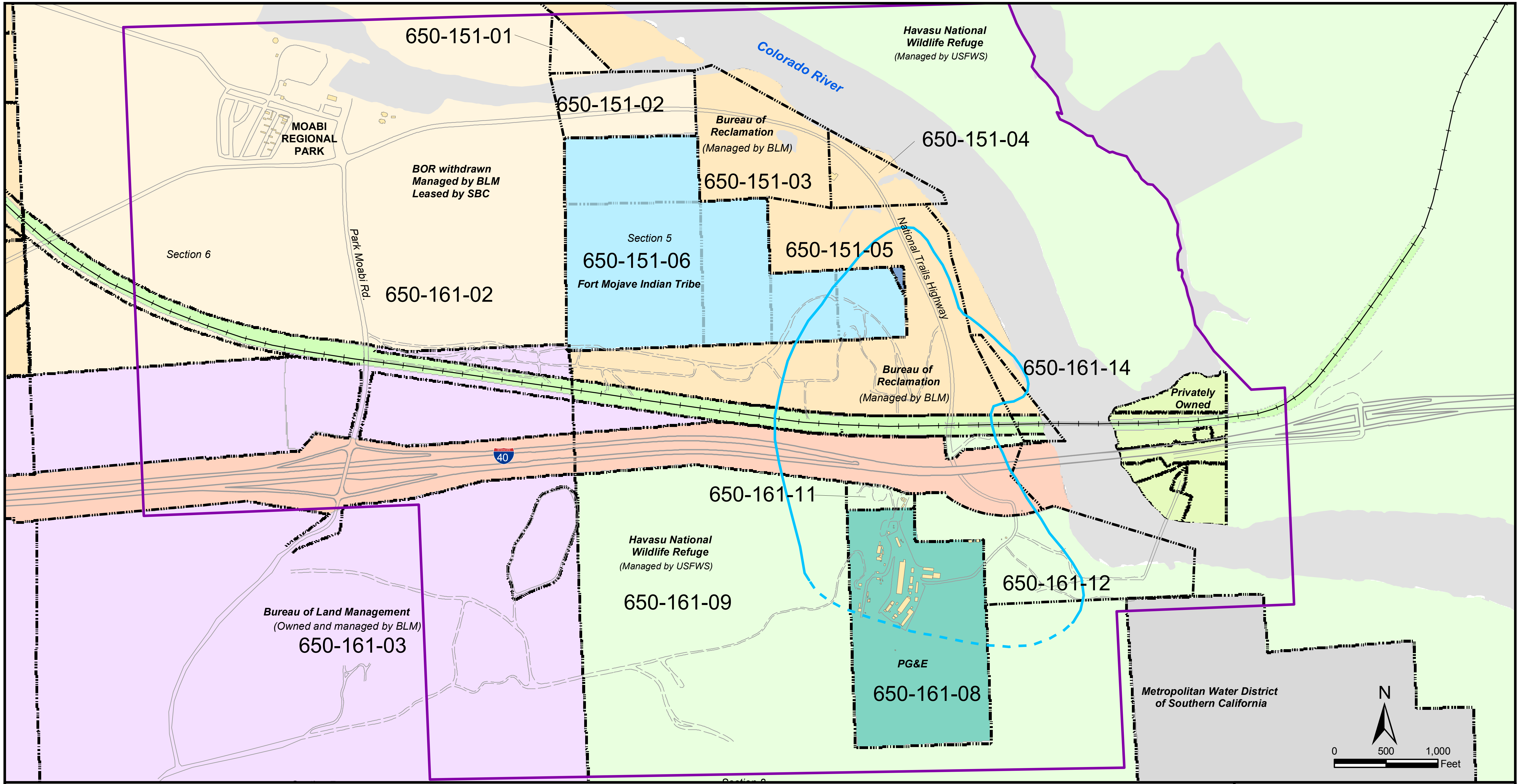

Legend

- Area of Potential Effect (APE)
- Railroad
- Parcel Boundary
- Highway
- Paved Road
- Dirt or Gravel Road
- Building

Owner

- 🟩 BNSF Railroad
- 🟪 Bureau of Land Management (Owned and Managed by BLM)
- 🟧 Bureau of Reclamation (Managed by BLM)
- 🟧 Caltrans Leased From Underlying Federal Owner
- 🟦 Fort Mojave Indian Tribe owner in fee, with PG&E easement and access for remediation
- 🟩 Havasu National Wildlife Refuge
- ⬜ Metropolitan Water District of Southern California
- 🟩 PG&E
- 🟨 Privately Owned
- 🟨 San Bernardino County Leased (Managed by BLM)
- 🟦 State of California

Approximate extent of hexavalent chromium [Cr(VI)] concentrations exceeding 32 micrograms per liter (µg/L) at any depth in groundwater based on October 2008 and July 2009 sampling events. Dashed where based on limited data. The outline of Cr(VI) depicted as greater than 32 µg/L near or under the Colorado River is 80 feet below the bottom elevation of the Colorado River.

Note:
The boundary lines shown are approximate and for reference only.

Sources:
1. San Bernardino County Assessor
2. Parcel quest
3. State Board of Equalization
4. Pacific Gas and Electric Company
5. Ecology and Environment and Plate maps provided by BLM.

FIGURE 2-2
SURROUNDING PROPERTIES

FINAL GROUNDWATER CORRECTIVE
MEASURES STUDY/FEASIBILITY REPORT
FOR SWMU 1/AOC 1 AND AOC 10
PG&E TOPOCK COMPRESSOR STATION
NEEDLES, CALIFORNIA

CH2MHILL

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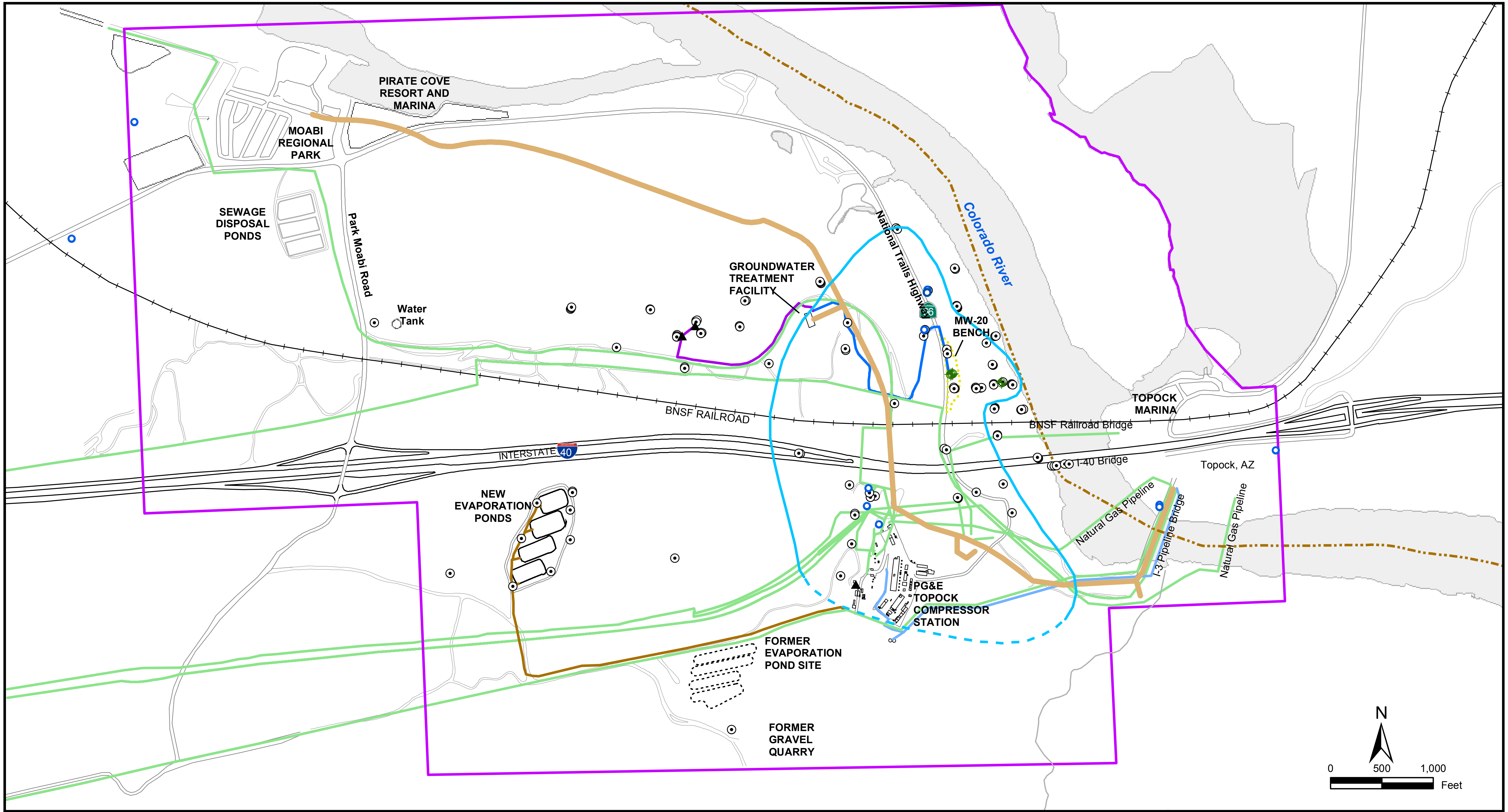

LEGEND

- ⊙ Groundwater Monitoring Well
- ○ Test Well or Supply Well
- ▲ Injection Well
- ⊕ Extraction Well
- Overhead Electric
- Gas Transmission Pipeline
- Potable Water Pipeline
- Underground Wastewater Pipeline
- Effluent Pipeline
- Multi-Utility Trench
- MW-20 Bench
- California-Arizona Border
- Area of Potential Effect (APE)
- Approximate extent of hexavalent chromium [Cr(VI)] concentrations exceeding 32 micrograms per liter (µg/L) at any depth in groundwater based on October 2008 and July 2009 sampling events. Dashed where based on limited data.The outline of Cr(VI) depicted as greater than 32 µg/L near or under the Colorado River is 80 feet below the bottom elevation of the Colorado River.

Note:
The locations of pipelines and existing infrastructure are approximate. The figure is not intended to be a comprehensive depiction of all existing infrastructure in the APE.

FIGURE 2-3
DEVELOPED LAND USES AND EXISTING INFRASTRUCTURE

FINAL GROUNDWATER CORRECTIVE MEASURES STUDY/
FEASIBILITY REPORT FOR SWMU 1/AOC 1 AND AOC 10
PG&E TOPOCK COMPRESSOR STATION
NEEDLES, CALIFORNIA

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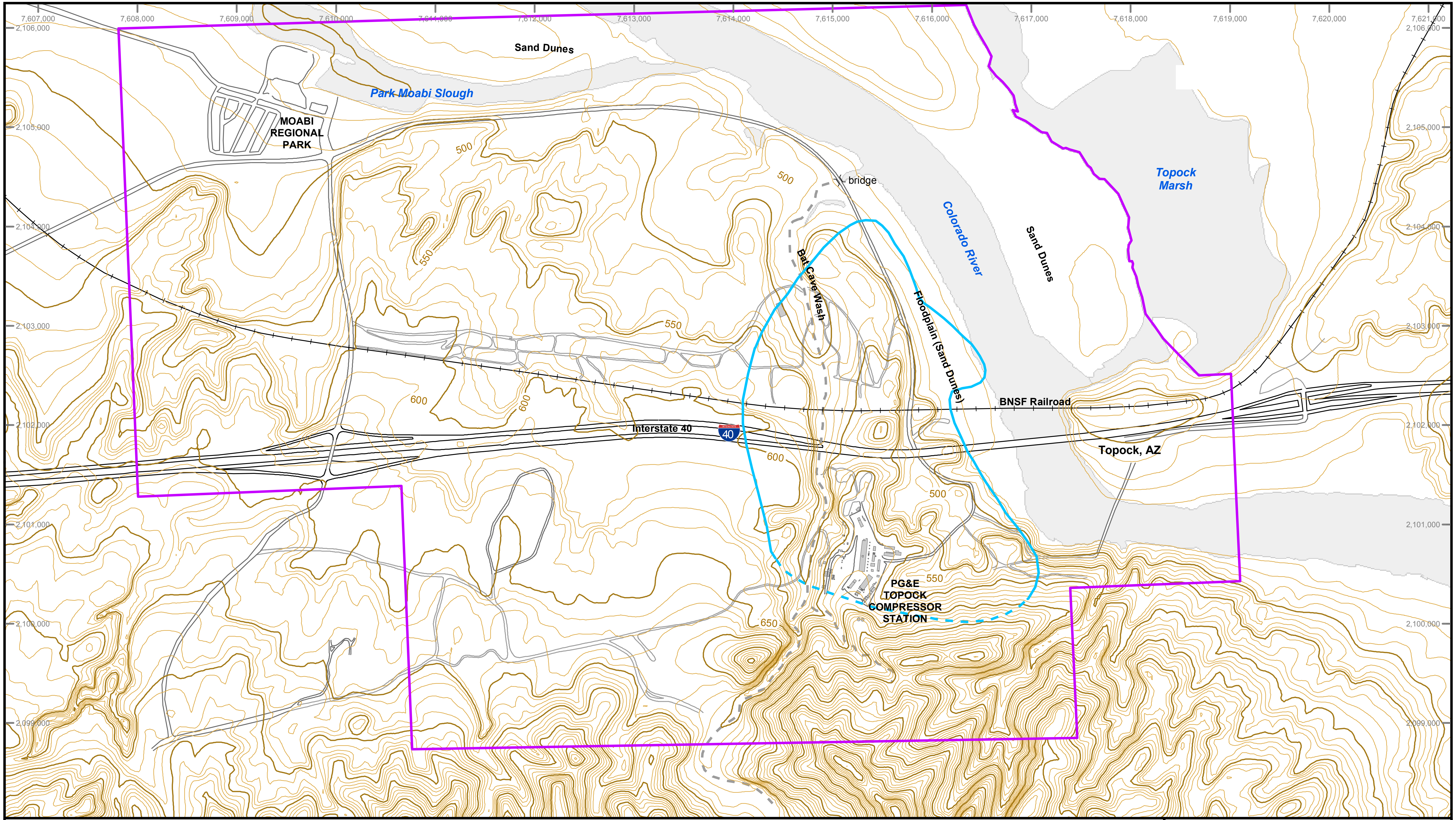

LEGEND

▭	Area of Potential Effect (APE)
―	10 foot contour
―	50 foot contour
◌	Approximate extent of hexavalent chromium [Cr(VI)] concentrations exceeding 32 micrograms per liter (µg/L) at any depth in groundwater based on October 2008 and July 2009 sampling events. Dashed where based on limited data The outline of Cr(VI) depicted as greater than 32 µg/L near or under the Colorado River is 80 feet below the bottom elevation of the Colorado River.

California State Plane, NAD 83, Zone 5, US Feet
Contour interval is 10 feet, with indexes at 50 feet.

Sources:
Topographic data from E & E, Inc. (1994), with additional aerial topographic mapping flown April 2004 (CH2M HILL)

N

0 500 1,000 Feet

FIGURE 2-4
SITE TOPOGRAPHY

FINAL GROUNDWATER CORRECTIVE
MEASURES STUDY/ FEASIBILITY REPORT
FOR SWMU 1/AOC 1 AND AOC 10
PG&E TOPOCK COMPRESSOR STATION
NEEDLES, CALIFORNIA

CH2MHILL

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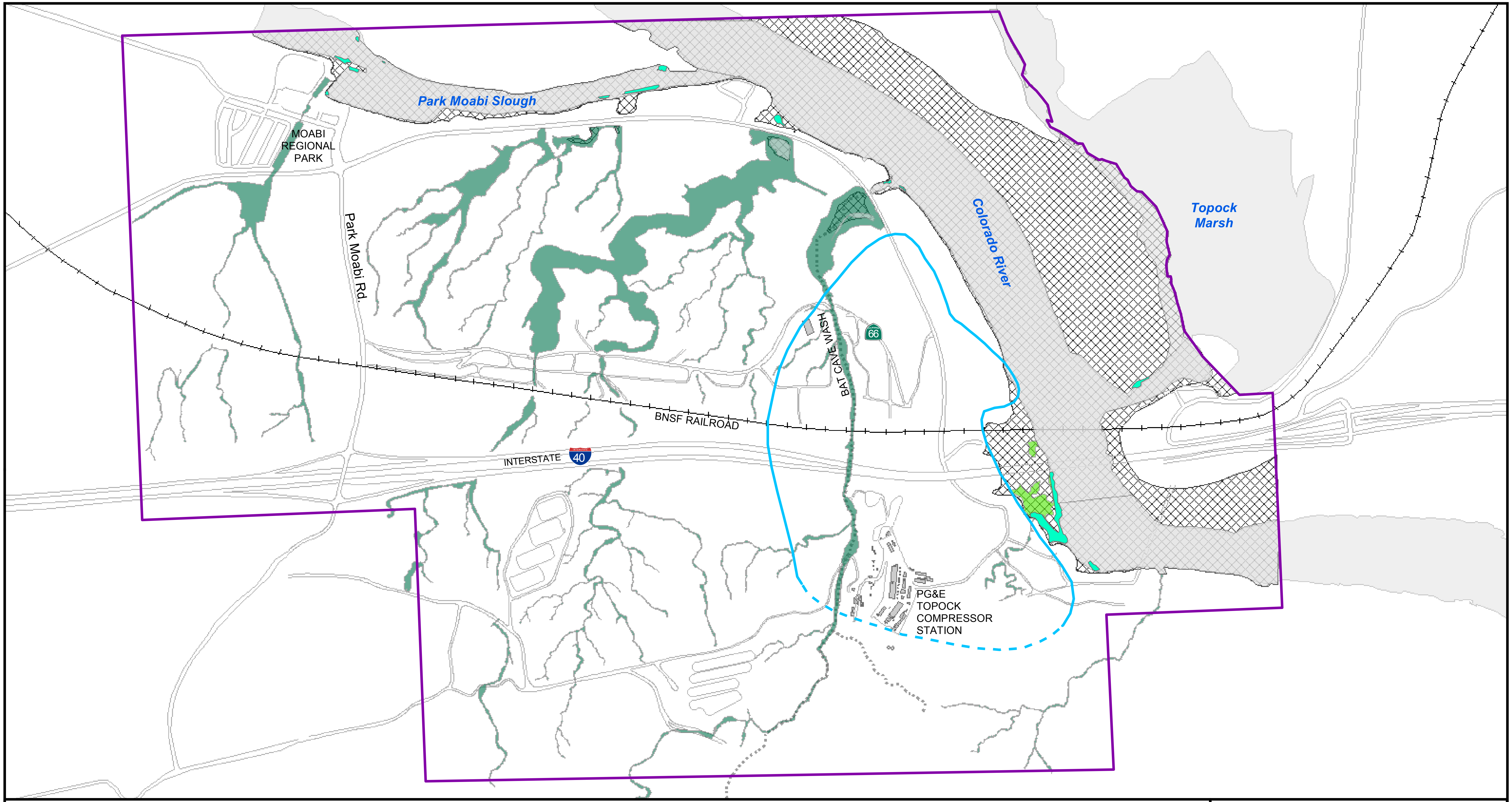


LEGEND

- ▭ Area of Potential Effect (APE)
- ▨ 100 –year floodplain/ bonytail chub critical habitat
- 🟩 Fringe Wetlands
- 🟩 Adjacent wetlands
- ⬜ USACE Waters of U.S. - Colorado River
- 🟩 USACE Waters of U.S.
- ◌ Approximate extent of hexavalent chromium [Cr(VI)] concentrations exceeding 32 micrograms per liter (µg/L) at any depth in groundwater based on October 2008 and July 2009 sampling events. Dashed where based on limited data. The outline of Cr(VI) depicted as greater than 32 µg/L near or under the Colorado River is 80 feet below the bottom elevation of the Colorado River.

Source:
Biological Resources survey for the Area of Potential Effect (APE) Topock Compressor Station (CH2M HILL 2005a) and the *Programmatic Biological Assessment for Pacific Gas and Electric Topock Compressor Station Remedial and Investigative Actions* (CH2M HILL 2007b).

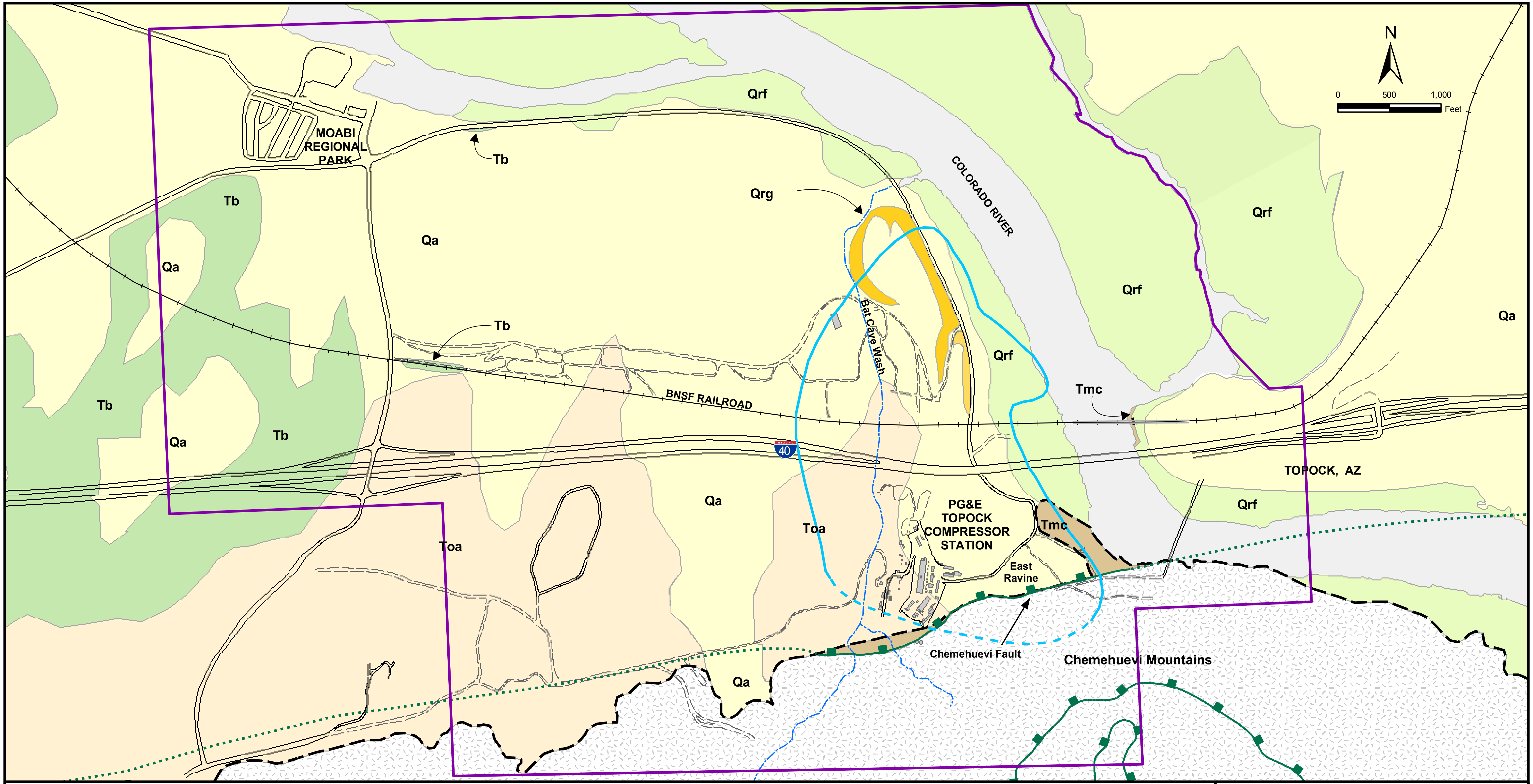
N

0 500 1,000
Feet

FIGURE 2-5
UNITED STATES ARMY CORPS OF ENGINEERS JURISDICTIONAL WATERS AND WETLANDS

FINAL GROUNDWATER CORRECTIVE MEASURES STUDY/ FEASIBILITY REPORT
FOR SWMU 1/AOC 1 AND AOC 10
PG&E TOPOCK COMPRESSOR STATION
NEEDLES, CALIFORNIA

CH2MHILL



LEGEND

🟩 Qrf = Quaternary Colorado River and recent Floodplain Deposits

🟧 Qrg = Quaternary River Gravels

🟨 Qa = Quaternary Alluvium and surficial deposits, undifferentiated

🟩 Tb = Bouse Formation

🟧 Toa = Tertiary Alluvium (Fanglomerate of Metzer and Loeltz)

🟫 Tmc = Miocene Conglomerate (Bedrock)

⬜ pTbr = Pre-Tertiary Bedrock (Metadiorite, Gneiss, Granitic Rocks)

■ Detachment Fault barbs on downthrown side

⋯ Detachment Fault concealed

▭ Area of Potential Effect (APE)

◌ Approximate extent of hexavalent chromium [Cr(VI)] concentrations exceeding 32 micrograms per liter (µg/L) at any depth in groundwater based on October 2008 and July 2009 sampling events. Dashed where based on limited data.The outline of Cr(VI) depicted as greater than 32 µg/L near or under the Colorado River is 80 feet below the bottom elevation of the Colorado River.

Note:

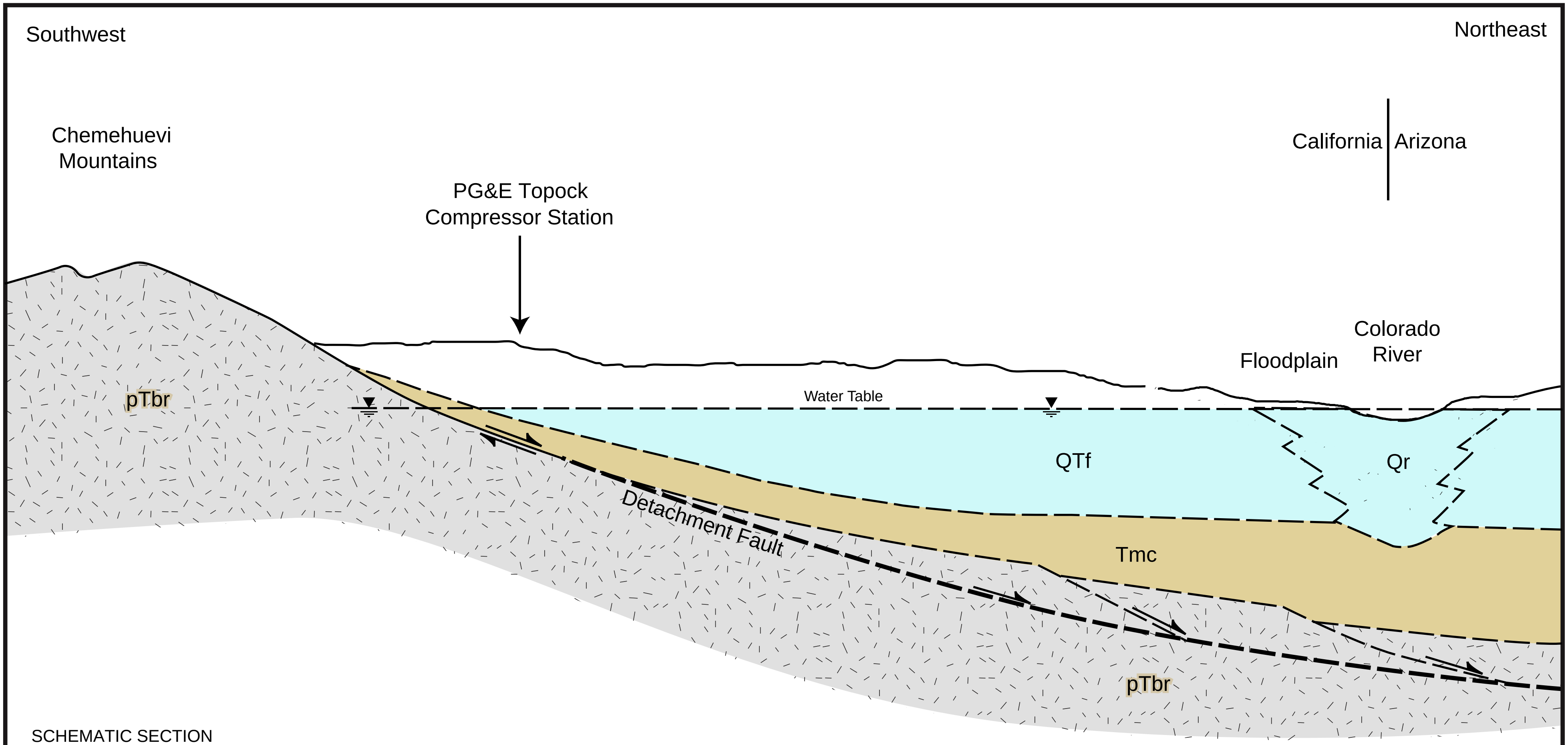
1. Generalized surface geologic map compiled from Metzger and Loeltz (1973), John (1987), Howard and others (1997), and PG&E technical reports.

2. The geologic map east of the Compressor Station was updated with mapping from the 2009 East Ravine investigation.

FIGURE 2-6
GEOLOGIC MAP

FINAL GROUNDWATER CORRECTIVE MEASURES STUDY/
FEASIBILITY REPORT FOR SWMU 1/AOC 1 AND AOC 10
PG&E TOPOCK COMPRESSOR STATION
NEEDLES, CALIFORNIA

CH2MHILL



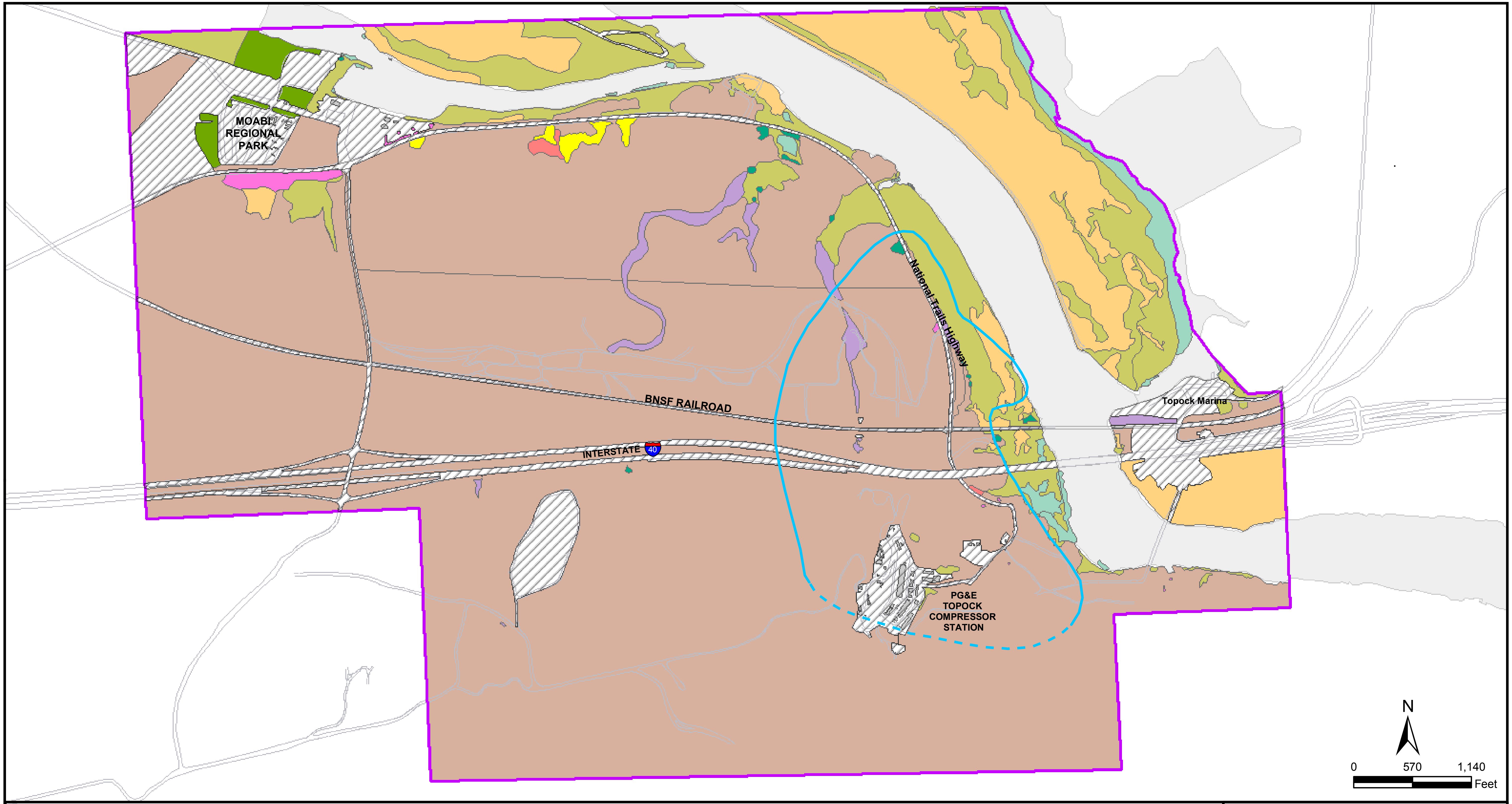
SCHEMATIC SECTION
NO SCALE

PRIMARY GEOLOGIC UNITS

QTf	Alluvial Fan Deposits (Qoa, Toa units)	**Alluvial Aquifer**
Qr	Colorado River Fluvial Deposits (Qr0, Qrl, Qr2, Qr3 units)	
Tmc	Miocene Conglomerate	**Bedrock**
pTbr	Metamorphic and Igneous Rocks	

FIGURE 2-7
SCHEMATIC HYDROGEOLOGIC CROSS SECTION

FINAL GROUNDWATER CORRECTIVE MEASURES STUDY/
FEASIBILITY STUDY REPORT
FOR SWMU 1/AOC 1 AND AOC 10
PG&E TOPOCK COMPRESSOR STATION
NEEDLES, CALIFORNIA



LEGEND

Area of Potential Effect (APE)

Approximate extent of hexavalent chromium [Cr(VI)] concentrations exceeding 32 micrograms per liter (µg/L) at any depth in groundwater based on October 2008 and July 2009 sampling events. Dashed where based on limited data.The outline of Cr(VI) depicted as greater than 32 µg/L near or under the Colorado River is 80 feet below the bottom elevation of the Colorado River.

Source: *Programmatic Biological Assessment for Pacific Gas and Electric Topock Compressor Station Remedial Investigative Actions* (CH2M HILL, 2007b)

Vegetation Communities	Approximate Acreage	Approximate % Composition
Arrow Weed	114	8.3
Creosote Bush Scrub	973	70.9
Landscaped	8	0.6
Mesquite	2	0.1
Mesquite/Palo Verde	8.3	0.9
Palo Verde	8.3	0.3
Salt Bush	8.3	0.1
Salt Cedar	8.3	8.1
Salt Cedar/Mesquite	3	.02
Wetland	15	1.1
▨ Developed	130	9.5

FIGURE 2-8
TOPOCK VEGETATION COMMUNITIES

FINAL GROUNDWATER CORRECTIVE
MEASURES STUDY/ FEASIBILITY REPORT
FOR SWMU 1/AOC 1 AND AOC 10
PG&E TOPOCK COMPRESSOR STATION
NEEDLES, CALIFORNIA

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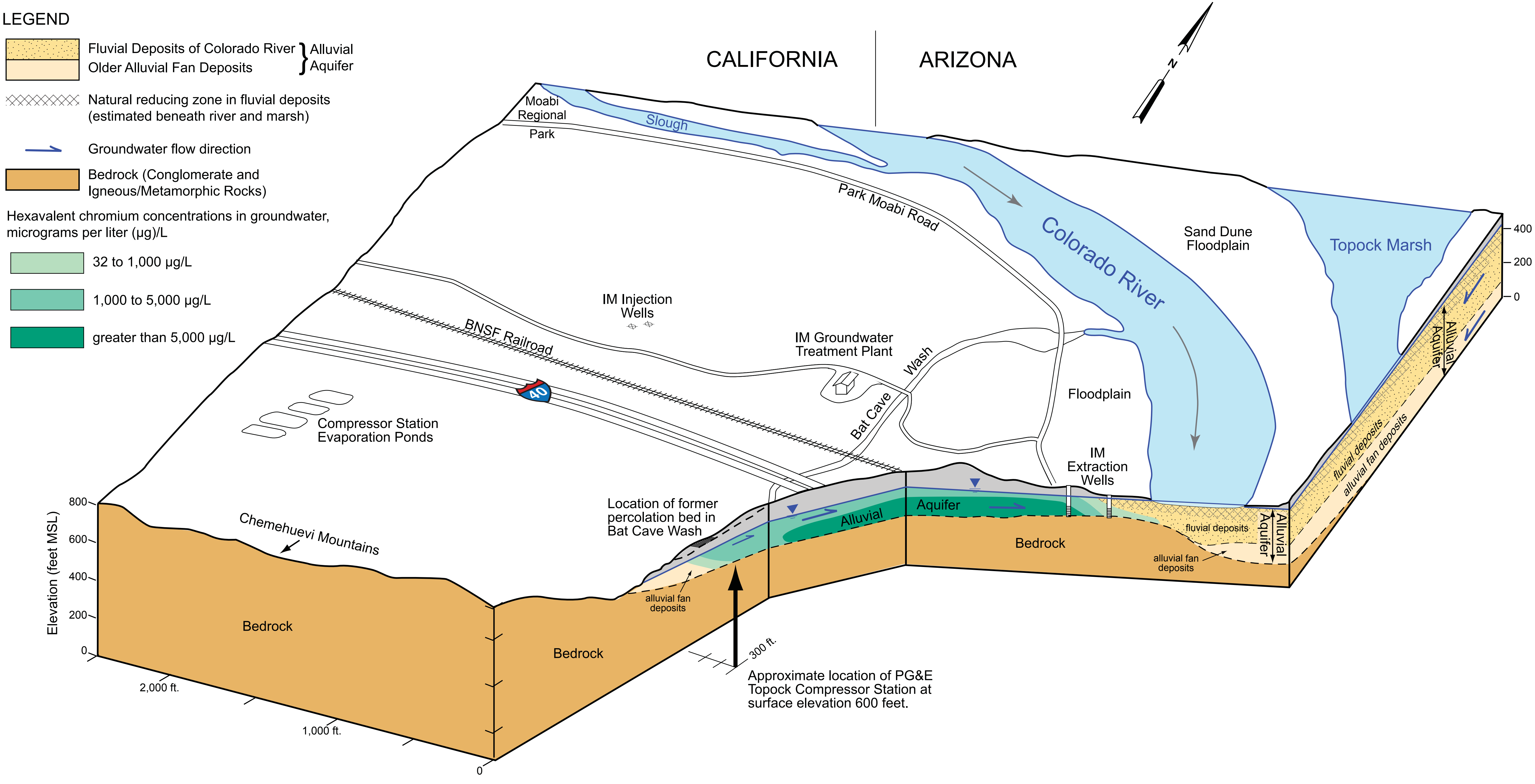
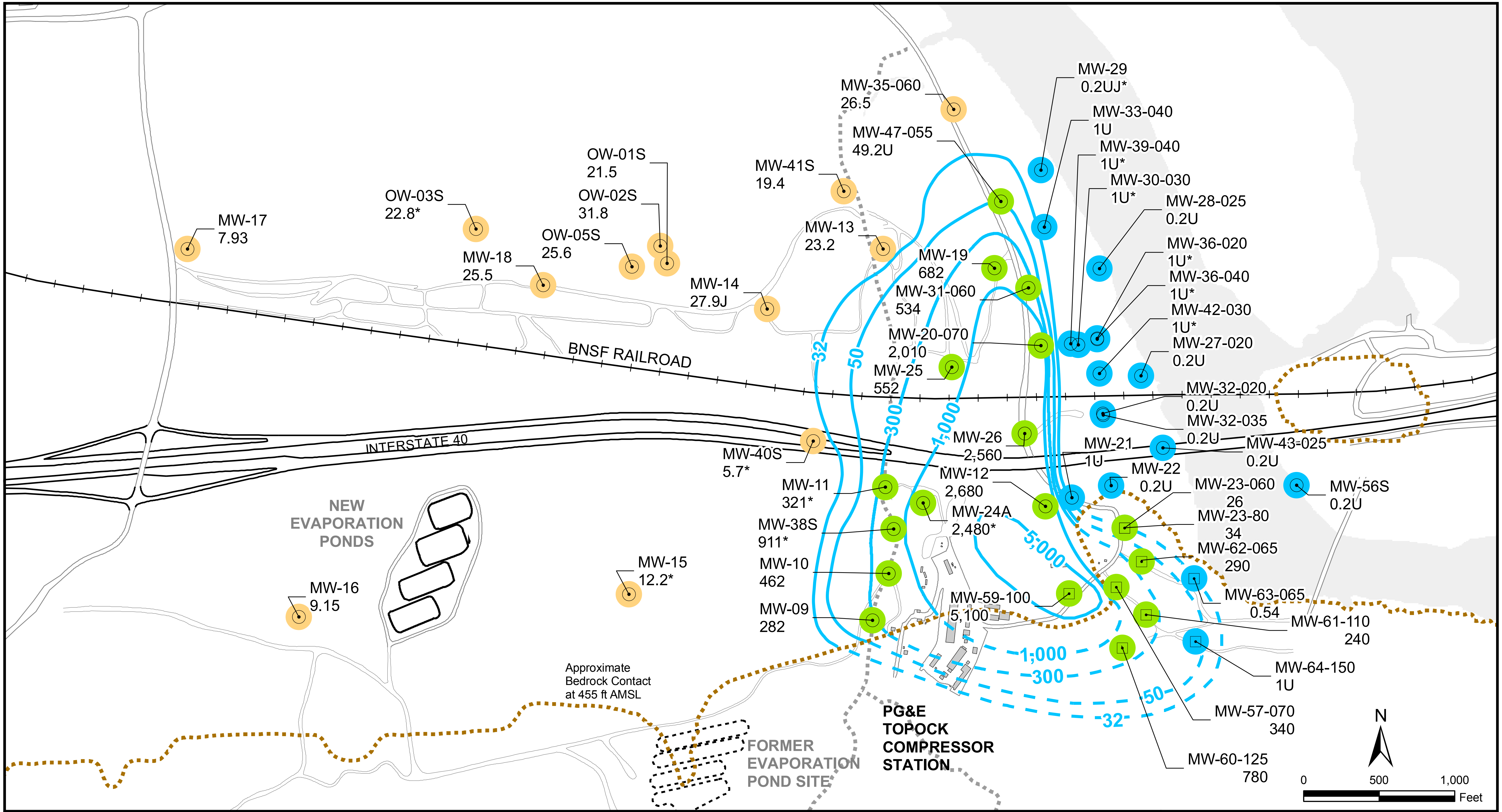


SCHEMATIC DIAGRAM

NOTE: In the 2009 East Ravine investigation, hexavalent chromium was found in bedrock groundwater above the site background level (32µg/L). East Ravine (not shown on this diagram) is located east of the compressor station and south of IM extraction wells. See hydrogeologic cross-section J-J' (Figure A-15, Appendix A).

FIGURE 2-9
TOPOCK SITE SURFACE AND SUBSURFACE FEATURES
FINAL GROUNDWATER CORRECTIVE MEASURES STUDY/
FEASIBILITY STUDY REPORT
FOR SWMU 1/AOC 1 AND AOC 10
PG&E TOPOCK COMPRESSOR STATION
NEEDLES, CALIFORNIA



LEGEND

⊡ Bedrock Well

⋯⋯ Bedrock Contact at 455-feet AMSL

⊙ Monitoring, Test, or Supply Well

⊕ Extraction Well

6.5 Concentration of Cr(VI) in micrograms per liter (µg/L)

U (0.2) Cr(VI) not detected at listed reporting limit

Cr(VI) Concentrations in Alluvial Aquifer

● Not detected at analytical reporting limit

● Concentration between reporting limit and 32 µg/L

● Concentration greater than 32 µg/L

〜 Approximate outline of hexavalent chromium [Cr(VI)] concentrations of 32 µg/L in shallow alluvial wells October 2008

- - Approximate outline of hexavalent chromium [Cr(VI)] concentrations of 32 ug/L or higher in shallow bedrock wells July 2009

Notes:

1. Results shown are maximum concentrations in primary and duplicate samples from wells completed in **shallow zone** of Alluvial Aquifer, October 2008 sampling.

2. Bedrock Well Sample result from July 2009.

3. *Results from 2007 or December 2008 (well not sampled during October 2008). OW and CW results are from November 2008 unless denoted by * (then they are from 2007).

FIGURE 2-10
GROUNDWATER Cr(VI) RESULTS IN SHALLOW WELLS OCTOBER 2008 AND JULY 2009

FINAL GROUNDWATER CORRECTIVE MEASURES STUDY/
FEASIBILITY STUDY REPORT FOR SWMU 1/AOC 1 and AOC 10
PG&E TOPOCK COMPRESSOR STATION
NEEDLES, CALIFORNIA

CH2MHILL

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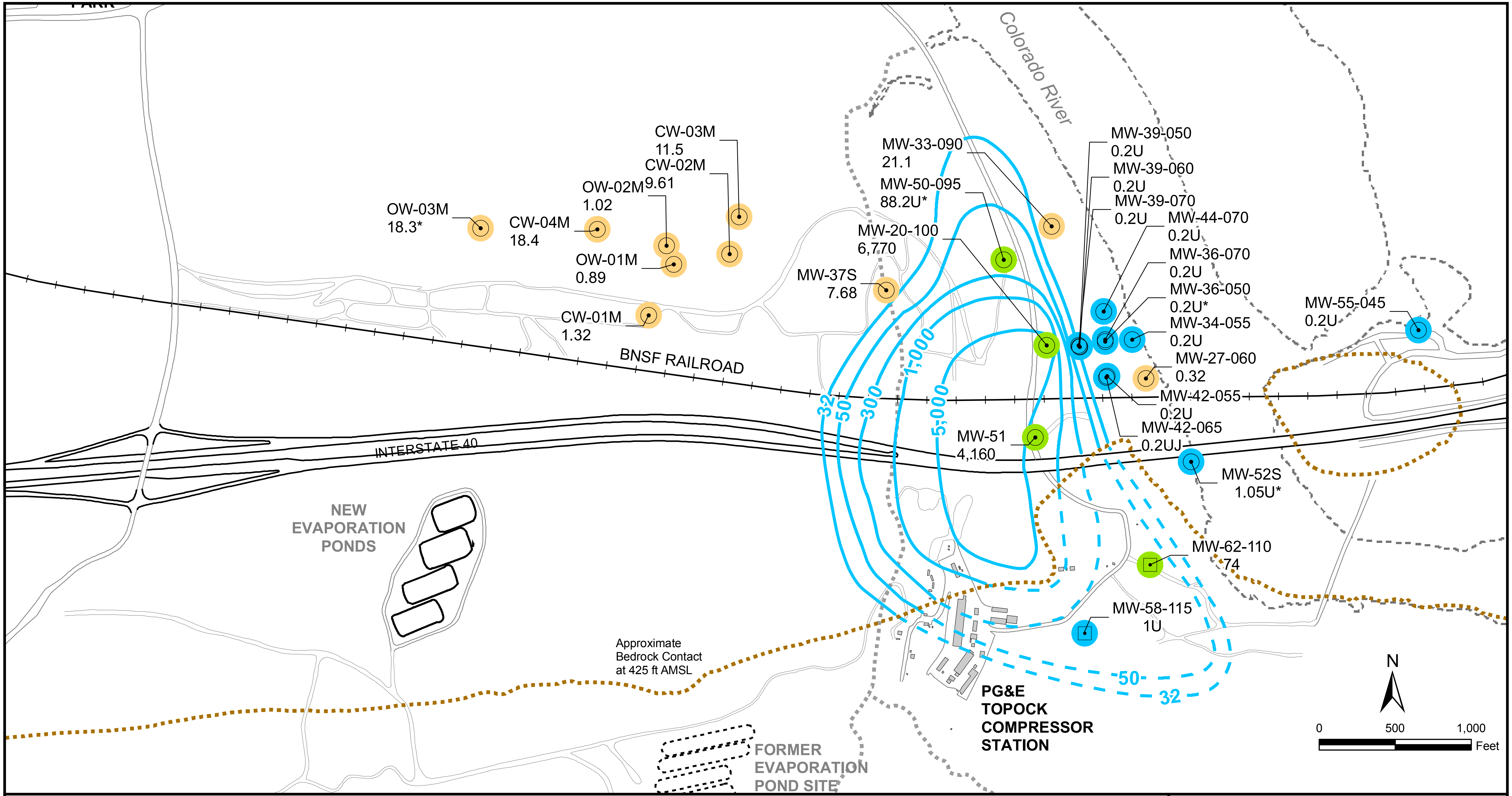

LEGEND

⊙ Monitoring, Test, or Supply Well

⊕ Extraction Well

⊡ Bedrock Well

······ Bedrock Contact

21 Concentration of Cr(VI) in micrograms per liter (µg/L)

U (0.2) Cr(VI) not detected at listed reporting limit

Cr(VI) Concentrations in Alluvial Aquifer

🔵 Not detected at analytical reporting limit

🟠 Concentration between reporting limit and 32 µg/L

🟢 Concentration greater than 32 µg/L

〜 Approximate outline of hexavalent chromium [Cr(VI)] concentrations of 32 µg/L or higher in mid-depth alluvial wells October 2008

- - Approximate outline of hexavalent chromium [Cr(VI)] concentrations of 32 ug/L or higher in mid-depth bedrock wells July 2009

Notes:

1. Results shown are maximum concentrations in primary and duplicate samples from wells completed in **mid-depth zone** of Alluvial Aquifer, October 2008 sampling.
2. * Results from 2007 or December 2008 (well not sampled during October 2008). OW and CW well results are from November 2008 unless denoted by * (then they are from 2007).
3. Bedrock Well Sample Results from July 2009.

FIGURE 2-11
GROUNDWATER Cr(VI) RESULTS IN MID-DEPTH WELLS OCTOBER 2008 AND JULY 2009

FINAL GROUNDWATER CORRECTIVE MEASURES STUDY/
FEASIBILITY STUDY REPORT FOR SWMU 1/AOC 1 and AOC 10
PG&E TOPOCK COMPRESSOR STATION
NEEDLES, CALIFORNIA

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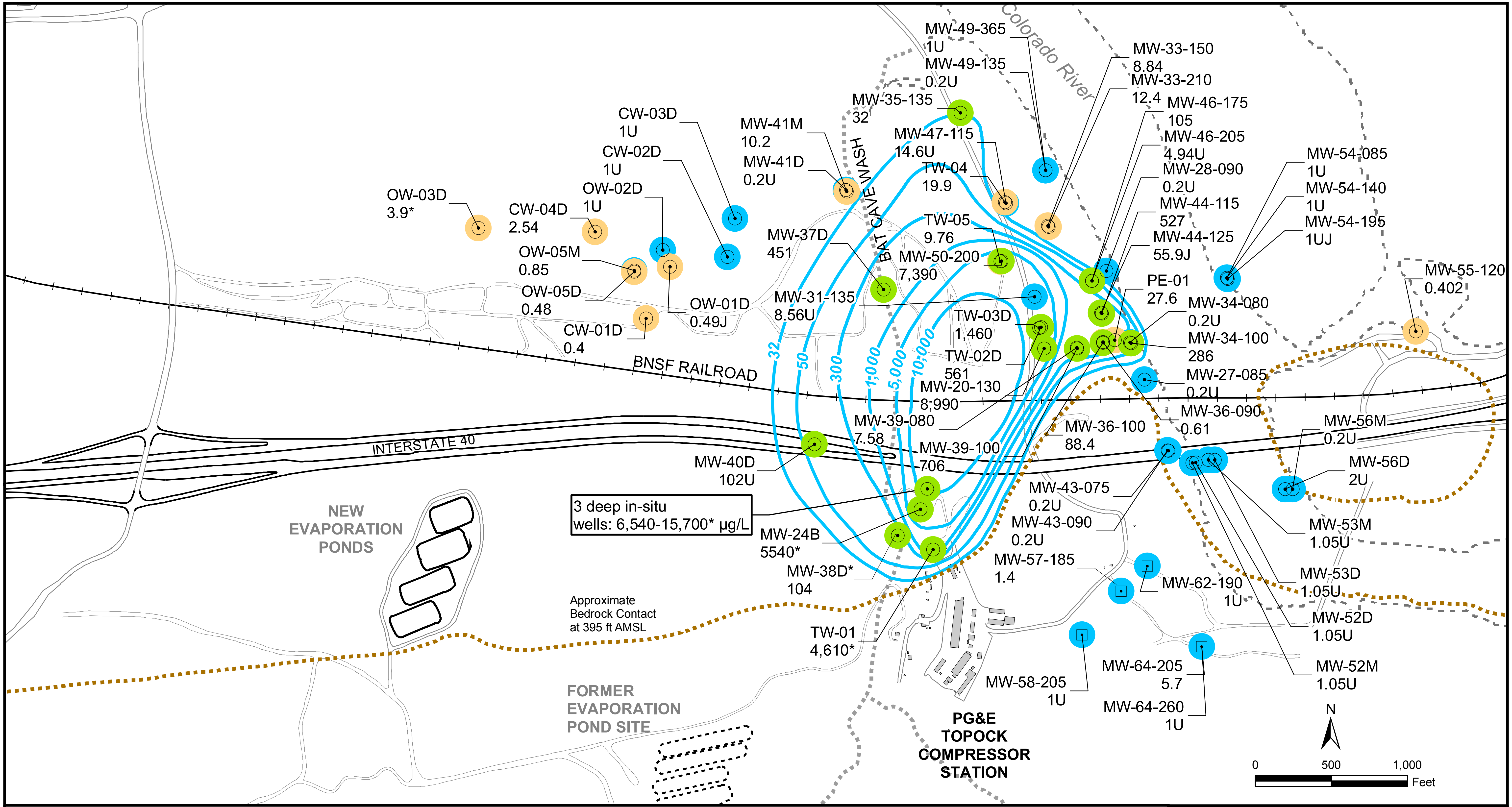

LEGEND

- Bedrock Contact
- ⊙ Monitoring, Test, or Supply Well
- ⊕ Extraction Well
- ⊡ Bedrock Well

3.9 Concentration of Cr(VI) in micrograms per liter (µg/L)

U (0.2) Cr(VI) not detected at listed reporting limit

Cr(VI) Concentrations in Alluvial Aquifer

- ● Not detected at analytical reporting limit
- ● Concentration between reporting limit and 32 µg/L
- ● Concentration greater than 32 µg/L

Approximate outline of hexavalent chromium [Cr(VI)] concentrations of 32 µg/L in Deep alluvial wells October 2008

Notes:

1. The estimated extent of Cr(VI) in the deep zone (80-90 feet below the Colorado River) is based upon data from nearby wells, hydraulic gradients, and flow lines predicted by the groundwater flow model. There are no wells or samples confirming the presence or extent of Cr(VI) under the Colorado River.
2. Results shown are maximum concentrations in primary and duplicate samples from wells completed in **Deep zone** of Alluvial Aquifer, October 2008 sampling.
3. Bedrock wells MW-57-185, MW-58-205, MW-62-190, MW-64-205 and MW-64-260 sample results from July 2009.
3. *Results from 2007 or December 2008 (well not sampled during October 2008). OW and CW well results are from November 2008 unless denoted by * (then they are from 2007).

FIGURE 2-12
GROUNDWATER Cr(VI) RESULTS IN DEEP WELLS
OCTOBER 2008 AND JULY 2009

FINAL GROUNDWATER CORRECTIVE MEASURES STUDY/
FEASIBILITY STUDY REPORT FOR SWMU 1/AOC 1 and AOC 10
PG&E TOPOCK COMPRESSOR STATION
NEEDLES, CALIFORNIA

CH2MHILL

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3.0 Remedial Action Objectives

This section identifies the objectives of this remedial action based on the results of the groundwater human health and ecological risk assessment (GWRA) and identification of ARARs. Section 3.1 summarizes the baseline GWRA, Section 3.2 summarizes the potential ARARs, and Section 3.3 identifies the remedial action objectives (RAOs).

3.1 Groundwater Human Health and Ecological Risk Assessment Conclusions Summary

The mandate of both the RCRA Corrective Action and CERCLA programs is to protect human health and the environment from current and potential threats posed by uncontrolled releases of hazardous substances into the environment. The *Final Human and Ecological Risk Assessment of Groundwater Impacted by Activities at Solid Waste Management Unit (SWMU) 1/Area of Concern (AOC 1) and SWMU 2, Topock Compressor Station Site Vicinity* (ARCADIS, 2009) was completed to assist risk management decision-making by quantitatively evaluating COPCs in groundwater and surface water and determining whether the COPCs are potential threats to human health or the environment. The COPCs that are related to the facility and are identified as potential risks to human or ecological receptors are identified as COCs that then become the focus of the RAOs and remedial alternatives.

The GWRA documented the conceptual site model, including identified sources of groundwater contamination, potential transport mechanisms, potential exposed populations and exposure pathways, and potential exposure point concentrations for impacts by activities at SWMU 1/AOC 1 and SWMU 2 (ARCADIS, 2009). The key conclusions of the GWRA, for purposes of defining objectives for this remedial action, are:

- The potential transport of constituents in groundwater to the Colorado River represents an insignificant transport pathway; floodplain COPCs are not being transported to the Colorado River at concentrations that exceed screening-level surface water criteria.
- There are no current direct or indirect complete exposure pathways for human contact with impacted site groundwater; thus, there are no human populations currently at risk of adverse health effects due to groundwater at the Topock site.
- There is no significant ecological exposure pathway for contact with impacted site groundwater; thus, there is no ecological population currently at risk of adverse effects due to the presence of COPCs in groundwater.
- Due to the possibility of future development of the groundwater as a drinking water supply, the GWRA included a quantitative risk characterization of future hypothetical human groundwater users that may be exposed to site groundwater in a residential setting. Both child and adult future hypothetical residential groundwater users were considered. Potential exposure through ingestion and dermal contact while bathing and

showering were evaluated. Potential cumulative cancer risks and noncancer hazard indices were estimated for all COPCs, including the constituents that were not related to SWMU 1/AOC 1. The risk characterization concluded that:

- Hexavalent chromium is present in site groundwater at concentrations that could pose a potential hazard to the future hypothetical human groundwater user, if the groundwater were to be developed as a potable source of water in the future. Based on the results of the risk estimates and the fact that the presence of Cr(VI) is related to historical releases from SWMU 1/AOC 1, Cr(VI) is a COC for this remedial action.
- The calculated noncarcinogenic risk-based remediation goal for Cr(VI) is 46 µg/L based on the hypothetical child receptor.

The GWRA determined that other COPCs were not either associated with SWMU 1/AOC 1 and/or not present in site groundwater at levels of potential concern to human health or the environment. DTSC and DOI, however, concluded that although the noncancer hazards associated with selenium, molybdenum, and nitrate are much lower than those associated with Cr(VI), these constituents do have risks above a hazard index of 1 and they do contribute to a hazard quotient greater than 1 at localized areas within the plume. DTSC directed that molybdenum, selenium, and nitrate be monitored in the groundwater monitoring program and their associated impacts be considered in future soil and soil to groundwater risk evaluations (DTSC 2009c, DOI 2009c).

3.2 Applicable or Relevant and Appropriate Requirements Summary

CERCLA requires that remedial alternatives attain ARARs unless they are waived. ARARs consist of regulations, standards, criteria, or limitations promulgated under federal or more stringent state laws.

ARARs are classified as chemical-specific, location-specific, or action-specific. Chemical-specific ARARs are generally health- or risk-based numerical values or methodologies applied to site-specific conditions that result in the establishment of a remediation goal. Location-specific ARARs are restrictions on the concentrations of hazardous substances or the conduct of activities because of the characteristics of the site or its immediate environment. Action-specific ARARs specify how a remedial alternative must be achieved. They are generally technology- or activity-based requirements or limitations and apply to specific remedial approaches rather than to a site.

The identification of site-specific ARARs is provided in Appendix B (DOI, 2009e). As the CERCLA remediation process advances past the CMS/FS, new information may become available, prompting DOI to revise the list of ARARs for the final Record of Decision. A summary of the key chemical, location, and action-specific ARARs, as described in Appendix B, for this remedial action are provided below.

3.2.1 Chemical-specific ARARs

The identified chemical-specific ARARs for Cr(VI), Cr(III), and Cr(T) in groundwater and surface water are shown in Table 3-1.

TABLE 3-1
Chemical-specific ARARs for Cr(VI), Cr(III), and Cr(T) in Groundwater and Surface Water
Final Groundwater Corrective Measures Study /Feasibility Study Report for SWMU 1/AOC 1 and AOC 10
PG&E Topock Compressor Station, Needles, California

ARAR	Unit	Cr(VI)	Cr(III)	Cr(T)
Groundwater				
Federal Safe Drinking Water Act (42 USC §300f, et seq., 40 CFR 141)	µg/L	N/A	N/A	100
California Safe Drinking Water Act (22 CCR δ64431, §64444, §64449)	µg/L	N/A[a]	N/A	50
Surface Water				
Federal Water Pollution Control Act (33 USC §§ 1251-1387, 40 CFR 131.38)	µg/L	11[c]	438[b]	N/A

Notes:

[a] In 2001, a law was enacted that requires the California Department of Public Health to establish a maximum contaminant level for Cr(VI) at a level as close as is technically and economically feasible to the contaminant's public health goal. In August 2009, the Office of Environmental Health Hazard Assessment released a draft public health goal for Cr(VI); however, the final public health goal will not be an ARAR because it is not a promulgated requirement, but any future maximum contaminant level developed by California Department of Public Health would be an ARAR.

[b] Freshwater aquatic life, chronic, assuming water hardness = 300,000 µg/L (calcium carbonate [$CaCO_3$] equivalents).

[c] Dissolved concentration.

µg/L = micrograms per liter.

CCR = California Code of Regulations.
CFR = Code of Federal Regulations.
N/A = not applicable.
USC = United States Code.

Source: DOI, 2009e (Appendix B).

3.2.2 Location-specific ARARs

Remedial action alternatives addressing chromium in groundwater at the Topock Compressor Station must consider the following location-specific requirements, depending on the location of the physical infrastructure associated with each alternative:

- **Federal Land Policy and Management Act.** In managing public lands, BLM is directed to take any action necessary to prevent unnecessary or undue degradation of the lands. Actions taken on the public land (i.e., BLM-managed land) portions of the Topock site should provide the optimal balance between authorized resource use and the protection and long-term sustainability of sensitive resources. Figure 2-2 in Section 2.0 illustrates the portions of the groundwater plume within BLM-managed land.

- **National Wildlife Refuge System Administration Act.** This Act governs the use and management of the HNWR portion of the Topock site. It requires that the USFWS evaluate ongoing and proposed activities and uses to ensure that such activities are appropriate and compatible with the mission of the National Wildlife Refuge System, as well as the specific purposes for which the HNWR was established. Figure 2-2 illustrates the portions of the groundwater plume within the HNWR. The Topock site includes portions of the HNWR. Prior to the selection of a remedial action by DOI/USFWS, that remedial action must be found by the Refuge Manager to be both an appropriate use of the HNWR and compatible with the mission of the HNWR and the Refuge System as a whole. Any remedial action proposed to be implemented on the HNWR that was not selected by DOI/USFWS would be subject to the formal appropriate use/compatibility determination process.

- **Fish and Wildlife Coordination Act.** This Act requires that any federally-funded or authorized modification of a stream or other water body must provide adequate provisions for conservation, maintenance, and management of wildlife resources and their habitat. Necessary measures should be taken to mitigate, prevent, and compensate for project-related losses of wildlife resources.
- **National Historic Preservation Act.** This statute and the implementing regulations require that a federal agency undertaking a remedial action at or near historic properties must take into account the effects of such undertaking on the historic properties. The federal agency must determine, based on consultation, if an undertaking’s effects would be adverse and seek ways that could avoid, mitigate, or minimize such adverse effects on a National Register or eligible property. The agency must then specify how adverse effects will be avoided or mitigated or acknowledge that such effects cannot be avoided or mitigated. The APE includes historic properties, as discussed in Section 2.2.6. Measures to avoid or mitigate adverse effects of any selected remedial action that are adopted by the agency through federal consultation must be implemented by the remedial action to comply with the National Historic Preservation Act.
- **National Archaeological and Historical Preservation Act. This statute requires the evaluatio**n and preservation of historical and archaeological data that might otherwise be irreparably lost or destroyed through any alteration of terrain as a result of federal construction projects or a federally licensed activity. The APE includes historical and archaeological data, as discussed in Section 2.2.6.
- **Archaeological Resources Protection Act.** This statute provides for the protection of archeological resources located on public and tribal lands. The Act establishes criteria that must be met for the land manager’s approval of any excavation or removal of archaeological resources if a proposed activity involves soil disturbances.
- **Historic Sites Act.** Pursuant to this Act, federal agencies must consider the existence and location of historic sites, buildings, and objects of national significance, using information provided by the National Park Service, to avoid undesirable impacts upon such landmarks. There are no designated historic landmarks within the APE, although 16 USC 461, through Public Law 106-45, provides for a cooperative program “for the preservation of the Route 66 corridor” through grants and other measures.
- **Native American Graves Protection and Repatriation Act.** This Act regulates the removal and trafficking of human remains and cultural items, including funerary and sacred objects. If remediation activities result in the discovery of Native American

human remains or related objects, these requirements must be met. The APE contains archaeological areas that may contain human remains.

- **American Indian Religious Freedom Act.** This Act requires that the United States protect and preserve for American Indians their inherent right of freedom to believe, express, and exercise their traditional religions.
- **Floodplain Management and Wetlands Protection.** Before undertaking an action, agencies are required to perform certain measures to avoid the long- and short-term impacts associated with the destruction of wetlands and the occupancy and modification of floodplains and wetlands. Figure 2-5 in Section 2.0 illustrates the locations of floodplain and wetlands in relation to the groundwater plume.

3.2.3 Action-specific ARARs

Action-specific requirements most likely to be triggered by this remedial action include:

- **Safe Drinking Water Act, Underground Injection Control.** Underground Injection Control Regulations ensure that any underground injection performed onsite will not endanger drinking water sources. Substantive requirements include, but are not limited to, regulation of well construction and well operation. These requirements will be applicable to alternatives that include underground injection as a part of the remedy.
- **Clean Water Act, Stormwater Management.** These regulations define the necessary requirements with respect to the discharge of stormwater under the National Pollutant Discharge Elimination System program. These regulations will apply if proposed remedial actions disturb more than 1 acre of soil and result in stormwater runoff that comes in contact with any construction activity from site remediation, or if proposed remedial actions involve specified industrial activities.
- **Endangered Species Act.** This Act makes it unlawful to remove or “take” threatened and endangered plants and animals and protects their habitats by prohibiting certain activities. As discussed in Section 2.2.7, examples of such species in or around the APE may include, but are not limited to, SWFL, desert tortoise, Colorado pikeminnow, razorback sucker, and bonytail chub. This Act will apply if the proposed remedial actions will result in the take of, or adverse impacts to, threatened and endangered species or their habitats.
- **Hazardous Waste Control Law and Regulations.** The California Hazardous Waste Control Law and regulations establish requirements for hazardous waste generators; operators of hazardous waste treatment, storage, or disposal units; and for corrective action taken in response to releases of hazardous waste from regulated units. Hazardous waste generators must determine if their waste is hazardous, manage the waste in accordance to specified requirements for accumulation in tanks and containers, use a hazardous waste manifest for offsite transportation of hazardous waste, send hazardous waste to an appropriately permitted offsite treatment or disposal facility, and retain specified records. These requirements will apply to all hazardous waste generated by onsite remedial activities. Units constructed to treat hazardous waste as part of the remediation must comply with additional operational and closure requirements.

- **Religious Freedom Restoration Act.** Under this Act, the government shall not substantially burden a person's exercise of religion, unless the application of the burden is in furtherance of a compelling government interest, and it is the least restrictive means of furthering that compelling interest. To constitute a "substantial burden" on the exercise of religion, a government action must (1) force individuals to choose between following the tenets of their religion and receiving a governmental benefit or (2) coerce individuals to act contrary to their religious beliefs by the threat of civil or criminal sanctions. If any remedial action selected imposes a substantial burden on a person's exercise of religion, it must be in furtherance of a compelling government interest and be the least restrictive means of achieving that interest.
- **Requirement for Land Use Covenants.** This regulation requires appropriate restrictions on use of property in the event that a proposed remedial alternative results in hazardous materials remaining at the property at levels that are not suitable for unrestricted use of the land. This is an ARAR with respect to privately-owned land at the Topock site.
- **SWRCB Resolution 68-16.** This resolution requires that any activity that discharges to existing high-quality waters must implement best practicable treatment necessary to assure that pollution or a nuisance will not occur and that the highest water quality consistent with maximum benefit to people of the State will be maintained. This resolution will apply to discharges from any remedial activity at the Topock site.
- **SWRCB Resolution 88-63.** This resolution specifies that, with certain exceptions, all surface and ground waters of the State are to be considered suitable, or potentially suitable, for municipal or domestic water supply. The Regional Water Quality Control Board and State Water Resources Board have designated the beneficial use of the ground and surface waters in the Topock Site area as "municipal and domestic water supply." This designation is set forth in the Basin Plan.
- **SWRCB Resolution 92-49.** This resolution establishes policies and procedures for investigation and cleanup and abatement of discharges under Water Code Section 13304, including the requirement that cleanup attain background water quality or the best water quality that is reasonable if background water quality cannot be restored. In addition, Section III.A of this Resolution states that the Regional Water Board shall" "concur with any investigative and abatement proposal which the discharger demonstrates and the Regional Water Board finds to have a substantial likelihood to achieve compliance within a reasonable time frame…"
- **Water Quality Control Plan: Colorado River Basin-Region 7, June 2006**. The Basin Plan designates the Colorado River and Colorado Hydrologic unit as having the beneficial use of "MUN" (municipal or domestic water supply). The Basin Plan also prescribes General Surface Water Objectives and Ground Water Objectives in addition to Specific Surface Water Objectives for the Colorado River, which include a flow-weighted average annual numeric criterion for salinity for the portion of the Colorado River on the Topock Site of 723 mg/L. This TDS value must not be exceeded in any remedial alternative being considered.

3.3 Remedial Action Objectives

The objectives of this remedial action are defined based on the conclusions of the GWRA and ARARs identification. The RAOs are intended to provide a general description of the cleanup objectives and to provide the basis for the development of site-specific remediation goals. In accordance with CERCLA guidance, RAOs specify the contaminant of concern, the exposure routes and receptors, and an acceptable contaminant concentration for each exposure pathway (United States Environmental Protection Agency [USEPA], 1988a-b). Protectiveness can be achieved by limiting or eliminating the exposure pathway, reducing or eliminating chemical concentrations, or both. RCRA Corrective Action guidance describes goals for final cleanup both in terms of protecting human health and the environment as well as performance standards that must also include controlling future sources of releases (USEPA, 2004).

The proposed RAOs for groundwater in this remedial action are to:

1. Prevent ingestion of groundwater as a potable water source having Cr(VI) in excess of the regional background concentration of 32 µg/L Cr(VI).
2. Prevent or minimize migration of Cr(T) and Cr(VI) in groundwater to ensure concentrations in surface water do not exceed water quality standards that support the designated beneficial uses of the Colorado River (11 µg/L Cr(VI)).
3. Reduce the mass of Cr(T) and Cr(VI) in groundwater at the site to achieve compliance with ARARs in groundwater. This RAO will be achieved through cleanup goal of regional background of 32 µg/L of Cr(VI).
4. Ensure that the geographic location of the target remediation area does not permanently expand following completion of the remedial action.

3.3.1 Preliminary Cleanup Goals

Preliminary cleanup goals are developed to provide risk reduction targets early in the RI/FS process. Cleanup goals may be refined based on the baseline risk assessment, ARARs, feasibility alternative analysis, and risk management considerations.

The preliminary cleanup goals to address the first RAO of reducing potential future human health risk from exposure to Cr(T) and Cr(VI) by ingestion of groundwater considered the exposure pathway and chemical concentrations of Cr(T) and Cr(VI) in groundwater at the site. As previously described, there is no existing use of groundwater within the Cr(VI) plume area and, therefore, no current complete pathway exists. However, to address the possibility that groundwater may be developed as a drinking water source in the future, the preliminary cleanup goals consider both the chemical-specific ARARs for drinking water, as well as the calculated noncancer risk-based remediation goal for Cr(VI), assuming future hypothetical human groundwater users that may be exposed to site groundwater in a residential setting. The California and federal maximum contaminant level for Cr(T) are 50 µg/L and 100 µg/L, respectively, and represent the chemical concentrations in drinking water considered safe for human consumption. No maximum contaminant level (MCL) exists for Cr(VI) although, in general, Cr(VI) has been shown to be more toxic than Cr(III) (United States Department of Human Health Services, 2008). Hexavalent chromium is currently regulated under the MCL for Cr(T). In 2001, a law was enacted that requires the California Department of Public Health to establish an MCL for Cr(VI) at a level as close as is technically and economically feasible to the contaminant's public health goal. In August 2009, the Office of Environmental Health Hazard Assessment released a draft public health goal for Cr(VI); however, the final public health goal will not be an ARAR because it is not a promulgated requirement, but any future MCL developed by California Department of Public Health would be an ARAR. As described in the GWRA, the calculated noncancer risk-based remediation goal for Cr(VI) is 46 µg/L.

Considering the above, and as a conservative measure, PG&E is considering the background level of Cr(T) and Cr(VI) in groundwater at the site as the preliminary cleanup goal for addressing risks associated with a hypothetical future groundwater user, rather than the MCL or the calculated noncancer risk-based remediation goal. Based on the results of a multi-year study, the background concentration for Cr(VI) in groundwater at the Topock site is 32 µg/L,[7] and the background concentration for Cr(T) in groundwater is 34 µg/L[8] (CH2M HILL, 2008c). The background values represent the calculated statistical UTL of natural background levels for Cr(VI) and Cr(T) in groundwater near the Topock site The preliminary cleanup goal of 32 µg/L of Cr(VI) is less than the calculated noncancer risk-based remediation goal of 46 µg/L for future hypothetical human groundwater users that may be exposed to site groundwater in a residential setting, and the preliminary cleanup goal of 34 µg/L Cr(T) is less than the California and federal MCLs for Cr(T) of 50 µg/L and 100 µg/L, respectively.

The second RAO—ensuring concentrations of Cr(T) and Cr(VI) in groundwater at the site do not cause exceedances in water quality standards that support the designated beneficial uses of the Colorado River—is being addressed in a similar manner as the first RAO. As previously described, evidence shows that the plume is not causing exceedance in water quality standards of the Colorado River. Surface water samples collected within the river near the site, both before and after implementation of the IM, show concentrations less than the federal water quality criteria for Cr(VI) (CH2M HILL, 2009a), and the GWRA concluded that the potential transport of constituents in groundwater to the Colorado River represents an insignificant transport pathway (ARCADIS, 2009). Similar to addressing the first RAO, PG&E is addressing the second RAO by using a conservative means to increase the level of certainty that surface water quality will continue to remain below surface water quality standards in the future by applying the background concentration for Cr(VI) and for Cr(T) as a cleanup goal in groundwater.

The third RAO—reduction of mass to achieve risk and ARAR target levels—is also being addressed in a manner similar to the first and second RAOs. Rather than achieving protectiveness or ARARs compliance by limiting or eliminating the exposure pathways, the RAO focuses on reducing or eliminating the chemical concentrations comprising the contaminant source. As a conservative measure, PG&E is proposing a preliminary cleanup goal of background concentrations for Cr(VI) and for Cr(T) for attainment of the third RAO. The background concentrations are lower than the MCL and lower than the calculated noncancer risk-based remediation goal.

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[7] The calculated statistical UTL for Cr(VI) is 31.8 µg/L; the 32 µg/L goal is the UTL rounded to the nearest whole number.

[8] The calculated statistical UTL for Cr(T) is 34.1 µg/L; the 34 µg/L goal is the UTL rounded to the nearest whole number.

The fourth RAO—ensuring that the geographic location of the target remediation area does not permanently expand following completion of the remedial action—included as requested by DTSC, is being addressed through implementation of the third RAO. By reducing the mass of Cr(VI) to achieve compliance with ARARs (50 µg/L Cr(VI) in groundwater and 11 µg/L Cr(VI) in surface water), the target remediation area will not expand following completion of the remedial action.

Under the geochemical conditions of site groundwater, dissolved chromium exists nearly entirely as Cr(VI). Historical data show that Cr(T) is equal to Cr(VI), allowing for analytical scatter. The reduced form, Cr(III), is highly insoluble, with precipitation reactions maintaining the concentration less than the analytical detection limit. As a result, measurement of RAO attainment in this remedial action will be focused on attaining the preliminary cleanup goal for Cr(VI) rather than Cr(T), and the treatment technologies will be focused on Cr(VI) rather than Cr(T).

3.3.2 Point of Compliance

The point of compliance for attainment of cleanup goals is throughout the area of contaminated groundwater, assuming that development of groundwater beneath the plume as a water supply may ultimately be pursued in the future. In establishing the point of compliance throughout the area of contaminated groundwater, the following are recognized:

- Attaining the cleanup goals at the point of compliance may be through active remediation or through natural means.
- Different areas of the plume may reach the media cleanup goal at different times.

3.3.3 Other Constituents Potentially Associated with SWMU1/AOC1

As described in the RFI/RI Volume 2 Report and RFI/RI Volume 2 Addendum, there are three other constituents in addition to Cr(VI) that are potentially related to releases from SWMU 1/AOC 1: molybdenum, selenium, and nitrate. The GWRA presents a thorough and conservative analysis of the potential human health risks posed by these three constituents under the assumption that a future resident consumes the water at a given well on a daily basis. Based on multiple lines of evidence presented in the GWRA, the GWRA concludes that molybdenum, nitrate, and selenium do not represent a significant health risk to future hypothetical users of the groundwater.

Although the GWRA concludes that these three constituents are not believed to be a source of significant risk/noncancer hazard, the regulatory agencies have requested that molybdenum, selenium, and nitrate continue to be monitored through the remediation process (DTSC 2009c, DOI 2009c). On a well-by-well basis (assuming water quality data from an individual groundwater monitoring or testing well would represent water quality from a future water supply well), the noncancer HI exceeded the threshold of 1.0 in one or more wells in the quantitative evaluation for these three constituents (ARCADIS, 2009). Specifically, selenium exceeds an HI of 1.0 in one well (with an HI of 2.0), nitrate exceeds an HI of 1.0 in one well (with an HI of 1.3), and molybdenum exceeds an HI of 1.0 in the baseline analysis at six wells (with an HI from 1.1 to 2.5). Taking into account essential nutrient considerations, molybdenum exceeds an HI of 1.0 at only one well (with an HI of

1.1). The methodology used in the GWRA conformed to USEPA risk assessment methods that are designed to be health protective and tend to overestimate rather than underestimate risk (ARCADIS, 2009). Key assumptions regarding exposure and toxicity tend to lead to a conservative bias in the estimates of risk/hazard, and for the GWRA included:

- **The assumption that water quality data from an individual groundwater monitoring or testing well would represent water quality from a future water supply well.** Monitoring wells are typically small-diameter wells with relative short screens, with screen locations biased towards the zones of highest contamination in the aquifer. Water supply wells are often screened across expanded aquifer thicknesses to optimize capacity and are constructed of sufficient diameter to house continuous supply pumping equipment.
- **The assumption that future human exposures are represented by the concentrations measured at an individual monitoring well, without accounting for mixing either horizontally or vertically as water is pulled into the well for supply needs.**
- **The assumption that the reasonably anticipated future land use anywhere within the site is residential use, leading to exposure assumptions that the future hypothetical residential groundwater users will use an onsite groundwater well for supplying all domestic water and will use this groundwater daily for an uninterrupted 30-year period.** Current (i.e., nonresidential) land uses at the site are likely to remain the same in the future. PG&E plans to continue owning and operating the Topock Compressor Station and associated property as an industrial operation for the foreseeable future. The railroad and highway will also continue in their current use for the foreseeable future. The primary conservation mission of USFWS, as it applies to the HNWR, limits human use of HNWR property, and in the future, human use of HNWR property will likely continue to be restricted to recreational uses (DOI, 2007c). Similarly, future use of the BLM-owned land at the site is likely to remain recreational, although DOI has indicated that residential use of that property cannot be precluded. Of the wells in the GWRA with an HI greater than 1.0 for molybdenum, selenium, and nitrate, and considering molybdenum's role as an essential nutrient, only one well (MW-46-175) is located on land where future residential land use is not specifically precluded as a reasonable future scenario.

Nevertheless, as a result of the well-by-well conclusions for molybdenum, selenium, and nitrate in the GWRA, as a conservative measure, institutional controls should be enforced throughout the treatment area during implementation of the remedial action to restrict ingestion of groundwater, and monitoring for these three constituents should continue. In order to attain the RAOs for Cr(VI) identified above, substantial movement of groundwater in the target remediation area—either through natural or induced measures—will be necessary, and under active treatment for Cr(VI), it is expected that significant mixing of groundwater in the target remediation area would occur both vertically and horizontally. As a result, concentrations of molybdenum, selenium, and nitrate measured at individual monitoring wells are expected to change during the course of remediation from the concentrations present today as, for example, multiple pore volumes of groundwater are moved through the aquifer. It is expected that following attainment of the RAOs for Cr(VI) and prior to removing the institutional controls, the concentration and distribution of these three constituents will be re-evaluated. Also, it is expected that monitoring and test wells at the site would be decommissioned at the completion of the remedial action following the determination that additional data collection from the wells are no longer needed to measure attainment of the RAOs.

In summary, within the treatment area, Cr(VI) in groundwater represents the predominant health hazard associated with any potential future domestic use of the groundwater; other potential facility-related constituents (molybdenum, selenium, and nitrate) were detected at elevated levels in localized areas associated with lower levels of risk. Institutional controls should be enforced during implementation of the remedial action to restrict ingestion of groundwater, and monitoring for these three constituents should be continued. Following attainment of the RAOs for Cr(VI) and prior to removing the institutional controls, the concentration and distribution of molybdenum, selenium, nitrate, and chromium should be re-evaluated.

4.0 Identification and Screening of Remedial Action Technologies

This section describes the identification and screening of remedial technologies to satisfy the identified RAOs for this remedial action. The identification and screening approach is consistent with the *Guidance for Conducting Remedial Investigations and Feasibility Studies under CERCLA* (USEPA, 1988a). The content of this section is summarized as:

- **General Response Actions.** The broad range of actions that will potentially satisfy the RAOs are identified.
- **Screening of Remedial Technologies and Process Options.** For each general response action, the potentially applicable remedial technologies and associated process options are identified and screened against the criterion of technical implementability.
- **Evaluation of Process Options.** Remedial technologies and associated process options are evaluated against the criteria of effectiveness, implementability, and relative cost.
- **Selection of Representative Process Options.** Process options are chosen for each technology type by considering the screening results and by identifying those that can represent the entire range of process options for a given technology type during the evaluation of alternatives.

4.1 General Response Actions

General response actions describe the broad range of actions that will satisfy the RAOs. General response actions may include no action, institutional controls, containment, removal, treatment, disposal, monitoring, or a combination of these. Similar to RAOs, general response actions are medium-specific. The media-specific general response actions for groundwater are:

- **No Action.** No attempt is made to satisfy the RAOs, and no remedial measures are implemented. The National Contingency Plan stipulates that any evaluation of remedial alternatives includes evaluation of the No Action alternative.
- **Institutional Controls.** These are actions using non-engineering methods to prevent interference with other remedial activities and/or to prevent access to, contact with, or use of contaminated groundwater.
- **Containment.** These are actions that result in contaminated groundwater being contained or controlled, thereby minimizing or eliminating the migration of contaminants and preventing direct exposure to contamination.
- **Removal.** These are actions taken to physically collect and remove the contaminated groundwater.

- **Treatment.** These are *in-situ* or *ex-situ* actions taken to treat groundwater using thermal, physical, chemical, and/or biological processes to reduce the toxicity, mobility, and/or volume of contamination.
- **Disposal.** These are actions taken to dispose or re-use treated or untreated groundwater at onsite or offsite locations.
- **Monitoring.** This is the short- and/or long-term collection and evaluation of data to record site conditions, monitor contamination levels, and evaluate progress of remedial actions to meet the RAOs.

Except for the No Action general response action, each general response action can be addressed by a number of remedial technologies. In this context, the following definitions apply:

- Remedial technologies are defined as the general categories of remedies under a general response action.
- Process options are specific categories of remedies within each remedial technology. The process options are used to implement each remedial technology.

4.2 Screening of Remedial Technologies and Process Options

Many technology types and process options are available to implement the general response actions described in Section 4.1. Table 4-1 (located at the end of this section) provides an initial list of technologies and process options. The purpose of initially considering a wide range of technologies and process options is to ensure that potentially applicable options are not overlooked early in the CMS/FS process.

The screening of these remedial technologies and process options is accomplished in three steps:

1. Technical implementability screening
2. Evaluation of process options
3. Selection of representative process options

The first step in the process involves screening the initial list of technologies and process options against the criterion of technical implementability. This first screening eliminates those technologies or process options that are not applicable or not workable for the contaminants and site characteristics found at the site. A second screening of the remaining process options against the criteria of effectiveness, implementability (both technical and administrative), and relative cost further reduces this list. The last step involves the selection of representative process options for each technology type to simplify the subsequent development and evaluation of remedial alternatives. These steps are specifically discussed in the following subsections.

4.2.1 Technical Implementability Screening

In this step, the initial list of technology types and process options is reduced by evaluating the implementability of the options. Technical implementability refers to the ability of the remedial technology or process option to meet the RAOs for the site. This first screening eliminates those technologies and process options that are clearly not applicable or are not workable for the contaminants or characteristics of the site.

The technical implementability screening of potential groundwater remediation technologies and process options is presented in Table 4-1. This table provides brief descriptions of the technologies and process options and provides screening rationale. Technologies and process options that are screened out because they are not technically implementable are shaded.

4.2.2 Evaluation of Process Options

After the technical implementability screening, the remaining technologies and process options are evaluated in greater detail using the criteria of effectiveness, implementability, and relative cost. In accordance with the *Guidance for Conducting Remedial Investigations and Feasibility Studies under CERCLA* (USEPA, 1988a), the evaluation of process options focuses more on effectiveness factors with less effort directed at the implementability and cost evaluation. A description of the screening criteria and how they are applied to the evaluation of process options is presented below.

- **Effectiveness**: Specific process options are evaluated for effectiveness by considering:
  - The ability of a process option to address the estimated areas or volumes of contaminated media and meet identified RAOs.
  - The potential impacts to human health and the environment during the construction and implementation phases.
  - The reliability and demonstrated success the process has shown with respect to the types of contamination and site conditions that will be encountered.
- **Implementability**: Implementability includes both the technical and administrative feasibility of implementing a technology process option. As discussed in Section 4.2.1, technical implementability is used as the initial screen to eliminate those options that are clearly not appropriate at the site. Therefore, this subsequent evaluation of process options places greater emphasis on the administrative or institutional aspects of using a process option such as potential restrictions on future land use of the site; the availability and capacity of treatment, storage, and disposal services; and the availability of the equipment and workers to implement the technology. Other aspects of implementability such as stakeholder acceptance will be discussed as part of the alternative evaluation in Section 5.0.
- **Relative Cost:** Cost plays a limited role in the screening of process options. Relative capital costs plus operations and maintenance costs are used rather than detailed estimates. The costs for each process option are evaluated on the basis of engineering judgment as high, medium, or low relative to the other process options in the same technology type.

The evaluation of process options is depicted in Table 4-2 (located at the end of this section). Technologies and process options that were screened out on the basis of effectiveness and/or implementability are shaded. None of the process options were screened out based on cost.

4.2.3 Selection of Representative Process Options

Following evaluations of effectiveness, implementability, and relative cost, process options are chosen to represent the range of options within a remedial technology type. These representative process options are chosen for each technology type by considering the screening results and by identifying those that can represent the entire range of process options. The representative process option may be chosen because performance and cost information is readily available, it has been previously identified or used at the site, or it otherwise ranks favorably among the other process options. The purpose of selecting a representative process option from all remaining options for each technology type (rather than including every remaining process option) is to simplify the subsequent development and evaluation of alternatives by reducing the number of alternatives formulated (USEPA, 1988a). For example, the use of conventional extraction wells is identified in Table 4-2 as the representative process option for groundwater collection. This was chosen because it is a proven, well-understood option and ranks high among the three options for groundwater collection (conventional extraction wells, horizontal wells, and trenches/drains). Cost and performance data for extraction wells are readily available. As a component of an alternative, conventional extraction wells will adequately represent groundwater collection during the evaluation against other alternatives. Use of conventional extraction wells in the alternative evaluation does not preclude the consideration of other groundwater collection options during the remedial design phase.

More than one process option may be selected for a technology type if the processes are sufficiently different in their performance that one would not adequately represent the other. For example, if horizontal wells and vertical wells were both applicable at a site, separate alternatives may be required to evaluate the groundwater extraction technology since the performance and cost of the two process options can be very different. Within a given technology, the specific process option implemented at the site may be modified during the remedial design phase, as well as during future optimization of the remedy, without compromising the evaluation and selection of alternatives in the CMS/FS (USEPA, 1988a).

The representative process options that were selected to be included in the alternative evaluations in Section 5.0 are presented in Table 4-2 and are summarized in Table 4-3.

TABLE 4-1
Primary Screening of Remedial Technologies and Process Options for Groundwater Remediation
Final Groundwater Corrective Measures Study /Feasibility Study Report for SWMU 1/AOC 1 and AOC 10, PG&E Topock Compressor Station, Needles, California

General Response Actions	Remedial Technology Types	Process Options	Descriptions	Primary Screening Comments	Pass Primary Screen?
No Action	None	None	No further actions are taken to address contaminated groundwater.	Required for consideration by the National Contingency Plan.	Yes
Institutional Controls	Access and Use Restrictions	Land Use Covenants/ Deed Restrictions	Deed restrictions or covenants are issued for property within potentially contaminated areas to prevent interference with other remedial activities and/or to prevent access to, contact with, or use of contaminated groundwater.	Retained as a potential component of the remedy until RAOs are achieved.	Yes
		Fences	Security fences are installed around potentially contaminated areas to limit access.	The contaminated groundwater ranges from approximately 28 to 135 feet bgs. Surface access restrictions via fences are not necessary to limit exposure to contaminated groundwater.	No
		Permits	Permits can be used to control future actions within the plume to prevent accidental exposure or prevent damage to the remedial activities. Substantive requirement for promulgated regulations would need to be met during implementation of the remedial action. Actual permits are not required for onsite CERCLA actions.	Substantive requirements of ARARs would need to be met during implementation of the remedy. Permits are retained as a potential component of the remedy until RAOs are achieved.	Yes
	Alternative Drinking Water Source	Cisterns or Tanks	Drinking water is dispensed to users from a centralized point.	Groundwater beneath and immediately adjacent to the plume is not currently being used as a drinking water source. However, future development of alternative water supplies may be necessary to support future development; therefore, this technology is retained.	Yes
		Bottled Water	Drinking water is obtained from a commercial vendor.	Groundwater beneath and immediately adjacent to the plume is not currently being used as a drinking water source. However, future development of alternative water supplies may be necessary to support future development; therefore, this technology is retained.	Yes
		Deeper or Upgradient Wells	Wells are installed deep or upgradient if these areas are isolated from contamination.	Groundwater beneath and immediately adjacent to the plume is not currently being used as a drinking water source. However, future development of alternative water supplies may be necessary to support future development; therefore, this technology is retained.	Yes

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General Response Actions	Remedial Technology Types	Process Options	Descriptions	Primary Screening Comments	Pass Primary Screen?
Institutional Controls, continued	Alternative Drinking Water Source (continued)	Relocation of Intake	Intake is relocated to an uncontaminated area.	Groundwater beneath and immediately adjacent to the plume is not currently being used as a drinking water source. However, future development of alternative water supplies may be necessary to support future development; therefore, this technology is retained.	Yes
		Municipal Water Supply	Additional water sources are established.	Groundwater beneath and immediately adjacent to the plume is not currently being used as a drinking water source. However, future development of alternative water supplies may be necessary to support future development; therefore, this technology is retained.	Yes
Containment	Capping	Native Soil	Uncontaminated native soil is placed over contaminated areas.	A surface barrier is not necessary to prevent direct contact to groundwater. The contaminated groundwater ranges from approximately 28 to 135 feet bgs. Capping might be used to mitigate localized infiltration and contaminant transport. This has not been assessed in the context of a technology for groundwater but may have application as a soils technology based on future evaluation of soils data.	No
		Clay Cap	Compacted clay is placed over contaminated area. Clay should be covered by at least 1 foot of silty sand or sandy soil to maintain the integrity of the clay cap.	A surface barrier is not necessary to limit infiltration or prevent direct contact to groundwater. The contaminated groundwater ranges from approximately 28 to 135 feet bgs. Precipitation in the area of the site is low. Groundwater moves very slowly at the site due to minimal local recharge. Capping might be used to mitigate localized infiltration and contaminant transport. This has not been assessed in the context of a technology for groundwater but may have application as a soils technology based on future evaluation of soils data.	No

TABLE 4-1
Primary Screening of Remedial Technologies and Process Options for Groundwater Remediation
Final Groundwater Corrective Measures Study /Feasibility Study Report for SWMU 1/AOC 1 and AOC 10, PG&E Topock Compressor Station, Needles, California

General Response Actions	Remedial Technology Types	Process Options	Descriptions	Primary Screening Comments	Pass Primary Screen?
Containment (continued)	Capping (continued)	Synthetic Membranes	Synthetic membrane is placed over prepared soil or geotextile surface that is over a contaminated area. The membrane is seamed by a variety of methods. The membrane must be compatible with the wastes present.	A surface barrier is not necessary to limit infiltration or prevent direct contact to groundwater. The contaminated groundwater ranges from approximately 28 to 135 feet bgs. Precipitation in the area of the site is low. Groundwater moves very slowly at the site due to minimal local recharge. Capping might be used to mitigate localized infiltration and contaminant transport. This has not been assessed in the context of a technology for groundwater but may have application as a soils technology based on future evaluation of soils data.	No
		Asphalt or Concrete Cap	Paving grade asphalt or concrete is placed over prepared contaminated area. Fill settlement must be evaluated in considering a concrete cap design.	A surface barrier is not necessary to limit infiltration or prevent direct contact to groundwater. The contaminated groundwater ranges from approximately 28 to 135 feet bgs. Precipitation in the area of the site is low. Groundwater moves very slowly at the site due to minimal local recharge. Capping might be used to mitigate localized infiltration and contaminant transport. This has not been assessed in the context of a technology for groundwater but may have application as a soils technology based on future evaluation of soils data.	No
		Multilayered Cap	Cap may be composed of natural soils, soil admixtures, clay, synthetic membranes, spray-on asphalts, asphalts concrete, or Portland cement concrete and placed over contaminated areas.	A surface barrier is not necessary to limit infiltration or prevent direct contact to groundwater. The contaminated groundwater ranges from approximately 28 to 135 feet bgs. Precipitation in the area of the site is low. Groundwater moves very slowly at the site due to minimal local recharge. Capping might be used to mitigate localized infiltration and contaminant transport. This has not been assessed in the context of a technology for groundwater but may have application as a soils technology based on future evaluation of soils data.	No

TABLE 4-1
Primary Screening of Remedial Technologies and Process Options for Groundwater Remediation
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General Response Actions	Remedial Technology Types	Process Options	Descriptions	Primary Screening Comments	Pass Primary Screen?
Containment (continued)	Vertical Barriers	Chemical Sealant/ Stabilizers	Water-dispersible emulsions and/or resins are placed over contaminated areas to form a crust that reduces water and wind or dust erosion. Most are nontoxic to plants and animals; temporary cover only.	A surface barrier is not necessary to limit infiltration or prevent direct contact to groundwater. The contaminated groundwater ranges from approximately 28 to 135 feet bgs. Precipitation in the area of the site is low. Groundwater moves very slowly at the site due to minimal local recharge. Capping might be used to mitigate localized infiltration and contaminant transport. This has not been assessed in the context of a technology for groundwater but may have application as a soils technology based on future evaluation of soils data.	No
		Soil-bentonite Slurry Wall	A vertical trench is excavated and filled with bentonite slurry to support the trench and is subsequently backfilled with a mixture of low-permeability material (1 x 10^{-6} cm/sec or lower) to redirect the groundwater flow.	Potential application in some portions of the site in conjunction with groundwater extraction for plume containment.	Yes
		Cement-bentonite Slurry Wall	A vertical trench is excavated and filled with bentonite slurry to support the trench and is subsequently backfilled with a mixture of cement and bentonite to form a solid barrier and redirect the groundwater flow.	Potential application in some portions of the site in conjunction with groundwater extraction for plume containment.	Yes
		Vibrating Beam Barrier Installation	Vibratory force is used to advance steel beam into ground; injection of a relatively thin wall of cement or bentonite as beam is withdrawn.	Vertical barriers may be used in conjunction with groundwater extraction for plume containment.	Yes
		Grout Curtains	Grout is pressure-injected along contamination boundaries in a regular overlapping pattern of drilled holes.	Less effective than other vertical barrier methods; may be applicable in some areas in conjunction with other technologies for plume containment.	Yes
		Sheet Piling	Steel sheet piling is driven along contamination boundaries.	Depth to groundwater contamination and depth to bedrock make implementation at this site impractical.	No
		Permeability Reduction Agents	Cement chemical grout or organic polymer is injected into the soil matrix to reduce permeability; experimental process option.	Similar implementation difficulties as other vertical barriers but is less effective; would require more intensive groundwater extraction and management than other vertical barriers.	No
		Ground Freezing (CRYOCELL process)	Conventional ground freezing technology is used to form a flow-impervious, removable, and fully monitored ice barrier that circumscribes the contaminant source *in-situ*.	Too energy-intensive; not feasible for the climate at the site.	No

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General Response Actions	Remedial Technology Types	Process Options	Descriptions	Primary Screening Comments	Pass Primary Screen?
Containment (continued)	Horizontal Barriers	Block Displacement	Controlled injection of slurry in notched injection holes produces a horizontal barrier beneath contamination; experimental process option.	Horizontal barriers are not necessary to achieve RAOs. The groundwater contamination is distributed vertically throughout the Alluvial Aquifer. Bedrock underlies the Alluvial Aquifer, and vertical hydraulic gradients in the Alluvial Aquifer are primarily upward.	No
		Grout Injection	Grout pressure is injected at depth through closely-spaced drilled holes.	Horizontal barriers are not necessary to achieve RAOs. The groundwater contamination is distributed vertically throughout the Alluvial Aquifer. Bedrock underlies the Alluvial Aquifer, and vertical hydraulic gradients in the Alluvial Aquifer are primarily upward.	No
		Ground Freezing	Similar to vertical barriers by ground freezing; experimental process option.	Horizontal barriers are not necessary to achieve RAOs. The groundwater contamination is distributed vertically throughout the Alluvial Aquifer. Bedrock underlies the Alluvial Aquifer. and vertical hydraulic gradients in the alluvial aquifer are primarily upward.	No
		Liners	Liners are placed to restrict vertical flow can be constructed of the same materials considered for cap construction.	Horizontal barriers are not necessary to achieve RAOs. The groundwater contamination is distributed vertically throughout the alluvial aquifer. Bedrock underlies the alluvial aquifer and vertical hydraulic gradients in the alluvial aquifer are primarily upward.	No
	Hydraulic Barriers	Extraction/Injection wells	Groundwater wells are used to control the movement of groundwater and create a hydraulic barrier.	Applicable to site conditions. Hydraulic containment by extraction requires management of extracted groundwater.	Yes
		Trenches/Drains	Low-permeability trenches are constructed to control the movement of groundwater and create a hydraulic barrier.	Applicable to site conditions. Hydraulic containment requires treatment and disposal of extracted groundwater.	Yes

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General Response Actions	Remedial Technology Types	Process Options	Descriptions	Primary Screening Comments	Pass Primary Screen?
Removal	Groundwater Collection	Conventional Extraction Wells	Conventional groundwater extraction/collection is pumping in vertical wells. Other extraction devices include vacuum-enhanced recovery, jet-pumping systems, etc. Extracted groundwater is treated *ex-situ* as required and is discharged or re-injected.	Applicable to site conditions. Extraction necessary for *ex-situ* treatment processes.	Yes
		Horizontal Wells or Angled Wells	A horizontal or angled well configuration is used for increasing production rate from low-permeability sites or to access areas that are inaccessible with vertical well technology.	May have limited applicability in some portions of the site. Angled and horizontal wells may assist in minimizing disturbance to the land. The existing aquifer permeability and the depth to contaminated groundwater make horizontal wells less appropriate than vertical wells for this site.	Yes
		Trenches/Drains	Trenches are filled with gravel or other high-permeability material to increase the production rate from low-permeability aquifers. Tile or perforated pipe can also be installed in the trench to collect and convey the contaminated groundwater.	Depths of contamination and existing hydrogeologic properties make this technology less effective than conventional extraction.	Yes
	Enhanced Extraction through Injection	Injection of clean or contaminated water	Clean water from an outside source, or clean or contaminated water re-circulated from within the site, is injected into the aquifer to increase hydraulic gradients toward the extraction wells and to increase the flushing rate.	Applicable to site conditions. Relatively flat water table and slow moving water within the aquifer means the natural flushing is slow.	Yes
	Enhanced Oil Recovery (EOR)	Thermal EOR	Many reservoir volumes of hot water, steam, or air are injected into a heavy-oil reservoir to reduce the viscosity of the oil, thus inducing flow used for clean up of low levels of oil.	Not applicable for hexavalent chromium.	No
		Chemical EOR	Micellular solution, polymer, or alkaline chemicals are injected into water/flooded reservoirs to reduce the surface tension between oil and the flooding medium. May spread contamination. Not applicable for cleanup of low levels of oil.	Not applicable for hexavalent chromium.	No
	Free-product Recovery	Free-product Recovery	Undissolved liquid-phase organics are removed from subsurface formations, either by active methods (pumping) or by a passive collection system.	Not applicable for hexavalent chromium.	No

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General Response Actions	Remedial Technology Types	Process Options	Descriptions	Primary Screening Comments	Pass Primary Screen?
Treatment	*In-situ* Biological Treatment	Aerobic Cometabolic Bioremediation	Water containing inducers and electron acceptor (oxygen) is injected to enhance aerobic biodegradation. Inducers serve as carbon sources that activate aerobic enzyme systems known to degrade chlorinated volatile organic compounds (VOCs) (fortuitous cometabolism).	Not applicable for hexavalent chromium.	No
		Biochemical Reduction	Electron donors are delivered via the subsurface within the target zone to stimulate anaerobic biodegradation of compounds. Biochemical reduction involves both biological reduction and biofacilitated chemical reduction, stimulated by injection of carbon substrate.	Applicable to site and contaminants.	Yes
		Phytoremediation	Plants and their associated rhizospheric microorganisms are used to remove, degrade, or contain chemical contaminants in groundwater.	Groundwater contamination is too deep for this to be applicable as an *in-situ* technology.	No
		Bioremediation Enhancements	Various process options (thermal, physical, and/or biochemical) are used to optimize *in-situ* anaerobic or aerobic biodegradation.	Applicable to site and contaminants.	Yes
	In-situ Physical-Chemical Treatment	Pneumatic Fracturing	Relatively low-pressure, high-volume injection of gas is used to create self-propped subsurface fracture patterns that minimize contaminant travel time via diffusion. Complements vapor or fluid extraction technologies.	The alluvial aquifer at Topock has adequate permeability so that fracturing methods are not needed; however, this technology is retained for potential application to supplement treatment in low-permeability portions of the site.	Yes
		Hydraulic Fracturing	High-pressure injection of fluids, followed by granular slurry, is used to create subsurface fracture patterns that minimize contaminant travel time via diffusion. Complements vapor or fluid extraction technologies.	The Alluvial Aquifer at Topock has adequate permeability so that fracturing methods are not typically needed; however, this technology is retained for potential application to supplement treatment in low-permeability portions of the site.	Yes
		Air Sparging	Air is injected into saturated matrices to remove contaminants through volatilization.	Not applicable for hexavalent chromium.	No
		Electrokinetic Treatment	Electrical fields are created by application of low-voltage power to subsurface electrodes, inducing contaminant transport. Can be used to extract contaminants, immobilize them *in-situ*, or to deliver chemical reactants or bioremediation enhancements.	Typically used in lower-permeability formations and in areas of high contaminant concentrations. The size of the groundwater plume and relatively high permeability of the aquifer are not well-suited for this technology.	No

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General Response Actions	Remedial Technology Types	Process Options	Descriptions	Primary Screening Comments	Pass Primary Screen?
Treatment (continued)	*In-situ* Physical-Chemical Treatment (continued)	Dual Phase Extraction	A high-powered vacuum system is applied to simultaneously remove soil vapors, groundwater, and other liquid (i.e., nonaqueous-phase liquid) from low-permeability or heterogeneous subsurface environments.	Not applicable for hexavalent chromium.	No
		Permeable Reactive Barriers	Permeable treatment walls are installed using trenches, fracturing, boreholes or other means to create a barrier wall across the flow path of a contaminant plume. As groundwater moves through the treatment wall, contaminants are passively removed in the treatment zones by physical, chemical, and/or biological processes.	Applicable to chromium, but traditional trench installation methods have not been used at the required depths. Other methods, such as fracturing or installing boreholes to create the walls, are less effective since these methods do not provide a continuous barrier.	Yes
		In-situ Air Stripping (Circulating Cells, Vacuum Vapor Extraction)	Groundwater is aerated and lifted within a well bore, re-infiltrates a different strata of the formation, and creates groundwater circulation. VOCs in groundwater are transferred to vapor phase and are removed from well.	Not applicable for hexavalent chromium.	No
		Surfactant/Cosolvent Flushing	A solution is delivered that enhances the transport of the targeted contaminants by physical displacement, solubilization, desorption, with subsequent recovery of both the solution and target contaminants.	Not necessary because chromium is soluble in water and does not adsorb appreciably to the soil matrix.	No
		In-situ Chemical Oxidation	Aqueous oxidizing agents (peroxide/iron, permanganate, or ozone) are injected to promote abiotic *in-situ* oxidation of chlorinated organic compounds.	Not applicable for hexavalent chromium.	No
		In-situ Chemical Reduction	Aqueous reducing agents are injected to promote *in-situ* reduction of compounds.	Is applicable to reduce hexavalent chromium.	Yes
	In-situ Thermal Treatment	Hot Water or Steam Flushing/Stripping	Steam is forced into an aquifer through injection wells to vaporize volatile and semi volatile contaminants. Vaporized components rise to the unsaturated zone, where they are removed by vacuum extraction and treated.	Not applicable for hexavalent chromium.	No

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General Response Actions	Remedial Technology Types	Process Options	Descriptions	Primary Screening Comments	Pass Primary Screen?
Treatment (continued)	*In-situ* Thermal Treatment (continued)	Dynamic Underground Stripping	*In-situ* steam injection, electrical resistance heating, and fluid extraction are combined to enhance contaminant removal from the subsurface. Contaminants are volatilized, driven to centrally-located extraction wells, removed to surface, and treated.	Not applicable for hexavalent chromium.	No
		Hydrous Pyrolysis/ Oxidation	Steam (and possibly oxygen) is injected to the subsurface. Injection is halted and steam condenses, allowing displaced groundwater to return to heated zone. Groundwater mixes with steam and oxygen, destroying contaminants *in-situ* by chemical oxidation.	Not applicable for hexavalent chromium.	No
	Monitored Natural Attenuation (MNA)	Monitored Natural Attenuation	Actions that rely on monitoring to show that natural subsurface processes such as dilution, volatilization, biodegradation, adsorption, dispersion, and chemical reactions with subsurface materials are reducing contaminant concentrations to acceptable levels within the desired period of time.	Potentially applicable given site geochemical conditions.	Yes
	Ex-situ Biological Treatment	Aerobic cometabolic bioremediation	Contaminants, inducers, and electron acceptor (oxygen) are combined in a bioreactor to enhance aerobic biodegradation. Inducers serve as carbon sources that activate aerobic enzyme systems known to degrade chlorinated VOCs (fortuitous cometabolism).	Not applicable for hexavalent chromium.	No
		Bioreactor	Contaminants and electron donors are combined in a bioreactor to stimulate anaerobic biodegradation of compounds.	May be applicable to reduce chromium.	Yes
		Phytoremediation	Plants and their associated rhizospheric microorganisms are used to remove, degrade, or contain chemical contaminants in groundwater.	Potential component of *ex-situ* treatment.	Yes
	Ex-situ Physical/ Chemical Treatment	Chemical Oxidation	Oxidizing agents are used to oxidize organic contaminants or inorganic reagents in an *ex-situ* reactor. Potential oxidizing agents are UV radiation, ozone, and/or hydrogen peroxide/ferrous iron, or permanganate.	Not applicable as a primary treatment option. In an *ex-situ* application, this technology may be a secondary process.	Yes[a]

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General Response Actions	Remedial Technology Types	Process Options	Descriptions	Primary Screening Comments	Pass Primary Screen?
Treatment (continued)	*Ex-situ* Physical/ Chemical Treatment (continued)	Chemical Reduction	Reducing agents (e.g., zero-valent iron) are used to reduce hexavalent chromium in an *ex-situ* reactor.	Potential component of *ex-situ* treatment.	Yes
		Air Stripping	Volatile organics are partitioned from groundwater by increasing the surface area of the contaminated water exposed to air. Aeration methods include packed towers, diffused aeration, tray aeration, and spray aeration.	Not applicable for hexavalent chromium.	No
		Filtration	Solid particles are isolated by running a fluid stream through a porous medium. The driving force is either gravity or pressure across the filtration medium.	Potential component of *ex-situ* treatment.	Yes[a]
		Ion Exchange	Ions from the aqueous phase are removed by exchange with innocuous ions on the exchange medium.	Potential component of *ex-situ* treatment, although ion exchange is not efficient in the relatively salty water at the site.	Yes
		Electrocoagulation Process	Electricity is passed through iron plates to generate ferrous iron to reduce the chromium and precipitate it from solution. The resulting sludge is settled in a clarifier for disposal.	Harder to control and offers no advantage over chemical dosing; energy intensive.	Yes
		Evaporation Technology	Contaminants are concentrated by using dry air to evaporate water vapor from contaminated water stream. Water vapor is then condensed and the concentrated water is heated until the desired concentration is reached in the dilute water.	Energy consumption is high; costs are high. Likely problems with formation of salt/gypsum.	No
		Reverse Osmosis	Water pressure is used to force water molecules through a very fine membrane, leaving the contaminants behind. Purified water is collected from the “clean” or “permeate” side of the membrane, and water containing the concentrated contaminants is disposed.	Not applicable as a primary treatment option because reverse osmosis cannot remove Cr(VI) down to the levels needed to meet the cleanup goals. In an *ex-situ* application, this technology may be a secondary process.	Yes[a]
		Liquid-phase Carbon Adsorption	Groundwater is pumped through a series of canisters or columns containing activated carbon to which dissolved organic contaminants adsorb. Periodic replacement or regeneration of saturated carbon is required.	Not applicable for hexavalent chromium.	No

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General Response Actions	Remedial Technology Types	Process Options	Descriptions	Primary Screening Comments	Pass Primary Screen?
Treatment (continued)	*Ex-situ* Physical/ Chemical Treatment (continued)	Precipitation	Dissolved contaminants are transformed into an insoluble solid, facilitating the contaminant's subsequent removal from the liquid phase by sedimentation or filtration. Usually uses pH adjustment, addition of a chemical precipitant, and flocculation.	Potential component of *ex-situ* treatment.	Yes
	Ex-situ Thermal Treatment	Incineration	Recovered free product is heated to very high temperatures to combust organic contaminants in the presence of oxygen.	Not applicable for hexavalent chromium.	No
Disposal	Land Application	Land Application	Aqueous wastes are applied to the upper soil horizon so they can be degraded, transformed, or immobilized and the water can infiltrate.	Possible disposal option to help flush the groundwater and enhance removal.	No
	Untreated Groundwater Discharge	Offsite permitted facility	Aqueous streams generated from remedial activities are removed from the site without treatment and transported to an offsite permitted facility for treatment.	This option is not well-suited as the primary disposal because the site is located in a sparsely-populated, rural area requiring long transport distances, potential for spill during transportation, and a high volume of truck traffic would be required. However, this option has been implemented as an interim measure at the site and will be retained as a contingency or limited action for interim periods.	Yes
	Treated Groundwater Discharge	Publicly Owned Treatment Works (POTW)	Aqueous streams are discharged to a POTW for treatment.	Site is located in a sparsely-populated, rural area. Long distances, need for pretreatment, and availability of POTW capacity reduce likelihood of implementing this option.	Yes
		Surface Waters	Aqueous streams are discharged to surface receiving streams.	Possible option, but not favorable due to sensitivities associated with the receiving waters.	Yes
		Injection	Treated groundwater or surface water is injected into onsite wells.	Potential application at this site. May help flush the groundwater and enhance movement. Need to evaluate compatibility for hydraulic control.	Yes
		Deep Well Injection	Aqueous wastes are injected into Class I wells. Recent guidance may further regulate this practice.	Potential application at this site.	Yes
		Evaporation Ponds	Surface impoundments are used to contain treated or untreated wastewater or groundwater until it evaporates.	Possible disposal for excess water.	Yes

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General Response Actions	Remedial Technology Types	Process Options	Descriptions	Primary Screening Comments	Pass Primary Screen?
Disposal (continued)	Treated Groundwater Discharge (continued)	Onsite Reuse	Treated water is used onsite.	Possible uses at the compressor station.	Yes
		Agricultural	Treated water is distributed for agricultural use.	Possible, but low demand in the area of the site, high TDS, and long distances reduce likelihood of implementing this option at this site.	Yes
Monitoring	Monitoring	Monitoring	Short-and/or long-term monitoring is implemented to record site conditions and contamination levels.	Useful in combination with other technologies to measure attainment of RAOs.	Yes

Notes:

[a] Retained for possible use as secondary component of a treatment train, but the option is not applicable as a primary treatment option for hexavalent chromium.

Shading indicates process option or technology is not retained for further consideration.

TABLE 4-2
Evaluation of Process Options for Groundwater Remediation
Final Groundwater Corrective Measures Study /Feasibility Study Report for SWMU 1 /AOC 1 and AOC 10, PG&E Topock Compressor Station, Needles, California

General Response Actions	Remedial Technology Types	Process Options	Descriptions	Effectiveness	Implementability	Relative Cost	Screening Comment
No Action	None	None	No further actions are taken to address contaminated groundwater.	Does not achieve remedial action objectives.	Implementable.	None.	Retained per the National Contingency Plan.
Institutional Controls	Access and Use Restrictions	Land Use Covenants/ Deed Restrictions	Deed restrictions or covenants are issued for property within potentially contaminated areas to prevent interference with other remedial activities and/or to prevent access to, contact with, or use of contaminated groundwater.	Can be effective to prevent accidental exposure to contaminated groundwater and to protect wells and facilities associated with the remedial action. The long-term effectiveness is dependent on continued monitoring and enforcement of the controls.	Would require coordination with multiple landowners and lease holders of property overlying the site to establish the control and ensure a mechanism is in place that provides a long-term commitment to enforce and monitor the controls to ensure controls are functioning as intended.	Low.	Retained as a potential component of the remedy until RAOs are achieved.
		Permits	Permits can be used to control future actions within the contaminated areas to prevent accidental exposure or prevent damage to the remedial activities. Substantive requirement for promulgated regulations would need to be met during implementation of the remedial action. Actual permits not required for onsite CERCLA actions.	Protects human health and the environment by ensuring the substantive requirements of applicable or relevant and appropriate regulations would be satisfied during implementation of the remedy.	Requires coordination with agencies overseeing substantive requirements of promulgated regulations.	Low.	Retained.
	Alternative Drinking Water Source	Cisterns or tanks, bottled water, deeper or upgradient wells, relocation of intakes, or municipal water supply	Alternate sources of water are obtained. Note that groundwater beneath and immediately adjacent to the plume is not currently being used as a drinking water source. However future development of alternative water supplies may be necessary to support future development.	Protects human health by preventing exposure to contaminated groundwater.	Alternate sources of drinking water are available and readily implemented if required.	Low to high capital and operation and maintenance cost, depending on process option chosen.	Retained.
Containment	Vertical Barriers	Soil-bentonite Slurry Wall	Slurry wall barriers consist of a vertical trench excavated perpendicular to the groundwater flow direction, filled with bentonite slurry to support the trench, and subsequently backfilled with a mixture of low-permeability material (1 x 10^{-6} cm/sec or lower).	Effectiveness is dependent on the continuity of the wall and the ability to key into the bedrock, which will be difficult to achieve at this site because of the depth of bedrock; does not reduce toxicity or volume of contaminants by itself. This technology requires groundwater extraction to control groundwater pressures from building up behind the barrier and potentially damaging the barrier or causing groundwater to flow under or around the barrier. The barrier has the potential to degrade or deteriorate over time. While the vast majority of the Cr(VI) plume is upgradient of the most promising area to construct an impermeable barrier wall, there are portions of the plume that are located closer to the Colorado River than the location on the floodplain where a wall could feasibly be constructed.	Implementation of a barrier to the required depths (>150 feet) is not proven and would involve a significant amount of heavy construction at the surface that will disturb large areas. Access may be a problem, as a 70- to 100-foot-wide construction corridor is generally needed. It is difficult to construct the barrier under the Burlington Northern Santa Fe Railroad and I-40 bridge due to low overhead access and the need to protect the integrity of the bridge foundations and roadbeds. Geotechnical analyses at the site indicate that excavation of the older alluvium overlying the bedrock may be impossible with conventional methods.	High capital cost; moderate operation and maintenance (O&M) cost due to need for groundwater extraction.	Not retained. Lack of a continuous aquitard at a depth that is within the vertical limits of traditional trenching equipment means extensive surface disturbance would be necessary to implement this technology.
		Cement-bentonite Slurry Wall	A vertical trench is excavated perpendicular to the groundwater flow direction filled with bentonite and cement slurry to support the trench and form a solid barrier.	Same as soil-bentonite slurry wall.	Same as soil-bentonite slurry wall.	Same as soil-bentonite slurry wall.	Not retained. See above reasons for soil-bentonite slurry wall.
		Vibrating Beam Barrier Installation	Vibratory force is used to advance steel beam into ground; injection of a relatively thin wall of cement or bentonite as beam is withdrawn.	Similar to the slurry wall barriers. Likely to result in higher permeability than slurry wall barriers because it becomes more difficult at depths of >150 feet to achieve continuity in the beam barrier due to difficulties keeping the sections vertical and aligned with one another.	This technology can be used at depths greater than 150 feet bgs and would have fewer surface impacts during construction than the slurry walls.	High capital cost; moderate O&M cost due to need for groundwater extraction.	Not retained. See above reasons for soil-bentonite slurry wall.

TABLE 4-2
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General Response Actions	Remedial Technology Types	Process Options	Descriptions	Effectiveness	Implementability	Relative Cost	Screening Comment
Containment (continued)	Vertical Barriers (continued)	Grout Curtains	Grout is pressure-injected along contamination boundaries in a regular overlapping pattern of drilled holes.	Same as slurry walls, but less effective than other vertical barriers due to discontinuities in the curtain.	Proven technology that has been extensively used in civil engineering projects but less frequently for site remediation. Equipment and vendors are readily available to implement.	High capital cost (usually more expensive than other techniques at moderate depths). Moderate O&M cost due to need for groundwater extraction.	Not retained. See above reasons for soil-bentonite slurry wall.
	Hydraulic Barriers	Extraction/Injection Wells	Groundwater wells are used to control the movement of groundwater and create a hydraulic barrier.	Effective method of hydraulic control; vertical wells are proven technology in widespread use for remediation projects. The hydrogeologic properties at the site are very conducive to groundwater extraction/injection with vertical wells. However, extraction wells may not be effective if the contamination is contained in low-permeability, fine-grained layers and, depending on the array of the wells, there could be extensive surface disturbance.	Readily implementable and currently being used to control groundwater at this site.	Low to moderate capital cost, low O&M cost.	Retained as representative process option for groundwater containment and removal.
		Trenches/Drains	Low-permeability trenches are constructed to control the movement of groundwater and create a hydraulic barrier.	Effective method of hydraulic control, particularly well suited to shallow, low-permeability aquifers.	Readily implementable. Commonly implemented at remediation sites. Depths of contamination and hydrogeologic properties at the PG&E Topock site make this technology less favorable than vertical wells.	Moderate capital cost, low O&M cost.	Retained. May have limited applicability in some portions of the site, but depths of contamination and existing hydrogeologic properties make this technology less effective than conventional extraction.
Removal	Groundwater Collection	Conventional Extraction Wells	Conventional groundwater extraction/ collection is pumping in vertical wells. Other extraction devices include vacuum enhanced recovery, jet-pumping systems, etc. Extracted groundwater treated *ex-situ* as required and discharged or re-injected.	Effective method of groundwater extraction; vertical wells are proven technology in widespread use for remediation projects. The hydrogeologic properties at the site are very conducive to groundwater extraction with vertical wells. However, these techniques may not be effective if the contamination is contained in low-permeability, fine-grained layers.	Readily implementable and currently being used to control groundwater at this site.	Low to moderate capital cost, low O&M cost.	Retained as representative process option for groundwater extraction.
		Horizontal Wells or Angled Wells	A horizontal or angled well configuration is used for increasing production rate from low-permeability sites or to access areas inaccessible with vertical well technology.	Effective method of groundwater extraction from large areas, and areas of lower permeability. Depths of contamination and site hydrogeologic condition make horizontal or angled wells less effective than vertical wells for this site. Vertical wells are preferred at the site since they are easier to install develop and maintain than horizontal wells. The site hydrogeology does not necessitate the use of horizontal wells. However, horizontal and angled wells are retained as they may have application in some portions of the site.	Readily implementable; more difficult to construct and develop than vertical wells.	Low to moderate capital cost, low O&M cost.	Retained. May have limited applicability in some portions of the site.
		Trenches/Drains	Trenches are filled with gravel or other high-permeability material to increase the production rate from low-permeability aquifers. Tile or perforated pipe can also be installed in the trench to collect and convey the contaminated groundwater.	Effective method of groundwater extraction, particularly well-suited to shallow, low-permeability aquifers.	Readily implementable. Commonly implemented at remediation sites. Depths of contamination and hydrogeologic properties at the PG&E Topock site make this technology less favorable than vertical wells.	Moderate capital cost, low O&M cost.	Retained. May have limited applicability in some portions of the site, but depths of contamination and existing hydrogeologic properties make this technology less effective than conventional extraction.
	Enhanced Extraction through Injection	Injection of clean or contaminated water	Clean water from an outside source, or clean or contaminated water re-circulated from within the site, is injected into the aquifer to increase hydraulic gradients toward the extraction wells and increase the flushing rate.	Effective for improving hydraulic gradients and increasing flushing rates through the aquifer potentially reducing cleanup times. However, these techniques may not be effective if the contamination is contained in low-permeability, fine-grained layers and, depending on the array of the wells, there could be extensive surface disturbance.	Readily implementable; offsite water source could be the same as the source for the compressor station.	Low to moderate capital cost, low to moderate O&M costs.	Retained. Offers advantages to traditional groundwater extraction.

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General Response Actions	Remedial Technology Types	Process Options	Descriptions	Effectiveness	Implementability	Relative Cost	Screening Comment
Treatment	*In-situ* Biological Treatment	Biochemical Reduction	Electron donors are delivered via the subsurface within the target zone to stimulate anaerobic biodegradation of compounds. Biochemical reduction involves both biological reduction and biofacilitated chemical reduction, stimulated by injection of carbon substrate.	Effective *in-situ* technology, particularly in homogeneous and permeable aquifers where the distribution of donors within the target area is more successful. Heterogeneity of aquifers can cause problems with vertical flow, limiting circulation.	The substrate can be delivered through injection, extraction and reinjection, or recirculation wells typically installed in a line to create a treatment zone across the groundwater flow path. Pilot testing at the site is underway to determine optimum spacing and operation of wells. Aquifer tests indicate the site may be amenable to recirculation.	Moderate capital cost, moderate O&M cost depending on number and type of wells.	Retained. Applicable to site and contaminants.
		Bioremediation Enhancements	Various process options (physical, and/or biochemical) are used to optimize *in-situ* anaerobic or aerobic biodegradation.	Similar to anaerobic bioremediation, with the addition of enhancements to improve treatment and/or distribution of media.	Similar to anaerobic bioremediation.	Similar to anaerobic bioremediation.	Retained. Applicable to site and contaminants.
	In-situ Physical-Chemical Treatment	Pneumatic Fracturing	Relatively low-pressure (less than 100 psig) high volume injection of gas is used to create self-propagating subsurface fracture patterns that minimize contaminant travel time. The fractures can facilitate removal of contaminants out of the geologic formation. The fractures may also be used to introduce beneficial substrates into the formation. The overall objective of fracturing is to overcome the transport limitations that are inherent at some remediation sites.	The technology is effective to supplement treatment in low-permeability portions of the site and to create pathways that minimize contaminant travel time.	Fracturing is an established concept that has been applied in various forms within the petroleum and water well industries for more than 50 years. Implementation for site remediation typically requires pilot studies and the collection of detailed geologic and geotechnical information. The target depths of most pneumatic fracturing projects have ranged from 10 to 50 feet. Deeper applications become inhibited by the soil/rock overburden pressures. The deepest applications of pneumatic fracturing for site remediation purposes have been 180 feet, but are inhibited by the soil overburden pressures.	Moderate capital cost, moderate O&M cost depending on number and type of wells.	Retained for potential use in low-permeability portions of the site
		Hydraulic Fracturing	High-pressure injection of fluids, followed by granular slurry, is used to create subsurface fracture. Complements vapor or fluid extraction technologies. The overall objective of fracturing is to overcome the transport limitations that are inherent at many remediation sites	The technology is effective to supplement treatment in low-permeability portions of the site and to create pathways that minimize contaminant travel time.	Fracturing is an established concept that has been applied in various forms within the petroleum and water well industries for more than 50 years. Implementation for site remediation typically requires pilot studies and the collection of detailed geologic and geotechnical information.	Moderate capital cost, moderate O&M cost depending on number and type of wells.	Retained for potential use in low-permeability portions of the site.
	In-situ Physical-Chemical Treatment (continued)	Permeable Reactive Barriers	Permeable treatment walls are installed across the flow path of a contaminant plume. As groundwater moves through the treatment wall, contaminants are passively removed in the treatment zones by physical, chemical, and/or biological processes.	Effective for chromium treatment. The effectiveness depends on the continuity and integrity of the wall. The treatment wall is subject to clogging and reduced permeability over time due to the buildup of chemical precipitates or microbial biofouling.	Traditional trench installation methods have not been used at the required depths. Trench stability becomes an issue at depths of 150 feet or greater. Other construction methods such as fracturing or the use of closely spaced or overlapping boreholes are implementable, but difficult to achieve the continuity required for effective passive treatment.	High capital cost, moderate O&M cost	Retained. Applicable to chromium, and may have limited applicability in areas where the noted implementability and effectiveness challenges can be overcome (e.g., in areas of shallower bedrock). The use of injection or recirculation wells to introduce a reactive media is more favorable for widespread implementation at this site.
		In-situ Chemical Reduction	Aqueous reducing agents are injected to promote *in-situ* reduction of compounds.	Effective *in-situ* technology, particularly in homogeneous and permeable aquifers where the distribution of reactive media within the target area is more successful.	The reactive treatment media can be delivered through injection, extraction and reinjection, or recirculation wells typically installed in a line to create a treatment zone across the groundwater flow path. Pilot testing at the site is underway to determine optimum spacing and operation of wells. Aquifer tests indicate the site may be amenable to recirculation.	Moderate capital cost, moderate O&M cost depending on number and type of wells.	Retained. Applicable to site and contaminants.

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General Response Actions	Remedial Technology Types	Process Options	Descriptions	Effectiveness	Implementability	Relative Cost	Screening Comment
Treatment (continued)	Monitored Natural Attenuation	Monitored Natural Attenuation	Actions that rely on monitoring to show that natural subsurface processes such as dilution, volatilization, biodegradation, adsorption, dispersion, and chemical reactions with subsurface materials are reducing contaminant concentrations to acceptable levels within the desired period of time.	Site characterization data have determined that reducing conditions are present in shallow to mid-depth fluvial wells and sediments near and underlying the river promoting chemical reduction and conversion of Cr(VI) to Cr(III). MNA works best where the source of contamination has been controlled or removed. Groundwater moves very slowly at the Topock site, so attenuation of the entire chromium plume upgradient of the floodplain area would require on the order of hundreds of years unless groundwater gradients are increased.	Typical monitoring networks for MNA include compliance wells to confirm that the constituents are being attenuated and that the plume is not expanding or migrating to undesirable locations. Additional wells might also be needed within the reducing zone to monitor the geochemical conditions where the attenuation is occurring. Throughout the duration of the MNA remedy, groundwater monitoring would be performed to evaluate the presence and extent of reducing conditions and to confirm that the plume was stable or shrinking.	Low capital cost, low operation and maintenance (O&M) cost.	Retained. MNA could be used alone or in conjunction with an active remedy such as pump-and-treat or *in-situ* remediation.
	Ex-situ Biological Treatment	Bioreactor	Contaminants and electron donors are combined in a bioreactor to stimulate anaerobic biodegradation of compounds.	Effective.	Implementable; vendors and equipment readily available.	High capital cost, moderate O&M cost.	Retained. Could be used in conjunction with other *ex-situ* treatment technologies to reduce chromium
		Phytoremediation	Plants and their associated rhizospheric microorganisms are used to remove, degrade, or contain chemical contaminants in groundwater.	Effective for removing metals. Additional research is required to verify effectiveness for site conditions.	Implementable, however, would require large surface area and would require extended period of time to establish the phytoremediation system.	High capital cost, low O&M cost.	Retained. Applicable to chromium. May not be appropriate for large flows due to space constraints, but could be used for treating a portion of the flow.
	Ex-situ Physical/ Chemical Treatment	Chemical Oxidation	Oxidizing agents are used to oxidize organic contaminants or inorganic reagents in an *ex-situ* reactor. Potential oxidizing agents are UV radiation, ozone, and/or hydrogen peroxide/ferrous iron, or permanganate.	Not appropriate for primary treatment of hexavalent chromium. In an *ex-situ* application, this technology may be a secondary process.	Implementable; equipment readily available.	High capital cost, moderate to high O&M cost.	Not retained. Other treatment methods are better suited for use as a secondary process in an *ex-situ* treatment train.
		Chemical Reduction	Reducing agents (e.g., zero-valent iron) are used to reduce hexavalent chromium in an *ex-situ* reactor.	Effective for chromium treatment.	Implementable; vendors and equipment readily available. Currently used in IM treatment plant.	Moderate capital cost, low to moderate O&M cost.	Retained.
		Filtration	Solid particles are isolated by running a fluid stream through a porous medium. The driving force is either gravity or pressure across the filtration medium.	Effective for chromium treatment.	Implementable. Vendors and equipment readily available. Currently used in Interim Measure treatment plant.	Moderate capital cost, low to moderate O&M cost.	Retained as potential component of *ex-situ* treatment.
		Ion Exchange	Ions from the aqueous phase are removed by exchange with innocuous ions on the exchange medium.	Effective treatment for metals, although not efficient in the relatively salty water at the site.	Readily implementable.	High capital cost, moderate O&M cost.	Retained as potential component of *ex-situ* treatment; however, not cost-effective because of the large waste stream generated and high TDS concentrations.
		Electrocoagulation Process	Electricity is passed through iron plates to reduce the chromium and precipitate it from solution. The resulting sludge is settled in a clarifier for disposal.	Effective for chromium treatment.	Implementable. Relies on electrochemical generation of ferrous iron, which may be harder to control than chemical dosing of the ferrous iron.	Moderate to high capital cost, high O&M cost.	Not retained. Harder to control and offers no advantage over chemical dosing. Energy intensive.
		Reverse Osmosis	Water pressure is used to force water molecules through a very fine membrane leaving the contaminants behind. Purified water is collected from the “clean” or “permeate” side of the membrane, and water containing the concentrated contaminants is disposed.	Not appropriate for primary treatment of hexavalent chromium but is an effective secondary process for the treatment of the reduced chromium.	Implementable. Equipment readily available.	High capital cost, high O&M cost.	Retained for use as a secondary process in an *ex-situ* treatment train; however, not cost-effective because of the large waste stream generated and high TDS concentrations.

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General Response Actions	Remedial Technology Types	Process Options	Descriptions	Effectiveness	Implementability	Relative Cost	Screening Comment
Treatment (continued)	*Ex-situ* Physical/ Chemical Treatment (continued)	Precipitation	Dissolved contaminants are transformed into an insoluble solid, facilitating the contaminant's subsequent removal from the liquid phase by sedimentation or filtration. Usually uses pH adjustment, addition of a chemical precipitant, and flocculation.	Effective for chromium treatment.	Implementable. Vendors and equipment readily available. Currently used in Interim Measure treatment plant.	High to moderate capital cost, low to moderate O&M cost.	Retained as potential component of *ex-situ* treatment.
Disposal	Untreated Groundwater Discharge	Offsite permitted facility	Aqueous streams generated from remedial activities are removed from the site without treatment and transported to an offsite permitted facility for treatment.	Effective	Implementability is limited by the fact that the site is located in a sparsely-populated, rural area requiring long transport distances, potential for spill during transportation, and a high volume of truck traffic would be required. This option has been implemented as an interim measure at the site.	Low capital cost, moderate to high O&M cost.	Retained for possible use as a contingency or limited action for interim periods.
	Treated Groundwater Discharge	Publicly-owned Treatment Works (POTW)	Aqueous streams are discharged to a POTW for treatment.	Effective. May require some minimal pretreatment of water.	Implementable, but site is located in a sparsely-populated, rural area, so long distances and the availability of a POTW willing to or capable of accepting the water is limited.	Moderate to high capital cost depending on distance and pretreatment needs. Moderate O&M cost.	Not retained. Long distances and availability of POTW capacity reduce likelihood of implementing this option.
		Surface Waters	Aqueous streams are discharged to surface receiving streams.	Effective.	Implementable, but not favorable due to sensitivities of the Colorado River; low acceptance to downstream users.	Low to moderate capital cost, low O&M cost.	Not retained. Not favorable due to sensitivities associated with the receiving waters
		Injection	Treated groundwater or surface water is injected into onsite wells.	Effective. May help flush the groundwater and enhance groundwater movement. However, these techniques may not be effective if the contamination is contained in low-permeability, fine-grained layers, and depending on the array of the wells, there could be extensive surface disturbance.	Readily implementable at the site. Currently used in the IM. The wells may be subject to clogging due to the buildup of chemical precipitates or microbial biofouling.	Low to moderate capital cost, low to moderate O&M cost.	Potential application at this site.
		Deep Well Injection	Aqueous streams are injected into Class I wells. Recent guidance may further regulate this practice.	Effective.	Potentially implementable at the site, but more difficult than shallow reinjection. Regulatory acceptance may be lower, and there are not the same flushing benefits as with reinjection into the upper contaminated portions of the aquifer.	Moderate to high capital and O&M cost.	Not retained. More difficult and expensive and less favorable than shallow reinjection.
		Evaporation Ponds	Surface impoundments are used to contain treated or untreated wastewater or groundwater until it evaporates.	Effective disposal option for the climate conditions at the site.	Existing ponds at the Topock Compressor Station may have additional capacity but would require modifying regulatory and lease agreements to allow additional waste streams to use the existing ponds.	Moderate capital cost assuming use of existing ponds; high capital costs for construction of new ponds, low O&M cost.	Retained for possible water disposal option.
		Onsite Reuse	Treated water is used onsite.	Effective. May be appropriate for some portion of the treated water.	Readily implementable at the site/ currently limited potential uses.	Low capital cost, low O&M cost.	Retained for possible uses at the compressor station.
		Agricultural	Treated water is distributed for agricultural use.	Effective for disposing of treated water.	Readily implementable, but low demand in the area of the site, high TDS of the groundwater, and long distances reduce likelihood of implementing this option at this site.	Low capital cost, low O&M cost.	Not retained; limited agriculture surrounding the site.
Monitoring	Monitoring	Monitoring	Short-and/or long-term monitoring is implemented to record site conditions and contamination levels.	Effective for measuring the performance of the remedy, compliance with standards, and progress of the remedial action.	Readily implementable.	Low capital cost, low O&M cost.	Retained for use with other technologies to measure attainment of RAOs.

Notes:

🟦	Blue shading indicates the process option is selected as the representative process option for developing alternatives in Section 5.0.
▨	Grey shading indicates the process option is not retained for further consideration.

TABLE 4-3
Representative Process Options for Groundwater Remediation
Final Groundwater Corrective Measures Study/Feasibility Study Report for SWMU 1/AOC 1 and AOC 10
PG&E Topock Compressor Station, Needles, California

General Response Action	**Remedial Technology**	**Representative Process Option**
No Action	None	None
Institutional Controls	Access and Use Restrictions	Land Use Covenants/ Deed Restrictions
Containment	Hydraulic Barriers	Extraction/Injection Wells
Removal	Groundwater Collection	Conventional Extraction Wells
	Enhanced Extraction through Injection	Injection of Clean or Contaminated Water
In-situ Treatment	Biological Treatment	*In-situ* Biochemical Reduction
	Monitored Natural Attenuation	Monitored Natural Attenuation
Ex-situ Treatment	Physical/Chemical Treatment	Chemical Reduction
Disposal	Treated Groundwater Discharge	Injection
Monitoring	Monitoring	Monitoring

5.0 Development and Analysis of Remedial Action Alternatives

5.1 Approach

Remedial action alternatives for the Alluvial Aquifer and bedrock in the East Ravine are identified and evaluated in this section. The remedial action alternatives are assembled from the technologies and process options identified in Section 4.0 and are evaluated in accordance with the requirements of both RCRA Corrective Action and CERCLA and to the level of specificity required for a CMS/FS analysis. For this CMS/FS, a focused number of alternatives are assembled by considering certain factors and criteria, as described in Section 5.2. Following description of the remedial alternatives in Section 5.3, the alternatives are evaluated individually against the evaluation criteria (Section 5.4) and then in comparison with each other (Section 5.5).

5.2 Assembly of Alternatives

In this section, remedial alternatives are assembled to address Cr(VI) in alluvial groundwater and in bedrock groundwater in the East Ravine. The alternatives are formulated by considering the site-specific conditions at the Topock site as described in Section 2.0, the RAOs discussed in Section 3.0, and the remedial process options selected in Section 4.0.

There are many possible combinations of technologies and process options that could be used to formulate alternatives. It is not practical to assemble every possible combination, nor is it necessary for the purposes of the alternative development and evaluation because many of the possible combinations are similar in performance and cost. Furthermore, selection of some options necessitates selection of other options (e.g., extraction of groundwater requires that a water disposal option also be selected). The intent of the alternative assembly process is to create a set of alternatives that represents a range of performance and cost options so that the alternatives can be comparatively evaluated against each other to determine a preferred alternative while meeting the requirements of RCRA and the National Contingency Plan (NCP). Once a preferred alternative is selected, changes to the specific process options within a given technology type can be made during remedial design and can be subsequently implemented without compromising the remedy selection process in the CMS/FS.

To assemble an appropriate range of alternatives, several factors are considered, including the factors identified in 40 CFR Section 300.430(a)(1)(iii). The NCP (40 Code of Federal Regulations [CFR] Section 300.430(e)) requires that, at a minimum, the following alternatives be considered:

- A no-action alternative.

- Source control alternatives that, as their principal element, employ treatment to reduce toxicity, mobility, and/or volume of contaminants. At least one of these alternatives should, to the degree possible, reduce the need for long-term management at the site.
- Source control alternatives that treat the principal risk posed by site contaminants but that vary the degree of treatment employed and the quantities and characteristics of the treatment residuals and untreated waste that must be managed.
- At least one source control alternative that provides containment of contaminants through engineering or institutional controls, with little or no treatment, but protects human health and the environment by preventing potential exposure or by reducing the mobility of contaminants.
- Alternatives that attain site-specific remediation levels within different restoration time periods using one or more technologies.
- Alternatives that include innovative treatment technologies if those technologies offer the potential for comparable or superior performance or implementability, fewer or less adverse impacts than other available approaches, or lower costs for levels of performance similar to that of demonstrated treatment technologies.

To meet the RAOs identified in Section 3.0, PG&E has established the following specific considerations for the development of alternatives. These considerations are consistent with RCRA and the NCP requirements listed above and help to further focus the assembly of alternatives. These considerations are to:

- Protect the Colorado River through geochemical barriers or hydraulic gradients to prevent Cr(VI) from entering the river.
- Target Alluvial Aquifer cleanup (estimated as the time at which 98 percent mass reduction occurs in the groundwater model simulations) in 40 years or less for those remedies that use active remediation.
- Provide sustainable treatment alternatives that minimize energy use and minimize the amount of residual treatment byproducts that require handling and offsite disposal.
- Develop alternatives that maximize the environmental benefit and ecological and human use associated with implementation, such as minimizing disturbance to sensitive cultural and biological resources by citing most remedial facilities in previously disturbed areas.

Technology types and the representative process options that passed the screening in Section 4.0 are discussed in the subsections below. The discussion is grouped by the general response action and includes both the site-specific considerations and rationale for incorporating the technologies and associated representative process options into the alternatives presented in Section 5.3.

5.2.1 No Action

As required by the NCP, a no action alternative will be formulated. No active construction or operational activities would occur. There would be no active treatment to reduce chromium concentrations in groundwater. While natural attenuation would occur within the fluvial sediments near the Colorado River, there would be no institutional control to restrict use of groundwater in locations where concentrations exceed the cleanup goals. No additional groundwater monitoring facilities would be constructed under this alternative, nor would any ongoing sampling or well maintenance activities be conducted to determine concentrations of contaminants in groundwater or in the Colorado River.

5.2.2 Institutional Controls

Institutional controls are legal and administrative tools used to maintain protection of human health and the environment. Land use covenants or deed restrictions to prevent groundwater use within the plume until cleanup goals are attained are the most appropriate institutional control for the Topock site. Such an institutional control would be effective for managing risk by restricting direct human contact with groundwater. However, a restriction on groundwater use alone would not meet long-term cleanup goals. Therefore, an institutional control is considered to be a single component of assembled remedial alternatives for risk management and should be combined with other technologies that are focused on reducing chromium concentrations within the plume.

Administration of an institutional control restricting groundwater use would have to be coordinated with the various landowners/managers that overlie the plume, identified on Figure 2-2: PG&E, BOR (managed by BLM), Caltrans (leased from federal owners), Burlington Northern Santa Fe Railroad, the USFWS (manager of the HNWR), and the Fort Mojave Indian Tribe (with easement and access to PG&E).

5.2.3 Removal

Removal of contaminated groundwater is an essential common component of an alternative involving *ex-situ* treatment. Removal of groundwater is also effectively used in combination with other remedial technologies that require controlling groundwater movement to enhance effectiveness of *in-situ* treatment or containment technologies. Extraction systems have generally demonstrated positive control of plumes at many sites and thus serve well as plume management tools but have historically failed to achieve widespread remediation of plumes due to the difficulty associated with achieving efficient mass removal during the latter stages of cleanup due primarily to rate-limited back diffusion of contaminants from low-permeable material (USEPA, 1997b; Palmer and Wittbrodt, 1991). The representative process option identified in Section 4.0 for removal of groundwater beneath the Topock site is conventional extraction wells in which pumps are used to draw groundwater into the wells and bring it to the surface. As noted in Tables 4-1 and 4-2 in Section 4.0, injection of water can be used to complement the groundwater extraction. Extraction and injection wells have been used successfully at the Topock site as part of the IM and *in-situ* pilot studies. Construction (drilling and completion) of extraction and injection wells is relatively straightforward in most instances and typically involves common construction equipment and material. Figure 5-1 shows a typical pump-and-treat system.

The main considerations for the number and locations of wells at the site pertain to site hydrogeology, plume location and depth, time to cleanup, and access considerations. Further considerations include appropriate mitigation measures to protect wildlife habitat and cultural resources, identified by the HNWR Manager and federal consultation related to cultural and historic properties. Extraction and injection wells included as part of the assembled alternatives would control groundwater gradients to prevent spreading of the plume and to optimize removal of contaminants in groundwater. In general, target extraction rates can be attained with a higher number of wells at lower individual pumping rates or a lower number of wells at higher individual pumping rates, although site conditions limit how much water a single well can yield. Pumping rates can be adjusted up or down, depending on project goals and capacity of the facilities to manage the extracted groundwater. As cleanup progresses, wells at different locations may be needed to optimize cleanup and/or replace wells that may become ineffective due to fouling or poor recovery of contaminants.

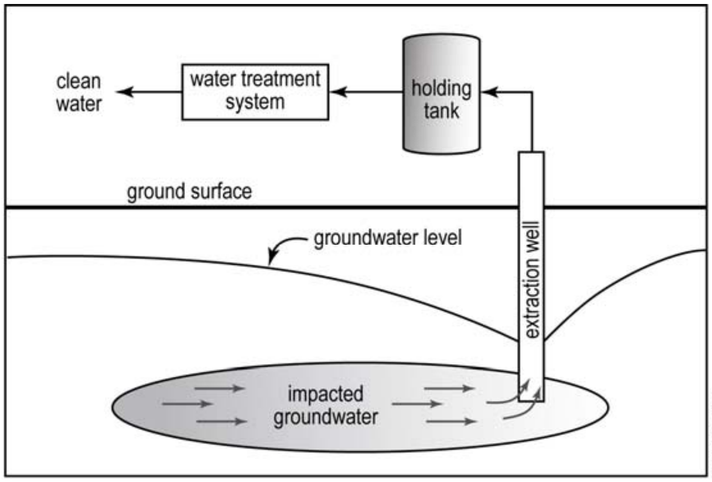

FIGURE 5-1
Typical Extraction and *Ex-situ* Treatment System
Source: USEPA, 2001a

In addition to the siting issues associated with groundwater capture efficiency, wells also must be located in areas that are accessible for construction, operation and maintenance, and management of extracted groundwater. Because much of the plume is outside of PG&E property, permission from the respective landowners for locating the wells and associated facilities is needed. Construction of wells and associated facilities, such as pipelines at the site, must also consider areas of the site that are of cultural or religious significance so that construction or other disturbance is minimized to the extent feasible. Other location constraints include sensitive habitats, historical sites, and topographic constraints, as discussed in Section 2.0. Major transportation and pipeline corridors cross the site and construction and operation of remedial facilities would be designed to not interrupt those existing operations.

Typically, extracted groundwater is transferred by pipeline, either aboveground or belowground. Aboveground piping does not require trenching and may be more appropriate in some applications such as short-term piping needs. Belowground piping provides more protection from the elements and from physical damage but is more expensive and is more disruptive to the environment to construct. Extraction wells can be piped individually or can be joined into a common manifold pipe. Pipelines containing untreated groundwater have to be designed and operated to prevent spills and leaks (e.g., appropriate containment, leak detection, security). Construction of pipelines involves the use of common construction equipment and materials and requires excavation of pipe trenches if the piping is located belowground. The number, size, and location of wells installed will affect the extent of piping and disturbances at the surface.

5.2.4 Disposal

Following removal of contaminated groundwater for *ex-situ* treatment, the groundwater must be managed and disposed of either onsite or offsite. Injection and land application are the representative process options selected in Section 4.0 for disposal of groundwater. The option of using onsite injection wells is incorporated into the alternatives for the Topock site. There are several advantages to injection wells over land application. Properly placed injection wells can enhance cleanup efficiency by creating larger hydraulic gradients that control groundwater flow and can help push the contaminants toward the extraction wells. Land application requires large areas of relatively flat ground and typically results in large losses of water to evaporation, which can increase the salt content of the aquifer below the land treatment area. With injection wells, there is no evaporative loss so there is no increase in salinity, and a larger proportion of the extracted groundwater is returned to the groundwater basin. Injection wells are also an essential component of remedial alternatives (in combination with extraction systems) that are predicated on the distribution of substrates throughout the aquifer to support *in-situ* treatment or to create hydraulic gradients that enhance the movement of contaminated groundwater toward and through *in-situ* remediation zones. Proper monitoring and careful design of the well locations are necessary to avoid the potential spread of contamination through uncontrolled movement of contaminated groundwater. Injection wells have been used successfully at the Topock site as part of the IM and the upland and floodplain *in-situ* pilot studies. Construction (drilling and completion) of injection wells is relatively straightforward in most instances and typically involves common construction equipment and materials. Two injection wells have been operating at the site as part of IM No. 3 since mid-2004. As is typical of injection wells, regular backwashing and periodic rehabilitation have been required to maintain the performance of these wells, but no unusual maintenance or operational challenges have been encountered.

The main considerations for the number and locations of injection wells at the site pertain to site hydrogeology, access considerations (for installation, monitoring, and maintenance), water chemistry, and purpose of the injection. Further considerations include appropriate mitigation measures to protect wildlife habitat and cultural resources, identified by the HNWR Manager and federal consultation related to cultural and historical properties. Injection wells included as part of the assembled alternatives would be located to facilitate the attainment of the remedial action objectives. Injection wells located at the outer and upgradient edges of the plume would serve to direct and accelerate plume migration toward cleanup facilities (e.g., *in-situ* reactive zone [IRZ] or extraction wells). Injection wells installed for establishing IRZs using groundwater recirculating strategies would be located to efficiently distribute reagent material. Number, size, and locations of injection wells are also affected by design flow rates and aquifer characteristics and capacity. As cleanup progresses, injection wells at different locations may be needed to optimize cleanup and/or replace wells that may become ineffective due to fouling or other means.

In addition to the siting issues associated with cleanup efficiency, injection wells also must be located in areas that are accessible for construction and operation and maintenance. Because much of the plume is outside of PG&E property, permission from the respective landowners for locating the injection wells is needed. Construction of injection wells and associated facilities such as pipelines at the site must also consider areas of the site that are of cultural or religious significance so that construction or other disturbance is minimized to the extent feasible. Other location constraints include sensitive habitats, historical sites, and topographic constraints, as discussed in Section 2.0. Major transportation and pipeline corridors cross the site and construction and operation of remedial facilities would be designed to not interrupt those existing operations.

Typically, groundwater is transferred to injection wells by pipeline, either aboveground or belowground. Pipelines containing untreated groundwater have to be designed and operated to prevent spills and leaks (e.g., appropriate containment, leak detection, security). Construction of pipelines involves common construction equipment and materials and requires excavation of pipe trenches for belowground piping. The number, size, and location of wells installed will affect the extent of piping and disturbances at the surface.

5.2.5 Monitored Natural Attenuation

Natural attenuation (also known as intrinsic remediation) relies on natural processes to reduce chemical concentrations. At the Topock site, attenuation occurs naturally in the fluvial sediments near the Colorado River, where reducing materials in the aquifer chemically and biochemically convert Cr(VI) to low solubility Cr(III) that precipitates out of solution and binds to the aquifer formation. Reducing conditions have been documented in shallow to mid-depth fluvial wells and sediments near and underlying the river. South of the railroad tracks, these reducing conditions are also encountered in deep wells near and beneath the river. The observed natural reducing conditions are characterized by the presence of organic carbon, dissolved iron, dissolved manganese, and ammonia in groundwater samples.

Under non-pumping conditions, as Cr(VI) migrates in groundwater from non-reducing conditions in the alluvial and deep fluvial sediments to reducing conditions near and beneath the river, it undergoes chemical reduction and reverts to Cr(III), which is immobilized in the sediments, as evidenced by its absence in groundwater samples collected from fluvial wells screened in reducing material. Stable isotope data from floodplain monitoring wells indicate that the decrease in Cr(VI) concentration does not occur by dilution, and laboratory testing of fluvial anaerobic core samples provides direct evidence of the reduction reaction. The general absence of Cr(VI) in reducing groundwater and the results of laboratory testing in fluvial core samples, indicate that there is significant capacity in the fluvial deposits underlying the river to reduce and remove Cr(VI) from groundwater (CH2M HILL, 2008e, 2009h). This process is a beneficial factor limiting Cr(VI) migration to the river under current conditions.

Chemical reduction of Cr(VI) to Cr(III) is effectively permanent and irreversible under site conditions. The only naturally-occurring oxidant that can accomplish the conversion of Cr(VI) to Cr(III) is solid manganese dioxide, MnO_2 (Fendorf, 1995). If this solid is present, the Cr^{3+} ion can adsorb to the MnO_2 surface, where a redox reaction can occur, with chromium oxidized and manganese reduced. However, under the reducing conditions present in the fluvial materials, MnO_2 is not stable, and manganese tends to exist as the dissolved cation $Mn^{2+,}$ as shown by the detectable manganese concentrations in these wells (CH2M HILL, 2009a).

While natural attenuation is recognized as a viable remediation approach, it is often accompanied by active treatment methods. Natural attenuation applied alone must be supported by sufficient evidence of its effectiveness, must be accommodated by a robust monitoring program, and would require a long time to achieve cleanup goals at the Topock site, where uncertainties remain regarding the extent to which reducing conditions in fluvial deposits provide a pervasive and permanent barrier to Cr(VI) contaminant migration to the river. Further, due to the relatively flat natural hydraulic gradients at the site, it is estimated that it would likely take more than 1,000 years to clean up groundwater by allowing natural groundwater flow to move the Cr(VI) plume through the reducing zone in the floodplain. The existing floodplain and river monitoring programs may be enhanced to ensure adequate monitoring of the effectiveness of natural attenuation. As it is recognized that natural attenuation occurs at the Topock site, natural attenuation may be considered a feature of the site that augments those active remedial alternatives that allow chromium in groundwater to contact the fluvial materials.

Conversely, active remedial alternatives that rely on groundwater flushing or extraction may alter these beneficial natural reducing conditions, as groundwater flushing/extraction causes an influx of toxic water and thus more oxidizing conditions can develop in the shallow floodplain aquifer. The reduction capacity and extent of the reducing zone are not precisely known, but the combinations of available core testing and groundwater data provide an approximate horizontal and vertical distribution of a predominantly reducing portion of the fluvial material, as described in the RFI/RI Volume 2 Report (CH2M HILL, 2009a). The flow regime of the Colorado River changed greatly following the closure of Hoover and Davis dams. Spring flooding that previously deposited organic detritus in the floodplain sediments no longer occurs. It is not clear how the change in flow regime will affect the reducing conditions in the floodplain in the coming decades and centuries, and it is not possible to accurately quantify the capacity of the fluvial sediments to retain their capability to reduce Cr(VI) contamination with sustained IM pumping or during pumping at potentially greater extraction rates. If the fluvial materials are flushed with enough oxic river water, it could result in a loss of their reductive capacity.

Regular monitoring of floodplain geochemistry has occurred since IM pumping began in 2004. To date, data collected do not strongly indicate that the reductive capacity of the fluvial materials has been compromised. However, the relatively short period of IM pumping (approximately 5 years) at relatively modest flow rates does not provide a sufficient dataset to make conclusions about the potential effects of much longer-term or higher-volume pumping that may be associated with a remedial action. As presented in the 2006 through 2009 combined Fourth Quarter and Annual Performance Evaluation Reports (CH2M HILL, 2006b, 2007c, 2008f, and 2009g), there are multiple lines of evidence that IM pumping has induced strong landward and downward hydraulic gradients from shallow floodplain wells and the river towards the IM pumping wells and that previously oxic river water has been drawn in towards pumping wells.

These lines of evidence (as documented in the reports) include:

- Changing deuterium isotope concentrations.
- Increasing oxidation reduction potential data for MW-33-40 and MW-33-90.
- Decreasing TDS concentrations in floodplain wells.

If pumping were to eventually reduce the reductive capacity of the fluvial materials, the loss of the reductive capacity could be partially mitigated by the injection of soluble carbon substrates to provide short-term replenishment or enhancement of the reducing capacity.

5.2.6 *In-situ* Treatment

In-situ treatment involves treating the contaminated groundwater belowground in the aquifer and can be accomplished by: (1) establishing discrete IRZs through which contaminated groundwater flows, (2) establishing reducing conditions across large portions of the Cr(VI) plume, or (3) a combination of the two. The main considerations for active *in-situ* treatment at the site are the type of reagent (which affects treatment residuals, contaminant half lives), the hydrogeology affecting distribution of reagent to all appropriate (contaminated) areas of the aquifer, and the methodology to deliver the reagent to the contaminated groundwater or move the contaminated groundwater toward an *in-situ* treatment zone. The reagent can be delivered through injection, extraction and reinjection, or recirculation wells and can include chemical reactive compounds or biological substrates that create or enhance an environment that favors the desired chemical alteration of the contaminant. For the purpose of assembling and evaluating groundwater alternatives at the Topock site, the representative process option for *in-situ* chemical treatment is termed biochemical reduction. In the context of this report, biochemical reduction refers to the reduction of Cr(VI) to Cr(III) using an organic substrate that promotes microbial growth which, in turn, creates an environment where the chromium is reduced and precipitated.

Two key factors are expected to limit the re-conversion of Cr(III) to Cr(VI) after *in-situ* reduction: the limited solubility of Cr(III) and the lack of availability and reactivity of an adequate oxidizer (MnO_2). Together, these factors are expected to limit any reoxidized Cr(VI) concentrations to levels similar to ambient background. Specifically, reduction of Cr(VI) to Cr(III) results in the formation of Cr(III) oxides that have a low solubility under the neutral and alkaline pH encountered in site groundwater. Appendix G presents the case that *in-situ* treatment of the aquifer will create reducing conditions where MnO_2 is not stable and Mn^{2+} will be present along with reduced levels of MnO_2. The appendix also presents data demonstrating the formation of more stable Cr(III) precipitates as a result of the IRZ and discusses the occlusion and passivation of MnO_2 surfaces as a result of the precipitation of a variety of non-reactive minerals formed in the IRZ. Thus, it is possible that MnO_2 capable of re-oxidizing Cr(III) could still be present in the same area of the aquifer where Cr(VI) has been reductively precipitated. While over the long term it cannot be said that the Cr(VI) reduction reaction is completely irreversible, the evidence presented in Appendix G, Section G.7, indicates that re-oxidation of Cr(III) to Cr(VI) is expected to be minimal and not lead to concentrations that exceed background. Two general methods for *in-situ* treatment would involve: (1) building a reactive barrier, with treatment occurring when groundwater moved through the barrier, or (2) building a reagent delivery system to distribute reagent throughout the plume. Both of these options could work at the site.

Constructing a reactive barrier could be accomplished by excavating a trench and backfilling the trench with reactive materials to create a subsurface wall that allows groundwater to pass through while prohibiting the movement of constituents. Other options include fracturing or the use of boreholes to inject reactive materials (such as zero valent iron) that the groundwater will pass through. Another option for creating a reactive barrier is to establish an IRZ using a line of wells that circulates reactive materials between each well. In any case, the barrier is installed across the flow path of the constituent plume, thereby allowing groundwater to move through the barrier below grade to reduce Cr(VI) to low solubility and less toxic Cr(III). The reactive barrier must be constructed down to an impermeable layer, such as bedrock, to prevent contaminated groundwater from passing beneath the barrier. A cross section of a typical IRZ barrier is shown in Figure 5-2.

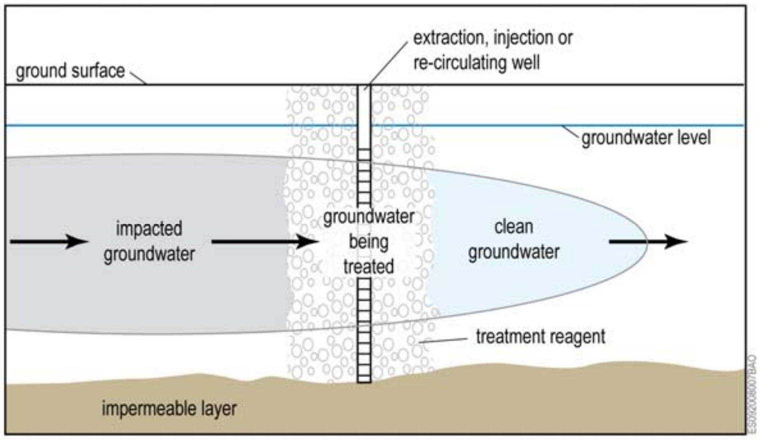

FIGURE 5-2
Typical Cross Section of an IRZ Barrier
Source: USEPA, 2001b

At the Topock site, the depth to bedrock at many places throughout the plume limits the constructability of a reactive barrier by trenching. The areas of the site with the shallowest bedrock are located in the southern floodplain. Bedrock in the northern portion of the floodplain dips sharply such that the distance from the ground surface increases from a surface outcrop to the south to more than 200 feet bgs. Depths of more than 100 feet bgs exceed the limits of most conventional barrier construction methods. Techniques for construction of a reactive barrier greater than 100 feet deep would disturb extensive surface area within the sensitive habitat of the floodplain. For these reasons, the IRZ is considered the most appropriate construction method for reactive barriers and is included in the assembled *in-situ* treatment alternatives.

Generally, reactive treatment zones are created by installing the media delivery wells in a line perpendicular to groundwater flow to allow spatial coverage of the plume. These may consist of wells for the injection or placement of reactive media into the aquifer or may consist of wells designed to both deliver the media and mix the groundwater by circulation. Circulation can be designed as vertical circulation or horizontal circulation. Well spacing, pumping circulation rates, and screen intervals can be designed based on aquifer properties to maximize coverage between circulation wells in a treatment line. Typical reactive treatment zone wells are shown in Figure 5-3.

The main considerations for the number and locations of *in-situ* treatment at the site pertain to site hydrogeology, plume location and depth, desired time to cleanup, and access considerations. Further considerations include appropriate mitigation measures to protect wildlife habitat and cultural resources, identified by the HNWR Manager and federal consultation related to cultural and historic properties. Greater numbers of wells and IRZ lines would distribute the substrate more quickly than fewer wells and IRZ lines. Combining IRZ lines with extraction and injection technologies would allow manipulation of groundwater flow to enhance distribution of reactant material.

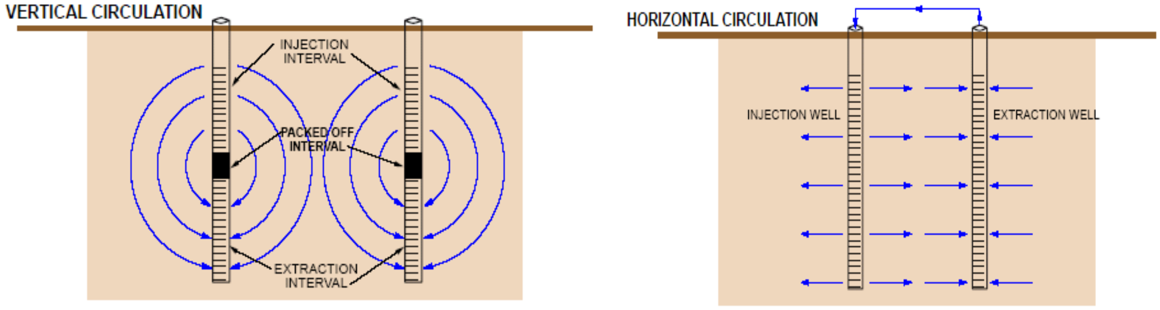

FIGURE 5-3
Typical Reactive Treatment Zone Well Configuration

Considerations for siting a reactive treatment zone include ensuring that facilities are located in areas that are accessible for construction, operation and maintenance, and management of the substrate storage and injection equipment. Utility lines (e.g., power) need to be constructed to operate the circulating and reagent delivery systems. Because much of the plume is outside the PG&E property, permission from the respective landowners for locating the *in-situ* treatment equipment would be required. Siting of the *in-situ* facilities must consider areas of the site that are of cultural or religious significance. Other location constraints include sensitive habitats, historical sites, and topographic constraints. Major transportation and pipeline corridors cross the site and construction and operation of remedial facilities would be designed to not interrupt those existing operations.

The type of reagent or substrate could affect the amount of infrastructure necessary for delivery (e.g., closer well spacing for reagents/substrates that move slower and have shorter half lives, or wider well spacing for reagents/substrates that move more quickly and have longer half lives). Delivery systems can be designed to allow for more frequent operation and maintenance (e.g., smaller storage tanks) or less frequent operation and maintenance (e.g., larger storage tanks).

There is potential for transient byproducts such as arsenic and manganese to exceed baseline and background concentrations during implementation of *in-situ* methods. Under ideal geochemical and hydrologic conditions described in Appendix G, arsenic and manganese byproducts should not be a significant issue. However, because of uncertainty in the complexity of aquifer lithology and geochemistry, large-scale implementation of *in-situ* treatment could result in elevated concentrations of arsenic and manganese that persist for longer than expected periods of time in some portions of the aquifer. Careful monitoring during the initial phase(s) of *in-situ* operation will enable early detection of these conditions. Specific contingencies will be in place to address any potential threat to the Colorado River or the aquifer.

Appendix G provides more detailed information on performance data from pilot studies conducted at the Topock site and other sites with chromium impacted groundwater, including *in-situ* byproducts. Different reactant materials may be applied to different areas of the site (e.g., floodplain vs. upland) to reflect different natural geochemical conditions.

There is a wide spectrum of organic carbon substrates available for anaerobic IRZ applications, including fermentable soluble substrates such as molasses, lactate, and whey; alcohols such as ethanol and methanol; semi-soluble substrates such as emulsified vegetable oil; and solids such as chitin and bark mulch. The selection of the appropriate substrate for a site depends on the balance between the mode of delivery and the substrate properties, and the rate of carbon utilization and the ability to overcome the ambient electron acceptor recharge (to establish a sufficiently reducing environment). More details on the various donor types as they relate to IRZ activities at Topock are discussed in Appendix G.

5.2.7 *Ex-situ* Treatment

Ex-situ treatment involves treating the contaminated groundwater in a system constructed aboveground. *Ex-situ* treatment must be combined with removal and disposal to transport the contaminated groundwater to the treatment system and manage the treated groundwater.

The main considerations when assembling *ex-situ* remedial alternatives for the Topock site include type of treatment, location of treatment, and capacity of treatment. *Ex-situ* treatment of groundwater has been effectively used at the Topock site as part of the IM. The IM treatment system involves chemical reduction by ferrous iron compounds followed by alkaline precipitation and filtration to remove chromium from the groundwater. While there are other technologies that may be used for *ex-situ* treatment, such as anaerobic bioremediation, ion exchange, electrochemical reduction followed by alkaline precipitation, or acidic reduction, the type of treatment used at the existing IM treatment plant is the representative treatment option included in the assembled alternatives. The other *ex-situ* treatment options would be considered during remedial design or during the future operation if another option is found to offer better treatment performance or implementability, fewer adverse impacts, or lower costs for similar levels of performance.

Ideally, *ex-situ* treatment facilities should be located close to the extraction and injection facilities to minimize the amount of pipelines and pump stations necessary to transport groundwater to and from the treatment system. The location should also be close to the power source, have available space for construction, and be in an accessible location for construction and operation. The location of treatment facilities must also consider areas of the site that are of cultural or religious significance so that construction or other disturbance is minimized to the extent feasible. Other location constraints include sensitive habitats, historical sites, topographic constraints, and existing infrastructure as discussed in Section 2.0. Possible locations for an *ex-situ* treatment plant are on the Topock Compressor Station property and at the current IM No. 3 treatment plant location.

The design flow rate is a critical variable in determining the size and layout of the *ex-situ* treatment facility. Larger design flows would require more treatment system capacity, and smaller design flows would require lower capacity. Flexibility of the treatment system over time will be necessary to accommodate changes in treatment flow and changes in the chromium concentrations in extracted groundwater.

Construction of the treatment system typically would involve construction of a building and storage tanks. The treatment plant and other aboveground equipment must be present for the entire duration of the active cleanup, with the associated space requirements and visual impact. The locations and number of wells installed will affect the extent of piping and disturbances at the surface.

An *ex-situ* treatment plant would require large amounts of energy and/or chemical inputs and would likely generate residuals such as sludge and cleaning waste that must be managed, typically through an offsite permitted facility. The *ex-situ* treatment plant would require continuous operation and maintenance.

5.2.8 Monitoring

Either short- or long-term monitoring is implemented to evaluate site conditions and contaminant levels. Monitoring alone will not reduce chromium concentrations; therefore, monitoring is combined with other technologies to form alternatives that are focused on reducing chromium concentrations within the plume. With the exception of the no action alternative, monitoring is a component of all of the assembled alternatives for measuring the performance of the remedy, compliance with standards, and progress of the remedial action. The monitoring incorporated into the alternatives includes the collection, management, and reporting of groundwater quality, surface water quality, and remedial system operational data.

Monitoring wells need to be located in areas that provide relevant data on groundwater hydraulics and chemistry. In addition, the monitoring wells need to be located in areas that are accessible. Additionally, and the same considerations previously described for extraction and injection wells regarding property ownership, the existence of major transportation and pipeline corridors, and sensitive areas of the site also apply to the monitoring wells. As remediation progresses and the plume changes in size and shape, monitoring wells may need to be abandoned or additional monitoring wells may need to be installed to provide adequate data for control and optimization of the remedial alternative.

5.2.9 Summary of Alternative Assembly

The technologies and process options have been assembled into the following alternatives for further evaluation in accordance with the considerations previously described:

- Alternative A – No Action
- Alternative B – Monitored Natural Attenuation (MNA)
- Alternative C – High-volume *In-situ* Treatment
- Alternative D – Sequential *In-situ* Treatment
- Alternative E – *In-situ* Treatment with Fresh Water Flushing
- Alternative F – Pump and Treat
- Alternative G – Combined Floodplain *In-situ*/Pump and Treat
- Alternative H – Combined Upland *In-situ*/Pump and Treat
- Alternative I – Continued Operation of Interim Measure

The assembly of remedial action alternatives from the various technologies and process options is shown in Table 5-1. Each of the general response actions, remedial technologies, and representative process options retained in Table 4-3 are listed in the left-hand columns, and the alternatives are listed across the top of Table 5-1. A check mark is placed under an alternative in the rows corresponding to the options that are included in that alternative. For example, use restrictions, groundwater collection, *in-situ* biochemical/chemical reduction, injection, and monitoring are all included for Alternative C – High-volume *In-situ* Treatment. As previously discussed, biochemical/chemical reduction is included in the alternative for the purpose of the CMS/FS, but other *in-situ* treatment options, such as anaerobic bioremediation, could be considered during remedial design. Similarly, injection is chosen as the disposal option because of the advantages stated previously in improving the extraction efficiency.

TABLE 5-1
Assembly of Alternatives
Final Groundwater Corrective Measures Study/Feasibility Study for SWMU 1/AOC 1 and AOC 10, PG&E Topock Compressor Station, Needles, California

General Response Action	**Remedial Technology**	**Representative Process Option**	**Alternative**[a]								
			A	**B**	**C**	**D**	**E**	**F**	**G**	**H**	**I**
No Action	None	None	**X**								
Institutional Controls	Access and Use Restrictions	Land Use Covenants/ Deed Restrictions		**X**	**X**	**X**	**X**	**X**	**X**	**X**	**X**
Containment	Hydraulic Barriers	Extraction/Injection Wells			**X**	**X**	**X**	**X**	**X**	**X**	**X**
Removal	Groundwater Collection	Extraction Wells			**X**	**X**	**X**	**X**	**X**	**X**	**X**
	Enhanced Extraction through Injection	Injection of Clean or Contaminated Water			**X**	**X**	**X**	**X**	**X**	**X**	**X**
In-situ Treatment	Biological Treatment	*In-situ* Biochemical Reduction			**X**	**X**	**X**		**X**	**X**	
	Monitored Natural Attenuation	Monitored Natural Attenuation [b]		**X**							
Ex-situ Treatment	Physical/Chemical Treatment	Chemical Reduction						**X**	**X**	**X**	**X**
Disposal	Treated Groundwater Discharge	Injection			**X**	**X**	**X**	**X**	**X**	**X**	**X**
Monitoring	Monitoring	Monitoring		**X**	**X**	**X**	**X**	**X**	**X**	**X**	**X**

Notes:

a) Alternative A – No Action
Alternative B – Monitored Natural Attenuation
Alternative C – High-volume *In-situ* Treatment
Alternative D – Sequential *In-situ* Treatment
Alternative E – *In-situ* Treatment with Fresh Water Flushing
Alternative F – Pump and Treat
Alternative G - Combined Floodplain *In-situ*/Pump and Treat
Alternative H - Combined Upland *In-situ*/Pump and Treat
Alternative I - Continued Operation of Interim Measure

b) Natural attenuation is a component of all remedial alternatives due to presence of reducing material in the shallow and mid-depth fluvial deposits along the Colorado River floodplain.

Because the site-specific considerations described in this section were used to focus the assembly of alternatives, all of the alternatives are considered viable for the site. An initial screening based on the criteria of effectiveness, implementability, and cost is not performed since all alternatives would pass the screening and would proceed to the detailed analysis. However, all three of these factors are considered in the detailed evaluation of alternatives presented in Sections 5.4 and 5.5.

5.3 Remedial Action Alternative Descriptions

The nine remedial action alternatives for the Alluvial Aquifer and bedrock groundwater in the East Ravine are described in the following subsections. The remedial alternatives were designed to a conceptual level of detail, sufficient to perform a comparative analysis on the alternatives and to develop the remedial cost estimates consistent with USEPA guidance for developing cost estimates for feasibility studies (USEPA, 2000). Appendix D provides the cost estimates, including alternative components, assumptions, and cost estimating factors.

In addition, a general description of potential technologies to address chromium in the bedrock of the East Ravine is provided herein. The bedrock remedy will be developed further during design.

The Topock groundwater model, originally documented in the *Groundwater Model Update Report, Topock Compressor Station, Needles California,* (CH2M HILL, 2005c), was used for conceptual design of the alternatives. Appendix E includes an evaluation demonstrating that this groundwater model is appropriate for conceptual design and analysis of alternatives to the level needed in the CMS/FS. The groundwater flow model was used in the development and analysis of alternatives to estimate well locations, flow rates, and time frames to achieve certain objectives (e.g., distribution of organic carbon substrate in a one pore volume flush, or movement of five pore volumes of water through aquifer materials). These objectives are assumed to be realistically achievable based on the conceptual hydrogeologic and contaminant model of the project site. Appendix F provides a more detailed description of how the model was used to develop the remedial alternatives and to estimate the time to reach objectives. Appendix F also includes simulated flowline maps for the active remedial alternatives. Supporting information for *in-situ* treatment design elements is included in Appendix G.

A large degree of uncertainty is inherent in the predicted time frames to achieve these objectives because of the limitations of this groundwater flow model in simulating the complex processes that control contaminant behavior in groundwater at this site. Furthermore, the degree to which these predicted time frames represent actual time frames for contaminant concentrations to reduce to background levels throughout the aquifer is not known. If a substantial amount of contamination is present in low-permeability zones, or if heterogeneous conditions limit the ability to flush water through or inject organic substrate into portions of the aquifer, time frames to achieve background levels throughout the aquifer using the active treatment alternatives will be considerably longer than estimated and could range from many decades to in excess of 100 years.

The alternatives discussions in this section present estimated time frames to achieve the stated objectives. These time frames remain the subject of considerable uncertainty and should not be construed to represent consensus estimates of the actual cleanup times that may be required to reach RAOs.

With the exception of Alternative I (Continued Operation of the Interim Measure), the active remediation alternatives (Alternatives C through H) were all designed to treat the entire area of the Cr(VI) plume, as defined by the 32 µg/L contour line, and to provide protection of the river either through geochemical barriers or hydraulic gradients. To facilitate meaningful comparison of the relative footprint and effectiveness of the active alternatives, all were designed to achieve certain goals (e.g., distribution of organic carbon substrate in a one pore volume flush or movement of five pore volumes of water through aquifer materials) in a roughly similar period of time (~40 years or less). Alternative I (Continued Operation of the Interim Measure) has been incorporated into this CMS/FS Report per DTSC's request (DTSC, 2008c-d); the configuration of Alternative I has not been modified to adjust to the goals of the remedial action (Section 3.0) but instead focuses on the goals of the IM (hydraulic control of the plume only).

As stated above, the remedial action alternatives were designed to a conceptual level of detail, sufficient to develop the remedial cost estimates consistent with USEPA guidance for developing cost estimates for feasibility studies (USEPA, 2000). Numbers and locations of remedial facilities and described operational elements are largely assumptions at this point in the definition of the alternatives and are used as a means to compare alternatives against each other. It is fully expected that changes to the numbers, locations, methods, configuration, and other assumptions made in developing the remedial costs will change for the selected alternative as it moves through the design, construction, and operational phases. Changes to the conceptual design for the alternative ultimately selected will be made during design, construction, and implementation to optimize the remedy to enhance performance to attain the RAOs, provide for adjustments due to field conditions, and comply with location- and action-specific ARARs and landowner and leaseholder requirements. An identification of the types of changes to the remedial alternatives that may be made during design, construction, and/or implementation to reduce the time to attain RAOs or reduce the footprint (type, location, and amount of infrastructure or operational activities) is identified in Table 5-2. An identification of the types of changes to the remedial alternatives that may be made during implementation to address contingency scenarios is identified in Table 5-3.

PG&E acknowledges that there are sensitive resources in the vicinity of the remedial action alternatives. At this early stage of analysis, the conceptual design of the remedial alternatives considered sensitive resources by re-positioning some infrastructure into previously disturbed areas. Important parameters throughout the design and implementation phases of the selected remedy will include: (1) implementing a remedial action in a manner that is respectful of, and causes minimal disturbance to, cultural resources particularly, resources that are of special significance to tribes in the area; (2) implementing a remedial action in a manner that limits disturbance to wildlife and their habitats; and (3) implementing a remedial action in a manner that complies with sensitive resource protection ARARs.

TABLE 5-2
Approaches to Optimizing Remedial Alternatives for Time and Footprint
Final Groundwater Corrective Measures Study/Feasibility Study for SWMU 1/AOC 1 and AOC 10, PG&E Topock Compressor Station, Needles, California

	Factors Affected				**Approach**	
					Time Optimized	**Footprint Optimized**
Alternative	**Extraction Wells**	**Injection Wells**	**IRZ Arrays**	**Above-Ground Treatment Plant**	**Description**	**Description**
A – No Action					Not applicable – cannot change time to cleanup.	Not applicable – cannot change footprint.
B – MNA					Not applicable – cannot change time to cleanup.	Not applicable – cannot change footprint.
C – High-volume *In-situ* Treatment	X	X	X		**Phase 1: Floodplain cleanup:** Adding another line of *in-situ* wells could somewhat shorten the floodplain cleanup. **Phase 2: Upland treatment by *in situ*:** The only way to significantly shorten the time to cleanup would be to increase the number of injection/extraction well arrays, which would start to approximate Alternative D. Increasing flow in the existing wells would have only limited benefit because the wells are already designed to push carbon most of the way across the distance between the injection and extraction wells.	**Phase 1: Floodplain cleanup:** Fewer injection wells could be used in the floodplain at the cost of achieving only partial distribution of carbon substrate and having to wait for natural groundwater flow to move contaminated groundwater through treatment zone. Because of the slow movement of groundwater at the site, this could add substantially to the cleanup time. **Phase 2: Upland treatment by *in situ*:** Fewer wells would result in partial distribution of carbon substrate between injection and extraction wells. It would then be necessary to wait until natural groundwater flow moved the remaining contaminated water through a treatment zone around the injection wells.
D – Sequential *In-situ* Treatment	X	X	X		Simultaneous implementation of two or more treatment zones could shorten time to cleanup	Fewer wells would result in partial distribution of carbon substrate between injection and extraction wells. It would then be necessary to wait until natural groundwater flow moved the remaining contaminated water through a treatment zone around the injection wells.
E – *In-situ* Treatment with Fresh Water Flushing	X	X	X		Assuming that there was adequate freshwater available, cleanup time could be shortened by increasing the rate of clean water flushing by injection wells and/or extraction in the floodplain.	Alternative E was designed with minimal footprint as a key design concept, so further optimization of footprint is not likely to be substantial.
F – Pump and Treat	X	X		X	Time could be shortened by increasing the pumping/injection rate and/or adding additional extraction/ injection wells. The increased flow rate would require a larger treatment plant. At higher flow rates, new well locations would be required to control interference between wells and maintain adequate capture.	Reducing flow could reduce size of treatment plant and number of injection wells. A pump–and-treat system with approximately half the capacity of IM No. 3 (with extraction during low river cycles only) could provide a minimum level of hydraulic control of the plume and would represent the minimum footprint for a pump-and-treat system, but this would add substantially to the cleanup time.
G – Combined Floodplain *In-situ*/Pump and Treat	X	X	X	X	**Floodplain cleanup:** Adding another line of *in-situ* wells could somewhat shorten the floodplain cleanup. **Upland treatment by pump-and-treat:** Time could be shortened by increasing the pumping/injection rate and/or adding additional extraction/injection wells. The increased flow rate would require a larger treatment plant. At higher flow rates, new well locations would be required to control interference between wells and maintain adequate capture.	**Floodplain cleanup:** Fewer injection wells could be used in the floodplain at the cost of achieving a slower distribution of carbon substrate and having to wait for groundwater flow to move contaminated groundwater through treatment zone. Because of the slow landward movement of floodplain groundwater under the influence of the upland pump and treat system at the site, this could add substantially to the cleanup time. **Upland treatment by pump and treat**: Due to high flows, this alternative currently has two or three wells at each location. Reducing flow rates could reduce number of injection wells to one at each of the four locations, but this would add substantially to the cleanup time.
H – Combined Upland *In-situ*/ Pump and Treat	X	X	X	X	Time could be shortened by increasing the pumping/injection rate and/or adding additional extraction/ injection wells. The increased flow rate would require a larger treatment plant. At higher flow rates, new well locations would be required to control interference between wells and maintain adequate capture. Additional IRZ lines could also be installed to shorten cleanup time.	Reducing flow could reduce size of treatment plant and number of extraction/injection wells. One of the IRZ lines could be eliminated, but this would likely result in substantially longer cleanup time.

TABLE 5-2
Approaches to Optimizing Remedial Alternatives for Time and Footprint
Final Groundwater Corrective Measures Study/Feasibility Study for SWMU 1/AOC 1 and AOC 10, PG&E Topock Compressor Station, Needles, California

	Factors Affected				**Approach**	
					Time Optimized	**Footprint Optimized**
Alternative	**Extraction Wells**	**Injection Wells**	**IRZ Arrays**	**Above-Ground Treatment Plant**	**Description**	**Description**
I – Continued Operation of IM					Not applicable – cannot change time to cleanup (by alternative definition).	Not applicable – cannot change footprint (by alternative definition).
					Time-optimized alternatives may be constrained: • By the amount of water that can be extracted and re-injected from the aquifer within the areas that are accessible. There is a limit to how much water can be produced from one well. Higher flows will mean more wells. Wells that pump large volumes of water must be located far enough apart to avoid interference, which can reduce the total pumping rate. • By the inability to access some areas. • In pump-and-treat options, by the maximum flow throughput of the treatment plant. The locations currently being considered—the Topock Compressor Station and the IM No. 3 area—have finite space availability due to cultural resources, existing infrastructure, and existing topography. Although it is difficult to accurately estimate the maximum flow capacity that can be fit within the available spaces, there clearly is a limit to that capacity. It can be assumed that the larger the plant, the more visible impact and more footprint it will have. • By the finite time required for remediation system implementation. Implementation includes designing; permitting and clearing with stakeholders, land owners, leaseholders, and regulators; constructing, and starting up a system. • For *in-situ* treatment options, by the time required to develop reducing conditions in the subsurface. *In-situ* treatment requires several months of time for delivery of reductant and growth of microorganisms across a given area to develop an IRZ.	Footprint-optimized alternatives may be constrained: • In several alternatives, by the need to prevent the plume from escaping 'capture' established by extraction or injection wells. • By the physical infrastructure required. *Ex-situ* treatment requires treatment plants including tanks, control systems, pumps, pipes, etc. *In-situ* treatment requires tanks for reductants and a structure to house the control system. Smaller flows will require smaller infrastructure. • By the effectiveness of natural attenuation and the acceptable time to cleanup. Reducing the footprint to eliminate active cleanup in portions of the plume causes the alternative to rely more on natural gradients and natural attenuation capacities at the site for the attainment of RAOs.

TABLE 5-3
Example Contingency Actions During Remedial Alternative Implementation
Final Groundwater Corrective Measures Study/Feasibility Study for SWMU 1/AOC 1 and AOC 10, PG&E Topock Compressor Station, Needles, California

Remedial Alternative	RAO/Criterion	Example Failure Modes	Example Causes	Example Contingency Action
B - Monitored Natural Attenuation	RAO #1: Prevent ingestion of groundwater as a potable water source having Cr(VI) in excess of the regional background concentration of 32 µg/L Cr(VI)	Development of potable water supply in area of plume prior to attainment of MCLs/plume migration to existing domestic supply wells.	Increased pumping of local domestic supply wells/ modification of existing land uses that result in installation of domestic supply wells within plume area.	Modification and enforcement of land use covenants/ provision of an alternative water supply.
	RAO #2: Prevent or minimize migration of Cr(T) and Cr(VI) in groundwater to ensure concentrations in surface water do not exceed water quality standards that support the designated beneficial uses of the Colorado River (11 µg/L Cr(VI)).	Floodplain reducing zone allows passage of groundwater without sufficient natural reduction of Cr(VI).	Change in natural conditions over time.	Under a pure natural attenuation remedy, no contingency plan would be available. Therefore, if this event occurred, an alternative remedy would be implemented.
	RAO #3: Reduce the mass of Cr(T) and Cr(VI) in groundwater at the site to achieve compliance with ARARs in groundwater. This RAO will be achieved through cleanup goal of regional background of 32 µg/L of Cr(VI)).	Floodplain reducing zone allows passage of groundwater without sufficient natural reduction of Cr(VI).	Change in natural conditions over time or insufficient reductive zone at depth.	Under a pure natural attenuation remedy, no contingency plan would be available. Therefore, if this event occurred, an alternative remedy would be implemented.
	RAO #4: Ensure that the geographic location of the target remediation area does not permanently expand following completion of the remedial action.	Same as RAO #3.	Same as RAO #3.	Under a pure natural attenuation remedy, no contingency plan would be available. Therefore, if this event occurred, an alternative remedy would be implemented.
	Comply with ARARs during implementation of the remedial action.	Change in natural conditions results in site contaminants in Colorado River in exceedance of ARARs.	Change in natural conditions over time.	Under a pure natural attenuation remedy, no contingency plan would be available. Therefore, if this event occurred, an alternative remedy would be implemented.
C - High-volume *In-situ* Treatment	RAO #1: Prevent ingestion of groundwater as a potable water source having Cr(VI) in excess of the regional background concentration of 32 µg/L Cr(VI).	Development of potable water supply in area of plume prior to attainment of MCLs/plume migration to existing domestic supply wells.	Increased pumping of local domestic supply wells/ modification of existing land uses that result in installation of domestic supply wells within plume area.	Modification and enforcement of land use covenants/ provision of an alternative water supply/Modify current remedy.
	RAO #2: Prevent or minimize migration of Cr(T) and Cr(VI) in groundwater to ensure concentrations in surface water do not exceed water quality standards that support the designated beneficial uses of the Colorado River (11 µg/L Cr(VI)).	IRZ array in floodplain allows passage of groundwater without sufficient treatment. Extraction and injection strategies are not effectively controlling gradients. Floodplain reducing zone allows passage of groundwater without sufficient treatment.	Insufficient well spacing or ineffective amendment delivery. Unexpected hydrogeologic conditions. River water adds oxygen due to landward gradient/ change in natural conditions over time.	Add wells and/or modify amendment delivery rates or methods. Add wells or modify extraction/injection rates. Add IRZ wells and/or modify amendment delivery rates or methods.
	RAO #3: Reduce the mass of Cr(T) and Cr(VI) in groundwater at the site to achieve compliance with ARARs in groundwater. This RAO will be achieved through cleanup goal of regional background of 32 µg/L of Cr(VI).	Insufficient *in-situ* treatment.	Insufficient well spacing/insufficient dosing type, quantity, or method/insufficient flow rates.	Add wells/modify extraction and injection rates/modify amendment type, delivery rates, and/or methods.
	RAO #4: Ensure that the geographic location of the target remediation area does not permanently expand following completion of the remedial action.	Same as RAO #3.	Same as RAO #3.	Same as RAO #3.
	Comply with ARARs during implementation of the remedial action.	Treatment byproducts result in concentrations in Colorado River in exceedance of ARARs.	Unexpected geochemical conditions in floodplain, inefficient treatment.	Add wells/modify reductant type, dosage, and/or delivery method.
D - Sequential *In-situ* Treatment	RAO #1: Prevent ingestion of groundwater as a potable water source having Cr(VI) in excess of the regional background concentration of 32 µg/L Cr(VI).	Development of potable water supply in area of plume prior to attainment of MCLs/plume migration to existing domestic supply wells.	Increased pumping of local domestic supply wells/ modification of existing land uses that result in installation of domestic supply wells within plume area.	Modification and enforcement of land use covenants/ provision of an alternative water supply/modify current remedy.

TABLE 5-3
Example Contingency Actions During Remedial Alternative Implementation
Final Groundwater Corrective Measures Study/Feasibility Study for SWMU 1/AOC 1 and AOC 10, PG&E Topock Compressor Station, Needles, California

Remedial Alternative	RAO/Criterion	Example Failure Modes	Example Causes	Example Contingency Action
	RAO #2: Prevent or minimize migration of Cr(T) and Cr(VI) in groundwater to ensure concentrations in surface water do not exceed water quality standards that support the designated beneficial uses of the Colorado River (11 µg/L Cr(VI)).	IRZ array in floodplain allows passage of groundwater without sufficient treatment. Extraction and injection strategies are not effectively controlling gradients. Floodplain reducing zone allows passage of groundwater without sufficient treatment.	Insufficient well spacing or ineffective amendment delivery. Unexpected hydrogeologic conditions. Change in natural conditions over time.	Add wells and/or modify amendment delivery rates or methods. Add wells modify injection/extraction rates. Add IRZ wells and/or modify amendment delivery rates or methods.
	RAO #3: Reduce the mass of Cr(T) and Cr(VI) in groundwater at the site to achieve compliance with ARARs in groundwater. This RAO will be achieved through cleanup goal of regional background of 32 µg/L of Cr(VI).	Insufficient *in-situ* treatment.	Insufficient well spacing/insufficient dosing type, quantity, or method.	Add wells/modify amendment type, delivery rates, and/or methods.
	RAO #4: Ensure that the geographic location of the target remediation area does not permanently expand following completion of the remedial action.	Same as RAO #3.	Same as RAO #3.	Same as RAO #3.
	Comply with ARARs during implementation of the remedial action.	Treatment byproducts result in concentrations in Colorado River in exceedance of ARARs.	Unexpected geochemical conditions in floodplain, inefficient treatment.	Add wells, modify reductant type, dosage, and/or delivery method.
E - *In-situ* Treatment with Fresh Water Flushing	RAO #1: Prevent ingestion of groundwater as a potable water source having Cr(VI) in excess of the regional background concentration of 32 µg/L Cr(VI).	Development of potable water supply in area of plume prior to attainment of MCLs/plume migration to existing domestic supply wells.	Increased pumping of local domestic supply wells/ modification of existing land uses that result in installation of domestic supply wells within plume area.	Modification and enforcement of land use covenants/ provision of an alternative water supply/modify current remedy.
	RAO #2: Prevent or minimize migration of Cr(T) and Cr(VI) in groundwater to ensure concentrations in surface water do not exceed water quality standards that support the designated beneficial uses of the Colorado River (11 µg/L Cr(VI)).	Extraction and injection strategies are not effectively controlling gradients. Floodplain reducing zone allows passage of groundwater without sufficient treatment.	Unexpected hydrogeologic conditions. River water adds oxygen due to landward gradient/ change in natural conditions over time.	Add wells or modify extraction/injection rates. Add IRZ wells and/or modify the amendment delivery rates or methods.
	RAO #3: Reduce the mass of Cr(T) and Cr(VI) in groundwater at the site to achieve compliance with ARARs in groundwater. This RAO will be achieved through cleanup goal of regional background of 32 µg/L of Cr(VI).	Insufficient *in-situ* treatment. Flushing not sufficiently moving mass to treatment zones.	Insufficient well spacing/Insufficient dosing type, quantity, or methods. Unexpected hydrogeologic conditions/Inefficient well locations, injection and extraction rates.	Add wells/modify amendment type, delivery rates and/or methods. Add wells/modify extraction and injection rates.
	RAO #4: Ensure that the geographic location of the target remediation area does not permanently expand following completion of the remedial action.	Same as RAO #3.	Same as RAO #3.	Same as RAO #3.
	Comply with ARARs during implementation of the remedial action.	Treatment byproducts result in concentrations in Colorado River in exceedance of ARARs.	Unexpected geochemical conditions in floodplain/ inefficient treatment process/extraction and injection strategies are not effectively controlling gradients.	Add wells/modify reductant type, dosage, delivery rates and/or methods. Add wells/modify extraction and injection rates.
F - Pump and Treat	RAO #1: Prevent ingestion of groundwater as a potable water source having Cr(VI) in excess of the regional background concentration of 32 µg/L Cr(VI).	Development of potable water supply in area of plume prior to attainment of MCLs/plume migration to existing domestic supply wells.	Increased pumping of local domestic supply wells/ modification of existing land uses that result in installation of domestic supply wells within plume area.	Modification and enforcement of land use covenants/ provision of an alternative water supply/Modify current remedy
	RAO #2: Prevent or minimize migration of Cr(T) and Cr(VI) in groundwater to ensure concentrations in surface water do not exceed water quality standards that support the designated beneficial uses of the Colorado River (11 µg/L Cr(VI)).	Extraction and injection strategies are not effectively controlling gradients. Floodplain reducing zone allows passage of groundwater without sufficient treatment.	Unexpected hydrogeologic conditions. River water adds oxygen due to landward gradient/ change in natural conditions over time.	Add wells or modify extraction and injection rates. Move wells or modify extraction and injection rates.
	RAO #3: Reduce the mass of Cr(T) and Cr(VI) in groundwater at the site to achieve compliance with ARARs in groundwater. This RAO will be achieved through cleanup goal of regional background of 32 µg/L of Cr(VI).	Flushing not sufficiently moving mass to extraction points.	Unexpected hydrogeologic conditions/inefficient well locations, injection and extraction rates.	Add wells and/or modify extraction and injection rates.

TABLE 5-3
Example Contingency Actions During Remedial Alternative Implementation
Final Groundwater Corrective Measures Study/Feasibility Study for SWMU 1/AOC 1 and AOC 10, PG&E Topock Compressor Station, Needles, California

Remedial Alternative	**RAO/Criterion**	**Example Failure Modes**	**Example Causes**	**Example Contingency Action**
	RAO #4: Ensure that the geographic location of the target remediation area does not permanently expand following completion of the remedial action.	Same as RAO #3.	Same as RAO #3.	Same as RAO #3.
	Comply with ARARs during implementation of the remedial action.	Injection of groundwater outside plume at concentrations that would result in exceedance of MCLs at water supply wells.	Ineffective control of treatment system byproducts, unanticipated hydrogeologic or geochemical conditions, extraction of groundwater with ambient concentrations of constituents.	Modify treatment process, add injection or extraction wells, modify flow rates.
G - Combined Floodplain *In-situ*/Pump and Treat	RAO #1: Prevent ingestion of groundwater as a potable water source having Cr(VI) in excess of the regional background concentration of 32 µg/L Cr(VI).	Development of potable water supply in area of plume prior to attainment of MCLs/plume migration to existing domestic supply wells.	Increased pumping of local domestic supply wells/ modification of existing land uses that result in installation of domestic supply wells within plume area.	Modification and enforcement of land use covenants/ provision of an alternative water supply/modify current remedy.
	RAO #2: Prevent or minimize migration of Cr(T) and Cr(VI) in groundwater to ensure concentrations in surface water do not exceed water quality standards that support the designated beneficial uses of the Colorado River (11 µg/L Cr(VI)).	IRZ array in floodplain allows passage of groundwater without sufficient treatment. Extraction and injection strategies are not effectively controlling gradients. Floodplain reducing zone allows passage of groundwater without sufficient treatment.	Insufficient well spacing or ineffective amendment delivery. Unexpected hydrogeologic conditions. River water adds oxygen due to landward gradient/ change in natural conditions over time.	Add wells and/or modify amendment delivery rates or methods. Add wells or modify injection/extraction rates. Add IRZ wells and/or modify amendment delivery rates or methods.
	RAO #3: Reduce the mass of Cr(T) and Cr(VI) in groundwater at the site to achieve compliance with ARARs in groundwater. This RAO will be achieved through cleanup goal of regional background of 32 µg/L of Cr(VI).	Insufficient *in-situ* treatment. Flushing not sufficiently moving mass to treatment zones or extraction points.	Insufficient well spacing/Insufficient dosing type, quantity, or methods. Unexpected hydrogeologic conditions/Inefficient well locations, injection and extraction rates .	Add wells/modify amendment type, delivery rates, and/or methods. Add wells and/or modify extraction injection rates.
	RAO #4: Ensure that the geographic location of the target remediation area does not permanently expand following completion of the remedial action.	Same as RAO #3.	Same as RAO #3.	Same as RAO #3.
	Comply with ARARs during implementation of the remedial action.	Treatment byproducts result in concentrations in Colorado River in exceedance of ARARs. Injection of groundwater outside plume at concentrations that would result in exceedance of MCLs at water supply wells.	Unexpected geochemical conditions in floodplain, inefficient treatment. Ineffective control of treatment system byproducts, unanticipated hydrogeologic or geochemical conditions, extraction of groundwater with ambient concentrations of constituents.	Add wells, modify reductant type, dosage, delivery rate and/or methods. Modify treatment process, add injection or extraction wells, modify flow rates.
H - Combined Upland *In-situ*/Pump and Treat	RAO #1: Prevent ingestion of groundwater as a potable water source having Cr(VI) in excess of the regional background concentration of 32 µg/L Cr(VI).	Development of potable water supply in area of plume prior to attainment of MCLs/plume migration to existing domestic supply wells.	Increased pumping of local domestic supply wells/ modification of existing land uses that result in installation of domestic supply wells within plume area.	Modification and enforcement of land use covenants/ provision of an alternative water supply/Modify current remedy.
	RAO #2: Prevent or minimize migration of Cr(T) and Cr(VI) in groundwater to ensure concentrations in surface water do not exceed water quality standards that support the designated beneficial uses of the Colorado River (11 µg/L Cr(VI).	Extraction and injection strategies are not effectively controlling gradients. Floodplain reducing zone allows passage of groundwater without sufficient treatment.	Unexpected hydrogeologic conditions. River water adds oxygen due to landward gradient/ change in natural conditions over time.	Add wells or modify extraction/injection rates. Move wells or modify extraction and injection rates.
	RAO #3: Reduce the mass of Cr(T) and Cr(VI) in groundwater at the site to achieve compliance with ARARs in groundwater. This RAO will be achieved through cleanup goal of regional background of 32 µg/L of Cr(VI).	Insufficient *in-situ* treatment. Flushing not sufficiently moving mass to treatment zones or extraction points.	Insufficient well spacing/insufficient dosing type, quantity, or method. Unexpected hydrogeologic conditions/inefficient well locations, injection and extraction rates	Add wells/modify amendment type, delivery rates and/or methods. Add wells/modify extraction and injection rates.
	RAO #4: Ensure that the geographic location of the target remediation area does not permanently expand following completion of the remedial action.	Same as RAO #3.	Same as RAO #3.	Same as RAO #3.

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Remedial Alternative	RAO/Criterion	Example Failure Modes	Example Causes	Example Contingency Action
	Comply with ARARs during implementation of the remedial action.	Treatment byproducts result in concentrations in Colorado River in exceedance of ARARs. Injection of groundwater outside plume at concentrations that would result in water quality degradation, for example exceedance of MCLs at water supply wells.	Unexpected geochemical conditions in floodplain, inefficient extraction locations and rates. Ineffective control of treatment system byproducts, unanticipated hydrogeologic conditions, extraction of groundwater with ambient concentrations of constituents.	Add wells, modify reductant type and dosage. Modify treatment process, add injection or extraction wells, modify flow rates.
I - Continued Operation of IM	RAO #1: Prevent ingestion of groundwater as a potable water source having Cr(VI) in excess of the regional background concentration of 32 µg/L Cr(VI).	Development of potable water supply in area of plume prior to attainment of MCLs/plume migration to existing domestic supply wells.	Increased pumping of local domestic supply wells/ modification of existing land uses that result in installation of domestic supply wells within plume area.	Modification and enforcement of land use covenants/ provision of an alternative water supply/modify current remedy.
	RAO #2: Prevent or minimize migration of Cr(T) and Cr(VI) in groundwater to ensure concentrations in surface water do not exceed water quality standards that support the designated beneficial uses of the Colorado River (11 µg/L Cr(VI)).	Extraction and injection strategies are not effectively controlling gradients. Floodplain reducing zone allows passage of groundwater without sufficient treatment.	Unexpected or change in hydrogeologic conditions. River water adds oxygen due to landward gradient/ change in natural conditions over time.	
	RAO #3: Reduce the mass of Cr(T) and Cr(VI) in groundwater at the site to achieve compliance with ARARs in groundwater. This RAO will be achieved through cleanup goal of regional background of 32 µg/L of Cr(VI).	Flushing not sufficiently moving mass to extraction points. Floodplain reducing zone allows passage of groundwater without sufficient treatment.	Unexpected hydrogeologic conditions/inefficient well locations, injection and extraction rates. River water adds oxygen due to landward gradient/ change in natural conditions over time.	
	RAO #4: Ensure that the geographic location of the target remediation area does not permanently expand following completion of the remedial action.	Same as RAO #3.	Same as RAO #3.	
	Comply with ARARs during implementation of the remedial action.	Injection of groundwater outside plume at concentrations that would result in exceedance of MCLs at water supply wells.	Ineffective control of treatment system byproducts, unanticipated hydrogeologic or geochemical conditions, extraction of groundwater with ambient concentrations of constituents.	

Notes:

Per the Corrective Action Consent Agreement (DTSC, 1996), a contingency plan/plans will be submitted with the Operations and Maintenances plan and the Construction work plan for the selected remedy.

Failure modes are hypothetical, and an informed contingency plan will be drafted in the design, construction, and operating plans for the elements of the selected remedy.

5.3.1 Addressing Chromium in Bedrock in East Ravine

As discussed in Section 2.3, groundwater containing elevated Cr(VI) was discovered in bedrock during investigations in the East Ravine. Additional investigation to determine the source and confirm the full extent of Cr(VI) in East Ravine bedrock is forthcoming. Based on data currently available, it appears that the Cr(VI) in bedrock is most prevalent in the mid- and shallow-depth wells. This is consistent with the observed upward hydraulic gradients in the bedrock and the observations of reducing conditions in the deeper bedrock wells. The average permeability of the bedrock is estimated to be less than 1 foot per day, much lower than the Alluvial Aquifer. Water-conducting fractures were found to be relatively sparsely distributed in East Ravine bedrock. Typically, the porosity in bedrock is much smaller than in Alluvial Aquifers. Thus it is estimated that the mass of Cr(VI) contained in the East Ravine bedrock is less than 1 percent of the total Cr(VI) mass in the plume.

Over small distances, the detailed groundwater flow pattern in fractured rock can differ substantially from flow in porous media because groundwater tends to follow the fractures as it moves downgradient. Although overall the rock contains and yields relatively little water, the velocity of groundwater flow through an individual fracture can be much larger than the typical groundwater velocity in a porous medium. At larger scales, the influence of individual fractures on groundwater flow direction and velocity becomes less important and groundwater in fractured rock can behave much like groundwater in a porous medium. The scale at which a fractured rock system can behave like a porous medium is not easily determined and varies depending on the density and orientation of conductive fractures. The groundwater model used to evaluate remedial alternatives for the Alluvial Aquifer is based on the assumption that the Bedrock Aquifer can be approximated as a porous medium. Although it is not uncommon to use such models to simulate flow in fractured rock, it has not yet been determined whether the East Ravine bedrock can be adequately simulated as an equivalent porous medium.

The existing model was used to evaluate a potential hydraulic capture system for East Ravine bedrock. Although the size and shape of the capture zone might be different if the hydraulic system is dominated by one or more primary fractures, the existing model can provide a representative estimate of the total pumping rate and approximate number and location of wells needed to provide hydraulic capture in the East Ravine bedrock.

The development of a hydraulic capture system for bedrock is assumed herein instead of developing and evaluating a range of remedial alternatives to attain RAOs in bedrock. The design of the East Ravine remedy will occur during the remedial design phase of the project. Due to the low volume of water from the bedrock compared to the volume of water in the Alluvial Aquifer, it is anticipated the remedial design for bedrock can be readily incorporated within any of the proposed active remedial alternative for the Alluvial Aquifer.

For purposes of this CMS/FS, the hydraulic containment component for the bedrock would involve pumping from a group of wells near the eastern (downstream) end of the East Ravine. The assumed location for these wells from a hydraulic and infrastructure perspective would be along the former National Trails Highway. A gas pipeline is buried beneath and alongside this portion of the National Trails Highway, but it is likely that well locations could be identified that would be sufficiently far from the pipeline yet still accessible from the roadway. Initial estimates are that approximately 15 wells, pumping a combined total of up to 10 gallons per minute, would be required to provide hydraulic capture of the area of Cr(VI) in East Ravine bedrock.

If it is determined that additional remedial effort is needed to reach RAOs in East Ravine bedrock, other technologies could be applied to supplement the pumping wells. In addition to pumping for hydraulic control, technologies that may be applicable to East Ravine bedrock would include, but are not limited to, freshwater injection for flushing and injection of carbon amendments for *in-situ* reduction of Cr(VI).

5.3.2 Alternative A – No Action

No active construction or operational activities would occur under this alterative. The operation of the existing IM system would not continue. There would be no active treatment to reduce Cr(VI) concentrations in groundwater. While natural attenuation would occur within most of the fluvial sediments near the Colorado River, there would be no land ownership changes initiated as part of the remedy and no institutional controls imposed to restrict use of groundwater in locations where Cr(VI) concentrations exceed the cleanup goals. No additional groundwater monitoring facilities would be constructed under this alternative nor would any ongoing sampling or well maintenance activities occur. This alternative does not include decommissioning of the existing wells or the IM treatment facilities.

5.3.3 Alternative B – Monitored Natural Attenuation

No active treatment to reduce Cr(VI) concentrations in groundwater would occur under this alternative. This alternative would rely only on the naturally reducing conditions in shallow floodplain areas of the site to remove Cr(VI) from groundwater. These reducing conditions are derived from naturally occurring organic carbon in the fluvial deposits associated with the river. Wherever the natural reducing capacity of the fluvial material is present, Cr(VI) is converted to its stable and less toxic form of Cr(III), which is essentially immobile. The reducing conditions in the fluvial sediments provide a natural geochemical barrier that greatly limits or prevents the movement of Cr(VI) through the fluvial sediments adjacent to and beneath the Colorado River, as discussed in Section 2.3. The estimate of the time for five pore volumes to be flushed through the reducing zone with this alternative is 540 years. The actual cleanup time will be dependent on the flushing efficiency of the aquifer and transport of Cr(VI) from all parts of the plume under natural hydraulic gradients to the natural reductive conditions in the floodplain. These factors are subject to considerable uncertainty. The estimated range of cleanup time is from 220 years (based on flushing of two pore volumes) to 2,200 years (based on flushing of 20 pore volumes). Figure 5-4 illustrates the conceptual remedial approach for Alternative B. (The remainder of the figures referenced in this section are included at the end of the section.)

Under this alternative, an institutional control would be maintained during the remediation period to restrict use of impacted groundwater until the cleanup goals are attained, thereby eliminating the pathway for human health risk from direct exposure to groundwater.

Under this alternative, the existing groundwater monitoring network would potentially be enhanced with additional groundwater monitoring wells, and the long-term corrective action monitoring program of routine sampling, analysis, and reporting would occur until the cleanup goals are attained.

Groundwater monitoring wells throughout the site would be decommissioned following the determination that additional information from the wells would not be needed to evaluate attainment of the cleanup goals. The roadways associated with accessing the monitoring wells would be restored using decompaction and grading techniques designed to decrease erosion and accelerate revegetation of native species or other as directed by the land manager.

5.3.3.1 Limitations

Although the reducing conditions in the shallow fluvial deposits within the floodplain and beneath the river have been present at every location where a well has been installed or a pore water sample has been collected, there is no way to prove that these conditions exist everywhere. Further, reducing conditions in fluvial deposits do not extend to deeper zones in some parts of the aquifer near the Colorado River, and non-reducing conditions are prevalent in the Alluvial Aquifer where the majority of the Cr(VI) plume exists. Over the centuries that would be required for MNA to reach cleanup goals, it is possible that the geochemistry or groundwater flow directions, or even the location of the Colorado River channel, could change significantly.

5.3.4 Alternative C – High-volume *In-situ* Treatment

Alternative C would involve active *in-situ* groundwater treatment by distributing an organic carbon substrate across the entire plume through high-volume pumping using a minimum number of wells installed primarily in previously disturbed areas. This alternative was designed to meet the RAOs stated in Section 3.0 by active groundwater treatment until cleanup goals are attained. This would involve construction of injection wells within the center of the plume and extraction wells at the plume margin. An organic carbon substrate would be injected to create geochemically-reduced conditions and to remove Cr(VI) from groundwater by converting it *in-situ* to insoluble Cr(III), thereby removing chromium from groundwater. Groundwater would be extracted along National Trails Highway and along the western margin of the plume, amended with a carbon substrate, and injected into the injection wells within the center of the plume. The extraction/injection well lines would form a recirculation system to induce a hydraulic gradient to distribute the carbon substrate throughout the plume. Although this remedy has been designed to minimize the number of wells outside previously disturbed areas, it still requires a sufficient number of wells due to the limited distance that carbon substrates can travel in the aquifer before they are fully metabolized by the microbes. Figure 5-5 illustrates the conceptual remedial approach for Alternative C. This alternative would consist of two phases: floodplain cleanup and interior plume cleanup.

5.3.4.1 Floodplain Cleanup

Phase 1 involves construction of an IRZ line across the width of the plume along National Trails Highway and construction of IRZ lines between National Trails Highway and the Colorado River. Organic carbon would be injected in the IRZ lines to treat the existing Cr(VI) in the alluvial zone of the floodplain aquifer. The IRZ along National Trails Highway would be constructed using a line of wells that could be used either as injection or extraction wells to circulate groundwater and to distribute the organic carbon substrate. The floodplain IRZs could be constructed using arrays of injection and extraction wells, or they could be constructed with injection wells only. The final design may be adjusted based on stakeholder and engineering considerations and the exact conditions present in the floodplain at the time of final remedy design. IRZ systems are operated in a flexible manner guided by real-time monitoring data, as discussed in Appendix G, Section G.5. Phase 1 would operate until cleanup goals within the plume east of National Trails Highway are attained, approximately 2 years. The purpose of Phase 1 is to provide a robust, wide barrier to convert Cr(VI) to Cr(III) in the area of the site nearest the Colorado River. The current monitoring well network in the floodplain and the additional Phase 1 monitoring wells would provide an extensive monitoring network to measure chromium concentrations and adjust the active interior plume cleanup following completion of Phase 1.

5.3.4.2 Interior Plume Cleanup

Phase 2 involves construction of extraction wells around the perimeter of the plume and injection wells through the interior of the plume. Water is pumped from the extraction wells, organic carbon is added, and the amended water is injected into the core of the plume. The organic carbon in the injected water creates geochemically-reduced conditions in the aquifer to remove the Cr(VI) from groundwater. The assumed total pumping/injection rate would be approximately 2,000 gallons per minute (gpm). Depending on the results of hydraulic testing of the injection and extraction wells, this phase of the alternative may be implemented in stages so that not all the wells are pumping at once. This staged implementation could allow for maximization of the injection rate at each injection well to improve the distribution of the organic carbon. It is estimated that approximately 16 years would be required in Phase 2 to distribute the organic carbon and flush recalcitrant zones. Due to the relatively large distance between the injection and extraction wells, it is anticipated that there will be areas of the plume where organic carbon is not able to reach. Alternative C provides for continued operation of the pumping and injection systems to flush the remaining Cr(VI) from those portions of the aquifer not adequately treated by *in-situ* methods. During this flushing period, carbon would continue to be added only at levels sufficient to treat the water being injected as part of aquifer flushing. After the initial distribution of carbon has been achieved, there is no need to continue to distribute the carbon across large areas of the aquifer since the water drawn from the perimeter will be treated and injected, while the water from the central portion of the plume will also be treated as it flows through the reduced zone generated from the initial high concentration injection of carbon around the injection wells.

The estimated time to complete the Phase 1 floodplain cleanup and to distribute the organic carbon and flush recalcitrant zones during Phase 2 is 18 years. The actual cleanup time will be dependent on the rate at which organic carbon can be distributed to all areas of contaminated groundwater and/or contaminated groundwater in recalcitrant zones can be flushed to areas where it will be treated by injected organic carbon. These factors are subject to considerable uncertainty. The estimated range of cleanup time is from 10 to 60 years. The estimated time for this alternative is derived based on the assumed configuration, as described above. The time to cleanup for this alternative could be adjusted by modifying the number and location of wells and/or by modifying the flow rates.

Under Alternative C, an institutional control would be maintained during the remediation period to restrict use of groundwater in the plume area until the cleanup goals are attained, thereby eliminating the pathway for human health risk from direct exposure to groundwater. The area subject to the institutional control would include a buffer area surrounding the plume to prevent the consumption of water that potentially could migrate from the plume in other directions as a result of pumping from hypothetical future local water supply wells.

Preliminary estimates suggest that construction activities for this alternative would include installation of approximately 33 dipolar-type IRZ well locations, approximately 22 extraction well locations at the plume margins; approximately 41 injection well locations within the plume center for carbon-amended water; approximately15 bedrock extraction well locations in the East Ravine;[9] and associated piping, substrate storage and delivery systems, and power distribution and process controls/instrumentation systems. Operation and maintenance activities for the *in-situ* systems would include periodic well maintenance, groundwater sample collection and analysis, refinement of the injection/recirculation systems, management of the substrates, equipment inspections, and periodic replacement of wells and other structures that become clogged or damaged.

Optimization of the remedy would occur throughout the design, construction, and operational phases of remedy implementation. Changes to the number, location, and configuration of the extraction, treatment, and injection systems, and/or changes to the type, method, and configuration of the treatment delivery systems, as approved by appropriate agencies, may occur to enhance performance of the remedy to attain the cleanup goals, and to respond to site conditions and performance issues. Contingency measures would be established for this alternative to address system breakdowns and operational issues (e.g., emergency backup equipment and procedures) and to specify alternate procedures to prevent non-attainment of RAOs.

Under this alternative, the existing groundwater monitoring network would be enhanced with additional groundwater monitoring wells, and the corrective action monitoring program of routine sampling, analysis, and reporting would occur until the cleanup goals are attained, including long-term monitoring following completion of the active treatment.

Following attainment of the cleanup goals, the final remedy facilities (extraction wells, injection wells, IRZ wells, reagent storage, and delivery systems) would also be decommissioned. Groundwater monitoring wells throughout the site would be abandoned following the determination that additional information from the wells would not be needed to evaluate attainment of the cleanup goals. After deconstruction and decommissioning of the facilities, the areas would be restored using decompaction and grading techniques designed to decrease erosion and accelerate revegetation of native species or other as directed by the land manager.

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[9] IRZ wells are intended for distribution of amendment along a single IRZ line to create a linear barrier. Injection and extraction wells are meant to distribute amendment across a broad area of the site. IRZ wells would likely be a smaller diameter and would be designed for lower flow rates than injection/extraction wells.

5.3.4.3 Limitations

In-situ technology has not often been applied to treat an entire plume of this size and depth. Alternative C would result in a plume-wide IRZ being established at the Topock site. There is uncertainty regarding the ability to obtain complete distribution of substrates across this large an area. Due to the limitations in achieving complete distribution of substrates, there would likely be some zones of the aquifer where RAOs would not be met in a timely manner without further optimization of the remedy. The calculation of reductant substrate delivery time throughout each targeted area is based on an assumption of a modeled single-pore-volume flush and an assumed half-life of reductant in the aquifer (explained in more detail in Appendix G). The uncertainty associated with these assumptions is applied equally to all alternatives that include *in situ* as part of the remedy. Concentrations of byproducts such as manganese and arsenic are likely to temporarily increase within portions of the treatment zone. These byproducts are not expected to be a significant issue as documented in Appendix G.

5.3.5 Alternative D – Sequential *In-situ* Treatment

Under this alternative, treatment of Cr(VI) in the plume would occur by injecting an organic carbon substrate throughout the plume to create geochemically reduced conditions to convert Cr(VI) to insoluble Cr(III), thereby removing chromium from groundwater. This alternative was designed to meet the RAOs stated in Section 3.0 by active groundwater treatment until cleanup goals are attained. Approximately 10 treatment zones, consisting of lines of injection and extraction wells, would be constructed and operated in phases to distribute an organic carbon substrate over the entire plume. Wells would be switched from extraction to injection as the implementation progress through different phases of treatment. Lines of wells would be constructed with piping and power to allow each line to be operated in either an injection or extraction mode. Water would be pumped from one line of wells and injected into the adjacent line of wells. Carbon substrate would be added to extracted water prior to injection. The carbon would be distributed throughout the aquifer in the area between the active injection and extraction well lines. The floodplain would be treated in the initial phase by pumping from wells near the river and injecting into wells near National Trails Highway. The final design may be adjusted based on stakeholder and engineering considerations. IRZ systems are operated in a flexible manner guided by real time monitoring data as discussed in Appendix G, Section G.5. Once carbon distribution is complete and Cr(VI) is below cleanup goals in the floodplain, the line of wells along National Trails Highway would be converted to extraction wells and injection would be moved to the adjacent line of wells west of National Trails Highway. This “leapfrog” pattern of moving the injection and extraction after each segment of the plume was treated would be repeated throughout all the lines of wells until the entire plume had been treated. It is estimated that approximately 1.5 to 2 years would be required to fully distribute carbon across each of the treatment zones. Figure 5-6 illustrates the conceptual remedial approach for Alternative D.

The estimate of the time to distribute organic carbon throughout the plume for this alternative is 15 years. The actual cleanup time will be dependent on the rate at which organic carbon can be distributed to all areas of contaminated groundwater and/or contaminated groundwater in recalcitrant zones can be flushed to areas where it will be treated by injected organic carbon. These factors are subject to considerable uncertainty. The estimate of the range of cleanup time is from 10 to 20 years. The estimated time to distribute organic carbon for this alternative is derived based on the assumed configuration as described above. The time for this alternative could be adjusted by modifying the number and location of wells and/or by modifying the flow rates. Operating more than one phase at a time would reduce the time to distribute organic carbon for this alternative.

Preliminary estimates suggest that construction activities for this alternative would include installation of wells that would alternate between extraction and injection at approximately 72 locations, 15 bedrock extraction well locations in the East Ravine, associated piping, substrate storage and delivery systems, power distribution, and process controls/instrumentation systems. Operation and maintenance activities for the *in-situ* systems would include periodic well maintenance, groundwater sample collection and analysis, refinement of the injection/recirculation systems, management of the substrates, equipment inspections, and replacement of wells and other structures that become clogged or damaged.

Optimization of the remedy would occur throughout the design, construction, and operational phases of remedy implementation. Changes to the number, location, and configuration of the extraction, treatment, and injection systems, and/or changes to the type, method, and configuration of the treatment delivery systems, may occur to enhance performance of the remedy to attain the cleanup goals and to respond to site conditions and performance issues. Contingency measures would be established for this alternative to address system breakdowns and operational issues (e.g., emergency backup equipment and procedures) and to specify alternate procedures to prevent non-attainment of RAOs.

Under this alternative, an institutional control would be maintained during the remediation period to restrict use of groundwater in the plume area until the cleanup goals are attained, thereby eliminating the pathway for human health risk from direct exposure to groundwater. The area subject to the institutional control would include a buffer area surrounding the plume to prevent the consumption of water that potentially could migrate from the plume in other directions as a result of pumping from hypothetical future local water supply wells.

Under this alternative, the existing groundwater monitoring network would be enhanced with additional groundwater monitoring wells, and the corrective action monitoring program of routine sampling, analysis, and reporting would occur until the cleanup goals are attained, including long-term monitoring following completion of the active treatment.

Following attainment of the cleanup goals, the final remedy facilities (extraction wells, injection wells, substrate storage, and delivery systems) would be decommissioned. Groundwater monitoring wells throughout the site would be decommissioned following the determination that additional information from the wells would not be needed to evaluate attainment of the cleanup goals. After deconstruction and decommissioning of the facilities, the areas would be restored using decompaction and grading techniques designed to decrease erosion and accelerate revegetation of native species or other as directed by the land manager.

5.3.5.1 Limitations

In-situ technology has not often been applied to treat an entire plume of this size and depth. Alternative D would result in a plume-wide IRZ being established at the Topock site. There is uncertainty regarding the ability to obtain complete distribution of substrates across this large an area. Due to the limitations in achieving complete distribution of substrates, there would likely be some zones of the aquifer where RAOs would not be met in a timely manner without further optimization of the remedy. Concentrations of byproducts such as manganese and arsenic are likely to temporarily increase within portions of the treatment zone. These byproducts are not expected to be a significant issue, as documented in Appendix G.

5.3.6 Alternative E – *In-situ* Treatment with Fresh Water Flushing

Alternative E involves flushing to accelerate plume movement through an IRZ barrier located along National Trails Highway. Flushing would be accomplished through a combination of fresh water injection and injection of carbon amended water in wells to the west of the plume. This alternative also includes extraction wells near the Colorado River to provide hydraulic capture of the plume, accelerate cleanup of the floodplain, and flush the groundwater with elevated Cr(VI) through the IRZ line. Additional extraction wells are located in an area northeast of the compressor station where the flushing efficiency from injection wells alone is relatively poor. This alternative was designed to meet the RAOs stated in Section 3.0 by active groundwater treatment until cleanup goals are attained. Figures 5-7a and 5-7b illustrate the conceptual remedial approach for Alternative E.

This alternative consists of three main elements: an IRZ line along the length of National Trails Highway, extraction wells near the Colorado River pumping carbon-amended water to the western area of the plume, and freshwater injected west of the plume to accelerate groundwater flow.

The IRZ along National Trails Highway would be constructed using a line of wells that could be used either as injection or extraction wells to circulate groundwater and distribute the organic carbon source.

The extraction wells near the river will provide hydraulic control to prevent water originating in the plume from reaching the river. Extraction near the river will also help to draw carbon-amended water a portion of the way across the floodplain to treat the existing Cr(VI) in the alluvial zone of the floodplain aquifer east of National Trails Highway. The extracted water will be amended with carbon substrate and re-injected in the western portion of the plume where it will help induce a hydraulic gradient to accelerate the movement of the site groundwater through the IRZ, where it would be treated. The assumed flow rate of groundwater extracted from the extraction wells, amended with carbon substrate, and re-injected is approximately 640 gpm. The primary purpose of adding carbon to the injected water would be to create treatment zones in the vicinity of each injection well where any Cr(VI) in the injected water would be reduced. In contrast to Alternatives C and D, which treat the upland entire area by *in-situ*, Alternative E does not result in a large volume of upland aquifer material being converted to a reducing zone. Therefore, the total amount of *in-situ* byproducts generated by Alternative E would be considerably less than with Alternatives C and D. To further accelerate the movement of groundwater towards reducing zones and to enhance distribution of the organic carbon, additional injection wells would be constructed in areas further to the west and north of the plume, and within the southern portion of the plume for freshwater injection. Freshwater injection would involve piping freshwater to the site from an offsite source. The injection of freshwater at an assumed rate of approximately 500 gpm would induce a hydraulic gradient to accelerate the movement of the site groundwater through the IRZ, where it would be treated. This fresh water injection also serves to constrain westward movement of the carbon amended water and flush much of this water eastward toward the extraction wells.

The estimated time for five pore volumes to be flushed with this alternative is approximately 29 years. The actual cleanup time will be dependent on the rate at which organic carbon can be distributed to all areas of contaminated groundwater in the floodplain and/or contaminated groundwater in recalcitrant zones in the upland areas can be flushed to the IRZ treatment line where it will be treated by injected organic carbon. These factors are subject to considerable uncertainty. It is estimated that the range of cleanup time is from 10 (based on two pore volumes) to 110 years (based on 20 pore volumes). The estimated time for this alternative is derived based on the assumed configuration described above. The estimated time for this alternative could be adjusted by modifying the number and location of wells and/or by modifying the flow rates. Under this alternative, an institutional control would be maintained during the remediation period to restrict use of groundwater in the plume area until the cleanup goals are attained, thereby eliminating the pathway for human health risk from direct exposure to groundwater. The area subject to the institutional control would include a buffer area surrounding the plume to prevent the consumption of water that potentially could migrate from the plume in other directions as a result of pumping from hypothetical future local water supply wells.

The offsite source of fresh water for this alternative could be the same as the water source for the Topock Compressor Station and is assumed to be available over the implementation period. The Topock Compressor Station is currently purchasing its water from wells in Arizona owned by Southwest Water Inc. Future water supply may be from the Colorado River or from wells on the California side of the river. Pipelines would be constructed to convey fresh water from the source to the injection wells. Potential sources of injection water would be tested for contaminants and to ensure compatibility with the aquifer where the water would be injected. Depending on the source of water, some minor pH adjustment might be required to make the water chemically compatible with the aquifer where it is injected and to prevent scaling in the injection wells. If needed, this pH adjustment would require a small system located along the pipeline corridor with equipment such as chemical storage tank(s), secondary containment, feed pump, and security enclosure such as a building or fence. If surface water source is used, filtration may be needed for sediment and bacteria removal (for injection well maintenance). Preliminary estimates suggest that construction activities for this alternative would include installation of approximately 18 dipolar-type IRZ well locations; approximately one extraction well location offsite for production of freshwater; approximately nine extraction well locations in the floodplain and immediately northeast of the compressor station; approximately 15 bedrock extraction well locations in the East Ravine; approximately four injection well locations for carbon-amended water; approximately four injection well locations for fresh water; and associated piping, substrate storage and delivery systems, power distribution, and process controls/instrumentation systems. Operation and maintenance activities for the *in-situ* systems would include periodic well maintenance, groundwater sample collection and analysis, refinement of the injection/recirculation systems, management of the substrates, equipment inspections, and periodic replacement of wells and other structures that become clogged or damaged. Optimization of the remedy would occur throughout the design, construction, and operational phases of remedy implementation. Changes to the number, location, and configuration of the extraction, treatment, and injection systems, and/or changes to the type, method, and configuration of the treatment delivery systems may occur to enhance performance of the remedy to attain the cleanup goals and to respond to site conditions and performance issues. Contingency measures would be established for this alternative to address system breakdowns and operational issues (e.g., emergency backup equipment and procedures) and to specify alternate procedures to prevent non-attainment of RAOs.

Under this alternative the existing groundwater monitoring network would be enhanced with additional groundwater monitoring wells, and the corrective action monitoring program of routine sampling, analysis, and reporting would occur until the cleanup goals are attained, including long-term monitoring following completion of the active treatment.

Following attainment of the cleanup goals, the final remedy facilities (IRZ wells, injection wells, substrate storage, and delivery systems) would be decommissioned. Groundwater monitoring wells throughout the site would be decommissioned following the determination that additional information from the wells would not be needed to evaluate attainment of the cleanup goals. After deconstruction and decommissioning of the facilities, the areas would be restored using decompaction and grading techniques designed to decrease erosion and accelerate revegetation of native species or other as directed by the land manager.

5.3.6.1 Limitations

Alternative E relies primarily on flushing to remove contaminants from the upland portion of the aquifer. This is analogous to the mass removal process used by pump-and-treat systems; however, in this alternative, the treatment is provided by an IRZ rather than a treatment plant. Extraction systems have generally demonstrated positive control of plumes at many sites—including Topock—and thus serve well as plume management tools. However, these systems historically have failed to achieve widespread remediation of plumes due to the difficulty associated with achieving efficient hydraulic recovery of a plume and the rate-limited back diffusion of contaminants from low-permeability material that result in prolonged cleanup times. At many sites, remedial alternatives that rely on flushing to remove contaminants (typical pump/treat systems) have reached a limit where concentrations are no longer being reduced effectively, but cleanup goals have not been met (USEPA, 1997b; Palmer and Wittbrodt, 1991). Hexavalent chromium does not strongly sorb to soils, which makes it more amenable to flushing type cleanup than some other contaminants, but it may still be difficult to reach cleanup levels across the entire plume by methods that rely on flushing. Due to the limitations of flushing as a remedial technology, there would likely be some zones of the aquifer where RAOs would not be met in a timely manner without further optimization of the remedy. It is not possible to predict what the limit of concentration reduction might be for flushing technology at the Topock site.

5.3.7 Alternative F – Pump and Treat

This alternative would involve pumping groundwater, *ex-situ* treatment to remove chromium from the groundwater, and reinjection of the treated water back to the aquifer. This alternative was designed to meet the RAOs stated in Section 3.0 by active groundwater treatment until cleanup goals are attained. The *ex-situ* treatment process is likely to include chemical reduction by addition of ferrous iron; oxidation, pH adjustment, and settling in a clarifier; and final filtration for a process that is essentially similar to the *ex-situ* treatment processes at the current IM No. 3 treatment plant, with the exception that reverse osmosis will not be a part of the *ex-situ* treatment process, as it is assumed salinity removal will not be needed. Extraction wells would be placed in the plume to extract groundwater. Extracted groundwater would be transported via piping to an aboveground treatment plant for treatment, and treated groundwater would be piped to injection wells. For this alternative, preliminary design suggests that extraction wells would be installed at approximately five locations within the plume In addition, bedrock extraction wells would be installed at approximately 15 locations in the East Ravine area. The assumed combined flowrate is approximately 1,280 gpm. Treated groundwater would be injected into injection wells at approximately three locations to the west of the plume and three locations in the southern portion of the plume near the mountain front. Chromium removed from the groundwater via *ex-situ* treatment would be collected in the sludge from the clarifier and filtration systems and would be transported offsite by truck to an appropriately-licensed disposal facility. Figure 5-8 illustrates the conceptual remedial approach for Alternative F.

The estimated time for five pore volumes to be flushed with this alternative is approximately 37 years. The actual cleanup time will be dependent on the flushing efficiency of the aquifer and is subject to considerable uncertainty. The length of time needed to attain cleanup goals in the Alluvial Aquifer would be longer if the flushing efficiency of the Alluvial Aquifer is less than estimated. It is estimated that the range of cleanup time could be from 15 years (based on two pore volumes) to 150 years (based on 20 pore volumes). The estimated time for five pore volumes to be flushed from the aquifer for this alternative is derived based on the assumed configuration described above. The estimated time for this alternative could be adjusted by modifying the number and location of wells and/or by modifying the flow rates.

As discussed above, the *ex-situ* treatment facilities should ideally be located close to the extraction and injection facilities to minimize the amount of pipelines and pump stations necessary to transport groundwater to and from the treatment system. The location should also be close to the power source, have available space for construction, and be in an accessible location for construction and operation. The location of treatment facilities must also consider areas of the site that are of cultural or religious significance so that construction or other disturbance is minimized to the extent feasible. Other location constraints include sensitive habitats, historical sites, and topographic constraints, as discussed in Section 2.0. Based on these factors, the location of the *ex-situ* treatment facilities is assumed to be within the lower yard of the Topock Compressor Station. An alternate location being considered, as required by DTSC's letter dated November 6, 2008 (DTSC, 2008c), is the location of the current IM treatment plant. The 1,280-gpm treatment plant anticipated under this alternative is considerably larger than the existing IM treatment plant. Sufficient level area for this larger plant is available at the lower yard of the compressor station. Substantially less level area is available at the current IM treatment plant location. Construction of a 1,280-gpm treatment plant at the current IM treatment plant location may require grading that would not be required at the compressor station or use of the IM construction staging area north of the existing IM treatment plant.

Alternatively, if it were necessary to construct the plant at the IM treatment plant location without grading, it might be necessary to extend the height of the building housing the plant to accommodate the needed equipment. The compressor station also offers a more reliable long-term source of electrical power for treatment plant operations. Figure 5-8 shows the anticipated locations for the *ex-situ* treatment facilities for this alternative.

Under this alternative, an institutional control would be maintained during the remediation period to restrict use of groundwater in the plume area until the cleanup goals are attained, thereby eliminating the pathway for human health risk from direct exposure to groundwater. The area subject to the institutional control would include a buffer area surrounding the plume to prevent the consumption of water that potentially could migrate from the plume in other directions as a result of pumping from hypothetical future local water supply wells.

Preliminary estimates suggest that construction activities would include: (1) installation of approximately five extraction well locations, approximately six injection well locations, approximately 15 bedrock extraction well locations in the East Ravine, and associated pipelines and (2) construction of an approximately 1,280-gpm treatment plant assumed to be located either on the Topock Compressor Station property or at the location of the present IM No. 3 treatment plant. See Appendix D for discussion of assumed flow per well.

Optimization of the remedy would occur throughout the design, construction, and operational phases of remedy implementation. Changes to the number, location, and configuration of the extraction, treatment, and injection systems may occur to enhance performance of the remedy to attain the cleanup goals and to respond to site conditions and performance issues. Contingency measures would be established for this alternative to address system breakdowns and operational issues (e.g., emergency backup equipment and procedures) and to specify alternate procedures to prevent non-attainment of RAOs.

Operation and maintenance of the aboveground treatment plant would include periodic groundwater sample collection and analysis, chemical controls, equipment maintenance and inspection, and process chemical and waste management. Operation and maintenance of the extraction and injection wells would also occur throughout the remediation period, including replacement of wells and other structures that become clogged or damaged.

Under this alternative the existing groundwater monitoring network would be enhanced with additional groundwater monitoring wells, and the corrective action monitoring program of routine sampling, analysis, and reporting would occur until the cleanup goals are attained, including long-term monitoring following completion of the active treatment.

Following attainment of the cleanup goals, the final remedy facilities (e.g., extraction wells, injection wells, treatment plant) would also be decommissioned. Groundwater monitoring wells throughout the site would be decommissioned following the determination that additional information from the wells would not be needed to evaluate attainment of the cleanup goals. After deconstruction and decommissioning of the facilities, the areas would be restored using decompaction and grading techniques designed to decrease erosion and accelerate revegetation of native species or other as directed by the land manager.

5.3.7.1 Limitations

The fundamental limitation of pump-and-treat technology as a final remedy is the ability of the extraction portion of the system to effectively remove contaminant mass from the aquifer. Extraction systems have generally demonstrated positive control of plumes at many sites—including Topock—and thus serve well as plume management tools. However, these systems have failed historically to achieve widespread remediation of plumes due to the difficulty associated with achieving efficient hydraulic recovery of a plume and the rate-limited back diffusion of contaminants from low-permeability material that result in prolonged cleanup times. At many sites, pump-and-treat systems, which rely on flushing to remove contaminants, have reached a limit where concentrations are no longer being reduced effectively, but cleanup goals have not been met (USEPA, 1997b; Palmer and Wittbrodt, 1991). Due to the limitations of flushing as a remedial technology, there would likely be some zones of the aquifer where RAOs would not be met in a timely manner without further optimization of the remedy. It is not possible to predict what the limit of concentration reduction might be for flushing technology at the Topock site. The pumping associated with Alternative F provides a landward gradient towards the extraction wells and away from the river, but in the process, river water may be drawn into the aquifer. The river water is aerobic and would become reduced as it moved out of the river and into the fluvial aquifer. Over the long period of time that this remedy would operate, the passage of this aerobic water through the fluvial sediments could result in some degradation of the natural reducing capacity. It is not possible to accurately predict where or to what extent this degradation in reducing capacity would occur.

5.3.8 Alternative G – Combined Floodplain *In-situ*/Pump and Treat

This alternative would combine floodplain cleanup by *in-situ* treatment with treatment of the uplands portion of the plume by extraction and reinjection with *ex-situ* treatment. The floodplain cleanup would involve construction of IRZ lines at National Trails Highway and between National Trails Highway and the Colorado River, as described in Phase 1 of Alternative C. Chromium in the upland portions of the site would be addressed by pumping groundwater, *ex-situ* treatment to remove chromium from the groundwater, and reinjection of the treated water back to the aquifer. This alternative is designed to meet the RAOs stated in Section 3.0 by active groundwater treatment until cleanup goals are attained.

The floodplain cleanup would involve construction of an IRZ line across the width of the plume along National Trails Highway and construction of IRZ lines between National Trails Highway and the Colorado River. Organic carbon would be injected in the IRZ lines to treat the existing Cr(VI) in the alluvial zone of the floodplain aquifer. The IRZ along National Trails Highway would be constructed using a line of wells that could be used either as injection or extraction wells to circulate groundwater and to distribute the organic carbon substrate. The floodplain IRZs could be constructed using arrays of injection and extraction wells or they could be constructed with injection wells only. The floodplain IRZs would operate until cleanup goals within the plume east of National Trails Highway are attained, estimated to require approximately 2 years to distribute organic carbon throughout the floodplain.

Concurrent with the floodplain cleanup, treatment of the plume in the upland portions of the site would be by an *ex-situ* process likely to involve a process that is essentially similar to the treatment processes at the current IM No. 3 treatment plant: chemical reduction by addition of ferrous iron; oxidation, pH adjustment, and settling in a clarifier; and final filtration. As with Alternative F, it is assumed that salinity removal will not be needed and that reverse osmosis will not be a part of the *ex-situ* treatment process. Extraction wells would be placed in the central portions of the plume to extract groundwater. Extracted groundwater would be transported via piping to an aboveground treatment plant for treatment, and treated groundwater would be piped to injection wells. For this alternative, preliminary design suggests that extraction wells would be installed at approximately five locations within the plume. In addition, bedrock extraction wells would be installed at approximately 15 locations in the East Ravine area. The assumed combined flowrate is approximately 1,230 gpm. Treated groundwater would be injected into injection wells at approximately three locations to the west and north of the plume, and three locations in the southern portion of the plume near the mountain front. Chromium removed from the groundwater via *ex-situ* treatment would be collected in the sludge from the clarifier and filtration systems and would be transported offsite by truck to an appropriately-licensed disposal facility. Figure 5-9 illustrates the conceptual remedial approach for Alternative G.

The estimated time for five pore volumes to be flushed with this alternative is approximately 22 years. The actual cleanup time will be dependent on the flushing efficiency of the aquifer and is subject to considerable uncertainty. The length of time needed to attain cleanup goals in the Alluvial Aquifer would be longer if the flushing efficiency of the Alluvial Aquifer is less than expected. The estimate for the likely range of cleanup time is from 10 years (based on two pore volumes) to 90 years (based on 20 pore volumes). The estimated time for five pore volumes to be flushed from the aquifer for this alternative is derived based on the assumed configuration as described above. The estimated time for this alternative could be adjusted by modifying the number and location of wells and/or by modifying the flow rates.

As discussed in Alternative F, the approximately 1,230-gpm *ex-situ* treatment plant anticipated under this alternative is considerably larger than the IM No. 3 treatment plant. Sufficient level area for this larger plant is available at the lower yard of the compressor station, and substantially less level area is available at the current IM treatment plant location. Construction of a 1,230-gpm treatment plant at the current IM treatment plant location may require grading that would not be required at the compressor station.

Alternatively, if it were necessary to construct the plant at the IM No. 3 location without grading, it might be necessary to extend the height of the building housing the plant to accommodate the needed equipment. The compressor station also offers a more reliable long-term source of electrical power for treatment plant operations. Figure 5-9 shows the anticipated locations for the *ex-situ* treatment facilities for this alternative.

Under this alternative an institutional control would be maintained during the remediation period to restrict use of groundwater in the plume area until the cleanup goals are attained, thereby eliminating the pathway for human health risk from direct exposure to groundwater. The area subject to the institutional control would include a buffer area surrounding the plume to prevent the consumption of water that potentially could migrate from the plume in other directions as a result of pumping from hypothetical future local water supply wells.

Preliminary estimates suggest that construction activities would include installation of approximately 33 dipolar-type IRZ well locations, approximately five extraction well locations, approximately six injection well locations, and approximately 15 bedrock extraction well locations in the East Ravine. See Appendix D for discussion of assumed flow per well. In addition, construction activities would include construction of associated pipelines, *in-situ* substrate storage and delivery systems, an approximately 1,230-gpm treatment plant assumed to be located either on the Topock Compressor Station property or at the location of the present IM No. 3 treatment plant, and power distribution and process controls/instrumentation systems for the *in-situ* and *ex-situ* treatment processes.

Optimization of the remedy would occur throughout the design, construction, and operational phases of remedy implementation. Changes to the number, location, and configuration of the extraction, *in-situ* treatment, *ex-situ* treatment, and injection systems and/or changes to the type, method, and configuration of the treatment delivery systems may occur to enhance performance of the remedy to attain the cleanup goals and to respond to site conditions and performance issues. Contingency measures would be established for this alternative to address system breakdowns and operational issues (e.g., emergency backup equipment and procedures) and to specify alternate procedures to prevent non-attainment of RAOs.

Operation and maintenance activities for the *in-situ* systems in the floodplain would include periodic well maintenance, groundwater sample collection and analysis, refinement of the injection/recirculation systems, management of the substrates, equipment inspections, and periodic replacement of wells and other structures that become clogged or damaged. Operation and maintenance of the aboveground treatment plant would include periodic groundwater sample collection and analysis, chemical controls, equipment maintenance and inspection, and process chemical and waste management. Operation and maintenance of the extraction and injection wells within the upland area would include replacement of wells and other structures that become clogged or damaged.

Under this alternative the existing groundwater monitoring network would be enhanced with additional groundwater monitoring wells, and the corrective action monitoring program of routine sampling, analysis, and reporting would occur until the cleanup goals are attained, including long-term monitoring following completion of the active treatment.

Following attainment of the cleanup goals, the final remedy facilities (e.g., IRZ wells, extraction wells, injection wells, *in-situ* reagent storage and delivery systems, and aboveground treatment plant) would also be decommissioned. Groundwater monitoring wells throughout the site would be decommissioned following the determination that additional information from the wells would not be needed to evaluate attainment of the cleanup goals. After deconstruction and decommissioning of the facilities, the areas would be restored using decompaction and grading techniques designed to decrease erosion and accelerate revegetation of native species or other as directed by the land manager.

5.3.8.1 Limitations

The fundamental limitation of pump-and-treat technology as a final remedy is the ability of the extraction portion of the system to effectively remove contaminant mass from the aquifer. Extraction systems have generally demonstrated positive control of plumes at many sites—including Topock—and thus serve well as plume management tools. However, these systems have failed historically to achieve widespread remediation of plumes due to the difficulty associated with achieving efficient hydraulic recovery of a plume and the rate-limited back diffusion of contaminants from low permeability material that result in prolonged cleanup times. At many sites, pump-and-treat systems, which rely on flushing to remove contaminants, have reached a limit where concentrations are no longer being reduced effectively, but cleanup goals have not been met (USEPA, 1997b; Palmer and Wittbrodt, 1991). Due to the limitations of flushing as a remedial technology, there would likely be some zones of the aquifer where RAOs would not be met in a timely manner without further optimization of the remedy. It is not possible to predict what the limit of concentration reduction might be for flushing technology at the Topock site. The pumping associated with Alternative G provides a landward gradient towards the extraction wells and away from the river, but in the process, river water may be drawn into the aquifer. The river water is aerobic and would become reduced as it moved out of the river and into the fluvial aquifer. Over the long period of time that this remedy would operate, the passage of this aerobic water through the fluvial sediments could result in some degradation of the natural reducing capacity. It is not possible to accurately predict where or to what extent this degradation in reducing capacity would occur. The carbon introduced into the floodplain during the *in-situ* treatment would mitigate some of the degradation of the natural reducing capacity.

5.3.9 Alternative H – Combined Upland *In-situ*/Pump and Treat

This alternative would combine *in-situ* treatment in the upland portions of the plume with pump-and-treat technology in the floodplain. While both Alternative G and Alternative H include a combination of *in-situ* treatment and pump and treat, this alternative differs from Alternative G by relying on *in-situ* to be the dominant feature of the cleanup rather than pump and treat. Chromium in the upland areas of the plume would be addressed by construction of several IRZ lines. The floodplain area of the site would be addressed by constructing a line of extraction wells along National Trails Highway. Extracted water from these wells would be split and managed in two ways: approximately half the extracted water would be treated by an *ex-situ* treatment plant and reinjected at locations outside the plume, while the remaining portion of the extracted water would be reinjected after being amended with a carbon source near the western edge of the plume. This alternative is designed to meet the RAOs stated in Section 3.0 by active groundwater treatment until cleanup goals are attained. Figure 5-10 illustrates the conceptual remedial approach for Alternative H.

The upland *in-situ* cleanup would involve construction of several IRZ lines across the length and width of the plume. Organic carbon would be injected in the IRZ lines to treat the existing Cr(VI) in the alluvial zone of the aquifer. IRZ lines would be constructed by recirculating between adjacent wells within each line or by use of vertical circulation wells.

Concurrent with the upland cleanup, groundwater extraction would be used in the floodplain area of the site to remove chromium-containing water and to provide for hydraulic control of the plume. Groundwater would be extracted through a series of extraction wells across the plume at the National Trails Highway. For this alternative, preliminary design suggests that approximately five extraction wells would be installed for an assumed combined flowrate of approximately 500 gpm. Extracted groundwater would be managed in two ways:

- Approximately one-half (200 to 300 gpm) of the extracted water would be transported via piping to an aboveground treatment plant. The *ex-situ* process is likely to involve a process that is essentially similar to the treatment processes at the current IM No. 3 treatment plant: chemical reduction by addition of ferrous iron; oxidation, pH adjustment, and settling in a clarifier; and final filtration. As with Alternatives F and G, it is assumed that salinity removal will not be needed and that reverse osmosis will not be a part of the *ex-situ* treatment process. Following *ex-situ* treatment, treated groundwater would be transported via pipeline to injection wells. Treated groundwater would be re-injected into injection wells at approximately four locations within and outside the plume boundary. Chromium removed from the groundwater via *ex-situ* treatment would be collected in the sludge from the clarifier and filtration systems and would be transported offsite by truck to an appropriately-licensed disposal facility.
- Approximately one-half (200 to 300 gpm) of the extracted water would be transported to the western edge of the plume, amended with carbon, and reinjected at approximately four locations near the western edge of the plume. The primary purpose of this reinjection is to increase the flushing efficiency by providing additional “push” to move the plume through the IRZ lines. Sufficient carbon would be added to this water to reduce the Cr(VI) in the injected water, thereby providing treatment of this water concurrent with reinjection. The flows would be balanced so that the treated water injection provides containment of all the flow lines emanating from the amended water injection wells, thus limiting the spread of the amended water and forcing it to flow back through the IRZ lines toward the extraction wells.

The estimated time to distribute organic carbon and flush contaminated groundwater for this alternative is 18 years. The actual cleanup time will be dependent on the rate at which organic carbon can be distributed to all areas of contaminated groundwater and/or contaminated groundwater in recalcitrant zones can be flushed. These factors are subject to considerable uncertainty. The estimated range of cleanup time is from 10 to 70 years. The estimated time for this alternative is derived based on the assumed configuration as described above. The time for this alternative could be adjusted by modifying the number and location of wells and/or by modifying the flow rates.

Possible locations for the *ex-situ* treatment plant are on the Topock Compressor Station property and at the current IM No. 3 treatment plant location. In comparison to Alternatives F and G, the *ex-situ* treatment plant for this alternative is considerably smaller and therefore would require less level area or grading than the treatment plant for Alternatives F and G. Figure 5-10 shows the anticipated locations for the *ex-situ* treatment facilities for this alternative.

Under this alternative, an institutional control would be maintained during the remediation period to restrict use of groundwater in the plume area until the cleanup goals are attained, thereby eliminating the pathway for human health risk from direct exposure to groundwater. The area subject to the institutional control would include a buffer area surrounding the plume to prevent the consumption of water that potentially could migrate from the plume in other directions as a result of pumping from hypothetical future local water supply wells.

Preliminary estimates suggest that construction activities for this alternative would include installation of approximately 39 dipolar-type IRZ well locations, approximately five extraction well locations, approximately 15 bedrock extraction well locations in the East Ravine, approximately four injection well locations for treated water, and approximately four injection wells for carbon-amended water. See Appendix D for discussion of assumed flow per well. In addition, construction activities would include construction of associated pipelines, *in-situ* substrate storage and delivery systems, an approximately 200- to 300-gpm treatment plant assumed to be located either on the Topock Compressor Station property or at the location of the present IM No. 3 treatment plant, and power distribution and process controls/instrumentation systems for the *in-situ* and *ex-situ* treatment processes.

Optimization of the remedy would occur throughout the design, construction, and operational phases of remedy implementation. Changes to the number, location, and configuration of the extraction, *in-situ* treatment, *ex-situ* treatment, and injection systems and/or changes to the type, method, and configuration of the treatment delivery systems may occur to enhance performance of the remedy to attain the cleanup goals and to respond to site conditions and performance issues. Contingency measures would be established for this alternative to address system breakdowns and operational issues (e.g., emergency backup equipment and procedures) and to specify alternate procedures to prevent non-attainment of RAOs.

Operation and maintenance activities for the *in-situ* systems would include periodic well maintenance, groundwater sample collection and analysis, refinement of the injection/recirculation systems, management of the substrates, equipment inspections, and periodic replacement of wells and other structures that become clogged or damaged. Operation and maintenance of the aboveground treatment plant would include periodic groundwater sample collection and analysis, chemical controls, equipment maintenance and inspection, and process chemical and waste management. Operation and maintenance of the extraction and injection wells would include replacement of wells and other structures that become clogged or damaged.

Under this alternative the existing groundwater monitoring network would be enhanced with additional groundwater monitoring wells, and the corrective action monitoring program of routine sampling, analysis, and reporting would occur until the cleanup goals are attained, including long-term monitoring following completion of the active treatment.

Following attainment of the cleanup goals, the final remedy facilities (e.g., IRZ wells, extraction wells, injection wells, *in-situ* reagent storage and delivery systems, and aboveground treatment plant) would also be decommissioned. Groundwater monitoring wells throughout the site would be decommissioned following the determination that additional information from the wells would not be needed to evaluate attainment of the cleanup goals. After deconstruction and decommissioning of the facilities, the areas would be restored using decompaction and grading techniques designed to decrease erosion and accelerate revegetation of native species or other as directed by the land manager.

5.3.9.1 Limitations

Alternative H relies on a combination of pump-and-treat and *in-situ* technologies to remove the bulk of the Cr(VI) and minimizes some of the limitations of both technologies. The construction of IRZs along linear axes would tend to minimize the production of byproducts because a minimal area of aquifer would be treated. There would also likely be aerobic zones downgradient from the IRZ lines where reduced species such as manganese and arsenic could be re-oxidized and attenuated. Flushing would be relied upon to remove contaminants from the majority of the aquifer, and the same limitations would apply as for the other alternatives that rely on flushing. Due to the limitations of flushing as a remedial technology, there would likely be some zones of the aquifer where RAOs would not be met in a timely manner without further optimization of the remedy. The presence of the multiple IRZ lines would minimize the distances across which the contaminants had to be moved and would therefore tend to make flushing more effective. Alternative H would draw river water into the floodplain and over time could degrade the natural reducing capacity of the floodplain.

5.3.10 Alternative I – Continued Operation of Interim Measure

This alternative would involve continued operation of the IM as the final remedial action at the site. The IM system would operate with the existing equipment with existing procedures using the existing process at the existing flow rate until RAOs are attained. The estimate of the time to flush five pore volumes of water through the aquifer for this alternative is 240 years. This estimate is subject to considerable uncertainty. The estimated range of cleanup time is from 100 to 960 years. Figure 5-11 illustrates the conceptual remedial approach for Alternative I.

The Interim Measure at the Topock site includes:

- Groundwater extraction by extraction wells in the floodplain area of the site. There are currently four extraction wells (TW-2S, TW-2D, TW-3D, and PE-1), two of which are currently in operation (TW-3D and PE-1).
- Transport of extracted groundwater to an aboveground treatment plant via underground pipelines.
- Treatment of groundwater in an aboveground treatment plant. The current groundwater treatment system is a continuous, multi-step process that involves reduction of Cr(VI) to Cr(III); precipitation and removal of precipitate solids by clarification and microfiltration; and lowering the naturally occurring TDS using reverse osmosis.
- Transport of treated groundwater to an injection well field via aboveground pipelines.
- Injection of treated groundwater into the Alluvial Aquifer. There are currently two injection wells (IW-02 and IW-03), both of which are in operation.

This alternative would involve the continued operation of the IM features above, with no changes to the existing configuration of the extraction, treatment, or injection. Unlike Alternatives C through H, this alternative would not include changes to the number, location, and configuration of remedial systems over time to optimize and enhance the performance of the alternative to meet changing conditions or to enhance performance of the remedy to attain the cleanup goals. Existing contingency procedures for the extraction system, treatment system, and injection system would continue to be implemented to ensure existing performance standards for the remedial components are maintained.

Operation of the aboveground treatment plant would include periodic groundwater sample collection and analysis, chemical controls, equipment maintenance and inspection, and process chemical and waste management. Operation and maintenance of the extraction and injection wells would also occur throughout the remediation period. Construction activities would occur from time to time over the operational period to replace wells or other structures that may become worn, clogged, or damaged. Two waste streams are generated by the aboveground treatment plant: (1) sludge from the filtration process, and (2) brine or concentrate from the reverse osmosis process. Both waste streams are removed from the treatment plant by truck and transported to offsite, permitted disposal facilities.

Under this alternative, an institutional control would be maintained during the remediation period to restrict use of groundwater in the plume area until the cleanup goals are attained, thereby eliminating the pathway for human health risk from direct exposure to groundwater. The area subject to the institutional control would include a buffer area surrounding the plume to prevent the consumption of water that potentially could migrate from the plume in other directions as a result of pumping from hypothetical future local water supply wells.

The existing monitoring systems are assumed to be sufficient to evaluate the performance of this alternative, and no additional monitoring wells would be constructed. The existing monitoring programs are assumed to be retained during the remediation period.

Following attainment of the cleanup goals, the final remedy facilities (e.g., extraction wells, injection wells, piping, and aboveground treatment plant) would also be decommissioned. Groundwater monitoring wells throughout the site would be decommissioned following the determination that additional information from the wells would not be needed to evaluate attainment of the cleanup goals. After deconstruction and decommissioning of the facilities, the areas would be restored using decompaction and grading techniques designed to decrease erosion and accelerate revegetation of native species or other as directed by the land manager.

5.3.10.1 Limitations

The IM No. 3 extraction wells are located to provide landward gradients in the floodplain but are not optimally located to remove Cr(VI) from the aquifer. Thus, operation of IM No. 3 is not an efficient way to remediate the plume. In addition, Alternative I would have all the limitations inherent in pump-and-treat technology as described in the discussion of Alternative F, namely, that pump and treat can control gradients and remove significant fractions of the contaminant mass but has been shown to be ineffective in achieving RAOs at many sites. Due to the limitations of flushing as a remedial technology, there would likely be some zones of the aquifer where RAOs would not be met in a timely manner without further optimization of the remedy.

The pumping associated with Alternative I provides a landward gradient towards the extraction wells and away from the river, but in the process, river water may be drawn into the aquifer. The river water is aerobic and would become reduced as it moved out of the river and into the fluvial aquifer. Over the long period of time that this remedy would operate, the passage of this aerobic water through the fluvial sediments could result in some degradation of the natural reducing capacity. It is not possible to accurately predict where or to what extent this degradation in reducing capacity would occur.

5.4 Detailed Analysis of Alternatives

As stated in Section 1.1, this CMS/FS is being developed in accordance with both RCRA Corrective Action and CERCLA. This section presents an overview of the evaluation criteria of RCRA Corrective Action (DTSC, 1996) and CERCLA (40 CFR Part 300.430), as considered together and applied in this CMS/FS report. It also presents a description of the evaluation criteria used to assess alternatives in the CMS/FS and applies those criteria to the alternatives presented in Section 5.3.

5.4.1 Overview of Evaluation Criteria

For a basis of comparing terminology, Table 5-4 shows the evaluation criteria of RCRA Corrective Action (DTSC, 1996) and CERCLA (40 CFR Part 300.430), as considered together and applied in this CMS/FS report. Table 5-4 presents the relevant foundation criteria of RCRA Corrective Action and CERCLA and shows how these criteria are used in the context of the CMS/FS.

The nine evaluation criteria are delineated into the following three categories:

- Threshold Criteria/Corrective Action Standards
- Balancing Criteria/Remedy Selection Decision Standards
- Modifying Criteria

The first two of the nine criteria are considered “threshold criteria” or “corrective action standards” that define the minimum level of acceptable performance for an alternative, and these must be met for an alternative to be considered eligible for selection. The next five of the nine criteria (referred to as “balancing criteria” under CERCLA or “remedy selection decision standards” under RCRA Corrective Action) are used to make comparisons among alternatives. The final two modifying criteria are used to incorporate regulatory and public concerns and comments into the consideration of alternatives. Descriptions of these three categories of criteria are presented below.

5.4.1.1 Threshold Criteria/Corrective Action Standards

This section presents the threshold criteria/corrective action standards.

Protect Human Health and the Environment, Attain Media Cleanup Goals, and Control Sources of Releases. This criterion must be met for an alternative to be eligible for selection and is used to assess whether and how the alternative achieves and maintains protection of human health and the environment. In accordance with 40 CFR Section 300.430(e)(9)(iii)(A), the evaluation of this criterion uses the assessments conducted under the other evaluation criteria, especially the remedy's long-term effectiveness and permanence, short-term effectiveness, and compliance with ARARs—and evaluates how risks are eliminated, reduced, or controlled through treatment or engineering or administrative controls. Overall protection to human health and the environment considers both reduction in baseline risks (risks associated with not implementing the remedial alternative), as well as protection of human health and the environment from affects caused by implementing the remedial alternative. This criterion is summarized by addressing:

TABLE 5-4
Remedial Alternative Evaluation Criteria
Final Groundwater Corrective Measures Study/Feasibility Study for SWMU 1/AOC 1 and AOC 10, PG&E Topock Compressor Station, Needles, California

RCRA Corrective Action (DTSC, 1996)	CERCLA (40 CFR Part 300.430)	Combined RCRA/CERCLA Criteria
Corrective Action Standards	**Threshold Criteria**	**Threshold Criteria/Corrective Action Standards**
• Be protective of human health and the environment • Attain media cleanup standards • Control sources of releases • Comply with applicable standards for management of wastes generated by the corrective action	• Overall protection of human health and the environment • Compliance with ARARs	• Protect human health and the environment, attain media cleanup goals, and control sources of releases • Comply with ARARs, including applicable standards for management of wastes generated by the remedial action
Remedy Selection Decision Factors	**Balancing Criteria**	**Balancing Criteria/Remedy Selection Decision Factors**
• Long-term effectiveness and reliability • Reduction of toxicity, mobility, or volume through treatment • Short-term effectiveness • Implementability • Cost	• Long-term effectiveness and permanence • Reduction of toxicity, mobility, or volume through treatment • Short-term effectiveness • Implementability • Cost	• Long-term effectiveness, permanence, and reliability • Reduction of toxicity, mobility, or volume through treatment • Short-term effectiveness • Implementability • Cost
	Modifying Criteria	**Modifying Criteria**
	• State acceptance • Community acceptance	• State acceptance • Community acceptance

- Protect human health and the environment.
- Attain media cleanup goals.
- Control sources of releases.

Comply with ARARs. This criterion evaluates whether each alternative would attain federal and state ARARs or whether there is a basis for invoking one of the statutory ARAR waivers with respect to an alternative. The ARARs for the Topock site are identified in Appendix B. ARARs include:

- Chemical-specific ARARS.
- Location-specific ARARs.
- Action-specific ARARs, including standards for management of wastes generated by the remedial action.

5.4.1.2 Balancing Criteria/Remedy Selection Decision Standards

This section presents the balancing criteria/remedy selection decision standards.

Long-term Effectiveness, Permanence, and Reliability. Long-term effectiveness refers to the period after the remedial action is complete. This criterion evaluates: (1) the risk remaining (residual) at the site after RAOs have been achieved from treatment residuals or untreated waste and (2) the extent and effectiveness of controls for managing the risk posed by treatment residuals or untreated wastes. The residual risk from treatment residuals or untreated waste can be measured by chemical concentrations or volume of the material remaining at the site after the remedial action is complete. This criterion also assesses the degree of certainty that the alternative will prove successful and is summarized by addressing the:

- Magnitude of residual risk remaining from untreated waste or treatment residuals at the conclusion of the remedial activities.
- Adequacy and reliability of controls such as containment systems and institutional controls that are necessary to manage the untreated waste or to manage treatment residuals that remain at the site.

Reduction of Toxicity, Mobility, or Volume through Treatment. This criterion considers the degree to which alternatives employ treatment technologies—as well as the anticipated performance of the treatment technologies—by evaluating the amount of hazardous material treated and the amount remaining onsite. The evaluation considers the magnitude of the reductions in toxicity, mobility, or volume of chemicals and the extent to which the treatment is irreversible. This criterion is summarized by addressing the:

- Amount of plume destroyed or treated.
- Degree of expected reduction in toxicity, mobility, and volume.
- Degree treatment is irreversible.
- Type and quantity of residual remaining after treatment.

Short-term Effectiveness. This criterion evaluates the effects of the alternative during the construction and implementation period of the remedial alternative before and until the time the RAOs are achieved. It assesses the short-term implementation effects that could occur to the community, to workers, and to the environment during the remedial action. Protection of the community entails evaluation of effects such as dust, visual considerations, or transportation. Protection of workers during implementation addresses the reliability of protective measures during implementation. Protection of the environment considers potential affects on sensitive resources, including disturbance to cultural resources and wildlife. Additionally, this criterion evaluates the short-term and cross-media impacts that could occur during implementation of the remedy. General consideration of sustainability would also be included in this criterion. This criterion addresses the:

- Time until remedial action objectives are achieved.
- Protection of the community during remedial action.
- Protection of the workers during remedial action.
- Protection of the environment during remedial action.

Implementability. The technical and administrative feasibility of alternatives and the availability of various services and materials is evaluated to assess the remedy's implementability. The ability to construct, operate, and maintain the technology given the site-specific conditions and the ability to monitor effectiveness of the remedy are the factors that comprise the technical implementability criterion. Administrative feasibility is defined as the ability to obtain approvals, rights of way, and permits (for offsite actions) and other administrative activities from other agencies. The availability of services and materials considers offsite treatment, storage capacity, disposal capacity, and services; necessary equipment and specialists; and other services and materials needed to implement the alternative. This criterion is summarized by addressing the:

- Technical feasibility.
- Administrative feasibility.
- Availability of services and materials.

Cost. This criterion includes an evaluation of the direct and indirect capital costs required to implement the alternative, as well as the annual operation and maintenance costs. The costs of each alternative are estimated to a level of accuracy of +50 to -30 percent, consistent with the preliminary nature of the design development (approximately 2 to 5 percent design development). This criterion is summarized by estimating the net present value of the alternative, as shown in Appendix D. Present-value analysis is a method to evaluate expenditures, either capital or operation and maintenance, that occur over different time periods. This standard methodology allows for cost comparisons of different remedial alternatives on the basis of a single cost figure for each alternative. Both the CACA (DTSC, 1996) and the NCP (40 CFR 300.430) require estimation of the net present value of capital and operation and maintenance costs for remedial alternatives. For long-term projects (e.g., project duration exceeding 30 years), USEPA guidance recommends that the present-value analysis also include a "no discounting" scenario (USEPA, 2000).

5.4.1.3 Modifying Criteria

This section presents the modifying criteria.

State Acceptance. This criterion is broadly defined as addressing the technical concerns of state agencies. Assessment of state concerns may not be completed until after comments on the CMS/FS are received and evaluated. State concerns can then be fully discussed in the Proposed Plan for public comment. The state concerns that shall be assessed include:

- The state's position and key concerns related to the preferred alternative and other alternatives.

- State comments on ARARs or the proposed use of waivers.

Community Acceptance. Community acceptance evaluates the public's concerns about each alternative. This assessment includes determining which components of the alternatives interested persons in the community support, have reservations about, or oppose. This assessment may not be completed until comments on the Proposed Plan are received. Community acceptance can then be fully assessed in the Proposed Plan and Record of Decision and/or the RCRA Responsive Summary and Statement of Basis.

5.4.1.4 Tribal Consultation

Federal agency consultation, by and through the BLM in cooperation with FWS, Reclamation, and DOI, has been ongoing throughout the development of this CMS/FS to date. According to DOI, the investigation of groundwater contamination from the Topock Compressor Station has generated significant interest and involvement by several federally recognized tribes that have ties to the area. In particular, several tribes reviewed and provided comments on the Draft CMS/FS through the Consultative Workgroup process and through federal consultation with the federal agencies. The BLM, on behalf of the federal agencies involved, initiated government-to-government consultation, as well as consultation under the National Historic Preservation Act, with nine tribes seeking written comments on the Draft CMS/FS Report, dated January 2009. Federal consultation meetings were conducted with four of these tribes seeking additional tribal input on the alternatives evaluated by the CMS/FS.

Several tribes commented that the Draft CMS/FS Report did not fully evaluate whether and, if so, how each alternative would comply with many of the action and location-specific ARARs pertaining to the identification and mitigation of effects on cultural resources. This concern has been addressed in the Final CMS/FS Report and will continue to be addressed as a preferred alternative is proposed and a selected alternative is designed and implemented.

Some tribes expressed concern that their views regarding the significance of the cultural resources that potentially may be affected by remedial action had not been adequately articulated in the Draft CMS/FS Report. These tribes expressed strong beliefs that remedy selection decisions must fully consider the significance of the cultural resources at the site and the importance of mitigating effects on those resources that may be caused by the groundwater remedy. Tribal views regarding the significance of the cultural resources at issue and the importance of mitigating adverse effects on those resources have been and will continue to be solicited and incorporated into the decision-making process through the CEQA EIR process and through past and future consultation with the federal agencies.

Some tribes felt it was imperative that any remedy selected involve as little impact as possible to the site, including minimizing the number of wells installed and other ground-disturbing activities. In their view, the time required to attain cleanup standards was far less important than minimizing impacts to the site. Accordingly, these tribes expressed a preference for Alternatives A or B. These tribes rejected as too intrusive each of the other alternatives, with the possible exception of Alternative E. One tribe also expressed its strong belief that the existing groundwater treatment facility, built for IM No. 3, should not be included in any final remedy and should be removed as soon as possible.

Other tribes felt strongly about the need to address quickly the potential risks to human health and the environment and protect water quality in the Colorado River and Lake Havasu. These tribes expressed concern about the length of time that could be required to achieve cleanup objectives if Alternatives A or B were selected. These tribes were concerned that existing conditions could change over time, thereby raising questions about the long-term effectiveness of Alternatives A and B. These tribes supported the more active alternatives, notwithstanding the additional surface impacts that would result. These tribes expressed a strong preference for the final remedy to include *ex-situ* treatment to accelerate the time frame of achieving cleanup goals and so that Cr(VI) would be physically removed from the environment rather than converted to Cr(III).

Tribal consultation will continue going forward as a preferred alternative is identified in the Proposed Plan by the federal agencies, and the plan is issued for review and comment by the tribes and members of the public. Once a remedy is selected, federal consultation is expected to continue within the framework of a Programmatic Agreement executed pursuant to the National Historic Preservation Act to ensure that tribal input fully informs decisions pertaining to the design and implementation of the remedial action.

5.4.2 Alternative Analysis

The alternative analysis consists of two steps. The first step is the individual detailed analysis of each alternative against seven of the nine evaluation criteria (Section 5.4.1). This analysis is discussed in detail in Table 5-5.[10] The table identifies how key components of each remedy address the specific criteria. The second step is the comparative analysis of alternatives relative to each other. This analysis is presented in text of Section 5.5.

As discussed in Section 2.1.3, groundwater within the Cr(VI) plume area is not used for potable or other uses; therefore, no complete exposure pathway currently exists. In addition, available data show that the Cr(VI) is not affecting the beneficial uses of the Colorado River (CH2M HILL, 2009a). A number of California requirements, identified as ARARs, require that the ground and surface water on the site shall have the beneficial use designation of “suitable, or potentially suitable, for municipal or domestic water supply.” Therefore, even if it is unlikely that groundwater would be developed as a drinking water source in the future, this alternatives analysis applies a conservative cleanup criterion of background level of Cr(T) and Cr(VI) in groundwater. Therefore, the following analysis uses this conservative background level as the cleanup goal for Cr(VI) to increase the level of certainty that no exposure to Cr(VI) in the groundwater will occur in the future.

5.5 Comparative Analysis of Alternatives

In this section, the results of the individual detailed analysis, shown in Table 5-5, are combined to identify the advantages and disadvantages of each alternative relative to one another. As discussed in Section 5.4, seven of the nine criteria are applied to this initial assessment; the last two modifying criteria of state acceptance and community acceptance will continue to be assessed through the public comment period and preparation of the

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[10] Only the threshold and balancing criteria are presented in the alternatives analysis in the CMS/FS. The modifying criteria of state and community acceptance will continue to be evaluated following receipt of agency and stakeholder comments on the Proposed Plan.

TABLE 5-5
Individual Detailed Analysis of Remedial Alternatives against Seven Criteria
Final Groundwater Corrective Measures Study/Feasibility Study for SWMU 1/AOC 1 and AOC 10, PG&E Topock Compressor Station, Needles, California

Alternative	Protect Human Health and the Environment Attain Media Cleanup Goals and Control Source of Releases	Comply with ARARs	Long-term Effectiveness, Permanence and Reliability	Reduction of Toxicity, Mobility, or Volume through Treatment	Short-term Effectiveness	Implementability	Cost Net Present Value
Alternative A – No Action	**Protect Human Health and the Environment.** This alternative would not provide additional protection of human health or the environment at the site, and therefore does not meet this threshold criterion No active remediation would occur under this alternative, and no institutional controls would exist to prohibit groundwater use for potable water supply in the short term. The existing plume would be left on surrounding landowner property without ongoing oversight. This alternative would not include monitoring to verify effectiveness of natural recovery process in fluvial sediments near the river over time, or to assess the effectiveness of natural recovery processes in the East Ravine bedrock. Because there would be no remedial facilities, there would be no disruption to sensitive resources during implementation of the action. **Attain Media Cleanup Goals.** The estimated time to attain RAOs for this alternative is between 220 and 2,200 years, as this alternative relies on natural groundwater flow towards and through the reducing materials near the Colorado River. The estimated time to achieve the RAOs was based on the simulated time to remove 98 percent of the Cr(VI) mass within the plume. The amount of Cr(VI) mass within the East Ravine bedrock is estimated to be less than one percent of the total plume mass, and therefore does not significantly affect the simulated time to cleanup. **Control Sources of Releases.** The historic practice of wastewater discharge to Bat Cave Wash and the use of hexavalent chromium at the site have been eliminated. Therefore, sources of wastewater discharge and hexavalent chromium have been controlled. However, the historic source of contaminated groundwater in bedrock at AOC 10 has not yet been determined and the evaluation of whether leaching of soil contamination to groundwater represents a significant transport pathway has not yet been completed.	**Chemical-specific ARARs.** Chemical-specific requirements would not be met. Because concentrations of chromium in groundwater would remain above MCLs for approximately 1,000 years without an institutional control preventing development as a drinking water supply, this alternative will not comply with federal (40 CFR Part 141-Subpart G) and California (22 CCR Division 4, Chapter 15) Drinking Water Act requirements for Cr(T) in groundwater used as a public water supply during this time. It would also not comply with water quality objectives for groundwater established in the Water Quality Control Plan for the Colorado River Basin, which are based on MCLs. This alternative is considered to comply with the Federal Water Pollution Control Act because surface water samples collected within the river near the site, both before and after implementation of the IM, show concentrations less than federal water quality criteria (40 CFR 131.38) for Cr(VI), and naturally occurring reducing conditions in sediments near the Colorado River and/or dilution provided by the river are expected to continue to prevent contaminated groundwater from causing exceedances of these standards in the river. However, over the centuries required for this alternative to achieve cleanup goals, these conditions may change, potentially resulting in a change in compliance status. In addition, further studies will be conducted during remedial design to assess the effectiveness of long-term natural attenuation in the East Ravine to attain water quality criteria. **Location-specific ARARs.** Location-specific requirements would not be triggered because no action is being taken. **Action-specific ARARs, including standards for management of wastes generated by the remedial action.** Action-specific requirements would not be met. This alternative does not comply with California State Water Board Resolution 92-49. Requirement to implement land-use covenant at property not suitable for unrestricted use will not be met (22 CCR 67391.1). Because no action is being taken, other action-specific requirements are not triggered.	**Magnitude of Residual Risk.** Alternative A would rely on natural attenuation processes to attain the cleanup goals. Without monitoring or further investigation activity; however, there would be no way to assess when the RAOs have been achieved or determine the magnitude of risk from residual contamination. Future changes in geochemistry or hydrogeologic characteristics would not be identified. Future exposure to contamination and impacts to the Colorado River or other receptors would not be detected. **Adequacy and Reliability of Controls.** Five year reviews would not be conducted. No long-term containment systems are required and no land disposal of treatment residuals is expected.	**Amount of Plume Destroyed or Treated.** As described in the RFI/RI Volume 2 Report (CH2M HILL, 2009a) and the *Phase II Anaerobic Core Testing Summary Report, PG&E Topock Compressor Station, Needles, California* (CH2M HILL, 2008e), site characterization data and laboratory testing support that there is significant reduction capacity in the anaerobic alluvial aquifer materials to reduce and remove Cr(VI) from groundwater. The results suggest that there is sufficient capacity within the floodplain and beneath the river to reduce at least a significant portion of the Cr(VI) plume were the plume to come in contact with these sediments. However, the extent and average capacity of this area to reduce Cr(VI) will remain an estimate, as it is not possible to quantify these properties at all locations. In addition, further studies to assess the effectiveness of long-term natural attenuation in the East Ravine will continue during remedial design. **Degree of Expected Reduction in Toxicity, Mobility, and Volume**. This alternative relies on the natural recovery processes near the Colorado river to biochemically convert Cr(VI) to Cr(T), reducing the toxicity and mobility of the site contaminants. Cr(III) is a less toxic and essentially immobile form of chromium. **Degree Treatment is Irreversible.** Once reduced to Cr(III), chromium takes the form of the Cr^{3+} ion and forms very low solubility oxides under the neutral and alkaline pH encountered in site groundwater. Solubility of chromium oxide Cr_2O_3 and chromium hydroxide, $Cr(OH)_3$, are low enough to maintain the Cr^{3+} concentration below the detection limit of 0.2 µg/L (Brookins, 1988; Schecher and McAvoy, 1998). Once reduced, Cr(III) does not readily become reoxidized to Cr(VI); however, Cr(III) that comes into contact with manganese oxide (MnO_2) or dissolved oxygen can be re-oxidized to Cr(VI), leading to increased concentrations of Cr(VI) over time. Two key factors are expected to limit the re-conversion of Cr(III) to Cr(VI) after *in-situ* reduction: the limited solubility of Cr(III) and the lack of availability and reactivity of an adequate oxidizer (MnO_2). Together these factors are expected to limit any reoxidized Cr(VI) concentrations to levels similar to ambient background levels. **Type and Quantity of Residual Remaining After Treatment**. The most significant residual byproducts will be manganese and arsenic, natural constituents of the aquifer matrix released into solution by reduction reactions. Because of the uncertainties associated with the aquifer complexities, there is the potential for elevated byproduct concentrations persisting in some portions of the aquifer. Once released, the reduced forms of manganese and arsenic will likely be attenuated through precipitation, sorption, diffusion, and co-precipitation.	**Protection of the Community During Remedial Action.** There would be no institutional control to prohibit use of groundwater prior to achieving the cleanup goals. While the groundwater is not currently used as a potable water source, the lack of institutional controls results in Alternative A ranked as not effective for controlling exposure in the short term. There would be no short-term disturbance to the community from construction, as no active construction or operational activities would occur under this alternative. **Protection of Workers During Remedial Action.** There would be no short-term disturbance to workers from construction, as no active construction or operational activities would occur under this alternative. **Protection of the Environment During Remedial Action.** There would be no short-term disturbance to the environment from construction, as no active construction or operational activities would occur under this alternative. **Time Until RAOs are Achieved.** It is estimated that between 220 and 2,200 years would be required to achieve the RAOs within the alluvial aquifer for this alternative. The estimated time to achieve the RAOs was based on the simulated time to remove 98 percent of the Cr(VI) mass within the plume. The amount of Cr(VI) mass within the East Ravine bedrock is estimated to be less than one percent of the total plume mass, and therefore does not significantly affect the simulated time to cleanup.	**Technical Feasibility.** No active construction or operational activities would occur under this alternative. **Administrative Feasibility.** Administratively this alternative would not likely be acceptable with other agencies and surrounding landowners and would require a high level of coordination to gain approval. **Availability of Services and Materials.** No active construction or operational activities would occur under this alternative.	$0

TABLE 5-5
Individual Detailed Analysis of Remedial Alternatives against Seven Criteria
Final Groundwater Corrective Measures Study/Feasibility Study for SWMU 1/AOC 1 and AOC 10, PG&E Topock Compressor Station, Needles, California

Alternative	Protect Human Health and the Environment Attain Media Cleanup Goals and Control Source of Releases	Comply with ARARs	Long-term Effectiveness, Permanence and Reliability	Reduction of Toxicity, Mobility, or Volume through Treatment	Short-term Effectiveness	Implementability	Cost Net Present Value
Alternative B – Monitored Natural Attenuation (MNA)	**Protect Human Health and the Environment.** Under Alternative B, treatment of chromium would occur within the natural reducing conditions of the fluvial sediments near the Colorado River to convert Cr(VI) to Cr(T). Existing surface water data show that Cr(VI) concentrations in the Colorado River are below water quality standards (CH2M HILL, 2009A). However, ongoing monitoring would be needed to assure continued protection of the river over the long duration of this remedy. Because of the slow movement of groundwater at the site, many centuries would pass before the Cr(VI) concentrations everywhere in the plume reached cleanup goals. During this long period of time, changes in groundwater flow directions or geochemical conditions in the reducing zone around the river could occur, which leads to uncertainty in the long-term protectiveness of this alternative. In addition, further studies o assess the effectiveness of long-term natural attenuation in the East Ravine will continue during remedial design. Alternative B protects human health by administration of an institutional control limiting exposure through restriction of groundwater use for potable supply until cleanup goals are met. There would be minimal remedial facilities (construction and sampling of monitoring wells) and therefore minimal disruption to sensitive resources during implementation of the action. Steps would be taken during construction and operation to limit disturbance to sensitive resources. Steps to limit disturbance to sensitive resources may include moving locations of infrastructure away from sensitive resources, modification of construction techniques (e.g., equipment or schedules), and modification of design elements (e.g., materials, configurations, sizes). Steps may also include programmatic elements such as awareness training for site personnel. **Attain Media Cleanup Goals.** The time to achieve RAOs for this alternative is estimated to be between 220 and 2,200 years because the alternative relies on natural groundwater flow towards and through the reducing soils near the Colorado The estimated time to achieve the RAOs was based on the simulated time to remove 98 percent of the Cr(VI) mass within the plume. The amount of Cr(VI) mass within the East Ravine bedrock is estimated to be less	**Chemical-specific ARARs.** Chemical-specific requirements will be met. Concentrations of chromium in groundwater would remain above MCLs for a period estimated to range from 220 to 2,200 years; however, during this period, an institutional control would prevent development as a drinking water supply; therefore, this alternative is considered to comply with federal (40 CFR Part 141-Subpart G) and California (22 CCR Division 4, Chapter 15) Drinking Water Act requirements for Cr(T) in groundwater delivered by a public water supply system. This alternative is considered to comply with the Federal Water Pollution Control Act because surface water samples collected within the river near the site, both before and after implementation of the IM, show concentrations less than federal water quality criteria (40 CFR 131.38) for Cr(VI), and naturally occurring reducing conditions in sediments near the Colorado River and dilution provided by the river are expected to continue to prevent contaminated groundwater from causing exceedances of these standards in the river. However, over the centuries required for this alternative to achieve cleanup goals, these conditions may change, potentially resulting in a change in compliance status. In addition, further studies will be conducted during remedial design to assess the effectiveness of long-term natural attenuation in the East Ravine bedrock to attain water quality criteria. **Location-specific ARARs.** Location-specific requirements will be met. Because surface water bodies are not being modified, USFWS coordination requirements (40 CFR 6.201) will not be triggered. Because RCRA-regulated treatment systems will not be constructed in a floodplain or seismic zone, RCRA seismic and floodplain requirements (40 CFR 264.18) will not be triggered. Construction of wells in floodplain or wetland areas will be performed in a manner that complies with federal floodplain and wetlands protection requirements (40 CFR 6.201). Steps will be taken during design and implementation to ensure compatibility with the National Wildlife Refuge System Administration Act. The requirements of the National Historic Preservation Act (16 U.S.C. § 470, *et seq*.) are applicable based on the presence of and potential impact to historic properties listed on, or eligible for listing on, the National Register of Historic Places. Other cultural resource requirements include those of the National Archaeological and Historic Preservation Act (16 U.S.C. § 469, *et seq*.), the Native American Graves Protection and Repatriation Act (25 U.S.C. § 3001, *et seq.*), and the Archaeological Resources Protection Act (16 U.S.C. § 470aa-ii, *et seq*.). The requirements of the Historic Sites Act (16 U.S.C. § 461 *et seq.*), may apply to Route 66. In addition, there may be applicable requirements of Pub. L. 106-45 to preserve Route 66. Location and action-specific religious freedom requirements are set forth in the American Indian Religious Freedom Act and Religious Freedom Restoration Act. As a threshold matter, this alternative cannot be eliminated for an inability to attain the various cultural resource ARARs. As the remedy selection process continues	**Magnitude of Residual Risk.** Similar to Alternative A, this alternative would rely on natural attenuation processes to attain the cleanup goals. Risk from residual contamination would be reduced as Cr(VI) mass within the plume is treated. **Adequacy and Reliability of Controls.** No controls would be included in this alternative following attainment of the RAOs. The reducing conditions in the shallow floodplain and beneath the river have been shown to be present at every location investigated and are expected to effectively treat the Cr(VI). However, the extent and average capacity of this area to reduce Cr(VI) will remain an estimate, as it is not possible to quantify these properties at all locations. In addition, further studies to assess the effectiveness of long-term natural attenuation in the East Ravine will continue during remedial design. Five-year reviews would be required for this alternative. No long-term containment systems are required and no land disposal of treatment residuals is expected.	**Amount of Plume Destroyed or Treated.** As described for Alternative A, site characterization data and laboratory testing support that there is significant reduction capacity in the anaerobic alluvial aquifer materials to reduce and remove Cr(VI) from groundwater. The results suggest that there is sufficient capacity within the floodplain and beneath the river to reduce at least a significant portion of the Cr(VI) plume were the plume to come in contact with these sediments. However, the extent and average capacity of this area to reduce Cr(VI) will remain an estimate, as it is not possible to quantify these properties at all locations. In addition, further studies to assess the effectiveness of long-term natural attenuation in the East Ravine will continue during remedial design. In contrast to Alternative A, this alternative would include monitoring to verify the effectiveness of the reducing zone over time. **Degree of Expected Reduction in Toxicity, Mobility, and Volume**. This alternative relies on the natural recovery processes near the Colorado river to biochemically convert Cr(VI) to Cr(T) in the groundwater plume to insoluble Cr(III) that precipitates out of solution and remains in the formation, reducing the toxicity and mobility of the site contaminants. Cr(III) is a less toxic and essentially immobile form of chromium **Degree Treatment is Irreversible.** Once reduced to Cr(III), chromium takes the form of the Cr^{3+} ion and forms very low solubility oxides under the neutral and alkaline pH encountered in site groundwater. Solubility of chromium oxide Cr_2O_3 and chromium hydroxide, $Cr(OH)_3$, are low enough to maintain the Cr^{3+} concentration below the detection limit of 0.2 µg/L (Brookins, 1988; Schecher and McAvoy, 1998). Once reduced, Cr(III) does not readily become reoxidized to Cr(VI); however, Cr(III) that comes into contact with manganese oxide (MnO_2) or dissolved oxygen can be re-oxidized to Cr(VI), leading to increased concentrations of Cr(VI) over time. Two key factors are expected to limit the re-conversion of Cr(III) to Cr(VI) after *in-situ* reduction: the limited solubility of Cr(III) and the lack of availability and reactivity of an adequate oxidizer (MnO_2). Together these factors are expected to limit any reoxidized Cr(VI) concentrations to levels similar to ambient background levels. **Type and Quantity of Residual Remaining After Treatment**. The most significant residual byproducts will be manganese and arsenic, natural constituents of the aquifer matrix released into solution by reduction reactions. Because of the uncertainties associated with the aquifer complexities, there is the potential for elevated byproduct concentrations persisting in some portions of the aquifer. Once released, the reduced forms of manganese and arsenic will likely be attenuated through precipitation, sorption, diffusion, and co-precipitation.	**Protection of the Community During Remedial Action.** During this period, institutional controls would be in effect to prohibit the future use of the groundwater for drinking water. Monitoring would be ongoing to verify the effectiveness of the reducing conditions in the fluvial sediments to provide a natural geochemical barrier to the Colorado River. The community would face limited disturbance from construction noise, physical hazards such as traffic, material transport from installation, and sampling of monitoring wells. Risks can be reduced through proper controls during construction and monitoring. **Protection of Workers During Remedial Action.** Workers would face general site hazards including heavy equipment, occupational noise exposure, slip and fall, etc. during well installation and sampling. General site hazards would be reduced by site-specific health and safety plans and safety equipment. Workers would be required to wear appropriate personal protective equipment and use best management practices to minimize exposure. **Protection of the Environment During Remedial Action.** Potential disturbance to the environmental impacts would be limited to well construction and ongoing monitoring. Measures will be taken during well construction and sampling to minimize environmental disturbance. Additional protections to the environment and community will be through compliance with ARARs such as for floodplain and wetland protection requirements. Preliminary design estimates suggest that 28 additional monitoring well locations would be required for this alternative. **Time Until RAOs are Achieved.** It is estimated that between 220 and 2,200 years would be required to achieve the RAOs for this alternative. The estimated time to achieve the RAOs was based on the simulated time to remove 98 percent of the Cr(VI) mass within the plume. The amount of Cr(VI) mass within the East Ravine bedrock is estimated to be less than one percent of the total plume mass, and therefore does not significantly affect the simulated time to	**Technical Feasibility.** MNA is technically implementable. Primary technology is installation, maintenance, and sampling of monitoring wells, which have been shown to be technically implementable at this site. Monitoring wells have been shown to be effective at monitoring the geochemical conditions in the floodplain during the RFI/RI and IM. **Administrative Feasibility.** MNA is administratively implementable. No offsite actions would be associated with MNA that would require permits from other agencies. The existing monitoring network is located off of PG&E property, so installation of any new monitoring facilities to supplement or replace existing monitoring facilities would have to be coordinated with and approved by the respective landowners. There may be challenges associated with administrative requirements of location-specific ARARs, such as archeological recordation. This alternative would include administration of an institutional control to prohibit use of groundwater within the plume until attainment of cleanup goals; the institutional control would need to be coordinated with the various landowners that overlie the plume. **Availability of Services and Materials.** Services, equipment, and materials for installation of additional groundwater monitoring wells are readily available. Some specialized equipment may be needed for construction of wells on the floodplain or construction of additional slant wells; however, these services can be made available. Disposal facilities for drill cuttings or development water generated from the well installation are widely available.	\$25,000,000 - \$54,000,000

TABLE 5-5
Individual Detailed Analysis of Remedial Alternatives against Seven Criteria
Final Groundwater Corrective Measures Study/Feasibility Study for SWMU 1/AOC 1 and AOC 10, PG&E Topock Compressor Station, Needles, California

Alternative	Protect Human Health and the Environment Attain Media Cleanup Goals and Control Source of Releases	Comply with ARARs	Long-term Effectiveness, Permanence and Reliability	Reduction of Toxicity, Mobility, or Volume through Treatment	Short-term Effectiveness	Implementability	Cost Net Present Value
	than one percent of the total plume mass, and therefore does not significantly affect the simulated time to cleanup. **<u>Control Sources of Releases.</u>** The historic practice of wastewater discharge to Bat Cave Wash and the use of hexavalent chromium at the site have been eliminated; therefore, sources of wastewater discharge and hexavalent chromium have been controlled. However, the historic source of contaminated groundwater in bedrock at AOC 10 has not yet been determined and the evaluation of whether leaching of soil contamination to groundwater represents a significant transport pathway has not yet been completed.	through the issuance of a Proposed Plan and the Record of Decision and a remedy is designed and implemented, the federal agencies will continue to engage in consultation with tribes, State Historic Preservation Officers, and others to identify potential effects on cultural resources and evaluate and implement reasonable and prudent mitigation measures, thereby ensuring that the selected remedy attains these ARARs. **<u>Action-specific ARARs, including standards for management of wastes generated by the remedial action.</u>** Most but not all action-specific requirements will be met. There will be no discharge of fill to wetlands or waterways (40 CFR 230.10), point source discharge of pollutants to waters of the United States (40 CFR Parts 122, 125), or other activities that alter the course, condition, or capacity of navigable waters (33 U.S.C. § 401 and 403). Remedial activities will comply with applicable National Pollutant Discharge Elimination System [NPDES] construction stormwater requirements (40 CFR 122.26). Remedial activities will not emit regulated hazardous air pollutants (40 CFR Parts 61, 63). Installation of monitoring wells will be performed in a manner that does not result in a "take" of threatened or endangered species, damage their critical habitat (50 CFR part 402), or impact migratory birds (15 USC § 703-712). Waste generated during remedial activities will be handled in compliance with hazardous waste generator requirements (22 CCR Division 4.5, Chapters 11, 12, 18). Regulated waste piles, tank systems, landfills, and miscellaneous units will not be constructed. Monitoring will be performed in accordance with RCRA (22 CCR Division 4.5, Ch. 14, Article 6) and California Water Code (23 CCR Div. 3, Chapter 15; 27 CCR Div. 2, Subdivision 1; Calif. Water Code Section 13801(c)) monitoring requirements. Because RAOs will achieve background levels for chromium, this alternative is consistent with the substantive provisions of State Water Resources Control Board (SWRCB) Resolution 68-16 that requires maintenance of the highest water quality consistent with maximum benefit to the people of the State. It will also result in achieving Basin Plan water quality objectives for chromium in groundwater. This alternative will not comply with California State Water Board Resolution 92-49. Appropriate land use covenants will be implemented (22 CCR 67391.1).			cleanup.		

TABLE 5-5
Individual Detailed Analysis of Remedial Alternatives against Seven Criteria
Final Groundwater Corrective Measures Study/Feasibility Study for SWMU 1/AOC 1 and AOC 10, PG&E Topock Compressor Station, Needles, California

Alternative	Protect Human Health and the Environment Attain Media Cleanup Goals and Control Source of Releases	Comply with ARARs	Long-term Effectiveness, Permanence and Reliability	Reduction of Toxicity, Mobility, or Volume through Treatment	Short-term Effectiveness	Implementability	Cost Net Present Value
Alternative C - High-volume *In-situ* Treatment	**Protect Human Health and the Environment.** Alternative C would protect human health and the environment in the long term through reduction of Cr(VI) concentrations in groundwater by *in-situ* treatment. Monitoring would provide data to evaluate the effectiveness of *in-situ* treatment. This alternative protects human health in the short term by limiting exposure through restriction of groundwater use as a potable water source until cleanup goals are met. Alternative C includes floodplain cleanup (mass removal and establishment of geochemical barrier) as the initial step in implementation, thereby providing additional protection to the river. Alternative C also includes extraction within the East Ravine bedrock to provide hydraulic control of East Ravine groundwater. This alternative involves construction and operation of active treatment facilities, including wells, pipelines, and tanks. Steps would be taken during construction and operation of the remedial facilities to limit disturbance to sensitive resources. Steps to limit disturbance to sensitive resources may include moving locations of infrastructure away from sensitive resources, modification of construction techniques (e.g., equipment or schedules), modification of design elements (e.g., materials, configurations, sizes). Steps may also include programmatic elements such as awareness training for site personnel. **Attain Media Cleanup Goals.** Alternative C includes *in-situ* treatment to attain cleanup goals for constituents in groundwater. The treated water would meet the chemical specific ARARs. **Control Sources of Releases.** The historic practice of wastewater discharge to Bat Cave Wash and the use of hexavalent chromium at the site have been eliminated. Therefore, sources of wastewater discharge and hexavalent chromium have been controlled. However, the historic source of contaminated groundwater in bedrock at AOC 10 has not yet been determined, and the evaluation of whether leaching of soil contamination to groundwater represents a significant transport pathway has not yet been completed.	**Chemical-specific ARARs.** Chemical-specific requirements will be met. By achieving cleanup goals less than MCLs, the remedy will comply with federal (40 CFR Part 141-Subpart G) and California (22 CCR Division 4, Chapter 15) Drinking Water Act requirements for Cr(T) in groundwater delivered by a public water supply system. This alternative is considered to comply with the Federal Water Pollution Control Act because surface water samples collected within the river near the site, both before and after implementation of the IM, show concentrations less than federal water quality criteria (40 CFR 131.38) for Cr(VI), and naturally occurring reducing conditions in sediments near the Colorado River and dilution provided by the river are expected to continue to prevent contaminated groundwater from causing exceedances of these standards in the river prior to remedy completion. By achieving cleanup goals in groundwater, the remedy will provide additional certainty that contaminated groundwater will not cause exceedances of Federal water quality criteria established under the federal Water Pollution Control Act (40 CFR 131.38) for Cr(VI) in the Colorado River in the long term. **Location-specific ARARs.** Location-specific requirements will be met. Because surface water bodies are not being modified, USFWS coordination requirements (40 CFR 6.201) will not be triggered. Because RCRA-regulated treatment systems will not be constructed in a floodplain or seismic zone, RCRA seismic and floodplain requirements (40 CFR 264.18) will not be triggered. Construction of wells and piping in floodplain or wetland areas will be performed in a manner that complies with federal floodplain and wetlands protection requirements (40 CFR 6.201). Steps will be taken during design and implementation to ensure compatibility with the National Wildlife Refuge System Administration Act. The requirements of the National Historic Preservation Act, 16 U.S.C. § 470, *et seq*., are applicable based on the presence of and potential impact to historic properties listed on, or eligible for listing on, the National Register of Historic Places. Other cultural resource requirements include those of the National Archaeological and Historic Preservation Act, 16 U.S.C. § 469, *et seq*., the Native American Graves Protection and Repatriation Act, 25 U.S.C. § 3001, *et seq.*, and the Archaeological Resources Protection Act, 16 U.S.C. § 470aa-ii, *et seq*. The requirements of the Historic Sites Act, 16 U.S.C. § 461 *et seq*., may apply to Route 66. In addition, there may be applicable requirements of Pub. L. 106-45 to preserve Route 66. Location and action-specific religious freedom requirements are set forth in the American Indian Religious Freedom Act and Religious Freedom Restoration Act. As a threshold matter, this alternative cannot be eliminated for an inability to attain the various cultural resource ARARs. As the remedy selection process continues through the issuance of a Proposed Plan and the Record of Decision and a remedy is designed and implemented, the federal agencies will continue to engage in consultation with tribes, State Historic Preservation	**Magnitude of Residual Risk.** Alternative C includes active *in-situ* treatment to attain cleanup goals for Cr(VI) in groundwater. Alternative C includes a group of bedrock extraction wells in the eastern (downgradient) end of the East Ravine, with the water from the bedrock extraction wells managed within the active treatment system for the alluvial aquifer. Risk from residual contamination would be reduced as Cr(VI) mass within the plume is treated. **Adequacy and Reliability of Controls.** *In-situ* technology has not often been applied to treat an entire plume of this size and depth. There is uncertainty associated with achieving complete distribution of carbon source substrate across this large of an area. Incomplete distribution can be overcome by achieving sufficient coverage to allow natural groundwater flow to transport any residual untreated chromium (that is not treated directly) to an adjacent treatment zone. Incomplete coverage also can be addressed through optimization of the remedy during implementation, which would involve additional dosing in areas where complete coverage was not achieved during the initial dose. Alternative C also requires the balanced operation of extraction wells and injection wells to meet the goal of reductant delivery across the entire plume while at the same time maintaining hydraulic containment of the plume. If an injection well is operated at too high a rate, it is possible that the pumping rate at a downgradient extraction well will be too low to maintain hydraulic containment. Flow adjustments in individual wells are possible but because the total rate of injection must equal the total rate of extraction, increases in pumping rates at one well will mean that pumping rates at other wells need to be reduced. Actual operation of a wellfield, as envisioned in Alternative C, will require a complex and continuous interplay between pumping rates, injection rates, water levels observed in monitoring wells and the stage in the Colorado River. Alternative C includes pumping within the East Ravine bedrock to ensure hydraulic control of East Ravine groundwater. Once the remedy is completed, monitoring inside and outside the plume and continued enforcement of institutional controls may be required to assess treatment byproducts. Five-year reviews would be required for this alternative.	**Amount of Plume Destroyed or Treated.** The intent of this alternative is to address the entire area of groundwater where Cr(VI) concentrations are higher than 32 µg/L. Alternative C also includes extraction within the East Ravine bedrock to provide hydraulic control of East Ravine groundwater. If it is determined that additional remedial effort is needed to reach RAOs in East Ravine bedrock, other technologies could be applied to supplement the pumping wells. In addition to pumping for hydraulic control, technologies that may be applicable to East Ravine bedrock would include, but are not limited to, freshwater injection for flushing and injection of carbon amendments for *in-situ* reduction of Cr(VI). The mass of Cr(VI) in East Ravine bedrock is estimated to be less than one percent of the total Cr(VI) plume mass. **Degree of Expected Reduction in Toxicity, Mobility, and Volume**. Alternative C includes *in-situ* treatment by distributing an organic carbon substrate throughout the plume to create geochemically-reduced conditions to convert Cr(VI) in groundwater to insoluble Cr(III), thereby reducing the toxicity and mobility of the site contaminants. Alternative C also includes extraction within the East Ravine bedrock to provide hydraulic control of East Ravine groundwater. **Degree Treatment is Irreversible.** The degree of reversibility of the Cr(VI) reduction reaction is expected to ultimately result in Cr(VI) concentrations at levels similar to ambient Cr(VI). **Type and Quantity of Residual Remaining After Treatment**. The most significant residual byproducts will be manganese and arsenic, natural constituents of the aquifer matrix released into solution by reduction reactions. Because of the uncertainties associated with the aquifer complexities, there is the potential for elevated byproduct concentrations persisting in some portions of the aquifer. Once released, the reduced forms of manganese and arsenic will likely be attenuated through precipitation, sorption, diffusion, and co-precipitation. Residual byproducts will be managed through careful system monitoring and operations both inside and outside the plume.	**Protection of the Community During Remedial Action.** The community would be protected during this period by prohibiting the use of the groundwater for drinking water through institutional controls. Treatment byproducts could be temporarily elevated within portions of the treatment zone (Appendix E) but are expected to reduce with time. Monitoring would be ongoing to verify the effectiveness of the reducing conditions in the fluvial sediments in providing a natural geochemical barrier to the Colorado River and to monitor for *in-situ* treatment byproducts. The community would face limited disturbance from construction noise, physical hazards such as traffic, material transport from construction, and operational activities. Risks can be reduced through proper controls during construction and operation. **Protection of Workers During Remedial Action.** Workers would face general site hazards including heavy equipment, occupational noise exposure, slip and fall, etc. General site hazards would be reduced by site-specific health and safety plans and safety equipment. Workers would be required to wear appropriate personal protective equipment and use best management practices to minimize exposure. **Protection of the Environment During Remedial Action.** Potential environmental impacts would be related to disturbance to the environment as a result of construction and operation. Preliminary design estimates suggest that this alternative would result in installation of approximately 111 remediation well locations, and , 32 monitoring well locations, piping, reagent storage and delivery systems, power, and instrumentation. Operation and maintenance activities would include periodic well maintenance, sample collection, refinement of the injection/recirculation systems, management of the reactant material, equipment inspections, and periodic replacement of wells and other structures that become clogged or damaged. Measures will be taken during construction, sampling, and operational activities to minimize environmental disturbance. This alternative includes infrastructure on the floodplain between National Trails Highway and the Colorado River.	**Technical Feasibility.** Alternative C is technically implementable. Installation of extraction wells, injections wells, pipelines, utilities, reagent storage and delivery systems, and process controls/instrumentation is technically implementable. Some wells may be challenging to install due to hydrogeologic conditions and excessive depths. Varied and abrupt topography and access limitations will present challenges to construction of wells, pipelines, and utilities, but the challenges can be overcome. This alternative includes installation of injection wells within Bat Cave Wash that will present challenges associated with maintaining protection against future damage or washout. Pilot testing has shown that *in-situ* treatment is technically implementable at this site. However, some uncertainty exists about the application of *in-situ* technology at this scale. Alternative C also requires the balanced operation of extraction wells and injection wells to meet the goal of reductant delivery across the entire plume while at the same time maintaining hydraulic containment of the plume. If an injection well is operated at too high a rate, it is possible that the pumping rate at a downgradient extraction well will be too low to maintain hydraulic containment. Flow adjustments in individual wells are possible but because the total rate of injection must equal the total rate of extraction, increases in pumping rates at one well will mean that pumping rates at other wells need to be reduced. Actual operation of a wellfield as envisioned in Alternative C will require a complex and continuous interplay between pumping rates, injection rates, water levels observed in monitoring wells and the stage in the Colorado River. Operation of the *in-situ* treatment system will require a high level of oversight during implementation to ensure that the system is optimized and modified as remediation progresses. **Administrative Feasibility.** Alternative C is administratively implementable. No offsite actions would be associated with Alternative C that would require permits from other agencies. Coordination and approval by respective landowners and leaseholders, including Burlington Northern-Santa Fe (BNSF), Caltrans, and other entities, would be required because installation of the extraction wells, injections wells, pipelines, utilities, reagent storage and delivery systems, and process controls/instrumentation would be	$119,000,000 - $255,000,000

TABLE 5-5
Individual Detailed Analysis of Remedial Alternatives against Seven Criteria
Final Groundwater Corrective Measures Study/Feasibility Study for SWMU 1/AOC 1 and AOC 10, PG&E Topock Compressor Station, Needles, California

Alternative	Protect Human Health and the Environment Attain Media Cleanup Goals and Control Source of Releases	Comply with ARARs	Long-term Effectiveness, Permanence and Reliability	Reduction of Toxicity, Mobility, or Volume through Treatment	Short-term Effectiveness	Implementability	Cost Net Present Value
		Officers, and others to identify potential effects on cultural resources and evaluate and implement reasonable and prudent mitigation measures, thereby ensuring that the selected remedy attains these ARARs. **<u>Action-specific ARARs, including standards for management of wastes generated by the remedial action.</u>** This alternative can be designed and implemented to attain action-specific requirements. Injection of reductant material and recirculation of groundwater will be performed in a manner that meets Federal Underground Injection Control requirements (40 CFR Parts 144-148). There will be no discharge of fill to wetlands or waterways (40 CFR 230.10), point source discharge of pollutants to waters of the United States (40 CFR Parts § 122, 125), or other activities that alter the course, condition, or capacity of navigable waters (33 USC 401 and 403). Remedial activities will comply with applicable NPDES construction stormwater requirements (40 CFR 122.26). Remedial activities will not emit regulated hazardous air pollutants (40 CFR Parts 61, 63). Installation of wells, piping, and reagent storage equipment will be performed in a manner that does not result in a "take" of threatened or endangered species, damage their critical habitat (50 CFR Part 402), or impact migratory birds (15 USC § 703-712). Waste generated during remedial activities will be handled in compliance with hazardous waste generator requirements (22 CCR Division 4.5, Chapters 11, 12, 18). Regulated waste piles, tank systems, landfills, and miscellaneous units will not be constructed. Monitoring will be performed in accordance with RCRA (22 CCR Division 4.5, Ch. 14, Article 6) and California Water Code (23 CCR Div. 3, Chapter 15; 27 CCR Div. 2, Subdivision 1; Calif. Water Code Section 13801(c)) monitoring requirements. Because RAOs will achieve background levels for chromium, this alternative is consistent with the substantive provisions of SWRCB Resolution 68-16 that requires maintenance of the highest water quality consistent with maximum benefit to the people of the State, and with the substantive provisions of SWRCB Resolution 92-49 that requires restoration of background water quality. It will also result in achieving Basin Plan water quality objectives for chromium in groundwater. Appropriate land use covenants will be implemented (22 CCR 67391.1).	No long-term containment systems are required and no land disposal of treatment residuals is expected.		Additional protections to the environment and community will be through compliance with ARARs such as for floodplain and wetland protection and stormwater requirements. **<u>Time Until RAOs are Achieved.</u>** It is estimated that 10 to 60 years would be required to achieve the RAOs for this alternative. The estimated time to achieve the RAOs was based on the simulated time to remove 98 percent of the Cr(VI) mass within the plume. The amount of Cr(VI) mass within the East Ravine bedrock is estimated to be less than one percent of the total plume mass, and therefore does not significantly affect the simulated time to cleanup.	constructed primarily outside of PG&E property. There may be challenges associated with administrative requirements of location-specific ARARs, such as archeological recordation. Administration of an institutional control to prohibit use of groundwater within the plume until attainment of cleanup goals would be required. The institutional control would need to be coordinated with the various landowners that overlie the plume. Water rights for the extraction systems under this alternative would be covered under existing remediation water rights so that no additional water rights would need to be procured. **<u>Availability of Services and Materials.</u>** Services, equipment, and materials for installation of the extraction wells, injections wells, pipelines, utilities, reagent storage and delivery systems, and process controls/instrumentation are readily available. Some specialized services may be needed for optimization of the reactant mix and delivery systems; however, these services can be made available. No wastes are produced from the *in-situ* treatment process that require offsite disposal. Offsite disposal facilities for drill cuttings or development water generated from the well installation are widely available.	

TABLE 5-5
Individual Detailed Analysis of Remedial Alternatives against Seven Criteria
Final Groundwater Corrective Measures Study/Feasibility Study for SWMU 1/AOC 1 and AOC 10, PG&E Topock Compressor Station, Needles, California

Alternative	Protect Human Health and the Environment Attain Media Cleanup Goals and Control Source of Releases	Comply with ARARs	Long-term Effectiveness, Permanence and Reliability	Reduction of Toxicity, Mobility, or Volume through Treatment	Short-term Effectiveness	Implementability	Cost Net Present Value
Alternative D - Sequential *In-situ* Treatment	**Protect Human Health and the Environment.** Alternative D would protect human health and the environment in the long term through reduction of Cr(VI) concentrations in groundwater by *in-situ* treatment. Monitoring would provide data to evaluate the effectiveness of *in-situ* treatment. This alternative protects human health in the short term by limiting exposure through restriction of groundwater use as potable water source until cleanup goals are met. Alternative D includes floodplain cleanup as the initial step in implementation, thereby providing additional protection to the river. Alternative D also includes extraction within the East Ravine bedrock to provide hydraulic control of East Ravine groundwater. This alternative involves construction and operation of active treatment facilities, including wells, pipelines, tanks, etc. Steps would be taken during construction and operation of the remedial facilities to limit disturbance to sensitive resources. Steps to limit disturbance to sensitive resources may include moving locations of infrastructure away from sensitive resources, modification of construction techniques (e.g., equipment or schedules), modification of design elements (e.g., materials, configurations, sizes). Steps may also include programmatic elements such as awareness training for site personnel. **Attain Media Cleanup Goals.** Alternative D includes *in-situ* treatment to attain cleanup goals for constituents in groundwater. **Control Sources of Releases.** The historic practice of wastewater discharge to Bat Cave Wash and the use of hexavalent chromium at the site have been eliminated; therefore, sources of wastewater discharge and hexavalent chromium have been controlled. However, the historic source of contaminated groundwater in bedrock at AOC 10 has not yet been determined, and the evaluation of whether leaching of soil contamination to groundwater represents a significant transport pathway has not yet been completed.	**Chemical-specific ARARs.** Chemical-specific requirements will be met. By achieving cleanup goals less than MCLs, the remedy will comply with federal (40 CFR Part 141-Subpart G) and California (22 CCR Division 4, Chapter 15) Drinking Water Act requirements for Cr(T) in groundwater delivered by a public water supply system. This alternative is considered to comply with the Federal Water Pollution Control Act because surface water samples collected within the River near the site, both before and after implementation of the IM, show concentrations less than federal water quality criteria (40 CFR 131.38) for Cr(VI), and naturally-occurring reducing conditions in sediments near the Colorado River and dilution provided by the river are expected to continue to prevent contaminated groundwater from causing exceedances of these standards in the river prior to remedy completion. By achieving cleanup goals in groundwater, the remedy will provide additional certainty that contaminated groundwater will not cause exceedances of federal water quality criteria established under the Federal Water Pollution Control Act (40 CFR 131.38) for Cr(VI) in the Colorado River in the long term. **Location-specific ARARs.** Location-specific requirements will be met. Because surface water bodies are not being modified, USFWS coordination (40 CFR 6.201) will not be triggered. Because RCRA-regulated treatment systems will not be constructed in a floodplain or seismic zone, RCRA seismic and floodplain requirements (40 CFR 264.18) will not be triggered. Construction of wells and piping in floodplain or wetland areas will be performed in a manner that complies with federal floodplain and wetlands protection requirements (40 CFR 6.201). Steps will be taken during design and implementation to ensure compatibility with the National Wildlife Refuge System Administration Act. The requirements of the National Historic Preservation Act (16 U.S.C. § 470, *et seq.*) are applicable based on the presence of and potential impact to historic properties listed on, or eligible for listing on, the National Register of Historic Places. Other cultural resource requirements include those of the National Archaeological and Historic Preservation Act (16 U.S.C. § 469, *et seq.*), the Native American Graves Protection and Repatriation Act (25 U.S.C. § 3001, *et seq.*), and the Archaeological Resources Protection Act (16 U.S.C. § 470aa-ii, *et seq.*). The requirements of the Historic Sites Act (16 U.S.C. § 461 *et seq.*) may apply to Route 66. In addition, there may be applicable requirements of Pub. L. 106-45 to preserve Route 66. Location and action-specific religious freedom requirements are set forth in the American Indian Religious Freedom Act and Religious Freedom Restoration Act. As a threshold matter, this alternative cannot be eliminated for an inability to attain the various cultural resource ARARs. As the remedy selection process continues through the issuance of a Proposed Plan and the Record of Decision and a remedy is designed and implemented, the federal agencies will continue to engage in consultation with tribes, State Historic Preservation Officers, and others to identify potential effects on cultural	**Magnitude of Residual Risk.** Alternative D includes active *in-situ* treatment to attain cleanup goals for Cr(VI) in groundwater. Alternative D includes a group of bedrock extraction wells in the eastern (downgradient) end of the East Ravine, with the water from the bedrock extraction wells managed within the active treatment system for the alluvial aquifer. Risk from residual contamination would be reduced as Cr(VI) mass within the plume is treated. **Adequacy and Reliability of Controls.** *In-situ* technology has not often been applied to treat an entire plume of this size and depth. Limitations for long-term success of this alternative are primarily associated with the ability to obtain complete distribution of substrates across the entire plume. There is uncertainty associated with achieving complete distribution of carbon source substrate across this large of an area. Incomplete distribution can be overcome by achieving sufficient coverage to allow natural groundwater flow to transport any residual untreated chromium (that is not treated directly) to an adjacent treatment zone. Incomplete coverage also can be addressed through optimization of the remedy during implementation, which would involve additional dosing in areas where complete coverage was not achieved during the initial dose. Alternative D includes pumping within the East Ravine bedrock to ensure hydraulic control of East Ravine groundwater. Once the remedy is completed, monitoring inside and outside the plume and continued enforcement of institutional controls may be required to assess *in-situ* treatment byproducts. Five-year reviews would be required for this alternative. No long-term containment systems are required and no land disposal of treatment residuals is expected.	**Amount of Plume Destroyed or Treated.** The intent of this alternative is to address the entire area of groundwater where Cr(VI) concentrations are higher than 32 µg/L. Alternative D also includes extraction within the East Ravine bedrock to provide hydraulic control of East Ravine groundwater. If it is determined that additional remedial effort is needed to reach RAOs in East Ravine bedrock, other technologies could be applied to supplement the pumping wells. In addition to pumping for hydraulic control, technologies that may be applicable to East Ravine bedrock would include, but are not limited to, freshwater injection for flushing and injection of carbon amendments for *in-situ* reduction of Cr(VI). The mass of Cr(VI) in East Ravine bedrock is estimated to be less than one percent of the total Cr(VI) plume mass. **Degree of Expected Reduction in Toxicity, Mobility, and Volume.** Alternative D includes *in-situ* treatment by distributing an organic carbon substrate throughout the plume to create geochemically-reduced conditions to convert Cr(VI) in groundwater to insoluble Cr(III) and thereby reducing the toxicity and mobility of the site contaminants. Alternative D also includes extraction within the East Ravine bedrock to provide hydraulic control of East Ravine groundwater. **Degree Treatment is Irreversible.** The degree of reversibility of the Cr(VI) reduction reaction is expected to ultimately result in Cr(VI) concentrations at levels similar to ambient Cr(VI) under the current pH conditions of aquifer. **Type and Quantity of Residual Remaining After Treatment.** The most significant residual byproducts will be manganese and arsenic, natural constituents of the aquifer matrix released into solution by reduction reactions. Because of the uncertainties associated with the aquifer complexities, there is the potential for elevated byproduct concentrations persisting in some portions of the aquifer. Once released, the reduced forms of manganese and arsenic will likely be attenuated through precipitation, sorption, diffusion, and co-precipitation. Residual byproducts will be managed through careful system monitoring and operations both inside and outside the plume.	**Protection of the Community During Remedial Action.** The community would be protected during this period by prohibiting the use of the groundwater for drinking water through institutional controls. Treatment byproducts could be temporarily elevated within portions of the treatment zone (Appendix E). The concentrations of byproducts could remain elevated at the site for a time but should eventually return to pre-remediation concentrations by adsorption reactions and be immobilized as the aquifer returned to aerobic conditions. Monitoring would be ongoing to verify the effectiveness of the fluvial sediments to provide a natural geochemical barrier to the Colorado River and to monitor for *in-situ* treatment byproducts. The community would face limited disturbance from construction noise, physical hazards such as traffic, material transport from construction, and operational activities. Risks can be reduced through proper controls during construction and operation. **Protection of Workers During Remedial Action.** Workers would face general site hazards including heavy equipment, occupational noise exposure, slip and fall, etc. General site hazards would be reduced by site specific health and safety plans, safety equipment. Workers would be required to wear appropriate personal protective equipment and use best management practices to minimize exposure. **Protection of the Environment During Remedial Action.** Potential environmental impacts would be related to disturbance to the environment as a result of construction and operation. Preliminary design estimates suggest that this alternative would result in installation of approximately 87 remediation well locations and, 40 additional monitoring well locations, piping, reagent storage and delivery systems, power, and instrumentation. Operation and maintenance activities would include periodic well maintenance, sample collection, refinement of the injection/recirculation systems, management of the reactant material, equipment inspections, and periodic replacement of wells and other structures that become clogged or damaged. Measures will be taken during construction, sampling, and operational activities to minimize environmental	**Technical Feasibility.** Alternative D is technically implementable. Installation of extraction wells, injection wells, pipelines, utilities, reagent storage and delivery systems, and process controls/instrumentation is technically implementable. Some wells may be challenging to install due to hydrogeologic conditions and excessive depths. Varied and abrupt topography and access limitations will present challenges to construction of wells, pipelines, and utilities, but the challenges can be overcome. This alternative includes installation of injection wells within Bat Cave Wash that will present challenges associated with maintaining protection against future damage or wash out. Pilot testing has shown that *in-situ* treatment is technically implementable at this site; however, there is a fair amount of uncertainty about the overall ability of the system to be able to work at this scale and there will be technical challenges associated with the ability to obtain complete distribution of substrates across a large area. Operation of the *in-situ* treatment system will require a high level of oversight during implementation to ensure that the system is optimized and modified as remediation progresses. **Administrative Feasibility.** Alternative D is administratively implementable. No offsite actions would be associated with Alternative D that would require permits from other agencies. Coordination and approval by respective landowners and leaseholders including BNSF, Caltrans, and other entities, would be required because installation of the extraction wells, injections wells, pipelines, utilities, reagent storage and delivery systems, and process controls/instrumentation would be constructed primarily outside of PG&E property. There may be challenges associated with administrative requirements of location-specific ARARs, such as archeological recordation. Administration of an institutional control to prohibit use of groundwater within the plume until attainment of cleanup goals would be required. The institutional control would need to be coordinated with the various landowners that overlie the plume. Water rights for the extraction systems under this alternative would be covered under existing remediation water rights so that no additional water rights need to	$118,000,000 - $254,000,000

TABLE 5-5
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Alternative	Protect Human Health and the Environment Attain Media Cleanup Goals and Control Source of Releases	Comply with ARARs	Long-term Effectiveness, Permanence and Reliability	Reduction of Toxicity, Mobility, or Volume through Treatment	Short-term Effectiveness	Implementability	Cost Net Present Value
		resources and evaluate and implement reasonable and prudent mitigation measures, thereby ensuring that the selected remedy attains these ARARs. **<u>Action-specific ARARs, including standards for management of wastes generated by the remedial action</u>.** This alternative can be designed and implemented to attain action-specific requirements. Injection of reductant material and recirculation of groundwater will be performed in a manner that meets Federal Underground Injection Control requirements (40 CFR Parts 144-148). There will be no discharge of fill to wetlands or waterways (40 CFR 230.10), point source discharge of pollutants to waters of the United States (40 CFR Parts 122, 125), or other activities that alter the course, condition, or capacity of navigable waters (33 USC § 401 and 403). Remedial activities will comply with applicable NPDES construction stormwater requirements (40 CFR 122.26). Remedial activities will not emit regulated hazardous air pollutants (40 CFR Parts 61, 63). Installation of wells, piping, and reagent storage equipment will be performed in a manner that does not result in a “take” of threatened or endangered species, damage their critical habitat (50 CFR Part 402), or impact migratory birds (15 USC § 703-712). Waste generated during remedial activities will be handled in compliance with hazardous waste generator requirements (22 CCR Division 4.5, Chapters 11, 12, 18). Regulated waste piles, tank systems, landfills, and miscellaneous units will not be constructed. Monitoring will be performed in accordance with RCRA (22 CCR Division 4.5, Ch. 14, Article 6) and California Water Code (23 CCR Div. 3, Chapter 15; 27 CCR Div. 2, Subdivision 1; Calif. Water Code Section 13801(c)) monitoring requirements. Because RAOs will achieve background levels for chromium, this alternative is consistent with the substantive provisions of SWRCB Resolution 68-16 that requires maintenance of the highest water quality consistent with maximum benefit to the people of the State and with the substantive provisions of SWRCB Resolution 92-49 that requires restoration of background water quality. It will also result in achieving Basin Plan water quality objectives for chromium in groundwater. Appropriate land use covenants will be implemented (22 CCR 67391.1).			disturbance. This alternative includes infrastructure on the floodplain between National Trails Highway and the Colorado River. Additional protections to the environment and community will be through compliance with ARARs such as for floodplain and wetland protection and stormwater requirements. **<u>Time Until RAOs are Achieved</u>** It is estimated that 10 to 20 years would be required to achieve the RAOs for this alternative The estimated time to achieve the RAOs was based on the simulated time to remove 98 percent of the Cr(VI) mass within the plume. The amount of Cr(VI) mass within the East Ravine bedrock is estimated to be less than one percent of the total plume mass, and therefore does not significantly affect the simulated time to cleanup.	be procured. **<u>Availability of Services and Materials.</u>** Services, equipment, and materials for installation of the extraction wells, injections wells, pipelines, utilities, reagent storage and delivery systems and process controls/instrumentation are readily available. Some specialized services may be needed for optimization of the reactant mix and delivery systems; however, these services can be made available. No wastes are produced from the *in-situ* treatment process that require offsite disposal. Offsite disposal facilities for drill cuttings or development water generated from the well installation are widely available.	

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Alternative	Protect Human Health and the Environment Attain Media Cleanup Goals and Control Source of Releases	Comply with ARARs	Long-term Effectiveness, Permanence and Reliability	Reduction of Toxicity, Mobility, or Volume through Treatment	Short-term Effectiveness	Implementability	Cost Net Present Value
Alternative E – *In-situ* Treatment with Fresh Water Flushing	**Protect Human Health and the Environment.** Alternative E would protect human health and the environment in the long term through reduction of Cr(VI) concentrations in groundwater by *in-situ* treatment. Monitoring would provide data to evaluate the effectiveness of *in-situ* treatment. This alternative protects human health in the short term by limiting exposure through restriction of groundwater use as potable water source until cleanup goals are met. Alternative E involves flushing the plume through an IRZ barrier located along Park Moabi road. Flushing would be accomplished through a combination of fresh water injection and injection of carbon amended water in wells to the west of the plume. This alternative also includes extraction wells near the Colorado River to provide hydraulic capture of the plume and to help flush the groundwater with elevated Cr(VI) through the IRZ lines. Additional extraction wells are located in an area northeast of the compressor station where the flushing efficiency from injection wells alone is relatively poor. Alternative E also includes extraction within the East Ravine bedrock to provide hydraulic control of East Ravine groundwater. This alternative involves construction and operation of active treatment facilities, including wells, pipelines, and tanks. Steps would be taken during construction and operation of the remedial facilities to limit disturbance to sensitive resources. Steps to limit disturbance to sensitive resources may include moving locations of infrastructure away from sensitive resources, modification of construction techniques (e.g., equipment or schedules), modification of design elements (e.g., materials, configurations, sizes). Steps may also include programmatic elements such as awareness training for site personnel. **Attain Media Cleanup Goals.** Alternative E includes active groundwater treatment through *in-situ* treatment and water flushing to attain cleanup goals. **Control Sources of Releases.** The historic practice of wastewater discharge to Bat Cave Wash and the use of hexavalent chromium at the site have been eliminated; therefore, sources of wastewater discharge and hexavalent	**Chemical-specific ARARs.** Chemical-specific requirements will be met. By achieving cleanup goals less than MCLs, the remedy will comply with federal (40 CFR Part 141-Subpart G) and California (22 CCR Division 4, Chapter 15) Drinking Water Act requirements for Cr(T) in groundwater delivered by a public water supply system. This alternative is considered to comply with the Federal Water Pollution Control Act because surface water samples collected within the river near the site, both before and after implementation of the IM, show concentrations less than federal water quality criteria (40 CFR 131.38) for Cr(VI), and naturally occurring reducing conditions in sediments near the Colorado River and dilution provided by the river, are expected to continue to prevent contaminated groundwater from causing exceedances of these standards in the river prior to remedy completion. By achieving cleanup goals in groundwater, the remedy will provide additional certainty that contaminated groundwater will not cause exceedances of Federal water quality criteria established under the Federal Water Pollution Control Act (40 CFR 131.38) for Cr(VI) in the Colorado River in the long term. **Location-specific ARARs.** Location-specific requirements will be met. Because surface water bodies are not being modified, USFWS coordination requirements (40 CFR 6.201) will not be triggered. Because RCRA-regulated treatment systems will not be constructed in a floodplain or seismic zone, RCRA seismic and floodplain requirements (40 CFR 264.18) will not be triggered. Construction of wells and piping in floodplain or wetland areas will be performed in a manner that complies with federal floodplain and wetlands protection requirements (40 CFR 6.201). Steps will be taken during design and implementation to ensure compatibility with the National Wildlife Refuge System Administration Act. The requirements of the National Historic Preservation Act 16 U.S.C. § 470, *et seq*.) are applicable based on the presence of and potential impact to historic properties listed on, or eligible for listing on, the National Register of Historic Places. Other cultural resource requirements include those of the National Archaeological and Historic Preservation Act (16 U.S.C. § 469, *et seq*.), the Native American Graves Protection and Repatriation Act (25 U.S.C. § 3001, *et seq.*), and the Archaeological Resources Protection Act (16 U.S.C. § 470aa-ii, *et seq*.), The requirements of the Historic Sites Act (16 U.S.C. § 461 *et seq.*), may apply to Route 66. In addition, there may be applicable requirements of Pub. L. 106-45 to preserve Route 66. Location and action-specific religious freedom requirements are set forth in the American Indian Religious Freedom Act and Religious Freedom Restoration Act. If a well for potable water is located in the future on land owned or controlled by the State of Arizona, the requirements of A.R.S. § 41-841 through 847 require that there will be no excavation of a historic site. Also, if a well for potable water is located on land other than Arizona state land, A.R.S. § 41-861 through 866 require that no human remains or specified cultural objects will be disturbed intentionally, and unintentional disturbances will	**Magnitude of Residual Risk.** Alternative E includes active *in-situ* treatment to attain cleanup goals for Cr(VI) in groundwater. Alternative E includes a group of bedrock extraction wells in the eastern (downgradient) end of the East Ravine, with the water from the bedrock extraction wells managed within the active treatment system for the alluvial aquifer. Risk from residual contamination would be reduced as Cr(VI) mass within the plume is treated. **Adequacy and Reliability of Controls.** Once the remedy is completed, monitoring inside and outside of the plume and continued enforcement of Institutional controls may be required to assess *in-situ* treatment byproducts. There is uncertainty associated with achieving complete distribution of carbon source substrate across this large of an area. Incomplete distribution can be overcome by achieving sufficient coverage to allow natural groundwater flow to transport any residual untreated chromium (that is not treated directly) to an adjacent treatment zone. Incomplete coverage also can be addressed through optimization of the remedy during implementation, which would involve additional dosing in areas where complete coverage was not achieved during the initial dose. Alternative E includes pumping within the East Ravine bedrock to ensure hydraulic control of East Ravine groundwater. Five-year reviews would be required for this alternative. No long-term containment systems are required and no land disposal of treatment residuals is expected. At many sites that rely on flushing to remove contaminants, a limit is reached where concentrations are no longer being reduced effectively, but cleanup goals have not been met. Hexavalent chromium does not strongly sorb to soils, which makes it more amenable to flushing than some other contaminants, but it may still be difficult to reach cleanup levels across the entire plume by relying on flushing technology. Maintaining hydraulic control through pumping or injection can be accomplished at the Topock site due to the flat groundwater gradients and lack of extensive aquitards within the Alluvial Aquifer.	**Amount of Plume Destroyed or Treated.** The intent of this alternative is to address the entire area of groundwater where Cr(VI) concentrations are higher than 32 µg/L. Alternative E also includes extraction within the East Ravine bedrock to provide hydraulic control of East Ravine groundwater. If it is determined that additional remedial effort is needed to reach RAOs in East Ravine bedrock, other technologies could be applied to supplement the pumping wells. In addition to pumping for hydraulic control, technologies that may be applicable to East Ravine bedrock would include, but are not limited to, freshwater injection for flushing and injection of carbon amendments for *in-situ* reduction of Cr(VI). The mass of Cr(VI) in East Ravine bedrock is estimated to be less than one percent of the total Cr(VI) plume mass. **Degree of Expected Reduction in Toxicity, Mobility, and Volume**. Alternative E includes *in-situ* treatment by distributing an organic carbon substrate within the floodplain to create geochemically-reduced conditions to convert Cr(VI) in groundwater to insoluble Cr(III) and thereby reducing the toxicity and mobility of the site contaminants. Alternative E also includes extraction within the East Ravine bedrock to provide hydraulic control of East Ravine groundwater. **Degree Treatment is Irreversible.** The degree of reversibility of the Cr(VI) reduction reaction is expected to ultimately result in Cr(VI) concentrations at levels similar to ambient Cr(VI) under the current pH conditions of aquifer. **Type and Quantity of Residual Remaining After Treatment**. The most significant residual byproducts will be manganese and arsenic, natural constituents of the aquifer matrix released into solution by reduction reactions. Once released, the reduced forms of manganese and arsenic will likely be attenuated through precipitation, sorption, diffusion, and co-precipitation. Residual byproducts will be managed through careful system monitoring and operations both inside and outside the plume.	**Protection of the Community During Remedial Action.** The community would be protected during this period by prohibiting the use of the groundwater for drinking water through institutional controls. Treatment byproducts could be temporarily elevated within portions of the treatment zone (Appendix E). The concentrations of byproducts could remain elevated at the site for a time but should eventually return to pre-remediation concentrations by adsorption reactions and eventually be immobilized as the aquifer returned to aerobic conditions. Monitoring would be ongoing to verify the effectiveness of the fluvial sediments to provide a natural geochemical barrier to the Colorado River and to monitor for *in-situ* treatment byproducts. The community would face limited disturbance from construction noise, physical hazards such as traffic, and material transport. Risks can be reduced through proper controls during construction and operation. **Protection of Workers During Remedial Action.** Workers would face general site hazards including heavy equipment, occupational noise exposure, slip and fall, etc. General site hazards would be reduced by site specific health and safety plans and safety equipment. Workers would be required to wear appropriate personal protective equipment and use best management practices to minimize exposure. **Protection of the Environment During Remedial Action.** Preliminary design estimates suggest that this alternative would result in installation of approximately 51 remediation well locations and 28 monitoring well locations, piping, reagent storage and delivery systems, and power and instrumentation. Operation and maintenance activities would include periodic well maintenance, sample collection, refinement of the injection/recirculation systems, management of the reactant material, equipment inspections, and periodic replacement of wells and other structures that become clogged or damaged. Measures will be taken during construction, sampling, and operational activities to minimize environmental disturbance. Measures to minimize environmental disturbance may include moving locations of infrastructure away from sensitive resources, modification of	**Technical Feasibility.** Alternative E is technically implementable. Construction of a new water supply well and delivery of the potable water via pipeline to injection wells is technically implementable, using standard pipeline construction methods. Installation of extraction wells, injections wells, pipelines, utilities, reagent storage and delivery systems, and process controls/instrumentation is technically implementable. Some wells may be challenging to install due to hydrogeologic conditions and excessive depths. Varied and abrupt topography and access limitations will present will present challenges to construction of wells, pipelines, and utilities, but the challenges can be overcome. Pilot testing has shown that *in-situ* treatment is technically implementable at this site. Operation of the *in-situ* treatment system will require a high level of oversight during implementation to ensure that the system is optimized and modified as remediation progresses. There will be technical challenges associated with reliance on flushing to remove contaminants due to the possibility of rate-limited back diffusion from low-permeable material, and it is expected that optimization of the remedy would throughout the design, construction, and operational phases to enhance performance of the remedy to attain the cleanup goals and to respond to site conditions and performance issues. **Administrative Feasibility.** Alternative E is administratively implementable. Installation of a water supply well in Arizona would need to be permitted by the Arizona Water Resources Department. Coordination and approval by respective landowners and leaseholders including BNSF and Caltrans and other entities would be required for installation of the extraction wells, injections wells, pipelines, utilities, reagent storage and delivery systems, and process controls/instrumentation that would be constructed primarily outside of PG&E property. Administration of an institutional control to prohibit use of groundwater within the plume until attainment of cleanup goals would be required. The institutional control would need to be coordinated with the various landowners that overlie the plume. Water rights for this alternative would be covered under existing remediation water rights so that no additional water rights need to be procured. There is no net consumptive use in this alternative	$92,000,000 - $198,000,000

TABLE 5-5
Individual Detailed Analysis of Remedial Alternatives against Seven Criteria
Final Groundwater Corrective Measures Study/Feasibility Study for SWMU 1/AOC 1 and AOC 10, PG&E Topock Compressor Station, Needles, California

Alternative	Protect Human Health and the Environment Attain Media Cleanup Goals and Control Source of Releases	Comply with ARARs	Long-term Effectiveness, Permanence and Reliability	Reduction of Toxicity, Mobility, or Volume through Treatment	Short-term Effectiveness	Implementability	Cost Net Present Value
	chromium have been controlled. However, the historic source of contaminated groundwater in bedrock at AOC 10 has not yet been determined, and the evaluation of whether leaching of soil contamination to groundwater represents a significant transport pathway has not yet been completed.	be reported. As a threshold matter, this alternative cannot be eliminated for an inability to attain the various cultural resource ARARs. As the remedy selection process continues through the issuance of a Proposed Plan and the Record of Decision, and a remedy is designed and implemented, the federal agencies will continue to engage in consultation with tribes, State Historic Preservation Officers, and others to identify potential effects on cultural resources and evaluate and implement reasonable and prudent mitigation measures, thereby ensuring that the selected remedy attains these ARARs. **Action-specific ARARs, including standards for management of wastes generated by the remedial action.** This alternative can be designed and implemented to attain action-specific requirements. Injection of reductant material and recirculation of groundwater will be performed in a manner that meets Federal Underground Injection Control requirements (40 CFR Parts 144-148). There will be no discharge of fill to wetlands or waterways (40 CFR 230.10), point source discharge of pollutants to waters of the United States (40 CFR Parts 122, 125), or other activities that alter the course, condition, or capacity of navigable waters (33 USC § 401 and 403). Remedial activities will comply with applicable NPDES construction stormwater requirements (40 CFR 122.26). Remedial activities will not emit regulated hazardous air pollutants (40 CFR Parts 61, 63). Installation of wells, piping, and reagent storage equipment will be performed in a manner that does not result in a "take" of threatened or endangered species, damage their critical habitat (50 CFR part 402), or impact migratory birds (15 USC § 703-712). Waste generated during remedial activities will be handled in compliance with hazardous waste generator requirements (22 CCR Division 4.5, Chapters 11, 12, 18). Regulated waste piles, tank systems, landfills, and miscellaneous units will not be constructed. Monitoring will be performed in accordance with RCRA (22 CCR Division 4.5, Ch. 14, Article 6) and California Water Code (23 CCR Div. 3, Chapter 15; 27 CCR Div. 2, Subdivision 1; Calif. Water Code Section 13801(c)) monitoring requirements. Because RAOs will achieve background levels for chromium, this alternative is consistent with the substantive provisions of SWRCB Resolution 68-16 that requires maintenance of the highest water quality consistent with maximum benefit to the people of the State and with the substantive provisions of SWRCB Resolution 92-49 that requires restoration of background water quality. It will also result in achieving Basin Plan water quality objectives for chromium in groundwater. Appropriate land use covenants will be implemented (22 CCR 67391.1). Arizona well standards (A.A.C. R-12-15-850; A.R.S. Title 5, Chapter 2, Article 10) will be met for potable water supply wells constructed in Arizona.			construction techniques (e.g., equipment or schedules), modification of design elements (e.g., materials, configurations, sizes), or implementation of programmatic elements such as awareness training for site personnel. This alternative includes infrastructure on the floodplain between National Trails Highway and the Colorado River. Additional protections to the environment and community will be through compliance with ARARs such as for floodplain and wetland protection and stormwater requirements. **Time Until RAOs are Achieved.** It is estimated that it would take 10 to 110 years to achieve the RAOs for this alternative. The estimated time to achieve the RAOs was based on the simulated time to remove 98 percent of the Cr(VI) mass within the plume. The amount of Cr(VI) mass within the East Ravine bedrock is estimated to be less than one percent of the total plume mass, and therefore does not significantly affect the simulated time to cleanup.	because extracted groundwater is returned to the basin through reinjection. There may be challenges associated with administrative requirements of location-specific ARARs, such as archeological recordation. This alternative would require a long-term secure source of potable water. **Availability of Services and Materials.** Services, equipment, and materials for installation of the extraction wells, injections wells, water supply well, pipelines, utilities, reagent storage and delivery systems and process controls/instrumentation are readily available. Some specialized services may be needed for optimization of the reactant mix and delivery systems, however, these services can be made available. No wastes are produced from the *in-situ* treatment process that require offsite disposal. Offsite disposal facilities for drill cuttings or development water generated from the well installation are widely available.	

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Alternative	Protect Human Health and the Environment Attain Media Cleanup Goals and Control Source of Releases	Comply with ARARs	Long-term Effectiveness, Permanence and Reliability	Reduction of Toxicity, Mobility, or Volume through Treatment	Short-term Effectiveness	Implementability	Cost Net Present Value
Alternative F – Pump and Treat	**Protect Human Health and the Environment.** Alternative F would protect human health and the environment in the long term through reduction of Cr(VI) concentrations in groundwater by *ex-situ* treatment. Monitoring would provide data to evaluate the effectiveness of *ex-situ* treatment. This alternative protects human health in the short term by limiting exposure through restriction of groundwater use as potable water source until cleanup goals are met. The groundwater extraction to remove groundwater for *ex-situ* treatment would provide a landward gradient in the floodplain, thereby preventing movement of Cr(VI) toward the river. However, continued groundwater extraction near the river may lead to long-term damage to the reducing blanket surrounding the riverbed. Alternative F also includes extraction within the East Ravine bedrock to provide hydraulic control of East Ravine groundwater. This alternative involves construction and operation of an above-ground treatment plant, and other facilities, including wells, and pipelines, etc. Steps would be taken during construction and operation of the remedial facilities to limit disturbance to sensitive resources. Steps to limit disturbance to sensitive resources may include moving locations of infrastructure away from sensitive resources, modification of construction techniques (e.g., equipment or schedules), modification of design elements (e.g., materials, configurations, sizes). Steps may also include programmatic elements such as awareness training for site personnel. However the energy requirements for operation of the treatment plant will be high and waste byproducts from the treatment plant would need to be transported to an offsite, permitted disposal facility. **Attain Media Cleanup Goals.** Alternative F includes extraction and *ex-situ* treatment to attain cleanup goals for constituents in groundwater. **Control Sources of Releases.** The historic practice of wastewater discharge to Bat Cave Wash and the use of hexavalent chromium at the site have been eliminated; therefore, sources of wastewater discharge and hexavalent chromium have been controlled.	**Chemical-specific ARARs.** Chemical-specific requirements will be met. By achieving cleanup goals less than MCLs, the remedy will comply with federal (40 CFR Part 141-Subpart G) and California (22 CCR Division 4, Chapter 15) Drinking Water Act requirements for Cr(T) in groundwater delivered by a public water supply system. This alternative is considered to comply with the Federal Water Pollution Control Act because surface water samples collected within the river near the site, both before and after implementation of the IM, show concentrations less than federal water quality criteria (40 CFR 131.38) for Cr(VI), and naturally occurring reducing conditions in sediments near the Colorado River and dilution provided by the river are expected to continue to prevent contaminated groundwater from causing exceedances of these standards in the river prior to remedy completion. By achieving cleanup goals in groundwater, the remedy will provide additional certainty that contaminated groundwater will not cause exceedances of Federal water quality criteria established under the Federal Water Pollution Control Act (40 CFR 131.38) for Cr(VI) in the Colorado River in the long term. **Location-specific ARARs.** Location-specific requirements will be met. Because surface water bodies are not being modified, USFWS coordination requirements (40 CFR 6.201) will not be triggered. Because RCRA-regulated treatment systems will not be constructed in a floodplain or seismic zone, RCRA seismic and floodplain requirements (40 CFR 264.18) will not be triggered. Construction of wells and piping in floodplain or wetland areas will be performed in a manner that compiles with federal floodplain and wetlands protection requirements (40 CFR 6.201). Steps will be taken during design and implementation to ensure compatibility with the National Wildlife Refuge System Administration Act. The requirements of the National Historic Preservation Act (16 U.S.C. § 470, *et seq*.) are applicable based on the presence of and potential impact to historic properties listed on, or eligible for listing on, the National Register of Historic Places. Other cultural resource requirements include those of the National Archaeological and Historic Preservation Act (16 U.S.C. § 469, *et seq*.), the Native American Graves Protection and Repatriation Act (25 U.S.C. § 3001, *et seq.*), and the Archaeological Resources Protection Act (16 U.S.C. § 470aa-ii, *et seq*.). The requirements of the Historic Sites Act, 16 U.S.C. § 461 *et seq*., may apply to Route 66. In addition, there may be applicable requirements of Pub. L. 106-45 to preserve Route 66. Location and action-specific religious freedom requirements are set forth in the American Indian Religious Freedom Act and Religious Freedom Restoration Act. As a threshold matter, this alternative cannot be eliminated for an inability to attain the various cultural resource ARARs. As the remedy selection process continues through the issuance of a Proposed Plan and the Record of Decision, and a remedy is designed and implemented, the federal agencies will continue to engage in consultation with tribes, State Historic Preservation	**Magnitude of Residual Risk.** Alternative F includes extraction and *ex-situ* treatment to attain cleanup goals for Cr(VI) in groundwater. Alternative F includes a group of bedrock extraction wells in the eastern (downgradient) end of the East Ravine, with the water from the bedrock extraction wells managed within the active treatment system for the alluvial aquifer .Risk from residual contamination in groundwater would be reduced as Cr(VI) mass within the plume is treated. **Adequacy and Reliability of Controls.** The *ex-situ* treatment process produces waste byproducts that would require long-term controls; transportation to and disposal in an offsite permitted facility is assumed to provide reliable long-term containment of the waste byproducts. Five-year reviews would be required for this alternative. Alternative F includes pumping within the East Ravine bedrock to ensure hydraulic control of East Ravine groundwater. Pump-and-treat technology is capable of reducing the size of plumes, and removing a large portion of the contaminant mass; however, at many sites, pump-and-treat systems which rely on flushing to remove contaminants have reached a limit where concentrations are no longer being reduced effectively, but cleanup goals have not been met. Thus, it may still be difficult to reach cleanup goals across the entire plume under this alternative. Maintaining hydraulic control through pumping or injection can be accomplished at the Topock site due to the flat groundwater gradients and lack of extensive aquitards within the Alluvial Aquifer. The pumping associated with Alternative F provides a landward gradient towards the extraction wells and away from the river, but in the process, river water may be drawn into the aquifer. The river water is aerobic and would become reduced as it moved out of the river and into the fluvial aquifer. Over the long period of time that this remedy would operate, the passage of this aerobic water through the fluvial sediments could result in some degradation of the natural reducing capacity. It is not possible to accurately predict where or to what extent this degradation in reducing capacity would occur.	**Amount of Plume Destroyed or Treated.** The intent of this alternative is to address the entire area of groundwater where Cr(VI) concentrations are higher than 32 µg/L. Alternative F also includes extraction within the East Ravine bedrock to provide hydraulic control of East Ravine groundwater. If it is determined that additional remedial effort is needed to reach RAOs in East Ravine bedrock, other technologies could be applied to supplement the pumping wells. In addition to pumping for hydraulic control, technologies that may be applicable to East Ravine bedrock would include, but are not limited to, freshwater injection for flushing and injection of carbon amendments for *in-situ* reduction of Cr(VI). The mass of Cr(VI) in East Ravine bedrock is estimated to be less than one percent of the total Cr(VI) plume mass. **Degree of Expected Reduction in Toxicity, Mobility, and Volume**. Alternative F includes *ex-situ* treatment in an above ground treatment plant likely using chemical reduction by addition of ferrous iron, oxidation, pH adjustment, and settling in a clarifier and final filtration. Similar to *in-situ* treatment, the *ex-situ* process converts Cr(VI) to Cr(III), thereby reducing the toxicity and mobility of the site contaminants. Alternative F also includes extraction within the East Ravine bedrock to provide hydraulic control of East Ravine groundwater. **Degree Treatment is Irreversible.** The Cr(VI) reduction reaction is not reversible. The Cr(VI) is removed from the groundwater through chemical reduction by ferrous iron compounds followed by alkaline precipitation and filtration. The resulting sludge is transported offsite to an appropriate permitted disposal facility for long-term management. The reversibility of the Cr(VI) reduction reaction depends on the geochemical conditions in the offsite permitted disposal facility. **Type and Quantity of Residual Remaining After Treatment**. Cr(III) from the treatment process is removed from the site and disposed in an offsite, permitted disposal facility.	**Protection of the Community During Remedial Action.** The community would be protected during this period by prohibiting the use of the groundwater for drinking water through institutional controls. Monitoring would be ongoing to verify the effectiveness of the fluvial sediments provide a natural geochemical barrier to the Colorado River. The community would face limited disturbance from construction noise, physical hazards such as traffic, and material transport. Risks can be reduced through proper controls during construction and operation. **Protection of Workers During Remedial Action.** Workers would face general site hazards including heavy equipment, occupational noise exposure, slip and fall, etc. General site hazards would be reduced by site specific health and safety plans and safety equipment. Workers would be required to wear appropriate personal protective equipment and use best management practices to minimize exposure. **Protection of the Environment During Remedial Action.** Preliminary design estimates suggest that this alternative would result in installation of approximately 26 remediation well locations and 24 monitoring well locations and the treatment plant. Additionally, operation of the *ex-situ* system would result in environmental impacts because substantial amount of electrical power would be required, as well as trucking requirements for delivery of treatment chemicals and disposal of wastes, with associated energy use and traffic hazards. Residuals would consist of waste byproducts containing Cr(III) and iron. Operation and maintenance of the aboveground treatment plant would include periodic sample collection, chemical controls, equipment maintenance and inspection, and process chemical and waste management. Measures will be taken during construction, sampling, and operational activities to minimize environmental disturbance. Additional protections to the environment and community will be through compliance with ARARs such as for floodplain and wetland protection and stormwater requirements. **Time Until RAOs are Achieved.**	**Technical Feasibility.** Alternative F is technically implementable. Installation of extraction wells, injection wells, pipelines, utilities, and *ex-situ* treatment plant is technically implementable. Implementation of the IM has shown that extraction, treatment, and injection are technically implementable at this site. However, there is some amount of uncertainty about the overall ability to remove contaminants relying on flushing technology. Some wells may be challenging to install due to hydrogeologic conditions and excessive depths, and varied and abrupt topography and access limitations will present challenges to construction of wells, pipelines, and utilities but the challenges can be overcome. Operation of the *ex-situ* treatment system will require a high level of oversight during implementation to ensure that the system is optimized and modified as remediation progresses. **Administrative Feasibility.** Alternative F is administratively implementable. No offsite actions would be associated with Alternative F that would require permits from other agencies. Installation of the extraction wells, injection wells, pipelines, and utilities would be constructed primarily outside of PG&E property so construction and operation of these facilities would have to be coordinated with and approved by the respective landowners and leaseholders, including BNSF, Caltrans, and other entities. There may be challenges associated with administrative requirements of location-specific ARARs, such as archeological recordation. Administration of an institutional control to prohibit use of groundwater within the plume until attainment of cleanup goals would be required. The institutional control would need to be coordinated with the various landowners that overlie the plume. **Availability of Services and Materials.** Services, equipment, and materials for installation of the extraction wells, injections wells, pipelines, utilities, and *ex-situ* treatment plant are readily available. Some specialized services may be needed for construction and operation of certain treatment components in the *ex-situ* treatment plant; however, these services can be made available. Waste byproducts would need to be	$187,000,000 - $401,000,000

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	However, the historic source of contaminated groundwater in bedrock at AOC 10 has not yet been determined, and the evaluation of whether leaching of soil contamination to groundwater represents a significant transport pathway has not yet been completed.	Officers, and others to identify potential effects on cultural resources and evaluate and implement reasonable and prudent mitigation measures, thereby ensuring that the selected remedy attains these ARARs. **<u>Action-specific ARARs, including standards for management of wastes generated by the remedial action.</u>** This alternative can be designed and implemented to attain action-specific requirements. Injection of treated groundwater will be performed in a manner that meets Federal Underground Injection Control requirements (40 CFR Parts 144-148). There will be no discharge of fill to wetlands or waterways (40 CFR 230.10), point source discharge of pollutants to waters of the United States (40 CFR Parts 122, 125), or other activities that alter the course, condition, or capacity of navigable waters (33 USC § 401 and 403). Remedial activities will comply with applicable NPDES construction stormwater requirements (40 CFR 122.26). Remedial activities will not emit regulated hazardous air pollutants (40 CFR Parts 61, 63). Installation of wells, piping, and *ex-situ* treatment plant will be performed in a manner that does not result in a “take” of threatened or endangered species, damage their critical habitat (50 CFR part 402), or impact migratory birds (15 USC § 703-712). Waste generated during remedial activities will be handled in compliance with hazardous waste generator requirements (22 CCR Division 4.5, Chapters 11, 12, 18). The treatment system will be constructed and operated in compliance with requirements for hazardous waste tank systems (22 CCR Div. 4.5, Ch. 14, Articles 2, 10); Regulated waste piles, landfills, and miscellaneous units will not be constructed. Monitoring will be performed in accordance with RCRA (22 CCR Division 4.5, Ch. 14, Article 6) and California Water Code (23 CCR Div. 3, Chapter 15; 27 CCR Div. 2, Subdivision 1; Calif. Water Code Section 13801(c)) monitoring requirements. Because RAOs will achieve background levels for chromium, this alternative is consistent with the substantive provisions of SWRCB Resolution 68-16 that requires maintenance of the highest water quality consistent with maximum benefit to the people of the State and with the substantive provisions of SWRCB Resolution 92-49 that requires restoration of background water quality. It will also result in achieving Basin Plan water quality objectives for chromium in groundwater. Appropriate land use covenants will be implemented (22 CCR 67391.1).			It is estimated that 15 to 150 years would be required to achieve the RAOs for this alternative. The estimated time to achieve the RAOs was based on the simulated time to remove 98 percent of the Cr(VI) mass within the plume. The amount of Cr(VI) mass within the East Ravine bedrock is estimated to be less than one percent of the total plume mass, and therefore does not significantly affect the simulated time to cleanup.	disposed of at an offsite, licensed disposal facility; although not widely available or close to the site, there are available disposal facilities elsewhere in California, Nevada, and/or Arizona. Offsite disposal facilities for drill cuttings or development water generated from the well installation, development, and sampling are widely available.	

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Alternative G - Combined Floodplain *In-situ*/Pump and Treat	**Protect Human Health and the Environment.** Alternative G would protect human health and the environment in the long term through reduction of Cr(VI) concentrations in groundwater by *in-situ* and *ex-situ* treatment. Monitoring would provide data to evaluate the effectiveness of the *in-situ* and *ex-situ* treatment. This alternative protects human health in the short term by limiting exposure through restriction of groundwater use as potable water source until cleanup goals are met. Alternative G includes floodplain cleanup, and the groundwater extraction to remove groundwater for *ex-situ* treatment would provide a landward gradient in the floodplain. These measures would provide additional protection to the river. However, continued groundwater extraction near the river may lead to long-term damage to the reducing blanket surrounding the riverbed. Alternative G also includes extraction within the East Ravine bedrock to provide hydraulic control of East Ravine groundwater. This alternative involves construction and operation of an above-ground treatment plant, and other facilities, including wells and pipelines. Steps would be taken during construction and operation of the remedial facilities to limit disturbance to sensitive resources. Steps to limit disturbance to sensitive resources may include moving locations of infrastructure away from sensitive resources, modification of construction techniques (e.g., equipment or schedules), modification of design elements (e.g., materials, configurations, sizes). Steps may also include programmatic elements such as awareness training for site personnel. However the energy requirements for operation of the treatment plant will be high and waste byproducts from the treatment plant would need to be transported to an offsite, permitted disposal facility. **Attain Media Cleanup Goals.** Alternative G includes *in-situ* treatment and extraction and *ex-situ* treatment to attain cleanup goals for constituents in groundwater **Control Sources of Releases.** The historic practice of wastewater discharge to Bat Cave Wash and the use of hexavalent chromium at the site have	**Chemical-specific ARARs.** Chemical-specific requirements will be met. By achieving cleanup goals less than MCLs, the remedy will comply with federal (40 CFR Part 141-Subpart G) and California (22 CCR Division 4, Chapter 15) Drinking Water Act requirements for Cr(T) in groundwater delivered by a public water supply system. This alternative is considered to comply with the Federal Water Pollution Control Act because surface water samples collected within the river near the site, both before and after implementation of the IM, show concentrations less than federal water quality criteria (40 CFR 131.38) for Cr(VI), and naturally occurring reducing conditions in sediments near the Colorado River and dilution provided by the river are expected to continue to prevent contaminated groundwater from causing exceedances of these standards in the river prior to remedy completion. By achieving cleanup goals in groundwater, the remedy will provide additional certainty that contaminated groundwater will not cause exceedances of Federal water quality criteria established under the Federal Water Pollution Control Act (40 CFR 131.38) for Cr(VI) in the Colorado River in the long term. **Location-specific ARARs.** Location-specific requirements will be met. Because surface water bodies are not being modified, USFWS coordination requirements (40 CFR 6.201) will not be triggered. Because RCRA-regulated treatment systems will not be constructed in a floodplain or seismic zone, RCRA seismic and floodplain requirements (40 CFR 264.18) will not be triggered. Construction of wells and piping in floodplain or wetland areas will be performed in a manner that complies with federal floodplain and wetlands protection requirements (40 CFR 6.201). Steps will be taken during design and implementation to ensure compatibility with the National Wildlife Refuge System Administration Act. The requirements of the National Historic Preservation Act (16 U.S.C. § 470, *et seq*.) are applicable based on the presence of and potential impact to historic properties listed on, or eligible for listing on, the National Register of Historic Places. Other cultural resource requirements include those of the National Archaeological and Historic Preservation Act (16 U.S.C. § 469, *et seq*.), the Native American Graves Protection and Repatriation Act (25 U.S.C. § 3001, *et seq*.), and the Archaeological Resources Protection Act (16 U.S.C. § 470aa-ii, *et seq*.). The requirements of the Historic Sites Act, 16 U.S.C. § 461 *et seq*., may apply to Route 66. In addition, there may be applicable requirements of Pub. L. 106-45 to preserve Route 66. Location and action-specific religious freedom requirements are set forth in the American Indian Religious Freedom Act and Religious Freedom Restoration Act. As a threshold matter, this alternative cannot be eliminated for an inability to attain the various cultural resource ARARs. As the remedy selection process continues through the issuance of a Proposed Plan and the Record of Decision, and a remedy is designed and implemented, the federal agencies will continue to engage in consultation with tribes, State Historic Preservation	**Magnitude of Residual Risk.** Alternative G includes *in-situ* treatment in the floodplain area of the site and *ex-situ* treatment in an above ground treatment plant in uplands areas of the site to attain cleanup goals for Cr(VI) in groundwater. Alternative G includes a group of bedrock extraction wells in the eastern (downgradient) end of the East Ravine, with the water from the bedrock extraction wells managed within the active treatment system for the alluvial aquifer .Risk from residual contamination in groundwater would be reduced as Cr(VI) mass within the plume is treated. **Adequacy and Reliability of Controls.** Once the remedy is completed, monitoring and continued enforcement of institutional controls may be required to assess *in-situ* treatment byproducts There is uncertainty associated with achieving complete distribution of carbon source substrate across this large of an area. Incomplete distribution can be overcome by achieving sufficient coverage to allow natural groundwater flow to transport any residual untreated chromium (that is not treated directly) to an adjacent treatment zone. Incomplete coverage also can be addressed through optimization of the remedy during implementation, which would involve additional dosing in areas where complete coverage was not achieved during the initial dose. The *ex-situ* treatment process produces waste byproducts that would require long-term controls; transportation to and disposal in an offsite permitted facility is assumed to provide reliable long-term containment of the waste byproducts. Alternative G includes pumping within the East Ravine bedrock to ensure hydraulic control of East Ravine groundwater. Five-year reviews would be required for this alternative. This alternative requires long-term containment systems (offsite) and land disposal of treatment residuals. Some residuals may remain after the remedy is completed; monitoring inside and outside the plume would be necessary to verify residual flushing. Pump-and-treat technology has been shown to be capable of reducing the size of plumes and removing a large portion of the contaminant mass. However, at many sites, pump-and-treat systems, which rely on flushing to remove contaminants, have reached a limit	**Amount of Plume Destroyed or Treated.** The intent of this alternative is to address the entire area of groundwater where Cr(VI) concentrations are higher than 32 µg/L. Alternative G also includes extraction within the East Ravine bedrock to provide hydraulic control of East Ravine groundwater. If it is determined that additional remedial effort is needed to reach RAOs in East Ravine bedrock, other technologies could be applied to supplement the pumping wells. In addition to pumping for hydraulic control, technologies that may be applicable to East Ravine bedrock would include, but are not limited to, freshwater injection for flushing and injection of carbon amendments for *in-situ* reduction of Cr(VI). The mass of Cr(VI) in East Ravine bedrock is estimated to be less than one percent of the total Cr(VI) plume mass. **Degree of Expected Reduction in Toxicity, Mobility, and Volume**. Alternative G includes *in-situ* treatment in the floodplain area of the site and *ex-situ* treatment in an aboveground treatment plant for uplands areas of the site. *In-situ* treatment in the floodplain would involve distributing an organic carbon substrate to create geochemically-reduced conditions to convert Cr(VI) in groundwater to insoluble Cr(III), thereby reducing the toxicity and mobility of the site contaminants. *Ex-situ* treatment in upland areas of the site in an aboveground treatment plant would likely involve using chemical reduction by addition of ferrous iron, oxidation, pH adjustment, and settling in a clarifier and final filtration. Similar to *in-situ* treatment, the *ex-situ* process converts Cr(VI) to Cr(III), thereby reducing the toxicity and mobility of the site contaminants. Cr(III) from the treatment process is removed from the site and disposed in an offsite, permitted disposal facility. Alternative G also includes extraction within the East Ravine bedrock to provide hydraulic control of East Ravine groundwater. **Degree Treatment is Irreversible.** The degree of reversibility of the *in-situ* Cr(VI) reduction reaction is expected to ultimately result in Cr(VI) concentrations at levels similar to ambient Cr(VI). The *ex-situ* Cr(VI) reduction reaction is not reversible. **Type and Quantity of Residual Remaining After Treatment**. The most significant residual byproducts from the *in-situ* treatment process will be manganese and arsenic, natural constituents of the aquifer matrix released into solution by reduction reactions. Once released, the reduced forms of manganese and arsenic will likely be attenuated through precipitation, sorption, diffusion, and co-precipitation. Residual byproducts will be managed through careful system monitoring and operations both inside and outside the plume.	**Protection of the Community During Remedial Action.** The community would be protected during this period by prohibiting the use of the groundwater for drinking water through institutional controls. Treatment byproducts could be temporarily elevated within portions of the treatment zone (Appendix G). The concentrations of byproducts could remain elevated at the site for a time but should eventually return to pre-remediation concentrations by adsorption reactions and eventually be immobilized as the aquifer returned to aerobic conditions. Monitoring would be ongoing to verify the effectiveness of the fluvial sediments provide a natural geochemical barrier to the Colorado River and to monitor for *in-situ* treatment byproducts. The community would face limited disturbance from construction noise, physical hazards such as traffic, and material transport. Risks can be reduced through proper controls during construction and operation. **Protection of Workers During Remedial Action.** Workers would face general site hazards including heavy equipment, occupational noise exposure, slip and fall, etc. General site hazards would be reduced by site specific health and safety plans and safety equipment. Workers would be required to wear appropriate personal protective equipment and use best management practices to minimize exposure. **Protection of the Environment During Remedial Action.** Preliminary design estimates suggest that this alternative would result in installation of approximately 59 remediation well locations and 30 monitoring well locations and the treatment plant. Additionally, operation of the *ex-situ* system would result in environmental impacts because substantial amount of electrical power would be required, as well as trucking requirements for delivery of treatment chemicals and disposal of wastes, with associated energy use and traffic hazards. Residuals would consist of waste byproducts containing Cr(III) and iron. Operation and maintenance of the aboveground treatment plant would include periodic sample collection, chemical controls, equipment maintenance and inspection, and process chemical and waste management. Measures will be taken	**Technical Feasibility.** Alternative G is technically implementable. Installation of extraction wells, injection wells, IRZ wells, pipelines, utilities, and *ex-situ* treatment plant is technically implementable. Implementation of the IM has shown that extraction, treatment, and injection are technically implementable at this site. However, there is some amount of uncertainty about the overall ability to remove contaminants relying on flushing technology. Some wells may be challenging to install due to hydrogeologic conditions and excess depths, and varied and abrupt topography and access limitations will present challenges to construction of wells, pipelines, and utilities but the challenges can be overcome. Operation of the *ex-situ* treatment system will require a high level of oversight during implementation to ensure that the system is optimized and modified as remediation progresses. **Administrative Feasibility.** Alternative G is administratively implementable. No offsite actions would be associated with Alternative G that would require permits from other agencies. The extraction wells, injections wells, pipelines, and utilities would be constructed primarily outside of PG&E property so construction and operation of these facilities would have to be coordinated with and approved by the respective landowners and leaseholders, including BNSF, Caltrans, and other entities. There may be challenges associated with administrative requirements of location-specific ARARs, such as archeological recordation. Administration of an institutional control to prohibit use of groundwater within the plume until attainment of cleanup goals would be required. The institutional control would need to be coordinated with the various landowners that overlie the plume. **Availability of Services and Materials.** Services, equipment, and materials for installation of the extraction wells, injections wells, pipelines, utilities, and *ex-situ* treatment plant are readily available. Some specialized services may be needed for construction and operation of certain treatment components in the *ex-situ* treatment plant; however, these services can be made available. Waste byproducts from the *ex-situ*	\$177,000,000 - \$380,000,000

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Alternative	Protect Human Health and the Environment Attain Media Cleanup Goals and Control Source of Releases	Comply with ARARs	Long-term Effectiveness, Permanence and Reliability	Reduction of Toxicity, Mobility, or Volume through Treatment	Short-term Effectiveness	Implementability	Cost Net Present Value
	been eliminated; therefore, sources of wastewater discharge and hexavalent chromium have been controlled. However, the historic source of contaminated groundwater in bedrock at AOC 10 has not yet been determined, and the evaluation of whether leaching of soil contamination to groundwater represents a significant transport pathway has not yet been completed.	Officers, and others to identify potential effects on cultural resources and evaluate and implement reasonable and prudent mitigation measures, thereby ensuring that the selected remedy attains these ARARs. **Action-specific ARARs, including standards for management of wastes generated by the remedial action.** This alternative can be designed and implemented to attain action-specific requirements. Injection of treated groundwater will be performed in a manner that meets Federal Underground Injection Control requirements (40 CFR Parts 144-148). There will be no discharge of fill to wetlands or waterways (40 CFR 230.10), point source discharge of pollutants to waters of the United States (40 CFR Parts 122, 125), or other activities that alter the course, condition, or capacity of navigable waters (33 USC § 401 and 403). Remedial activities will comply with applicable NPDES construction stormwater requirements (40 CFR 122.26). Remedial activities will not emit regulated hazardous air pollutants (40 CFR Parts 61, 63). Installation of wells, piping, reagent storage equipment, and *ex-situ* treatment plant will be performed in a manner that does not result in a “take” of threatened or endangered species, damage their critical habitat (50 CFR part 402), or impact migratory birds (15 USC § 703-712). Waste generated during remedial activities will be handled in compliance with hazardous waste generator requirements (22 CCR Division 4.5, Chapters 11, 12, 18). The treatment system will be constructed and operated in compliance with requirements for hazardous waste tank systems (22 CCR Div. 4.5, Ch. 14, Articles 2, 10); Regulated waste piles, landfills, and miscellaneous units will not be constructed. Monitoring will be performed in accordance with RCRA (22 CCR Division 4.5, Ch. 14, Article 6) and California Water Code (23 CCR Div. 3, Chapter 15; 27 CCR Div. 2, Subdivision 1; Calif. Water Code Section 13801(c)) monitoring requirements. Because RAOs will achieve background levels for chromium, this alternative is consistent with the substantive provisions of SWRCB Resolution 68-16 that requires maintenance of the highest water quality consistent with maximum benefit to the people of the State and with the substantive provisions of SWRCB Resolution 92-49 that requires restoration of background water quality. It will also result in achieving Basin Plan water quality objectives for chromium in groundwater. Appropriate land use covenants will be implemented (22 CCR 67391.1).	where concentrations are no longer being reduced effectively, but cleanup goals have not been met. Thus, it may still be difficult to reach cleanup levels across the entire plume by methods that rely on flushing. It is not possible to predict what the limit of concentration reduction might be for flushing technology at the Topock site. Maintaining hydraulic control through pumping or injection can be accomplished at the Topock site due to the flat groundwater gradients and lack of extensive aquitards within the Alluvial Aquifer. The pumping associated with Alternative G provides a landward gradient towards the extraction wells and away from the river, but in the process, river water may be drawn into the aquifer. The river water is aerobic and would become reduced as it moved out of the river and into the fluvial aquifer. Over the long period of time that this remedy would operate, the passage of this aerobic water through the fluvial sediments could result in some degradation of the natural reducing capacity. It is not possible to accurately predict where or to what extent this degradation in reducing capacity would occur.		during construction, sampling, and operational activities to minimize environmental disturbance. This alternative includes infrastructure on the floodplain between National Trails Highway and the Colorado River. Additional protections to the environment and community will be through compliance with ARARs such as for floodplain and wetland protection and stormwater requirements. **Time Until RAOs are Achieved.** It is estimated that 10 to 90 years would be required to achieve the RAOs for this alternative. The estimated time to achieve the RAOs was based on the simulated time to remove 98 percent of the Cr(VI) mass within the plume. The amount of Cr(VI) mass within the East Ravine bedrock is estimated to be less than one percent of the total plume mass, and therefore does not significantly affect the simulated time to cleanup.	treatment plant would need to be disposed of at an offsite, licensed disposal facility; although not widely available or close to the site, there are available disposal facilities elsewhere in California, Nevada, and/or Arizona. Offsite disposal facilities for drill cuttings or development water generated from the well installation, development, and sampling are widely available.	

TABLE 5-5
Individual Detailed Analysis of Remedial Alternatives against Seven Criteria
Final Groundwater Corrective Measures Study/Feasibility Study for SWMU 1/AOC 1 and AOC 10, PG&E Topock Compressor Station, Needles, California

Alternative	Protect Human Health and the Environment Attain Media Cleanup Goals and Control Source of Releases	Comply with ARARs	Long-term Effectiveness, Permanence and Reliability	Reduction of Toxicity, Mobility, or Volume through Treatment	Short-term Effectiveness	Implementability	Cost Net Present Value
Alternative H - Combined Upland *In-situ*/ Pump and Treat	**Protect Human Health and the Environment.** Alternative H would protect human health and the environment in the long term through reduction of Cr(VI) concentrations in groundwater by *in-situ* and *ex-situ* treatment. Monitoring would provide data to evaluate the effectiveness of the *in-situ* and *ex-situ* treatment. This alternative protects human health in the short term by limiting exposure through restriction of groundwater use as a potable water source until cleanup goals are met. Alternative H includes floodplain cleanup, and the groundwater extraction to remove groundwater for *ex-situ* treatment would provide a landward gradient in the floodplain. These measures would provide additional protection to the river. However, continued groundwater extraction near the river may lead to long-term damage to the reducing blanket surrounding the riverbed. Alternative H also includes extraction within the East Ravine bedrock to provide hydraulic control of East Ravine groundwater. This alternative involves construction and operation of an aboveground treatment plant and other facilities, including wells and pipelines. Steps would be taken during construction and operation of the remedial facilities to limit disturbance to sensitive resources. Steps to limit disturbance to sensitive resources may include moving locations of infrastructure away from sensitive resources, modification of construction techniques (e.g., equipment or schedules), modification of design elements (e.g., materials, configurations, sizes). Steps may also include programmatic elements such as awareness training for site personnel. However, the energy requirements for operation of the treatment plant will be high and waste byproducts from the treatment plant would need to be transported to an offsite, permitted disposal facility. **Attain Media Cleanup Goals.** Alternative H includes *in-situ* treatment and extraction and *ex-situ* treatment to attain cleanup goals for constituents in groundwater. **Control Sources of Releases.** The historic practice of wastewater discharge to Bat Cave Wash and the use of hexavalent chromium at the site have	**Chemical-specific ARARs.** Chemical-specific requirements will be met. By achieving cleanup goals less than MCLs, the remedy will comply with federal (40 CFR Part 141-Subpart G) and California (22 CCR Division 4, Chapter 15) Drinking Water Act requirements for Cr(T) in groundwater delivered by a public water supply system. This alternative is considered to comply with the Federal Water Pollution Control Act because surface water samples collected within the river near the site, both before and after implementation of the IM, show concentrations less than federal water quality criteria (40 CFR 131.38) for Cr(VI), and naturally occurring reducing conditions in sediments near the Colorado River and dilution provided by the river are expected to continue to prevent contaminated groundwater from causing exceedances of these standards in the river prior to remedy completion. By achieving cleanup goals in groundwater, the remedy will provide additional certainty that contaminated groundwater will not cause exceedances of federal water quality criteria established under the Federal Water Pollution Control Act (40 CFR 131.38) for Cr(VI) in the Colorado River in the long term. **Location-specific ARARs.** Location-specific requirements will be met. Because surface water bodies are not being modified, USFWS coordination requirements (40 CFR 6.201) will not be triggered. Because RCRA-regulated treatment systems will not be constructed in a floodplain or seismic zone, RCRA seismic and floodplain requirements (40 CFR 264.18) will not be triggered. Construction of wells and piping in floodplain or wetland areas will be performed in a manner that complies with federal floodplain and wetlands protection requirements (40 CFR 6.201). Steps will be taken during design and implementation to ensure compatibility with the National Wildlife Refuge System Administration Act. The requirements of the National Historic Preservation Act (16 U.S.C. § 470, *et seq*.) are applicable based on the presence of and potential impact to historic properties listed on, or eligible for listing on, the National Register of Historic Places. Other cultural resource requirements include those of the National Archaeological and Historic Preservation Act (16 U.S.C. § 469, *et seq*.), the Native American Graves Protection and Repatriation Act, (25 U.S.C. § 3001, *et seq*.), and the Archaeological Resources Protection Act, 16 U.S.C. § 470aa-ii, *et seq*.). The requirements of the Historic Sites Act (16 U.S.C. § 461 *et seq*.) may apply to Route 66. In addition, there may be applicable requirements of Pub. L. 106-45 to preserve Route 66. Location and action-specific religious freedom requirements are set forth in the American Indian Religious Freedom Act and Religious Freedom Restoration Act. As a threshold matter, this alternative cannot be eliminated for an inability to attain the various cultural resource ARARs. As the remedy selection process continues through the issuance of a Proposed Plan and the Record of Decision, and a remedy is designed and implemented, the federal agencies will continue to engage in consultation with tribes, State Historic Preservation	**Magnitude of Residual Risk.** Alternative H includes the application of *in-situ* treatment in the upland areas of the site and *ex-situ* treatment in an aboveground treatment plant in the floodplain area of the site to attain cleanup goals for Cr(VI) in groundwater. Alternative H includes a group of bedrock extraction wells in the eastern (downgradient) end of the East Ravine, with the water from the bedrock extraction wells managed within the active treatment system for the alluvial aquifer. Risk from residual contamination in groundwater would be reduced as Cr(VI) mass within the plume is treated. **Adequacy and Reliability of Controls.** Once the remedy is completed, monitoring and continued enforcement of institutional controls may be required to assess *in-situ* treatment byproducts. There is uncertainty associated with achieving complete distribution of carbon source substrate across this large of an area. Incomplete distribution can be overcome by achieving sufficient coverage to allow natural groundwater flow to transport any residual untreated chromium (that is not treated directly) to an adjacent treatment zone. Incomplete coverage also can be addressed through optimization of the remedy during implementation, which would involve additional dosing in areas where complete coverage was not achieved during the initial dose. The *ex-situ* treatment process produces waste byproducts that would require long-term controls; transportation to and disposal in an offsite permitted facility is assumed to provide reliable long-term containment of the waste byproducts. Alternative H includes pumping within the East Ravine bedrock to ensure hydraulic control of East Ravine groundwater. Five-year reviews would be required for this alternative. This alternative requires long-term containment systems (offsite) and land disposal of treatment residuals. Some residuals may remain after the remedy is completed; monitoring inside and outside the plume would be necessary to verify residual flushing. Pump-and-treat technology has been shown to be capable of reducing the size of plumes, and removing a large portion of the contaminant mass. At many sites that rely on pump-and-treat technology and flushing to remove contaminants, a	**Amount of Plume Destroyed or Treated.** The intent of this alternative is to address the entire area of groundwater where Cr(VI) concentrations are higher than 32 μg/L. Alternative H also includes extraction within the East Ravine bedrock to provide hydraulic control of East Ravine groundwater. If it is determined that additional remedial effort is needed to reach RAOs in East Ravine bedrock, other technologies could be applied to supplement the pumping wells. In addition to pumping for hydraulic control, technologies that may be applicable to East Ravine bedrock would include, but are not limited to, freshwater injection for flushing and injection of carbon amendments for *in-situ* reduction of Cr(VI). The mass of Cr(VI) in East Ravine bedrock is estimated to be less than one percent of the total Cr(VI) plume mass. **Degree of Expected Reduction in Toxicity, Mobility, and Volume**. Alternative H includes *in-situ* treatment in the upland areas of the site and *ex-situ* treatment in an aboveground treatment plant for the floodplain area of the site. *In-situ* treatment would involve distributing an organic carbon substrate to create geochemically-reduced conditions to convert Cr(VI) in groundwater to insoluble Cr(III), thereby reducing the toxicity and mobility of the site contaminants. *Ex-situ* treatment in the floodplain area of the site in an aboveground treatment plant would likely involve using chemical reduction by addition of ferrous iron, oxidation, pH adjustment, and settling in a clarifier and final filtration. Similar to *in-situ* treatment, the *ex-situ* process converts Cr(VI) to Cr(III), thereby reducing the toxicity and mobility of the site contaminants. Cr(III) from the treatment process is removed from the site and disposed of in an offsite, permitted disposal facility. **Degree Treatment is Irreversible.** The degree of reversibility of the *in-situ* Cr(VI) reduction reaction is expected to ultimately result in Cr(VI) concentrations at levels similar to ambient Cr(VI). The *ex-situ* Cr(VI) reduction reaction is not reversible. Alternative H also includes extraction within the East Ravine bedrock to provide hydraulic control of East Ravine groundwater. **Type and Quantity of Residual Remaining After Treatment**. The most significant residual byproducts from the *in-situ* treatment process will be manganese and arsenic, natural constituents of the aquifer matrix released into solution by reduction reactions. Once released, the reduced forms of manganese and arsenic will likely be attenuated through precipitation, sorption, diffusion, and co-precipitation. Residual byproducts will be managed through careful system monitoring and operations both inside and outside the plume.	**Protection of the Community During Remedial Action.** The community would be protected during this period by prohibiting the use of the groundwater for drinking water through institutional controls. Treatment byproducts could be temporarily elevated within portions of the treatment zone (Appendix E). The concentrations of byproducts could remain elevated at the site for a time but should eventually return to pre-remediation concentrations by adsorption reactions and eventually be immobilized as the aquifer returned to aerobic conditions. Monitoring would be ongoing to verify the effectiveness of the fluvial sediments in providing a natural geochemical barrier to the Colorado River and to monitor for *in-situ* treatment byproducts. The community would face limited disturbance from construction noise and physical hazards such as traffic related to material transport. Risks can be reduced through proper controls during construction and operation. **Protection of Workers During Remedial Action.** Workers would face general site hazards including heavy equipment, occupational noise exposure, slip and fall, etc. General site hazards would be reduced by site-specific health and safety plans and safety equipment. Workers would be required to wear appropriate personal protective equipment and use best management practices to minimize exposure. **Protection of the Environment During Remedial Action.** Preliminary design estimates suggest that this alternative would result in installation of approximately67 remediation well locations and 32 monitoring well locations and the treatment plant. Additionally, operation of the *ex-situ* system would result in environmental impacts because a substantial amount of electrical power would be required, as well as trucking requirements for delivery of treatment chemicals and disposal of wastes, with associated energy use and traffic hazards. Residuals would consist of waste byproducts containing Cr(III) and iron. Operation and maintenance of the aboveground treatment plant would include periodic sample collection, chemical controls, equipment maintenance and inspection, and process chemical and waste management. Measures will be taken	**Technical Feasibility.** Alternative H is technically implementable. Installation of extraction wells, injection wells, IRZ wells, pipelines, utilities, and *ex-situ* treatment plant is technically implementable. Implementation of the IM has shown that extraction, treatment, and injection are technically implementable at this site. However, there is some amount of uncertainty about the overall ability to remove contaminants relying on flushing technology. Some wells may be challenging to install due to hydrogeologic conditions and excess depths, and varied and abrupt topography and access limitations will present challenges to construction of wells, pipelines, and utilities but the challenges can be overcome. This alternative includes installation of an IRZ within Bat Cave Wash that will present challenges associated with maintaining protection against future damage or washout. Pilot testing has shown that *in-situ* treatment is technically implementable at this site. However, some uncertainty exists about the application of i*n-situ* technology at this scale. Operation of the *ex-situ* and *in-situ* treatment system will require a high level of oversight during implementation to ensure that the system is optimized and modified as remediation progresses. **Administrative Feasibility.** Alternative H is administratively implementable. No offsite actions would be associated with Alternative H that would require permits from other agencies. The extraction wells, injections wells, pipelines, and utilities would be constructed primarily outside of PG&E property so construction and operation of these facilities would have to be coordinated with and approved by the respective landowners and leaseholders including BNSF, Caltrans, and other entities. There may be challenges associated with administrative requirements of location-specific ARARs, such as archeological recordation. Administration of an institutional control to prohibit use of groundwater within the plume until attainment of cleanup goals would be required. The institutional control would need to be coordinated with the various landowners that overlie the plume. **Availability of Services and Materials.** Services, equipment, and materials for installation of the extraction wells,	$127,000,000 - $273,000,000

TABLE 5-5
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Alternative	Protect Human Health and the Environment Attain Media Cleanup Goals and Control Source of Releases	Comply with ARARs	Long-term Effectiveness, Permanence and Reliability	Reduction of Toxicity, Mobility, or Volume through Treatment	Short-term Effectiveness	Implementability	Cost Net Present Value
	been eliminated; therefore, sources of wastewater discharge and hexavalent chromium have been controlled. However the historic source of contaminated groundwater in bedrock at AOC 10 has not yet been determined, and the evaluation of whether leaching of soil contamination to groundwater represents a significant transport pathway has not yet been completed.	Officers, and others to identify potential effects on cultural resources and evaluate and implement reasonable and prudent mitigation measures, thereby ensuring that the selected remedy attains these ARARs. **<u>Action-specific ARARs, including standards for management of wastes generated by the remedial action.</u>** This alternative can be designed and implemented to attain action-specific requirements. Injection of treated groundwater will be performed in a manner that meets Federal Underground Injection Control requirements (40 CFR Parts 144-148). There will be no discharge of fill to wetlands or waterways (40 CFR 230.10), point source discharge of pollutants to waters of the United States (40 CFR Parts 122, 125), or other activities that alter the course, condition, or capacity of navigable waters (33 USC § 401 and 403). Remedial activities will comply with applicable NPDES construction stormwater requirements (40 CFR 122.26). Remedial activities will not emit regulated hazardous air pollutants (40 CFR Parts 61, 63). Installation of wells, piping, reagent storage equipment, and *ex-situ* treatment plant will be performed in a manner that does not result in a “take” of threatened or endangered species, damage their critical habitat (50 CFR part 402), or impact migratory birds (15 USC § 703-712). Waste generated during remedial activities will be handled in compliance with hazardous waste generator requirements (22 CCR Division 4.5, Chapters 11, 12, 18). The treatment system will be constructed and operated in compliance with requirements for hazardous waste tank systems (22 CCR Div. 4.5, Ch. 14, Articles 2, 10); regulated waste piles, landfills, and miscellaneous units will not be constructed. Monitoring will be performed in accordance with RCRA (22 CCR Division 4.5, Ch. 14, Article 6) and California Water Code (23 CCR Div. 3, Chapter 15; 27 CCR Div. 2, Subdivision 1; Calif. Water Code Section 13801(c)) monitoring requirements. Because RAOs will achieve background levels for chromium, this alternative is consistent with the substantive provisions of SWRCB Resolution 68-16 that requires maintenance of the highest water quality consistent with maximum benefit to the people of the State and with the substantive provisions of SWRCB Resolution 92-49 that requires restoration of background water quality. It will also result in achieving Basin Plan water quality objectives for chromium in groundwater. Appropriate land use covenants will be implemented (22 CCR 67391.1).	limit is reached where concentrations are no longer being reduced effectively, but cleanup goals have not been met. Hexavalent chromium does not strongly sorb to soils, which makes it more amenable to flushing than some other contaminants, but it may still be difficult to reach cleanup levels across the entire plume. It is not possible to predict what the limit of concentration reduction might be for flushing technology at the Topock site. Maintaining hydraulic control through pumping or injection can be accomplished at the Topock site due to the flat groundwater gradients and lack of extensive aquitards within the Alluvial Aquifer. The pumping associated with Alternative H provides a landward gradient towards the extraction wells and away from the river, but in the process, river water may be drawn into the aquifer. The river water is aerobic and would become reduced as it moved out of the river and into the fluvial aquifer. Over the long period of time that this remedy would operate, the passage of this aerobic water through the fluvial sediments could result in some degradation of the natural reducing capacity. It is not possible to accurately predict where or to what extent this degradation in reducing capacity would occur.		during construction, sampling, and operational activities to minimize environmental disturbance. Additional protections to the environment and community will be through compliance with ARARs such as for floodplain and wetland protection and stormwater requirements. **<u>Time Until RAOs are Achieved.</u>** It is estimated that between 10 and 70 years would be required to achieve the RAOs for this alternative. The estimated time to achieve the RAOs was based on the simulated time to remove 98 percent of the Cr(VI) mass within the plume. The amount of Cr(VI) mass within the East Ravine bedrock is estimated to be less than one percent of the total plume mass, and therefore does not significantly affect the simulated time to cleanup.	injections wells, pipelines, utilities, and *ex-situ* treatment plant are readily available. Some specialized services may be needed for construction and operation of certain treatment components in the *ex-situ* treatment plant; however, these services can be made available. Waste byproducts from the *ex-situ* treatment plant would need to be disposed of at an offsite, licensed disposal facility; although not widely available or close to the site, there are available disposal facilities elsewhere in California, Nevada, and/or Arizona. Offsite disposal facilities for drill cuttings or development water generated from the well installation, development, and sampling are widely available.	

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Alternative	Protect Human Health and the Environment Attain Media Cleanup Goals and Control Source of Releases	Comply with ARARs	Long-term Effectiveness, Permanence and Reliability	Reduction of Toxicity, Mobility, or Volume through Treatment	Short-term Effectiveness	Implementability	Cost Net Present Value
Alternative I – Continued Operation of Interim Measure	**Protect Human Health and the Environment.** Alternative I would protect human health and the environment in the long term throughout most of the site through reduction of Cr(VI) concentrations in groundwater by *ex-situ* treatment. Monitoring would provide data to evaluate the effectiveness of *ex-situ* treatment. Uncertainty exists regarding the flow direction of groundwater in bedrock at AOC 10 for this alternative. This alternative protects human health in the short term by limiting exposure through restriction of groundwater use as potable water source until cleanup goals are met. The groundwater extraction to remove groundwater for *ex-situ* treatment would provide a landward gradient in the floodplain, thereby preventing movement of Cr(VI) toward the river; however, continued groundwater extraction near the river may lead to long-term damage to the reducing blanket surrounding the riverbed. No new construction is initially required, but steps would be taken during future construction (for routine replacement of existing facilities and structures) and during the operation of the remedial facilities to limit disturbance to sensitive resources. Steps to limit disturbance to sensitive resources may include moving locations of infrastructure away from sensitive resources, modification of construction techniques (e.g., equipment or schedules), modification of design elements (e.g., materials, configurations, sizes). Steps may also include programmatic elements such as awareness training for site personnel. The energy requirements for operation of the treatment plant will be high, and two waste streams are generated by the aboveground treatment plant: (1) sludge from the filtration process; and (2) brine or concentrate from the reverse osmosis process. Both waste streams would be removed from the treatment plant by truck and transported to offsite, permitted disposal facilities. **Attain Media Cleanup Goals.** Alternative I includes extraction at the leading edge of the alluvial aquifer and *ex-situ* treatment to attain cleanup goals for constituents in groundwater. The estimated time to achieve the RAOs in bedrock has not yet been estimated, pending the results of further AOC-10 investigations.	**Chemical-specific ARARs.** Chemical-specific requirements will be met. By achieving cleanup goals less than MCLs, the remedy will comply with federal (40 CFR Part 141-Subpart G) and California (22 CCR Division 4, Chapter 15) Drinking Water Act requirements for Cr(T) in groundwater delivered by a public water supply system. This alternative is considered to comply with the Federal Water Pollution Control Act because surface water samples collected within the river near the site, both before and after implementation of the IM, show concentrations less than federal water quality criteria (40 CFR 131.38) for Cr(VI), and naturally occurring reducing conditions in sediments near the Colorado River and dilution provided by the river are expected to continue to prevent contaminated groundwater from causing exceedances of these standards in the river prior to remedy completion. By achieving cleanup goals in alluvial groundwater, the remedy will provide additional certainty that contaminated groundwater will not cause exceedances of federal water quality criteria established under the Federal Water Pollution Control Act (40 CFR 131.38) for Cr(VI) in the Colorado River in the long term. However, as there is uncertainty regarding the flow direction of groundwater in bedrock at AOC 10, further studies would be needed to assess resulting gradient directions and the effectiveness of long-term natural attenuation in East Ravine bedrock in attaining water quality criteria. **Location-specific ARARs.** Location-specific requirements will be met. Because surface water bodies are not being modified, USFWS coordination requirements (40 CFR 6.201) will not be triggered. Because RCRA-regulated treatment systems will not be constructed in a floodplain or seismic zone, RCRA seismic and floodplain requirements (40 CFR 264.18) will not be triggered. Construction of wells and piping in floodplain or wetland areas will be performed in a manner that compiles with federal floodplain and wetlands protection requirements (40 CFR 6.201). Steps will be taken during design and implementation to ensure compatibility with the National Wildlife Refuge System Administration Act. The requirements of the National Historic Preservation Act (16 U.S.C. § 470, *et seq*.) are applicable based on the presence of and potential impact to historic properties listed on, or eligible for listing on, the National Register of Historic Places. Other cultural resource requirements include those of the National Archaeological and Historic Preservation Act (16 U.S.C. § 469, *et seq*.), the Native American Graves Protection and Repatriation Act, 25 U.S.C. § 3001, *et seq*.), and the Archaeological Resources Protection Act (16 U.S.C. § 470aa-ii, *et seq*.). The requirements of the Historic Sites Act (16 U.S.C. § 461 *et seq*.) may apply to Route 66. In addition, there may be applicable requirements of Pub. L. 106-45 to preserve Route 66. Location and action-specific religious freedom requirements are set forth in the American Indian Religious Freedom Act and Religious Freedom Restoration Act.	**Magnitude of Residual Risk.** Alternative I includes extraction and *ex-situ* treatment to attain cleanup goals for Cr(VI) in groundwater. Risk from residual contamination in groundwater would be reduced as Cr(VI) mass within the plume is treated. **Adequacy and Reliability of Controls.** The *ex-situ* treatment process produces sludge and brine that would require long-term controls; transportation to and disposal in offsite permitted facilities is assumed to provide reliable long-term containment of the sludge and brine. Five-year reviews would be required for this alternative. Pump-and-treat technology is capable of reducing the size of plumes and removing a large portion of the contaminant mass. However at many sites, pump-and-treat systems which rely on flushing to remove contaminants have reached a limit where concentrations are no longer being reduced effectively, but cleanup goals have not been met. Thus, it may still be difficult to reach cleanup goals across the entire plume under this alternative. The pumping associated with Alternative I provides a landward gradient towards the extraction wells and away from the river, but in the process, river water may be drawn into the aquifer. The river water is aerobic and would become reduced as it moved out of the river and into the fluvial aquifer. Over the long period of time that this remedy would operate, the passage of this aerobic water through the fluvial sediments could result in some degradation of the natural reducing capacity. It is not possible to accurately predict where or to what extent this degradation in reducing capacity would occur. Alternative I does not include pumping within the East Ravine bedrock.	**Amount of Plume Destroyed or Treated.** This alternative is the continued operation of the Interim Measure, which was designed for hydraulic control of the Cr(VI) in the floodplain area of the site. . **Degree of Expected Reduction in Toxicity, Mobility, and Volume**. Alternative I includes *ex-situ* treatment in an aboveground treatment plant using a continuous, multi-step process that involves reduction of Cr(VI) to Cr(III); precipitation and removal of precipitate solids by clarification and microfiltration; and lowering the naturally-occurring TDS using reverse osmosis. Similar to *in-situ* treatment, the *ex-situ* process converts Cr(VI) to Cr(III), thereby reducing the toxicity and mobility of the site contaminants. **Degree Treatment is Irreversible.** The Cr(VI) reduction reaction is not reversible. The Cr(VI) is removed from the groundwater through chemical reduction by ferrous iron compounds followed by alkaline precipitation and filtration. The resulting sludge is transported offsite to an appropriate permitted disposal facility for long-term management. The reversibility of the Cr(VI) reduction reaction depends on the geochemical conditions in the offsite permitted disposal facility. **Type and Quantity of Residual Remaining After Treatment**. Cr(III) resulting from the treatment process is removed from the site and disposed of in an offsite, permitted disposal facility.	**Protection of the Community During Remedial Action.** The community would be protected during this period by prohibiting the use of the groundwater for drinking water through institutional controls. Monitoring would be ongoing to verify the effectiveness of the fluvial sediments provide a natural geochemical barrier to the Colorado River. The community would face limited disturbance from construction noise, and physical hazards such as traffic related to material transport. Risks can be reduced through proper controls during construction and operation. **Protection of Workers During Remedial Action.** Workers would face general site hazards including heavy equipment, occupational noise exposure, slip and fall, and so on. General site hazards would be reduced by site-specific health and safety plans and safety equipment. Workers would be required to wear appropriate personal protective equipment and use best management practices to minimize exposure. **Protection of the Environment During Remedial Action.** This alternative would not require the installation of any additional extraction, injection, or monitoring wells. Operation of the *ex-situ* system would result in environmental impacts because a substantial amount of electrical power would be required, as well as trucking requirements for delivery of treatment chemicals and disposal of wastes, with associated energy use and traffic hazards. Residuals would consist of sludge containing Cr(III) and iron, and brine or concentrate from the reverse osmosis process. Operation and maintenance of the aboveground treatment plant would include periodic sample collection, chemical controls, equipment maintenance and inspection, and process chemical and waste management. Measures will be taken during construction, sampling, and operational activities to minimize environmental disturbance. Additional protections to the environment and community will be through compliance with ARARs such as for floodplain and wetland protection and stormwater requirements. **Time Until RAOs are Achieved.** It is estimated that between 100 and 960	**Technical Feasibility.** Alternative I is technically implementable. Implementation of the IM has shown that extraction, treatment, and injection are technically implementable at this site. However, there is some amount of uncertainty about the overall ability to remove contaminants relying on flushing technology. Operation of the *ex-situ* treatment system will require some oversight during implementation to ensure that the system is operating correctly, but this alternative would not include changes to the number, location, and configuration of remedial systems over time to optimize and enhance the performance of the alternative to meet changing conditions or to enhance performance of the remedy to attain the cleanup goals. **Administrative Feasibility** Alternative I is administratively implementable. No offsite actions would be associated with Alternative I that would require permits from other agencies. Since the remedial facilities for Alternative I are already in place, there would be no new construction for Alternative I; however, operation and maintenance (that may require construction to replace system components) would need to be coordinated with and approved by the respective landowners. There may be challenges associated with administrative requirements of location-specific ARARs, such as archeological recordation. Administration of an institutional control to prohibit use of groundwater within the plume until attainment of cleanup goals would be required. The institutional control would need to be coordinated with the various landowners that overlie the plume. **Availability of Services and Materials.** Some specialized services may be needed for operation of certain treatment components in the *ex-situ* treatment plant; however, these services can be made available. Treatment byproducts would need to be disposed of at an offsite, licensed disposal facility; although not widely available or close to the site, there are available disposal facilities elsewhere in California, Nevada, and/or Arizona. Offsite disposal facilities for drill cuttings or development water generated from the well replacement, development, and sampling are widely available.	\$186,000,000 - \$398,000,000

TABLE 5-5
Individual Detailed Analysis of Remedial Alternatives against Seven Criteria
Final Groundwater Corrective Measures Study/Feasibility Study for SWMU 1/AOC 1 and AOC 10, PG&E Topock Compressor Station, Needles, California

Alternative	Protect Human Health and the Environment Attain Media Cleanup Goals and Control Source of Releases	Comply with ARARs	Long-term Effectiveness, Permanence and Reliability	Reduction of Toxicity, Mobility, or Volume through Treatment	Short-term Effectiveness	Implementability	Cost Net Present Value
	Control Sources of Releases. The historic practice of wastewater discharge to Bat Cave Wash and the use of hexavalent chromium at the site have been eliminated; therefore, sources of wastewater discharge and hexavalent chromium have been controlled. However, the historic source of contaminated groundwater in bedrock at AOC 10 has not yet been determined, and the evaluation of whether leaching of soil contamination to groundwater represents a significant transport pathway has not yet been completed.	As a threshold matter, this alternative cannot be eliminated for an inability to attain the various cultural resource ARARs. As the remedy selection process continues through the issuance of a Proposed Plan and the Record of Decision, and a remedy is designed and implemented, the federal agencies will continue to engage in consultation with tribes, State Historic Preservation Officers, and others to identify potential effects on cultural resources and evaluate and implement reasonable and prudent mitigation measures, thereby ensuring that the selected remedy attains these ARARs. **Action-specific ARARs, including standards for management of wastes generated by the remedial action.** This alternative can be designed and implemented to attain action-specific requirements. Injection of treated groundwater will be performed in a manner that meets Federal Underground Injection Control requirements (40 CFR Parts 144-148). There will be no discharge of fill to wetlands or waterways (40 CFR 230.10), point source discharge of pollutants to waters of the United States (40 CFR Parts 122, 125), or other activities that alter the course, condition, or capacity of navigable waters (33 USC § 401 and 403). Remedial activities will comply with applicable NPDES construction stormwater requirements (40 CFR 122.26). Remedial activities will not emit regulated hazardous air pollutants (40 CFR Parts 61, 63). Wells, piping, and the *ex-situ* treatment plant already exist, and were constructed in a manner that did not result in a "take" of threatened or endangered species, damage their critical habitat (50 CFR part 402), or impact migratory birds (15 USC § 703-712). Waste generated during remedial activities will be handled in compliance with hazardous waste generator requirements (22 CCR Division 4.5, Chapters 11, 12, 18). The treatment system was constructed and is operated in compliance with requirements for hazardous waste tank systems (22 CCR Div. 4.5, Ch. 14, Articles 2, 10); regulated waste piles, landfills, and miscellaneous units will not be constructed. Monitoring will be performed in accordance with RCRA (22 CCR Division 4.5, Ch. 14, Article 6) and California Water Code (23 CCR Div. 3, Chapter 15; 27 CCR Div. 2, Subdivision 1; Calif. Water Code Section 13801(c)) monitoring requirements. Because RAOs will achieve background levels for chromium, this alternative is consistent with the substantive provisions of SWRCB Resolution 68-16 that requires maintenance of the highest water quality consistent with maximum benefit to the people of the State. It will also result in achieving Basin Plan water quality objectives for chromium in groundwater. This alternative will not comply with California State Water Board Resolution 92-49. Appropriate land use covenants will be implemented (22 CCR 67391.1).			years would be required to achieve the RAOs for this alternative. The estimated time to achieve the RAOs was based on the simulated time to remove 98 percent of the Cr(VI) mass within the plume. The amount of Cr(VI) mass within the East Ravine bedrock is estimated to be less than one percent of the total plume mass, and therefore does not significantly affect the simulated time to cleanup.		

Note: Refer to Appendices D and F for assumptions supporting conceptual design of the alternatives.

Proposed Plan. Figure 5-12 presents the comparison of the alternatives against these seven criteria. In general terms, the comparative analysis is a qualitative review of how each alternative achieves the RAOs described in Section 3.0, how each reflects various risks and benefits to its implementation, and the associated tradeoffs.

5.5.1 Protect Human Health and the Environment, Attain Media Cleanup Goals, and Control Sources of Releases

This criterion is summarized by addressing the following factors:

- Protect human health and the environment
- Attain media cleanup goals
- Control sources of releases

The following subsections address each of these factors.

5.5.1.1 Protect Human Health and the Environment

As concluded in the groundwater risk assessment, there are no current direct or indirect complete exposure pathways for contact with site groundwater, and there are no human or ecological populations currently at risk of adverse health effects due to groundwater at the Topock site (ARCADIS, 2009). All alternatives will need to rely on institutional controls until their completion to ensure that exposure pathways are not created during the remedial process. Alternative A does not include institutional controls and therefore provides the possibility of future exposure to human populations in residential setting prior to attainment of cleanup goals. Alternatives B through I include an institutional control that would prohibit use of the groundwater as a potable water supply/drinking water source until the cleanup goals are attained, thereby eliminating the potential future pathway for human health risk from direct exposure to groundwater. Alternatives B and I are considered less protective than Alternatives C, D, E, F, G, and H because of the considerably longer time that an institutional control would need to be maintained to prohibit use of the groundwater as a potable water supply/drinking water source. Alternatives C through G are all considered equally protective in this regard.

With regard to verifiable river protection, Alternatives C, D, E, F, G and H are considered equally protective. Alternative I ranks lower than Alternatives C through H because of the considerably longer time until cleanup goals are achieved. Existing data show that concentrations in surface water collected from the Colorado River, both upgradient and downgradient of the site, both before and after implementation of the interim measure, are below water quality standards that support the designated uses of the Colorado River (CH2M HILL, 2009a), and the groundwater risk assessment concluded that the potential transport of constituents in groundwater to the Colorado River represents an insignificant transport pathway (ARCADIS, 2009). The two alternatives that rely on natural processes to convert Cr(VI) to Cr(III) (Alternatives A and B) have some uncertainty about protection of the river in the long term because there is no way to prove that the reducing conditions exist everywhere, and over the centuries that would be required for natural processes to reach cleanup goals, it is possible that the geochemistry or groundwater flow directions, or even the location of the Colorado River channel, could change significantly. Further studies to assess the effectiveness of long-term natural attenuation in the East Ravine will continue during remedial design.

Alternatives C, D, E, and G include floodplain cleanup (mass removal and establishment of geochemical barriers in the floodplain) as the initial step in the implementation. Alternatives E, F, G, H, and I include extraction and, thereby, hydraulic control, providing additional certainty of river protection. Alternatives C through H also include extraction within the East Ravine bedrock to provide hydraulic control of East Ravine groundwater. For Alternative I, uncertainty exists regarding the flow direction of groundwater in bedrock at East Ravine.

These two approaches (mass removal/establishment of geochemical barrier in floodplain and hydraulic containment) both will require a high level of management to ensure that the natural reducing conditions in the floodplain are not damaged or otherwise altered in a manner that diminishes the natural reductive capacity of the floodplain. Management of reducing conditions will involve regular sampling of groundwater to monitor redox conditions and possibly dosing with organic carbon to restore floodplain reducing capacity if it becomes depleted.

5.5.1.2 Attain Media Cleanup Goals

All of the remedial alternatives would attain the media (groundwater) cleanup goals, although the time to achieve the goals would vary depending upon the type of treatment. The estimated time to achieve the RAOs was based on the simulated time to remove 98 percent of the Cr(VI) mass within the plume. The amount of Cr(VI) mass within the East Ravine bedrock is estimated to be less than one percent of the total plume mass, and therefore does not significantly affect the simulated time to cleanup.

Alternatives A, B, and I would require the longest time to attain the media cleanup goals. It is estimated that Alternatives C, D, E, F, G, and H would attain the cleanup goals sooner through induced treatment, either *in-situ*, *ex-situ*, or both, with Alternative D likely requiring the least time because of the localized, intensive nature of the *in-situ* treatment activities.

By attaining the cleanup goals, the alternatives would reduce the potential human health risk from exposure to Cr(VI) and Cr(T) through the hypothetical future use of groundwater as a potable water supply/drinking water source in the long term (after cleanup goals have been attained). As discussed in Section 3.3.1, the preliminary cleanup goal for Cr(VI) (32 µg/L) is lower than the calculated noncancer risk-based remediation goal for Cr(VI) (46 µg/L), assuming future hypothetical human groundwater users that may be exposed to site groundwater in a residential setting.

5.5.1.3 Control Sources of Releases

The historic practice of wastewater discharge to Bat Cave Wash and the use of hexavalent chromium at the site have been eliminated. Therefore, sources of wastewater discharge and hexavalent chromium have been controlled. However, the historical source of contaminated groundwater in bedrock at AOC 10 has not yet been determined, and the evaluation of whether leaching of Cr(VI) from contaminated soils represents a significant transport pathway to groundwater has not yet been completed. There is no distinction between the alternatives with respect to this criterion.

5.5.1.4 Overall Ranking for Protect Human Health and the Environment, Attain Media Cleanup Goals, and Control Sources of Releases

In summary, Alternative A does not meet the threshold criteria for protecting human health and the environment because there would be no institutional controls imposed to restrict use of groundwater in locations where Cr(VI) concentrations exceed the cleanup goals, and there would be no monitoring to evaluate changes in geochemical conditions near the river over the long time period required to reach the cleanup goals. Alternatives B through I are all considered to meet the threshold criteria of protecting human health and the environment. Alternatives C, D, E, F, G, and H were ranked high for this criterion; these alternatives would all provide for protection of human health from exposure due to use of groundwater as a drinking water supply in both the short term and long term. These alternatives would also provide additional certainty for river protection as a result of floodplain cleanup (mass removal in the floodplain and establishment of a geochemical barrier) as the initial step in implementation and/or through hydraulic control. Alternatives B and I ranked medium for this criterion primarily because of the long time required to attain cleanup goals, which would require long-term use of institutional controls, as well as the uncertainty about the robustness of the natural geochemical conditions near the river over this relatively long time for Alternative B, and the high level of operation and maintenance for Alternative I.

5.5.2 Comply with Applicable or Relevant and Appropriate Requirements

The following paragraphs present the evaluation of compliance with ARARs (DOI, 2009e).This threshold criterion evaluates whether each alternative would attain the federal and state ARARs identified for the cleanup of Cr(VI) in the groundwater at the Topock site. An alternative must attain all identified ARARs, or provide grounds for invoking an ARAR waiver, in order to be eligible for selection. The ARARs for the Topock site are identified in Appendix B and have been determined to be ARARs for this site by the DOI. In addition, each alternative described in this CMS/FS has been evaluated by DOI in terms of its attainment of ARARs.

There are a number of cultural resource ARARs identified for the site. In general, they require that a federal agency identify and consider the effects of an undertaking on cultural resources and seek ways, through consultation, to avoid, minimize, or mitigate any adverse effects. As a threshold matter, none of the alternatives under consideration in this CMS/FS has been determined to fail to satisfy these cultural resource ARARs. As the remedy selection process continues through the issuance of a Proposed Plan and the Record of Decision and a remedy is designed and implemented, the federal agencies will continue to engage in consultation with tribes, State Historic Preservation Officers, and others to identify potential effects on cultural resources and to seek ways to avoid, minimize, or mitigate any adverse effects, thereby ensuring that the selected remedy attains these ARARs.

In addition, with respect to any remedial action to be undertaken within the HNWR, the National Wildlife System Administration Act has been identified as an ARAR. This statute governs the use and management of National Wildlife Refuges, requiring that ongoing and proposed activities and uses on a Refuge are appropriate and compatible with both the mission of the National Wildlife Refuge System, as well as the specific purposes for which a Refuge was established. Prior to the selection of a remedial action by DOI/USFWS, that remedial action must be found by the HNWR Manager to be both an appropriate use of the Refuge and compatible with the mission of the Refuge and the Refuge System as a whole. Any remedial action proposed to be implemented on the HNWR that was not selected by DOI/USFWS would be subject to the formal appropriate use/compatibility determination process. As a threshold matter, none of the alternatives under consideration in this CMS/FS has been determined to fail to satisfy this ARAR. After a remedy is selected by DOI/USFWS, USFWS will identify, during remedial design and implementation, those measures necessary to ensure that the selected remedy satisfies this ARAR.

Finally, based on the specific circumstances presented at the Topock site, Alternatives A, B, and I do not satisfy all identified ARARs. Specifically, these alternatives would not satisfy the "reasonable time frame" requirement established by the California State Water Resources Control Board Resolution 92-49. This Resolution requires that the selected remedy have "a substantial likelihood to achieve compliance, within a reasonable time frame, with the cleanup goals and objectives" established for a site. At DOI's request, the Water Board has interpreted this requirement in light of the specific alternatives under consideration at the Topock site. The Water Board is the state entity that originally identified this Resolution as a potential ARAR for this site, and it is the Water Board's responsibility to interpret and enforce this Resolution. In a letter, dated October 7, 2009, the DTSC as the lead State agency forwarded the recommendation from the Water Board stated that: "With respect to the nine alternatives and estimated cleanup time frames described in PG&E's draft Corrective Measures Study/Feasibility Study (CMS/FS), dated January 2009, Alternatives A, B, and I would not comply with the 'reasonable time frame' provision in Section III.A. of Resolution 92-49. Alternatives C through H would comply with this provision." Based on the analysis and supporting information provided by the Water Board, DOI concurs with the Water Board's interpretation of this Resolution as it pertains to the Topock site. In summary, alternatives C, D, E, F, G and H have been determined to comply with all ARARs. As a threshold matter, none of the alternatives under consideration in this CMS/FS has been determined to fail to satisfy cultural resource ARARs or the National Wildlife System Administration Act. Alternatives A, B, and I would not satisfy the ARAR requirements of the California State Water Resources Control Board Resolution 92-49, and thus fail to meet this threshold criterion.

5.5.3 Long-term Effectiveness, Permanence, and Reliability

This criterion is summarized by addressing the:

- Magnitude of residual risk remaining from untreated waste or treatment residuals at the conclusion of the remedial activities.
- Adequacy and reliability of controls such as containment systems and institutional controls that are necessary to manage the untreated waste or to manage treatment residuals that remain at the site.

The following subsections address these factors.

5.5.3.1 Magnitude of Residual Risk

All nine of the alternatives would reduce concentrations of Cr(VI) in groundwater at the site, either through natural reductive processes (Alternatives A and B), through *in-situ* treatment (Alternatives C, D, E, G, and H), and/or through *ex-situ* treatment (Alternatives F, G, H, and I). Alternatives C through H also include extraction within the East Ravine bedrock.

As such, the magnitude of residual risk from Cr(VI) remaining is comparable for all alternatives (after RAOs are met). Risk from residual contamination in groundwater would be reduced as Cr(VI) mass within the plume is treated.

5.5.3.2 Adequacy and Reliability of Controls

Alternatives that incorporate *ex-situ* treatment (Alternatives F, G, H, and I) will produce sludge as a treatment byproduct, and Alternative I will also produce a brine or concentrate from the reverse osmosis process. Long-term controls would be required for the treatment byproducts. Disposal in a permitted, offsite facility is assumed to provide reliable long-term containment for the byproducts.

With the exception of Alternative A, all the alternatives would include 5-year reviews to evaluate the effectiveness of the remedy to attain RAOs, as well as the adequacy and reliability of controls. Because Alternative A would not include monitoring or 5-year reviews, future changes in geochemistry or hydrogeologic characteristics would not be identified.

With regard to the degree of certainty that the alternative will be successful, there are uncertainties associated with all nine alternatives. Alternatives A and B only rely on natural attenuation to convert Cr(VI) to Cr(III). While the reducing conditions have been shown to be robust, there is no way to prove that these conditions exist everywhere, and over the centuries that would be required for MNA to reach cleanup goals, it is possible that the geochemistry or groundwater flow directions, or even the location of the Colorado River channel, could change significantly.

Alternatives C, D, E, G, and H include *in-situ* treatment, and there is uncertainty associated with distribution of carbon source substrates across this large of an area. It is possible that these uncertainties can be overcome by achieving sufficient coverage to allow natural transport of the residual chromium (that is not treated directly) to contact the treatment zones created. This concern is also addressed through optimization of the remedy during implementation and is expected to be more challenging in alternatives that target the whole plume for distribution of substrates (Alternatives C and D), in comparison to alternatives where *in-situ* treatment is limited to establishment of a geochemical barrier in the floodplain.

Alternatives E, F, G, and H rely on flushing technology. Many sites that rely on flushing to remove contaminants have reached a limit where concentrations are no longer being reduced effectively, but cleanup goals have not been met, and it is not possible to predict what the limit of concentration reduction might be for flushing technology at the Topock site. Maintaining hydraulic control through pumping or injection can be accomplished at the Topock site due to the flat groundwater gradients and lack of extensive aquitards within the Alluvial Aquifer. Alternatives C, D, E, F, G, and H include provisions for optimization of the remedy during or after the active phase. These provisions for optimization are not included with Alternative I.

Alternatives C through H include pumping within the East Ravine bedrock to ensure hydraulic control of East Ravine groundwater.

5.5.3.3 Overall Ranking for Long-term Protectiveness, Permanence, and Reliability

In summary, Alternative A (No Action) ranked the lowest of all alternatives because this alternative does not include monitoring to verify the effectiveness of natural recovery processes and to determine when the RAOs have been achieved. Any future changes in site conditions that may cause undesirable impacts to the Colorado River or unacceptable exposures to other receptors would not be detected under Alternative A. Alternative B ranked medium because, in contrast to Alternative A, Alternative B would include monitoring and institutional controls; however, this alternative relies on natural attenuation to convert Cr(VI) to Cr(III), and while the reducing conditions have been shown to be robust, there is no way to prove that these conditions exist everywhere. Over the centuries that would be required for MNA to reach cleanup goals, it is possible that the geochemistry or groundwater flow directions, or even the location of the Colorado River channel, could change significantly.

Alternatives F, G, H, and I all ranked medium for long-term effectiveness, permanence, and reliability. These alternatives include *ex-situ* treatment; the resulting waste generation requiring land disposal of treatment residuals at an offsite, permitted landfill requires long-term containment, management, and monitoring that are not required by the alternatives that include *in-situ* treatment.

Alternatives C, D, and E ranked medium-high for this criterion. While there is uncertainty regarding the ability to distribute substrates across the targeted area, and Alternative E relies on flushing to remove contaminants from the upland portion of the aquifer, comparatively few long-term controls are expected for these alternatives following attainment of cleanup goals.

5.5.4 Reduction of Toxicity, Mobility, or Volume through Treatment

This criterion is summarized by addressing the:

- Amount of plume destroyed or treated.
- Degree of expected reduction in toxicity, mobility, and volume.
- Degree to which treatment is irreversible.
- Type and quantity of residual remaining after treatment.

The following subsections address each of these factors.

5.5.4.1 Amount of Plume Destroyed or Treated

All nine alternatives would address the entire area of groundwater within the Alluvial Aquifer where Cr(VI) concentrations are higher than 32 µg/L, either through natural reductive processes (Alternatives A and B), through *in-situ* treatment (Alternatives C, D, E, G, and H), and/or through *ex-situ* treatment (Alternatives F, G, H, and I).

Alternatives C through H also include extraction within the East Ravine bedrock to provide hydraulic control of East Ravine groundwater. If it is determined that additional remedial effort is needed to reach RAOs in East Ravine bedrock, other technologies could be applied to supplement the pumping wells. In addition to pumping for hydraulic control, technologies that may be applicable to East Ravine bedrock would include, but are not limited to, freshwater injection for flushing and injection of carbon amendments for insitu reduction of Cr(VI).

Because the mass of Cr(VI) in East Ravine bedrock is estimated to be less than one percent of the total Cr(VI) plume mass, the amount of the plume treated is considered comparable for all alternatives.

5.5.4.2 Degree of Expected Reduction in Toxicity, Mobility, and Volume

All nine alternatives involve reduction of Cr(VI) to Cr(III); Cr(III) is a less toxic and essentially immobile form of chromium.

Alternatives A and B rely on the natural reducing conditions in fluvial materials near the Colorado River to reduce Cr(VI) to Cr(III) through no active treatment, while the remaining alternatives involve active treatment to reduce Cr(VI) to Cr(III) either *in-situ* (Alternatives C, D, E, G, and H) and/or *ex-situ* (Alternatives F, G, H, and I). Alternatives C through H also include extraction within the East Ravine bedrock to provide hydraulic control of East Ravine groundwater.

The degree of treatment for Alternatives A and B is considered lower than for Alternatives C through I because the extent of reduction in toxicity, mobility, and volume of Cr(VI) in Alternative A and B is less certain, while the entire Alluvial Aquifer plume would be targeted by active treatment in Alternatives C through I. The intent of Alternatives C through I is reduction of Cr(VI) concentrations to 32 µg/L and, therefore, the reduction of the toxicity, mobility, and volume of Cr(VI) through treatment.

5.5.4.3 Degree to Which Treatment is Irreversible

Reduction of Cr(VI) in an *ex-situ* treatment process such as for Alternatives F, G, H and I is not reversible. The Cr(VI) is removed from the groundwater through chemical reduction by ferrous iron compounds followed by alkaline precipitation and filtration. The resulting sludge is transported offsite to an appropriate disposal facility for long-term management.

The degree to which the Cr(VI) reduction is irreversible is similar for the alternatives involving *in-situ* treatment (Alternatives A, B, C, D, E, G, and H). As discussed in Section 5.2.6, once reduced to Cr(III), chromium takes the form of the Cr^{3+} ion and forms very low solubility oxides under the neutral and alkaline pH encountered in site groundwater. Solubility of chromium oxide Cr_2O_3 and chromium hydroxide, $Cr(OH)_3$, are low enough to maintain the Cr^{3+} concentration below the detection limit of 0.2 µg/L (Brookins, 1988; Ball and Nordstrom, 1998). Once reduced, Cr(III) does not readily become reoxidized to Cr(VI); however, Cr(III) that comes into contact with manganese oxide (MnO_2) or dissolved oxygen can be re-oxidized to Cr(VI), leading to increased concentrations of Cr(VI) over time. Two key factors are expected to limit the reconversion of Cr(III) to Cr(VI) after *in-situ* reduction: the limited solubility of Cr(III) and the lack of availability and reactivity of an adequate oxidizer (MnO_2). Together these factors are expected to limit any reoxidized Cr(VI) concentrations to levels similar to ambient background.

5.5.4.4 Type and Quantity of Residual Remaining After Treatment

Alternatives C through I differ in the type and quantity of residual remaining after treatment. Alternatives C, D, E, G, and H include *in-situ* treatment, where iron, manganese, and arsenic are potential residual byproducts. Alternatives C and D include *in-situ* treatment throughout the plume, while Alternatives E, G, and H include more limited *in-situ* treatment either within the floodplain area (Alternatives E and G) or the upland areas (Alternative H). Alternatives F, G, H, and I involve *ex-situ* treatment that generates sludge as a treatment byproduct.

Manganese is present in the Alluvial Aquifer as Mn(IV) in solid manganese oxide, and in the fluvial aquifer found adjacent to the Colorado River, manganese is present in its reduced, soluble Mn(II) form. *In-situ* reduction locally transforms Mn(IV) to soluble Mn(II) and the oxide dissolves, leading to the temporary formation of a zone with soluble manganese. After the organic carbon in the IRZ is degraded, soluble manganese is reprecipitated in its oxidized Mn(IV) form.

Natural arsenic is present in the Alluvial Aquifer commonly in association with iron oxide minerals, as an adsorbed and/or coprecipitated phase. In the fluvial aquifer found adjacent to the Colorado River, arsenic is present in its reduced, soluble As(III) form. Under reducing conditions within the fluvial zone, the iron oxides dissolved as iron is reduced from Fe(III) to Fe(II), releasing the associated As(V) and partially reducing it to As(III). In a similar way, when an IRZ is formed by the injection of a carbon source, a zone with soluble arsenic is formed, though at a lower maximum concentration than the fluvial zone found adjacent to the Colorado River (see Appendix G).

Both Mn(II) and As(III) are attenuated by adsorption reactions and consequently do not transport rapidly through groundwater. They both are significantly attenuated within the anaerobic IRZ zone, generally with limited migration out of the reduced zone. Mn(II) and As(III) are also easily reoxidized and immobilized when they reach a more oxidizing environment.

It is expected that byproducts such as arsenic and manganese will exceed baseline and background concentrations during implementation of *in-situ* methods. Under ideal geochemical and hydrologic conditions described in Appendix G arsenic and manganese byproducts should not be a significant issue. However, because of uncertainty in the complexity of aquifer lithology and geochemistry, large-scale implementation of *in-situ* treatment could result in elevated concentrations of arsenic and manganese that persist for longer than expected periods of time in some portions of the aquifer. Careful monitoring during the initial phase(s) of *in-situ* operation will enable early detection of these conditions. Specific contingency measures will be available to address potential threat to the Colorado River or the aquifer.

Alternatives C and D are designed to produce reducing conditions in all portions of the plume and therefore would temporarily produce zones around the injection wells with the most manganese and arsenic. Depending on the resulting groundwater concentrations of these elements, some monitoring time may be required following the active treatment phase before they are naturally reprecipitated within the aquifer.

Alternatives E and G include an initial phase of floodplain cleanup using *in-situ* technology, and Alternative H includes *in-situ* treatment in the upland areas. Alternative E would also include *in-situ* application in a limited area around the upland injection wells but, unlike Alternatives C and D, would not result in producing reducing conditions throughout the upland. These alternatives affect a much smaller area with *in-situ* treatment than Alternatives C and D and therefore would be expected to require less monitoring following the active period of each alternative. Only those portions of the floodplain that are currently oxidizing will be treated by *in-situ*, and these zones will potentially have soluble manganese and arsenic which, in time, should return to the solid phase within the aquifer. Careful monitoring of potential byproducts both inside and outside the plume will be conducted. Naturally reduced areas of the floodplain adjacent to the Colorado River have high concentrations of solid phase organic carbon, which already have contributed to high concentrations of dissolved iron, manganese, and arsenic.

Alternatives F, G, and H involve *ex-situ* treatment that generates sludge as a treatment byproduct. Alternative I will also generate brine or concentrate from the reverse osmosis process. The sludge and/or brine would be managed by disposal at an offsite, permitted disposal facility.

5.5.4.5 Overall Ranking for Reduction of Toxicity, Mobility, or Volume through Treatment

In summary, Alternatives F, G, and I are ranked high because the toxicity, mobility, and volume of Cr(VI) is reduced throughout the plume. Byproducts from *in-situ* treatment are expected to be localized to the reducing zone formed by the IRZ and within the range of naturally occurring concentrations found at the site (Appendix G) but could remain temporarily elevated above baseline and background concentrations in some portions of the aquifer. If monitoring indicates that byproducts remain elevated for an extended period of time, appropriate actions will be taken. For these reasons, Alternatives C, D, E, and H are ranked medium high. Byproducts from *ex-situ* treatment would be managed through disposal at an offsite, permitted disposal facility. Alternatives A and B ranked medium because the amount of plume destroyed or treated is less certain due to the passive nature of treatment and the extent and average capacity of the floodplain area to naturally reduce Cr(VI) over time.

5.5.5 Short-term Effectiveness

This criterion addresses:

- Time until remedial action objectives are achieved.
- Protection of the community during remedial action.
- Protection of the workers during remedial action.
- Protection of the environment during remedial action.

The following subsections address each of these factors. Tables 5-6A and 5-6B summarize the estimated component quantities and various features discussed under this criterion for each alternative.

TABLE 5-6A
Remedial Alternative Component Summary for Short-term Effectiveness Evaluation
Final Groundwater Corrective Measures Study/Feasibility Study for SWMU 1/AOC 1 and AOC 10, PG&E Topock Compressor Station, Needles, California

	Well Locations			***Ex-situ* Treatment**	**Pipelines, Utilities, Roads (Lengths in 1,000s of feet)**						**Extraction, Injection, and IRZ Well Locations by Area**			
Alternative	**Remediation** [b]	**Monitoring**	**Total**	**Above ground Treatment Plant**	**Piping**	**Trenches**	**Electrical**	***In-Situ* Reduction Zone**	**Access Roads**	**Number Under Crossings**	**Upland**	**Floodplain**	**Bedrock (East Ravine)**	**Estimated Time to Cleanup (Years)** [a]
A - No Action	0	0	0	0	0	0	0	-	0	0	0	0	0	220-2,200
B - Monitored Natural Attenuation	0	28	28	0	0	0	0	-	0	0	0	0	0	220-2,200
C - High-volume *In-situ* Treatment	111	32	143	0	18.4	24.4	29.6	5.3	7.7	1	49	47	15	10-60
D - Sequential *In-situ* Treatment	87	40	127	0	26.2	31.2	55.3	25	8.0	2	62	10	15	10-20
E - *In-situ* Treatment with Fresh Water Flushing	51	28	79	0	23.8	21.0	23.6	2.9	3.0	0	12	24	15	10-110
F - Pump and Treat	26	24	50	1	16.9	13.0	12.7	0	3.0	2	11	0	15	15-150
G - Combined Floodplain *In-situ*/ Pump and Treat	59	30	89	1	18.0	16.6	20.3	5.3	6.0	2	11	33	15	10-90
H - Combined Upland *In-situ*/Pump and Treat	67	32	99	1	24.0	22.1	24.9	6.6	5.8	1	47	5	15	10-70
I - Continued Operation of Interim Measure	0	0	0	1	0	0	0	0	0	0	0	0	0	100-960

Notes: Quantities shown in this table were developed for conceptual cost estimating and alternative comparison purposes. Actual quantities and distances may change based on site-specific considerations, constraints, or future evaluation. Quantities are for initial construction and do not include subsequent construction associated with future optimization or replacement during the remedial implementation period.

[a] See Appendix D.

[b] – Remediation Well Locations include extraction wells, injection wells, and wells for IRZ system. There may be more than one well per location based on site conditions. For cost estimating purposes, the number of remediation wells (not well locations) is included in Appendix D, Table D-19A.

Note: Refer to Appendices D and F for assumptions supporting conceptual design of the alternatives.

TABLE 5-6B
Remedial Alternative Component Summary for Short-term Effectiveness Evaluation
Final Groundwater Corrective Measures Study/Feasibility Study for SWMU 1/AOC 1 and AOC 10, PG&E Topock Compressor Station, Needles, California

Alternative	**Description**	**Extraction, gpm**	**Injection, gpm**	**Net Consumptive Use, gpm**	**Annual Energy Use, kW-hr/yr**	**Waste, Tons/Year**	**CO_2, Tons per Year**[d]	**Truck, Trips per Year**
A - No Action	No Action	N/A	N/A	N/A [a]	0	0	0	0
B - Monitored Natural Attenuation	Monitored Natural Attenuation	N/A	N/A	N/A	0	0	40	0
C - High-volume *In-situ* Treatment	High Volume *In-situ* Treatment	2,000	2,000	0 [b]	1,300,000	0	820	200
D - Sequential *In-situ* Treatment	Sequential *In-situ* Treatment	27-1,500	27-1,500	0 [b]	1,300,000	0	760	60
E - *In-situ* Treatment with Fresh Water Flushing	*In-situ* Treatment with Freshwater Flushing	1,140	1,140	0 [b]	560,000	0	400	16
F - Pump and Treat	Pump and Treat	1,280	1,280	0 [b]	5,400,000	3,100	3,100	260
G - Combined Floodplain *In-situ*/ Pump and Treat	Combined Floodplain *In-situ*/Pump and Treat	1,230	1,230	0 [b]	5,500,000	3,100	3,200	280
H - Combined Upland *In-situ*/Pump and Treat	Combined Upland *In-situ*/Pump and Treat	500	500	0 [b]	2,600,000	650	1,600	150

TABLE 5-6B
Remedial Alternative Component Summary for Short-term Effectiveness Evaluation
Final Groundwater Corrective Measures Study/Feasibility Study for SWMU 1/AOC 1 and AOC 10, PG&E Topock Compressor Station, Needles, California

I - Continued Operation of Interim Measure	Continued Operation of Interim Measure [c]	125-133	124-132	1-3	1,800,000	220	1,300	290

Notes:

Quantities shown in this table are estimates developed for conceptual cost estimating and alternative comparison purposes. Actual quantities and rates may change based on site-specific considerations, constraints, or future evaluation.

af-yr = acre-feet per year

[a] Not applicable as no pumping for extraction or injection is a part of the alternative.

[b] Approximate value.

[c] Rates are based on recent plant performance (December 2008 to March 2009). Rates are adjusted to account for plant downtime. As described in Appendix F, extraction rate assumption and injection rate assumption for estimating cleanup time for Alternative I are 135 gpm and 120 gpm, respectively.

[d] Alternative specific assumptions regarding number of vehicle trips were developed. Vehicles trips include heavy truck, field vehicle (light truck) and personal vehicles for employees. Vehicle carbon dioxide emissions based on the following:

- 0.0016 CO_2 equivalents (tons/mile) for diesel heavy truck at 7 miles per gallon (mpg).
- 0.0008 CO_2 equivalents (tons/mile) for field vehicle at 15 mpg.
- 0.0006 CO_2 equivalents (tons/mile) for personal vehicle at 20 mpg.

CO_2 equivalents for diesel vehicles based on California Climate Action Registry General Reporting Protocol, March 2007: http://www.climateregistry.org/PROTOCOLS/grcp/.

CO_2 equivalents for gasoline vehicles based on USEPA Office of Transportation and Air Quality data: http://www.epa.gov/OMS/climate/420f05004.htm.

CO_2 emissions include those for electrical power generation at 0.00521 tons per kilowatt-hour. Average value for Natural Gas from Environmental Costs of Electricity, Pace University Center for Environmental and Legal Studies (Oceana Publications, 1990), which includes data (in pounds) from PLC Inc., and Oak Ridge National Laboratories for the United States Department of Energy.

5.5.5.1 Time Until Remedial Action Objectives are Achieved

Under Alternatives A and B, the time required for the natural recovery processes to achieve the RAOs is estimated to range from 220 to 2,200 years. Alternative I is estimated to require from 100 to 960 years to achieve the RAOs. The active remediation technologies associated with Alternatives C through H are designed to significantly shorten the time to achieve RAOs; therefore, all of these alternatives ranked higher than Alternatives A, B, and I for this aspect of short-term effectiveness. The ranges in times to cleanup for all alternatives are shown in Tables 5-6A and 5-6B. The estimated time to achieve the RAOs was based on the simulated time to remove 98 percent of the Cr(VI) mass within the plume. The amount of Cr(VI) mass within the East Ravine bedrock is estimated to be less than one percent of the total plume mass, and therefore does not significantly affect the simulated time to cleanup.

5.5.5.2 Protection of the Community During Remedial Action

Under Alternative A (No Action), no remedial action would occur; therefore, there would be no short-term disturbance to the community from construction activities. However, Cr(VI) in groundwater would not be addressed, the time for natural recovery processes to occur is estimated to be over 200 years, and performance monitoring would not be included in this alternative. Further, Alternative A would not include an institutional control to limit exposure from future development of a water supply within the plume prior to attainment of cleanup goals.

Alternatives B through I all include an institutional control to prohibit development of a water supply within the plume area prior to attainment of cleanup goals, thereby providing protection to the community from exposure via a hypothetical future drinking water source during the remediation period. When compared to Alternatives C through I, Alternative B would cause the least short-term disturbance to the community since minimal construction would occur to add groundwater monitoring wells to the existing network.

The four *ex-situ* treatment alternatives, Alternatives F, G, H and I, were ranked low with respect to effects to the community, workers and environment during implementation of the remedy from construction and operation of an aboveground treatment plant. Construction of an aboveground treatment plant (Alternatives F, G, and H) would include foundation, exterior structure, tanks, piping, pumps, equipment, controls and instrumentation. Operation and maintenance of the aboveground treatment plant would include periodic sample collection, chemical controls, equipment maintenance and inspection, and process chemical and waste management. Construction and operation of the *ex-situ* system would result in greater environmental disturbance than the *in-situ* treatment alternatives due to the greater amount of construction, aboveground visual impact, worker/operator presence onsite, and electrical power that would be required for the building and operation of a treatment plant. Operation of the *ex-situ* system would result in greater trucking requirements for chemical delivery and waste disposal than the *in situ* treatment systems. Greater trucking requirements for chemical delivery and waste transportation and disposal would generate the greatest amount of waste. Alternative I does not require construction of a new treatment plant, but does include a high level of operation and maintenance for a substantially longer period than the treatment plant associated with Alternatives F, G, and H. With respect to effects to the community during implementation of the *in-situ* alternatives, Alternatives C and E were comparably ranked as high for short-term effectiveness because these alternatives would result in a similar and relatively limited amount of construction and operation of the remedial facilities. As shown in Table 5-6A, Alternative C would include installation of more wells than Alternative E; however, Alternative E would involve more piping and trenches than Alternative C. Operation and maintenance activities for Alternatives C, D and E are similar and include periodic well maintenance, sample collection, and refinement of the injection/recirculation systems; management of the reactant material; equipment inspections; and periodic replacement of wells and other structures that become clogged or damaged. Controls would be implemented during construction and operational phases to limit disturbance to the community during the remedial activities.

Alternative D involves implementation of *in-situ* treatment systems similar to Alternatives C and E. However, in contrast to Alternatives C and E, Alternative D does not minimize construction of remedial facilities in previously disturbed areas and would therefore result in more disruption to the community than Alternatives C and E. Alternative D, therefore, was ranked low for protection of the community during implementation of the remedy.

5.5.5.3 Protection of the Workers During Remedial Action

Under Alternative A (No Action), no remedial action would occur; therefore, there would be no short-term disturbance to workers from construction activities.

When compared to Alternatives C through I, Alternative B would cause the least short-term disturbance to construction workers since minimal construction would occur to add groundwater monitoring wells to the existing network (see Tables 5-6A and 5-6B). However, the monitoring effort that involves activity at the site and possible Cr(VI) exposure to workers would continue for centuries.

The four *ex-situ* treatment alternatives—Alternatives F, G, H, and I—are considered to rank lower than the other alternatives with respect to protection of workers due to construction and operation of the aboveground treatment plant associated with these alternatives. Construction of an aboveground treatment plant (Alternatives F, G, and H) would include foundation, exterior structure, tanks, piping, pumps, equipment, controls, and instrumentation. Operation and maintenance of the aboveground treatment plant would include periodic sample collection, chemical controls, equipment maintenance and inspection, and process chemical and waste management. Construction and operation of the *ex-situ* system would result in greater presence of workers/operators onsite than the other alternatives. As shown in Table 5-6B, operation of the *ex-situ* system would result in greater trucking requirements for chemical delivery and waste disposal than the *in-situ* treatment systems. Alternative I does not require construction of a new treatment plant but does include a high level of operation and maintenance for a substantially longer period than the treatment plant associated with Alternatives F, G, and H.

With respect to effects to workers during implementation of the *in-situ* alternatives, Alternatives C and E were comparably ranked higher than the other active alternatives because these alternatives would result in a similar and limited amount of construction and operation of the remedial facilities. As shown in Table 5-6A, Alternative C would include installation of more wells than Alternative E; however, Alternative E would involve more piping and trenches than Alternative C. Operation and maintenance activities for

Alternatives C, D, and E are comparable and include periodic well maintenance, sample collection, and refinement of the injection/recirculation systems; management of the reactant material; equipment inspections; and periodic replacement of wells and other structures that become clogged or damaged. Controls would be implemented during construction and operational phases to protect workers during the remedial activities.

5.5.5.4 Protection of the Environment During Remedial Action

Under Alternative A (No Action), no remedial action would occur; therefore, there would be no short-term disturbance to the environment from construction activities.

When compared to Alternatives C through I, Alternative B would cause the least short-term disturbance to the environment since minimal construction would occur to add groundwater monitoring wells to the existing network (see Tables 5-6A and 5-6B). However, the monitoring effort that involves activity at the site and possible Cr(VI) exposure to workers or releases to the environment would continue for centuries under Alternative B.

Alternatives C through I address the second RAO stated in Section 3.0 (to ensure that concentrations of Cr(T) and Cr(VI) in groundwater at the site do not cause exceedances in water quality standards that support the designated uses of the Colorado River) in a comparable manner through floodplain cleanup, mass removal in the floodplain, establishment of a geochemical barrier (Alternatives C, D, E, and G), and/or hydraulic control (Alternatives E, F, G, H, and I) and are considered equally effective in protecting river water quality during the remediation period. As stated in the evaluation of long-term effectiveness, with the exception of Alternative I, these alternatives include provisions for optimization of the remedy during the implementation period.

The four *ex-situ* treatment alternatives, Alternatives F, G, H, and I, were ranked comparably low with respect to protection of the environment due to construction and operation of the aboveground treatment plant. Construction of an aboveground treatment plant (Alternatives F, G, and H) would include foundation, exterior structure, tanks, piping, pumps, equipment, controls, and instrumentation. Operation and maintenance of the aboveground treatment plant would include periodic sample collection, chemical controls, equipment maintenance and inspection, and process chemical and waste management. Construction and operation of the *ex-situ* system would result in greater environmental disturbance than the *in-situ* treatment alternatives due to the greater amount of construction, aboveground visual impact, and electrical power that would be required for the building and operation of a treatment plant. Operation of the *ex-situ* system would result in greater trucking requirements for chemical delivery and waste disposal than the *in-situ* treatment systems. Alternative I does not require construction of a new treatment plant but does include a high level of operation and maintenance for a substantially longer period than the treatment plant associated with Alternatives F, G, and H.

For those alternatives that include *in-situ* treatment (Alternatives C, D, E, G, and H), concentrations of byproducts such as manganese and arsenic are likely to temporarily increase within portions of the treatment zone. Although these elements are expected to naturally re-precipitate within the anaerobic zone (as part of sulfide or iron precipitates) or to become re-oxidized and attenuate through sorption and precipitation in the aerobic zones outside the treatment zone over time (Appendix G) because of uncertainty in the complexity of aquifer lithology and geochemistry, large-scale implementation of *in-situ* treatment could result in unacceptably high concentrations of arsenic and manganese that persist for longer than expected periods of time in some portions of the aquifer. For these alternatives, monitoring and continued enforcement of institutional controls may be required for some time period to assess *in-situ* treatment byproducts once the remedy is complete.

With respect to effects to the environment during implementation of the *in-situ* alternatives, Alternatives C and E were comparably ranked higher because these alternatives would result in a similar and limited amount of construction and operation of the remedial facilities. As shown in Table 5-6A, Alternative C would include installation of more wells than Alternative E; however, Alternative E would involve more piping and trenches than Alternative C. Operation and maintenance activities for Alternatives C, D, and E are comparable and include periodic well maintenance, sample collection, and refinement of the injection/recirculation systems; management of the reductant material; equipment inspections; and periodic replacement of wells and other structures that become clogged or damaged. Controls would be implemented during construction and operational phases to limit disturbance to the environment during the remedial activities.

Alternative D involves implementation of *in-situ* treatment systems similar to Alternatives C and E. However, in contrast to Alternatives C and E, Alternative D does not minimize construction of remedial facilities in previously disturbed areas and would therefore result in greater impacts to the environment than Alternatives C and E. Alternative D, therefore, was ranked low for protection of the environment during implementation of the remedy.

5.5.5.5 Overall Ranking for Short term Effectiveness

Taking all of these aspects of short-term effectiveness into consideration, Alternative B was ranked medium because of the minimal footprint but relatively long time to cleanup. Alternatives C and E were ranked medium-low because of the comparatively shorter remediation period and relatively limited construction and operational activities that would occur primarily in previously disturbed areas. Alternatives A, D, F, G, H, and I received a low ranking for short-term effectiveness. Alternative A was ranked low primarily because of the extensive time to cleanup with no controls during the remedial period. Alternatives F, G, H, and I were ranked low as a result of construction and operation of an aboveground treatment plant and the greater amount of construction, aboveground visual impact, worker/operator presence onsite, electrical power requirements, and trucking requirements for chemical delivery and waste transportation and disposal. Alternative D ranked low primarily because the location of remedial facilities would not be limited to previously disturbed areas and because of the need for subsequent additional disturbance from grading, road construction, facility construction, and operation and maintenance.

5.5.6 Implementability

This criterion is summarized by addressing the:

- Technical feasibility.
- Administrative feasibility.
- Availability of services and materials.

The following subsections address each of these factors.

5.5.6.1 Technical Feasibility

Alternative A is easily implementable because no remedial action would be taken. Alternatives B through I involve remedial technologies that are technically implementable to construct and consist of a combination of monitoring wells, extraction wells, injection wells, pipelines, utilities, and/or treatment facilities that have been constructed at a smaller scale at the Topock site during the IM, *in-situ* pilot studies, and RFI/RI site characterization. The more robust remedial alternatives involving *in-situ* or *ex-situ* treatment (Alternatives C through I) have greater technical implementability challenges than those alternatives that rely solely on natural attenuation in the fluvial sediments of the Colorado River for treatment. Alternatives C through I also would require a higher level of oversight during implementation to ensure that the systems are optimized and modified as remediation progresses. Alternative I has been in operation for a number of years and has been shown to be technically feasible, although it was designed for a different set of goals than this remedial action. Alternatives C and D have technical challenges associated with the ability to obtain complete distribution of substrates across a large area Alternatives E, F, G, H, and I have technical challenges associated with reliance on flushing to remove contaminants. Alternatives E, G, and H have fewer technical challenges associated with *in-situ* treatment than Alternatives C and D because the *in-situ* treatment is confined to portions of the site. Alternatives C, D, and H include construction of injection/extraction wells for *in-situ* treatment within Bat Cave Wash that presents challenges associated with maintaining protection against future damage or wash out. Alternative C includes the additional technical challenge of balancing reductant delivery throughout the plume while maintaining hydraulic containment.

Treatment byproducts would be generated by the *ex-situ* treatment process under Alternatives F, G, H, and I; the sludge (and brine for Alternative I) would require disposal at an offsite, licensed disposal facility. Wastes generated from installation, development, maintenance, and sampling of wells under Alternatives B through H would be characterized for disposal and transported to a licensed, offsite disposal facility as required.

5.5.6.2 Administrative Feasibility

Alternatives B through I would each include administration of an institutional control to prohibit use of groundwater associated with the plume until attainment of cleanup goals. The institutional control would need to be coordinated with the various landowners that overlie the plume. Alternatives B through I are considered equal in the administrative challenges associated with the institutional control, although the institutional control associated with Alternatives B and I would be in place considerably longer than the institutional control associated with Alternatives C, D, E, F, G, and H.

There may be challenges associated with administrative requirements of location-specific ARARs, such as archeological recordation. These administrative challenges increase for alternatives with the most infrastructure and highest level of operation and maintenance.

Alternative E is the only alternative that includes installation of a new water supply well, and a pipeline to transport the water. Approvals for the water supply well and pipelines would have to be obtained through the landowners and associated water agencies.

Each of the alternatives, with the exception of Alternative A, would require construction of remedial and/or monitoring facilities outside of PG&E property. Construction and operation of these facilities would need to be coordinated with and approved by the respective landowners, including Burlington Northern-Santa Fe and Caltrans for Alternatives C through H. Since the remedial facilities for Alternative I are already in place, there would be no new construction for Alternative I; however, operation and maintenance for this and other alternatives (that may require construction to replace system components due to equipment aging and breakdown) would need to be coordinated with and approved by the respective landowners.

5.5.6.3 Availability of Services and Materials

All alternatives consist of remedial technologies that are readily available in the marketplace. Some specialized services and equipment may be needed for construction and operation of the *ex-situ* treatment plant under Alternatives F, G, H, and I or for the optimization of the reactant mix and delivery systems in the *in-situ* treatment systems under Alternatives C, D, E, G, and H; however, these services can be made available. Offsite disposal facilities are available for the wastes expected to be generated from the *ex-situ* treatment in Alternatives F, G, H, and I.

5.5.6.4 Overall Ranking for Implementability

In summary, Alternatives A and B are ranked high for implementability because Alternative A involves no remedial action, and the only remedial activities associated with Alternative B are monitoring well construction and maintenance and administration of an institutional control. Alternative I also ranked high because the system has been shown to be technically implementable over the years it has operated. Alternatives D, E, F, G, and H were ranked medium because while these alternatives are administratively implementable, there will be technical challenges associated with the active treatment processes. Alternative E requires additional approvals from landowners and associated water agencies for the water supply well and pipeline. Alternative C was ranked low for this criterion because of the relatively more complex technical challenges associated with balancing reductant delivery and hydraulic containment of the plume, as well as construction within Bat Cave Wash.

5.5.7 Cost

The cost estimates for each alternative are located in Appendix D. Table 5-7 summarizes the estimated present value and nominal (total lifetime alternative) costs for the remedial alternatives. The costs for Alternatives A and B are the lowest; therefore, these alternatives are ranked high in cost-effectiveness. Alternatives C, D, E, and H are the next most costly; therefore, these alternatives are ranked medium in cost-effectiveness. Alternatives F, G, and I are the most expensive of the alternatives and are therefore ranked low in cost-effectiveness.

TABLE 5-7
Remedial Alternative Cost Summary
Final Groundwater Corrective Measures Study/Feasibility Study for SWMU 1/AOC 1 and AOC 10, PG&E Topock Compressor Station, Needles, California

Description	**Net Present Value**	**Nominal Costs**
Alternative A—No Action	$0	$0
Alternative B—Monitored Natural Attenuation	$25,000,000 - $54,000,000	$513,000,000
Alternative C—High Volume *In-situ* Treatment	$119,000,000 - $255,000,000	$206,000,000
Alternative D—Sequential *In-situ* Treatment	$118,000,000 - $254,000,000	$191,000,000
Alternative E—*In-situ* Treatment with Freshwater Flushing	$92,000,000 - $198,000,000	$184,000,000
Alternative F—Pump and Treat	$187,000,000 - $401,000,000	$443,000,000
Alternative G—Combined Floodplain *In-situ*/Pump and Treat	$177,000,000 - $380,000,000	$329,000,000
Alternative H—Combined Upland *In-situ*/Pump and Treat	$127,000,000 - $273,000,000	$225,000,000
Alternative I—Continued Operation of Interim Measure	$186,000,000 - $398,000,000	$2,030,000,000

Note:
See Appendix D for cost estimate assumptions.

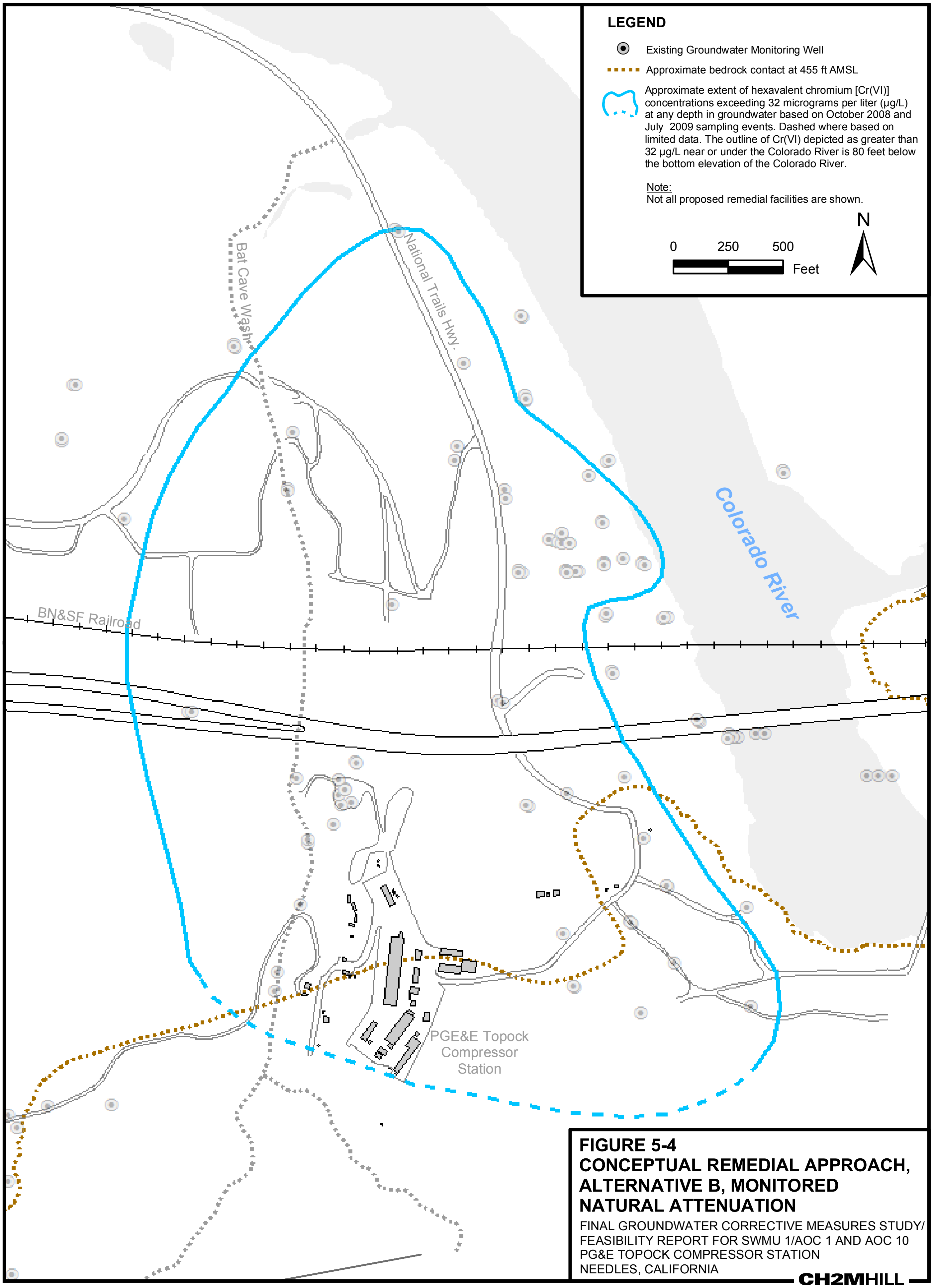

FIGURE 5-4
CONCEPTUAL REMEDIAL APPROACH, ALTERNATIVE B, MONITORED NATURAL ATTENUATION

FINAL GROUNDWATER CORRECTIVE MEASURES STUDY/
FEASIBILITY REPORT FOR SWMU 1/AOC 1 AND AOC 10
PG&E TOPOCK COMPRESSOR STATION
NEEDLES, CALIFORNIA

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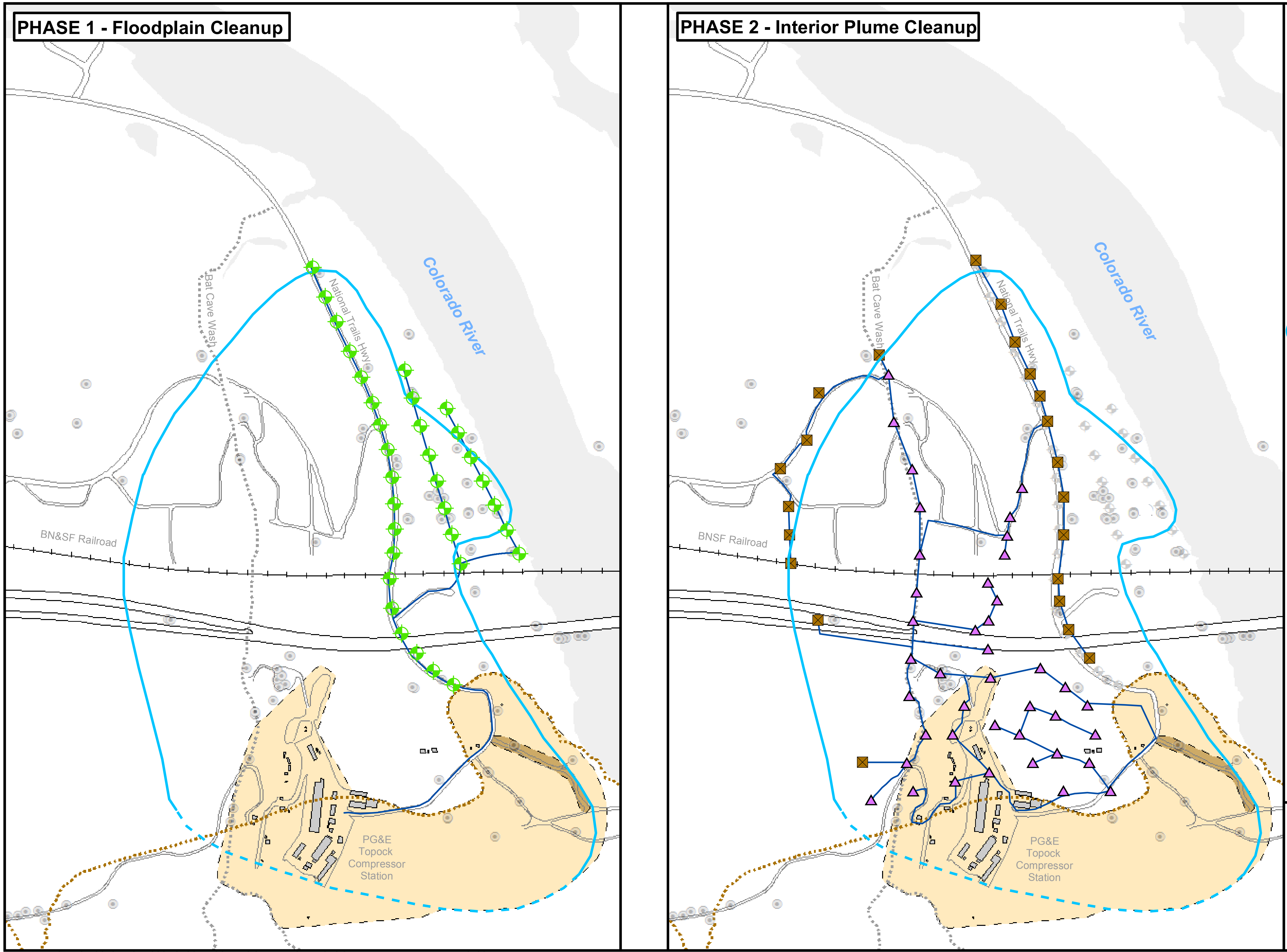

LEGEND

▨ Extraction Well

△ Injection Well For Carbon-Amended Water

⊕ IRZ Recirculation Wells

▭ Approximate area where additional infrastructure maybe necessary for bedrock remedial activities in the East Ravine.

▬ Approximately 15 bedrock wells for bedrock remedial activities in the East Ravine

◉ Existing Groundwater Monitoring Well

— Utility/Pipeline Trench

⋯ Approximate bedrock contact at 455 ft MSL elevation

◌ Approximate extent of hexavalent chromium [Cr(VI)] concentrations exceeding 32 micrograms per liter (µg/L) at any depth in groundwater based on October 2008 and July 2009 sampling events. Dashed where based on limited data. The outline of Cr(VI) depicted as greater than 32 µg/L near or under the Colorado River is 80 feet below the bottom elevation of the Colorado River.

Notes:

1. Required piping, wells and locations are approximate at this time. Multiple wells could be installed at each of the identified locations depending upon actual well performance.
2. Phase 1 features shown in grey on Phase 2 map for reference.
3. Not all proposed remedial facilities are shown.

N

0 500 1,000 Feet

FIGURE 5-5
CONCEPTUAL REMEDIAL APPROACH, ALTERNATIVE C, HIGH VOLUME *IN-SITU* TREATMENT

FINAL GROUNDWATER CORRECTIVE MEASURES STUDY/ FEASIBILITY REPORT
FOR SWMU 1/AOC 1 AND AOC 10
PG&E TOPOCK COMPRESSOR STATION
NEEDLES, CALIFORNIA

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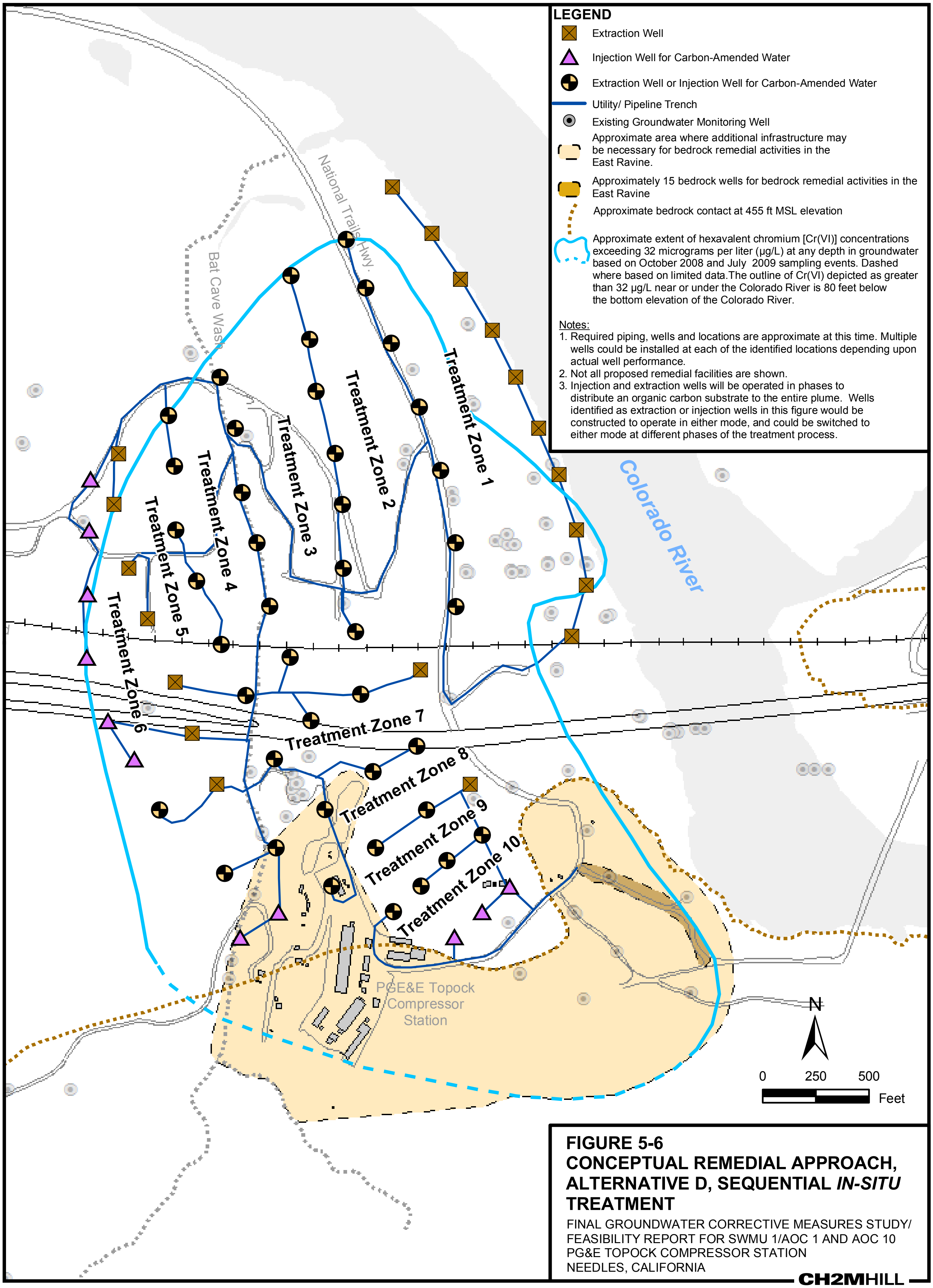

Notes:

1. Required piping, wells and locations are approximate at this time. Multiple wells could be installed at each of the identified locations depending upon actual well performance.
2. Not all proposed remedial facilities are shown.
3. Injection and extraction wells will be operated in phases to distribute an organic carbon substrate to the entire plume. Wells identified as extraction or injection wells in this figure would be constructed to operate in either mode, and could be switched to either mode at different phases of the treatment process.

FIGURE 5-6
CONCEPTUAL REMEDIAL APPROACH, ALTERNATIVE D, SEQUENTIAL *IN-SITU* TREATMENT

FINAL GROUNDWATER CORRECTIVE MEASURES STUDY/
FEASIBILITY REPORT FOR SWMU 1/AOC 1 AND AOC 10
PG&E TOPOCK COMPRESSOR STATION
NEEDLES, CALIFORNIA

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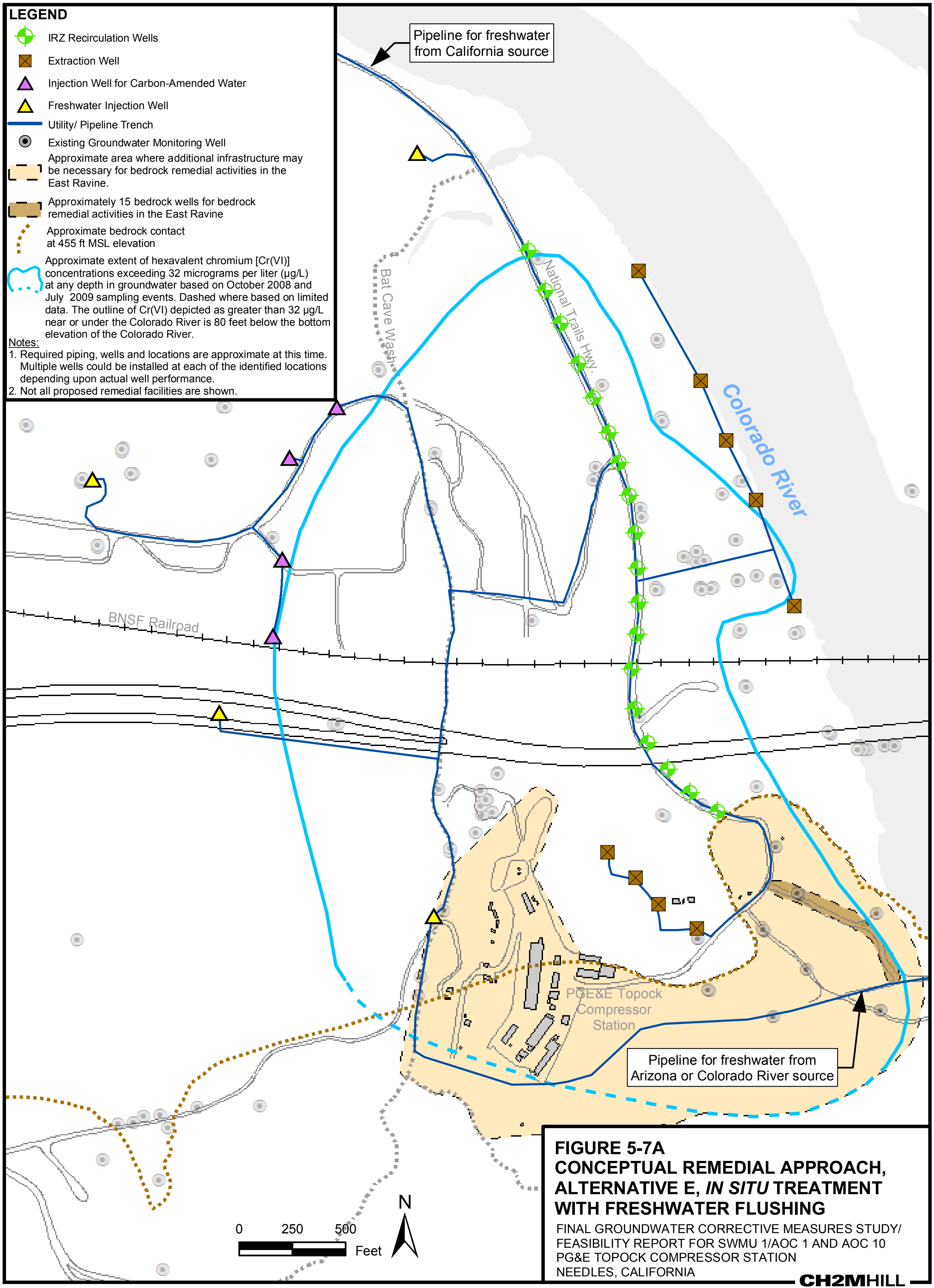

LEGEND

- ⊕ IRZ Recirculation Wells
- ☒ Extraction Well
- ▲ Injection Well for Carbon-Amended Water
- △ Freshwater Injection Well
- — Utility/ Pipeline Trench
- ◉ Existing Groundwater Monitoring Well
- ▭ Approximate area where additional infrastructure may be necessary for bedrock remedial activities in the East Ravine.
- ▨ Approximately 15 bedrock wells for bedrock remedial activities in the East Ravine
- ⋯ Approximate bedrock contact at 455 ft MSL elevation
- ◯ Approximate extent of hexavalent chromium [Cr(VI)] concentrations exceeding 32 micrograms per liter (µg/L) at any depth in groundwater based on October 2008 and July 2009 sampling events. Dashed where based on limited data. The outline of Cr(VI) depicted as greater than 32 µg/L near or under the Colorado River is 80 feet below the bottom elevation of the Colorado River.

Notes:

1. Required piping, wells and locations are approximate at this time. Multiple wells could be installed at each of the identified locations depending upon actual well performance.
2. Not all proposed remedial facilities are shown.

FIGURE 5-7A
CONCEPTUAL REMEDIAL APPROACH, ALTERNATIVE E, *IN SITU* TREATMENT WITH FRESHWATER FLUSHING

FINAL GROUNDWATER CORRECTIVE MEASURES STUDY/
FEASIBILITY REPORT FOR SWMU 1/AOC 1 AND AOC 10
PG&E TOPOCK COMPRESSOR STATION
NEEDLES, CALIFORNIA

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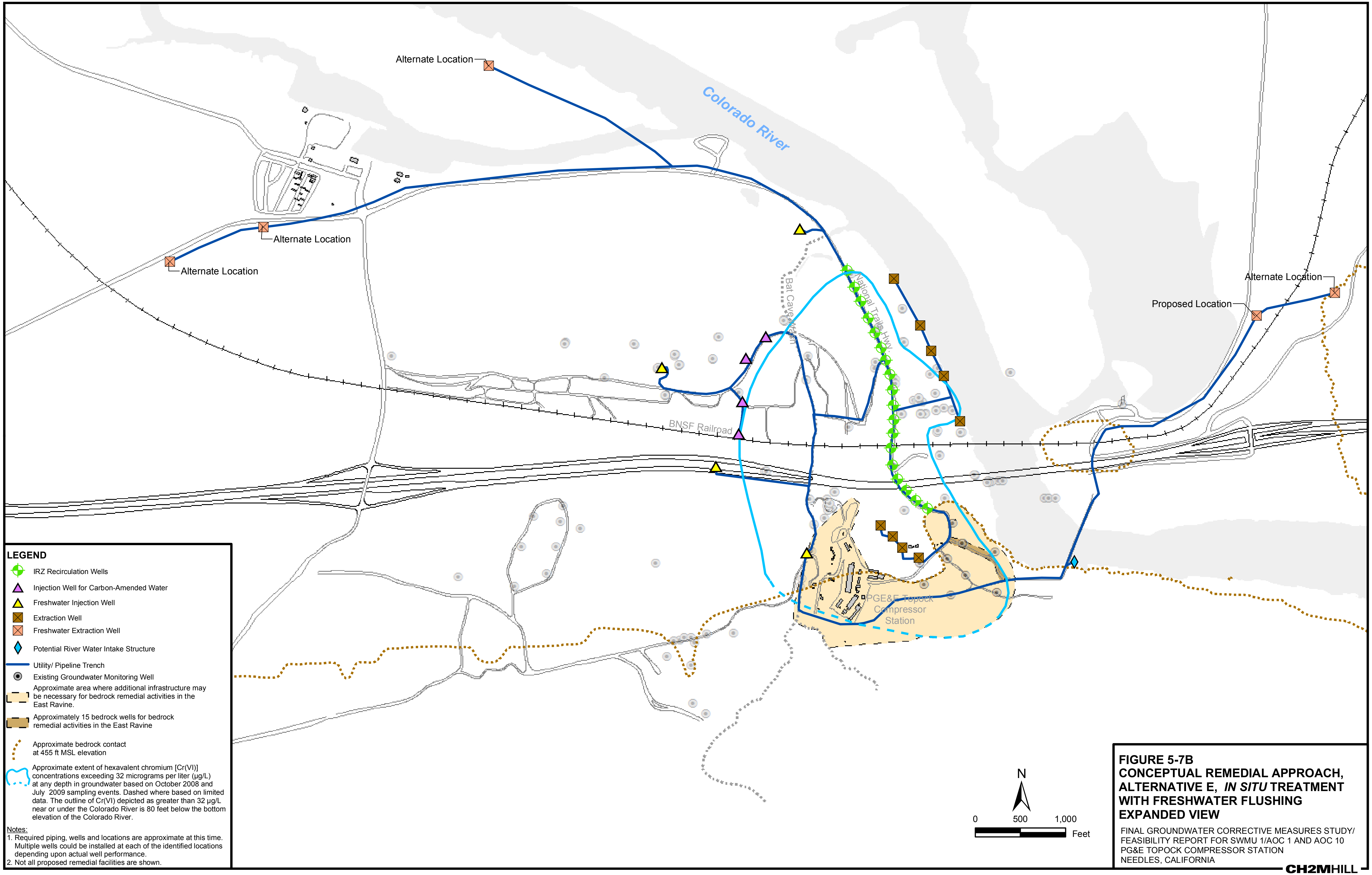

LEGEND

⊕	IRZ Recirculation Wells
▲	Injection Well for Carbon-Amended Water
△	Freshwater Injection Well
☒	Extraction Well
☒	Freshwater Extraction Well
◆	Potential River Water Intake Structure
—	Utility/ Pipeline Trench
◉	Existing Groundwater Monitoring Well
▭	Approximate area where additional infrastructure may be necessary for bedrock remedial activities in the East Ravine.
▨	Approximately 15 bedrock wells for bedrock remedial activities in the East Ravine
⋯	Approximate bedrock contact at 455 ft MSL elevation
⋯	Approximate extent of hexavalent chromium [Cr(VI)] concentrations exceeding 32 micrograms per liter (µg/L) at any depth in groundwater based on October 2008 and July 2009 sampling events. Dashed where based on limited data. The outline of Cr(VI) depicted as greater than 32 µg/L near or under the Colorado River is 80 feet below the bottom elevation of the Colorado River.

Notes:
1. Required piping, wells and locations are approximate at this time. Multiple wells could be installed at each of the identified locations depending upon actual well performance.
2. Not all proposed remedial facilities are shown.

FIGURE 5-7B
CONCEPTUAL REMEDIAL APPROACH, ALTERNATIVE E, *IN SITU* TREATMENT WITH FRESHWATER FLUSHING EXPANDED VIEW

FINAL GROUNDWATER CORRECTIVE MEASURES STUDY/ FEASIBILITY REPORT FOR SWMU 1/AOC 1 AND AOC 10
PG&E TOPOCK COMPRESSOR STATION
NEEDLES, CALIFORNIA

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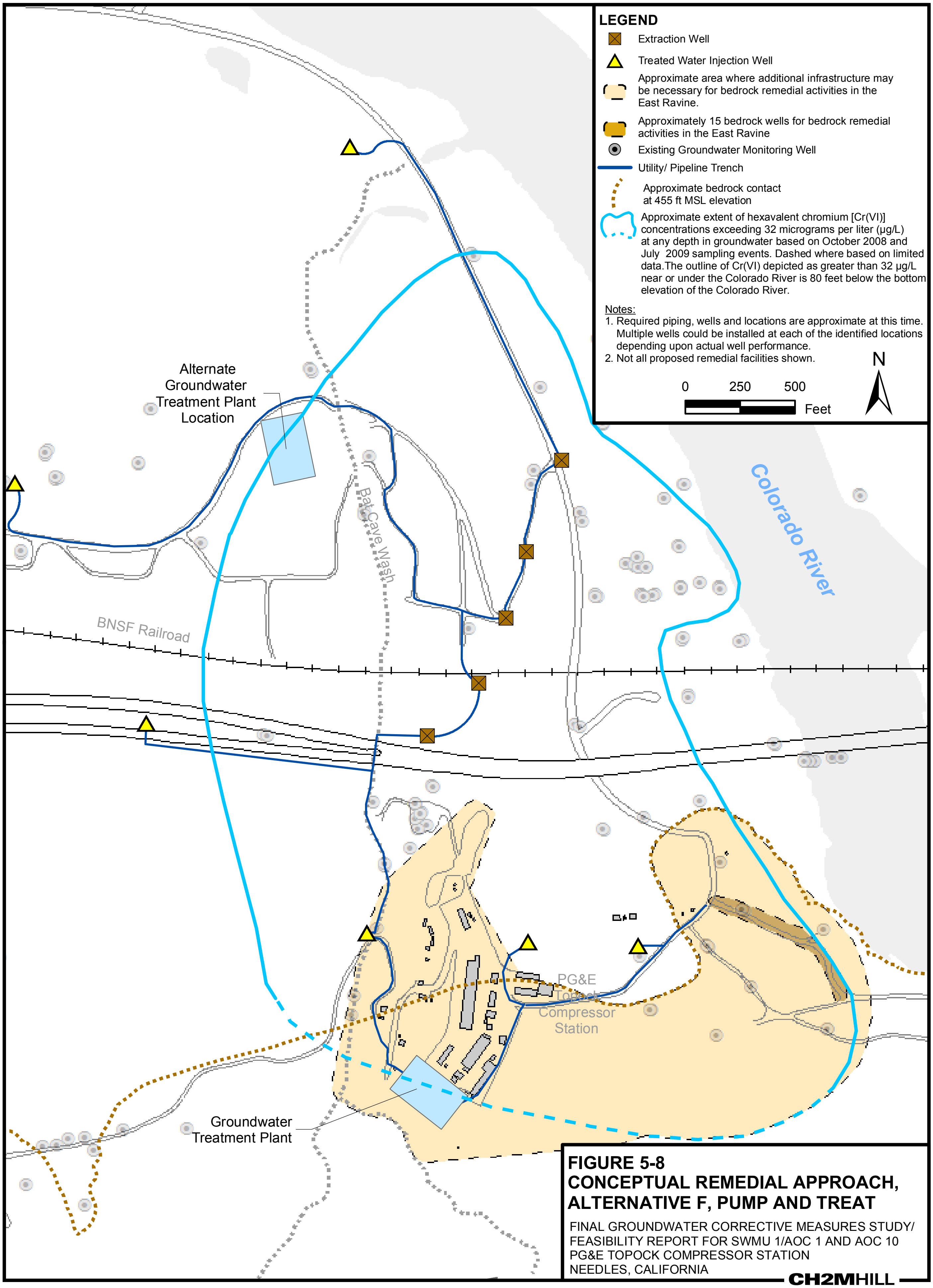

FIGURE 5-8
CONCEPTUAL REMEDIAL APPROACH, ALTERNATIVE F, PUMP AND TREAT

FINAL GROUNDWATER CORRECTIVE MEASURES STUDY/
FEASIBILITY REPORT FOR SWMU 1/AOC 1 AND AOC 10
PG&E TOPOCK COMPRESSOR STATION
NEEDLES, CALIFORNIA

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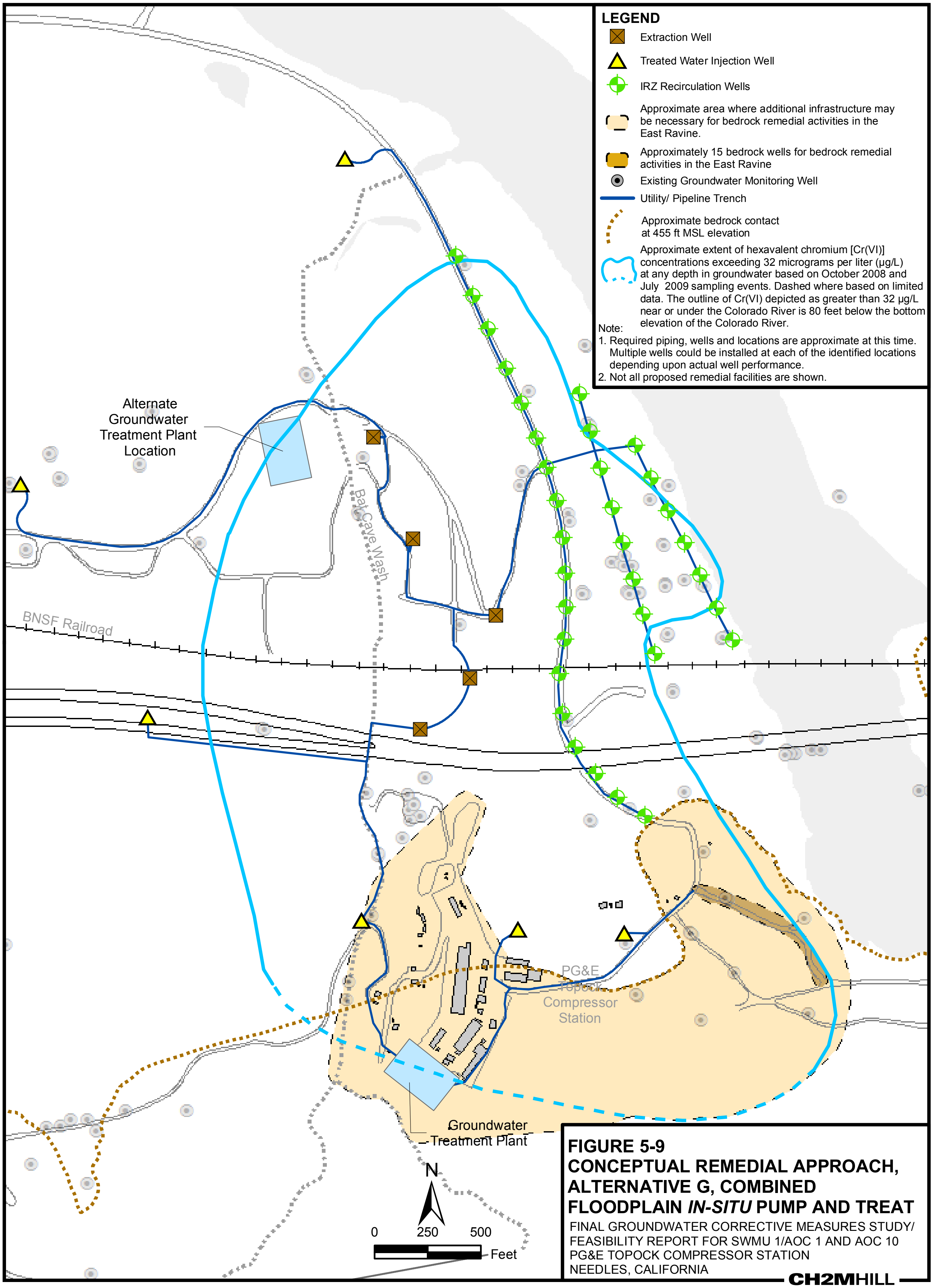

Note:
1. Required piping, wells and locations are approximate at this time. Multiple wells could be installed at each of the identified locations depending upon actual well performance.
2. Not all proposed remedial facilities are shown.

FIGURE 5-9
CONCEPTUAL REMEDIAL APPROACH, ALTERNATIVE G, COMBINED FLOODPLAIN *IN-SITU* PUMP AND TREAT

FINAL GROUNDWATER CORRECTIVE MEASURES STUDY/
FEASIBILITY REPORT FOR SWMU 1/AOC 1 AND AOC 10
PG&E TOPOCK COMPRESSOR STATION
NEEDLES, CALIFORNIA

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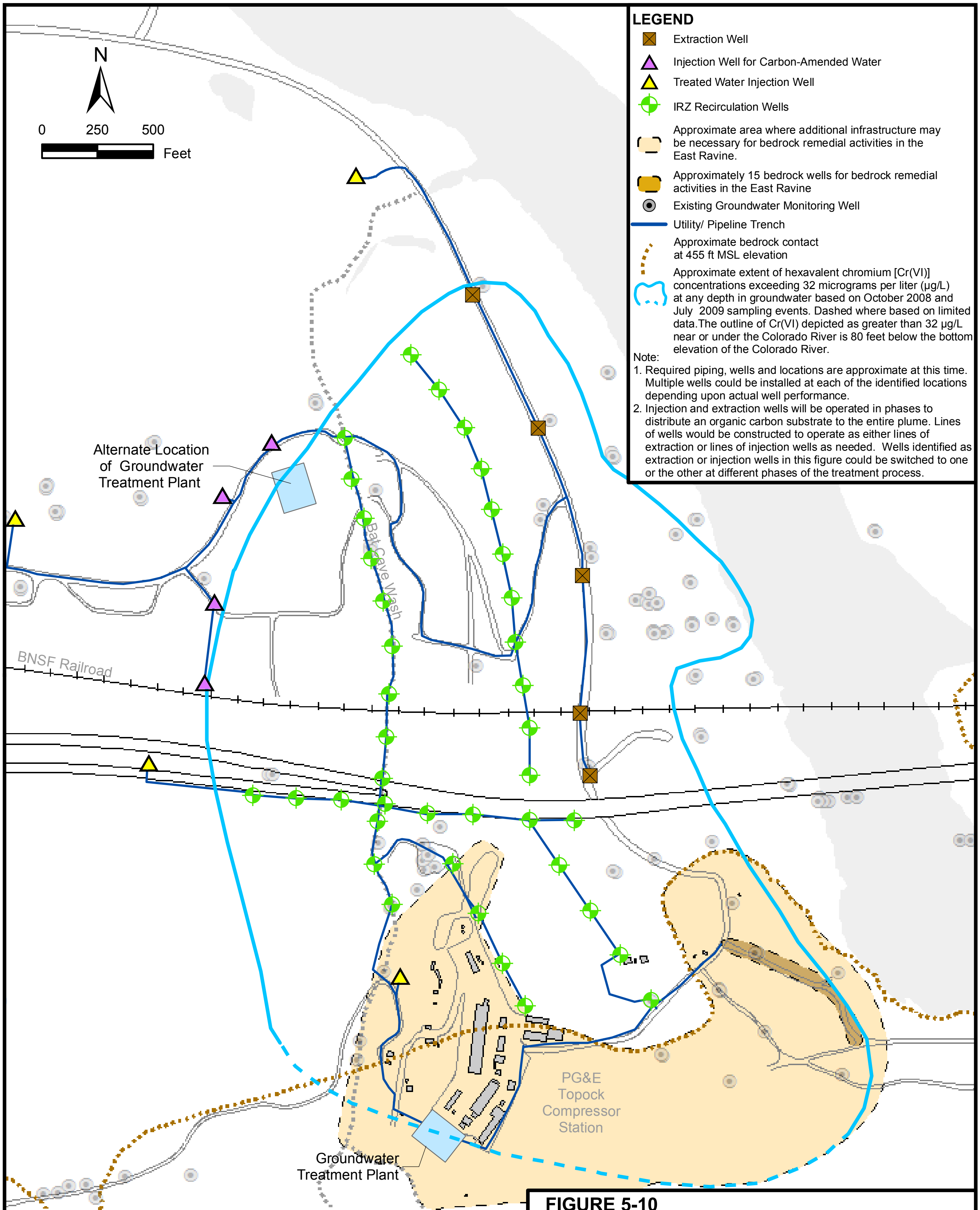

Note:
1. Required piping, wells and locations are approximate at this time. Multiple wells could be installed at each of the identified locations depending upon actual well performance.
2. Injection and extraction wells will be operated in phases to distribute an organic carbon substrate to the entire plume. Lines of wells would be constructed to operate as either lines of extraction or lines of injection wells as needed. Wells identified as extraction or injection wells in this figure could be switched to one or the other at different phases of the treatment process.

FIGURE 5-10
CONCEPTUAL REMEDIAL APPROACH, ALTERNATIVE H COMBINED UPLAND *IN-SITU/*PUMP AND TREAT

FINAL GROUNDWATER CORRECTIVE MEASURES STUDY/
FEASIBILITY REPORT FOR SWMU 1/AOC 1 AND AOC 10
PG&E TOPOCK COMPRESSOR STATION
NEEDLES, CALIFORNIA

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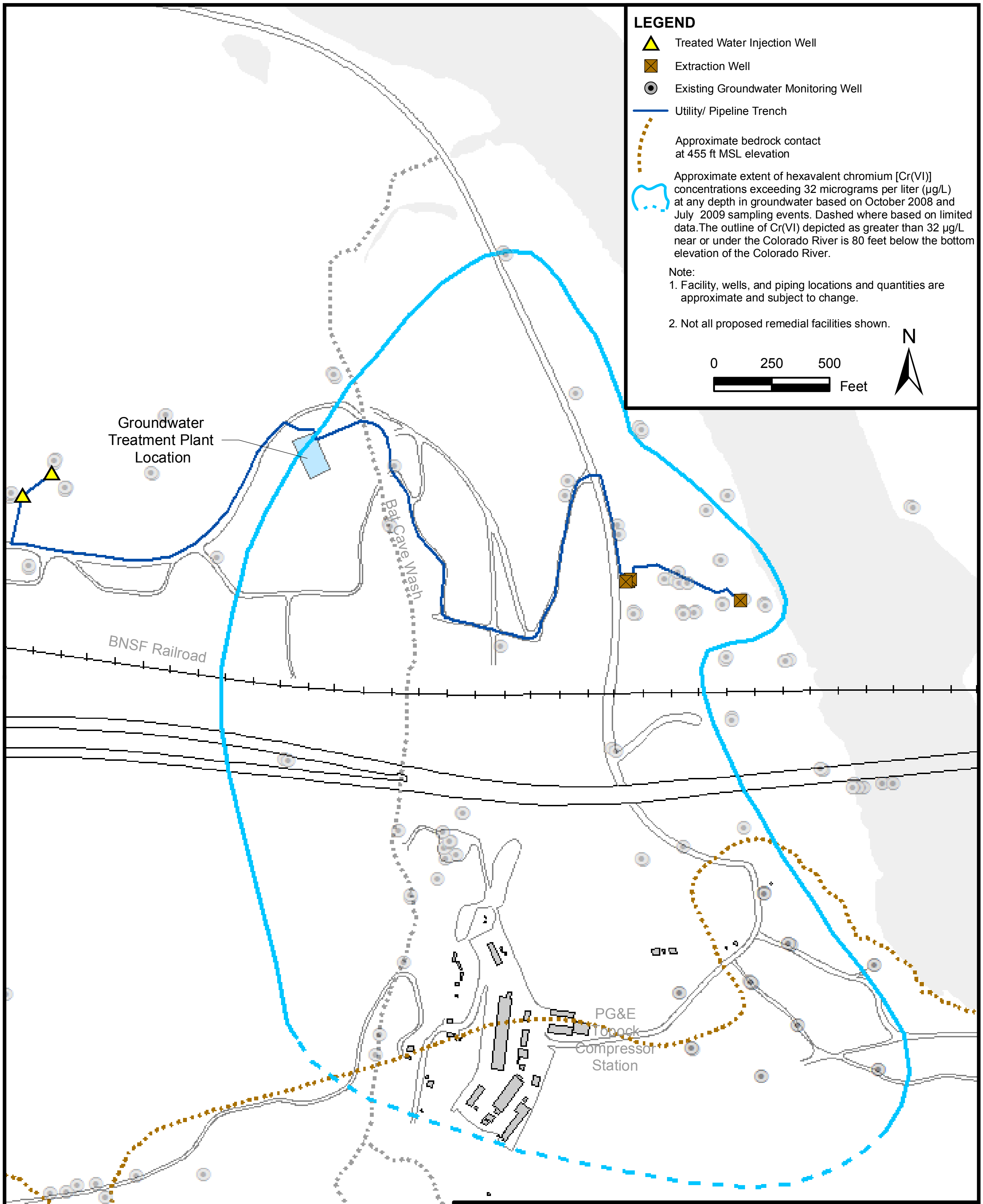

FIGURE 5-11
CONCEPTUAL REMEDIAL APPROACH, ALTERNATIVE I CONTINUED OPERATION OF INTERIM MEASURE

FINAL GROUNDWATER CORRECTIVE MEASURES STUDY/
FEASIBILITY REPORT FOR SWMU 1/AOC 1 AND AOC 10
PG&E TOPOCK COMPRESSOR STATION
NEEDLES, CALIFORNIA

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CRITERIA	ALTERNATIVE A No Action	ALTERNATIVE B Monitored Natural Attenuation	ALTERNATIVE C High Volume *In-Situ* Treatment	ALTERNATIVE D Sequential *In-Situ* Treatment	ALTERNATIVE E *In-Situ* Treatment with Fresh Water Flushing	ALTERNATIVE F Pump and Treat	ALTERNATIVE G Combined Floodplain *In-Situ* Treatment /Pump and Treat	ALTERNATIVE H Combined Upland *In-Situ* Treatment/ Pump and Treat	ALTERNATIVE I Continued Operation of Interim Measure	SUMMARY
Protect human health and the environment, attain media cleanup goals, and control source of releases • Protect human health and the environment • Attain media cleanup goals • Control sources of releases	○	◑	●	●	●	●	●	●	◑	• Alternatives C, D, E, F, G, and H are ranked high because they would all provide for protection of human health from exposure due to use of groundwater as a drinking water supply in both the short term and long term and would protect the Colorado River as a result of floodplain cleanup and/or through hydraulic control. • Alternatives B and I ranked medium primarily because of the long time required to attain cleanup goals, long-term use of institutional controls, as well as the uncertainty about the robustness of the natural geochemical conditions near the river over this relatively long time for Alternative B, and the high level of operation and maintenance and potential for degradation of the natural reducing capacity in the floodplain due to flow of aerobic river water through the fluvial sediments from long-term extraction in the floodplain for Alternative I. • Alternative A ranked low because there would be no institutional controls imposed to restrict use of groundwater in locations where Cr(VI) concentrations exceed the cleanup goals and no monitoring to evaluate changes in geochemical conditions near the river over the long time period required until cleanup goals are attained.
Comply with ARARs • Chemical-specific ARARS • Location-specific ARARs • Action-specific ARARs, including standards for management of wastes generated by the remedial action	○	○	●	●	●	●	●	●	○	• Alternatives C, D, E, F, G, and H ranked high because DOI has determined that as a threshold matter, none of these alternatives can be eliminated based on the alternative's inability to satisfy cultural resources ARARs or the National Wildlife System Administration Act. • Alternatives A, B, and I are ranked low because DOI has determined these alternatives would not satisfy the requirements of the California State Water Resources Control Board Resolution 92-49.
Long-term effectiveness, permanence and reliability • Magnitude of residual risk remaining from untreated waste or treatment residuals at the conclusion of the remedial activities • Adequacy and reliability of controls such as containment systems and institutional controls that are necessary to manage the untreated waste or to manage treatment residuals that remain at the site	○	◑	◕	◕	◕	◑	◑	◑	◑	• Alternatives C, D, and E ranked medium-high because there is uncertainty regarding the ability to distribute substrates across the targeted area and Alternative E relies on flushing to remove contaminants from the upland portion of the aquifer; comparatively, few long-term controls are expected for these alternatives following attainment of cleanup goals. • Alternatives F, G, H, and I all ranked medium because the resulting waste byproducts from the ex-situ treatment process require long-term containment, management, and monitoring at an offsite disposal facility. • Alternative B ranked medium because it includes monitoring and institutional controls; however, the ability of the natural attenuation processes to convert Cr(VI) to Cr(III) is uncertain over the centuries that would be required for MNA to reach cleanup goals. • Alternative A (No Action) ranked the low because this alternative does not include monitoring to verify the effectiveness of natural recovery processes and to determine when the RAOs have been achieved. Any future changes in site conditions that may cause undesirable impacts to the Colorado River or unacceptable exposures to other receptors would not be detected under Alternative A.
Reduction of toxicity, mobility, or volume through treatment • Amount of plume destroyed or treated • Degree of expected reduction in toxicity, mobility, and volume • Degree treatment is irreversible • Type and quantity of residual remaining after treatment	◑	◑	◕	◕	◕	●	●	◕	●	• Alternatives C, D, E, F, G, H, and I ranked high because the toxicity, mobility, and volume of Cr(VI) is reduced throughout the plume. Byproducts from in-situ treatment are expected to be localized to the reducing zone formed by the IRZ and within the range of naturally occurring concentrations found at the site (Appendix G) but could remain temporarily elevated above baseline and background concentrations in some portions of the aquifer. Byproducts from ex-situ treatment would be managed through disposal at an offsite, permitted disposal facility. • Alternatives A and B ranked medium because the amount of plume destroyed or treated is less certain due to passive nature of treatment and the extent and average capacity of the floodplain area to naturally reduce Cr(VI) overtime.
Short term effectiveness • Time until remedial action objectives are achieved • Protection of the community during remedial actions • Protection of the workers during remedial actions • Protection of the environment during remedial actions	○	◑	◔	○	◔	○	○	○	○	• Alternative B ranked medium because of the minimal footprint but relatively long time to cleanup. • Alternatives C and E ranked medium-low because of the comparatively shorter remediation period and relatively limited construction and operational activities that would occur primarily in previously disturbed areas. • Alternative A ranked low primarily because of the extensive time to cleanup with no controls during the remedial period. • Alternatives F, G, H, and I were ranked low as a result of construction and operation of an aboveground treatment plant and the greater amount of construction, aboveground visual impact, worker/operator presence onsite, and electrical power and trucking requirements for chemical delivery and waste transportation and disposal. • Alternative D ranked low primarily because the location of remedial facilities would not be limited to previously disturbed areas and because of the need for subsequent additional disturbance from grading, road construction, facility construction, and operation and maintenance.
Implementability • Technical feasibility • Administrative feasibility • Availability of services and materials	●	●	○	◑	◑	◑	◑	◑	●	• Alternatives A and B ranked high because Alternative A involves no remedial action, and the only remedial activities associated with Alternative B are monitoring well construction and maintenance and administration of an institutional control. • Alternative I ranked high because the system has been shown to be technically implementable over the years it has operated. • Alternatives D, E, F, G, and H ranked medium because while these alternatives are administratively implementable, there will be technical challenges associated with the active treatment processes. • Alternative C was ranked low for this criterion because of the relatively more complex technical challenges associated with balancing reductant delivery and hydraulic containment of the plume, as well as construction within Bat Cave Wash.
Cost effectiveness	●	●	◑	◑	◑	○	○	◑	○	• See Table 5-7 for estimated costs.

Comparative Rating

○	Low
◔	Medium-Low
◑	Medium
◕	Medium-High
●	High

Note:
The assessment of state and community acceptance is not completed until comments on the Proposed Plan are received after the public comment period.

FIGURE 5-12
Qualitative Comparison of Remedial Alternatives
Final Groundwater Corrective Measure Study/
Feasibility Study Report for SWMU 1/AOC 1 and AOC 10
PG&E Topock Compressor Station, Needles, California

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6.0 Recommended Remedial Action Alternative

This CMS/FS Report presents the identification and evaluation of various remedial alternatives to address the remedial action goals for groundwater contamination associated with SWMU 1/AOC1 and AOC 10 at the PG&E Topock Compressor Station.

Nine alternatives were identified:

- Alternative A - No Action
- Alternative B - Monitored Natural Attenuation
- Alternative C - High Volume *In-situ* Treatment
- Alternative D - Sequential *In-situ* Treatment
- Alternative E - *In-situ* Treatment with Fresh Water Flushing
- Alternative F - Pump and Treat
- Alternative G - Combined Floodplain *In-situ*/Pump and Treat
- Alternative H - Combined Upland *In-situ*/Pump and Treat
- Alternative I - Continued Operation of Interim Measure

The alternatives above were defined to a sufficient level of detail to develop remedial cost estimates in accordance with USEPA guidance for feasibility studies. The alternatives were evaluated against the threshold and balancing criteria of RCRA Corrective Action and CERCLA.

PG&E's recommendation for the preferred alternative, based on the conclusions of the comparative analysis in Section 5.5, is **Alternative E - *In-situ* Treatment with Fresh Water Flushing**. Alternative E provides the best balance of advantages and tradeoffs for the remedial action. This alternative involves flushing to push the plume through an IRZ barrier located along Park Moabi Road. Flushing would be accomplished through a combination of potable water injection and injection of carbon amended water in wells to the west of the plume. This alternative includes extraction wells near the Colorado River to provide hydraulic capture of the plume, accelerate cleanup of the floodplain, and help flush the groundwater with elevated Cr(VI) through the IRZ line. Alternative E also includes bedrock extraction wells in the eastern (downgradient) end of the East Ravine, with the water from the bedrock extraction wells managed within the active treatment system for the Alluvial Aquifer. Carbon amended water from injection wells, within and outside of the plume, will be monitored for potential byproducts migration and managed through careful design and operation. Additional extraction wells are located in an area northeast of the compressor station where the flushing efficiency from injection wells alone is relatively poor.

Alternative E meets both of the threshold criteria of (1) protecting human health and the environment, attaining media cleanup goals (over a reasonable timeframe), and controlling sources of releases; and (2) compliance with the identified chemical-, location-, and action-specific ARARs. As a threshold matter, Alternative E cannot be eliminated for an inability to attain the various cultural resource ARARs. As the remedy selection process continues through the issuance of a Proposed Plan and the Record of Decision, and as a remedy is designed and implemented, the federal agencies will continue to engage in consultation with tribes, State Historic Preservation Officers, and others to identify potential effects on cultural resources and will seek ways to avoid, minimize, or mitigate any adverse effects, thereby ensuring that the selected remedy attains these ARARs. The alternative also provides a sufficient degree of long-term effectiveness, permanence, and reliability; is implementable; is relatively cost-effective; and provides a sufficient degree of protectiveness to the community, workers, and environment during implementation.

Additional advantages of Alternative E include the following:

- In comparison to Alternative A (No Action), Alternative E includes active treatment of the Cr(VI) plume to address the RAOs, as well as monitoring and institutional controls, to limit exposure during the remediation period. Alternative A would leave the plume in place without controls or monitoring and would not comply with ARARs.
- In comparison to Alternative B (MNA), Alternative E would provide a higher degree of reliability in treatment and achieve the cleanup goals in substantially less time.
- Alternative C (High Volume *In-situ* Treatment) and Alternative D (Sequential *In-situ* Treatment) also rely on *in-situ* treatment technology. In contrast to Alternative E, however, the *in-situ* treatment concept for Alternatives C and D involves distributing carbon throughout the plume, while Alternative E involves flushing the plume toward an established *in-situ* reductive zone. Both concepts have technical challenges that can be overcome. Alternative E provides *in-situ* treatment with fewer wells but more pipelines than Alternatives C and D. Generation of *in-situ* treatment byproducts would be considerably less than with Alternatives C and D because the *in-situ* component of Alternative E would only be applied along National Trails Highway and in a limited area around each of the upland injection wells. Overall, a much smaller fraction of the aquifer would become reduced with Alternative E than with Alternatives C and D. In comparison to Alternative D, Alternative E would involve construction primarily in previously disturbed areas, thereby resulting in less grading and construction of fewer access roads.
- In comparison to Alternatives F, G, H, and I that include *ex-situ* treatment, Alternative E is substantially more cost-effective and would result in substantially fewer effects to the community, workers, and environment. Alternatives F, G, and H require the construction of a large aboveground treatment plant with a high level of energy requirements that would generate waste byproducts to be transported offsite with associated energy use and traffic hazards. Alternatives F, G, H, and I would generate waste byproducts from an *ex-situ* treatment plant that would require long-term monitoring and containment after the RAOs at the site are attained.

As discussed in Section 5.5, the comparative analysis did not consider the evaluation criteria of state and community acceptance. DTSC and DOI will formally address the modifying criteria of State Acceptance and Community Acceptance during the final remedy selection under the Record of Decision and DTSC's final remedy adoption. Following completion of this CMS/FS Report, DTSC will propose a remedy through a RCRA Statement of Basis, and DOI will issue a Proposed Plan identifying a preferred alternative for public comment. After evaluation and response to public comments, DTSC and DOI will select a final remedy through the preparation of the final Statement of Basis and a CERCLA Record of Decision, respectively. Following selection of the remedy by DTSC and DOI, the final remedy design and approval processes will begin, wherein additional detail on the implementation of the remedy will be developed and documentation required by various location- and action-specific ARARs will be prepared. As required by the CACA, PG&E will prepare a Corrective Measures Implementation Work Plan that more specifically describes the size, shape, form, and content of the selected remedy; describes the key components or elements needed; provides conceptual drawings and schematics; and includes procedures and schedules for implementing the selected remedy. Other operations and maintenance and construction plans may also be prepared prior to construction and operation of the selected remedy.

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Appendix A
Summary of Findings Associated with the East Ravine Groundwater Investigation

Appendix A

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PG&E Topock Compressor Station
Needles, California

Prepared for

California Department of Toxic Substances Control

On Behalf of

Pacific Gas and Electric Company

December 16, 2009

CH2MHILL
155 Grand Avenue, Suite 1000
Oakland, CA 94612

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This report was prepared under the supervision of a
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Acronyms and Abbreviations

µg/L	micrograms per liter
AOC	Area of Concern
bgs	below ground surface
BLM	United States Bureau of Land Management
CERCLA	Comprehensive Environmental Response, Compensation, and Liability Act of 1980
CDFG	California Department of Fish and Game
CMS/FS	corrective measures study/feasibility study
COPC	contaminant of potential concern
CSM	conceptual site model
Cr(T)	total dissolved chromium
Cr(VI)	hexavalent chromium
DQE	data quality evaluation
DOI	United States Department of the Interior
DTSC	California Environmental Protection Agency, Department of Toxic Substances Control
ELAP	Environmental Laboratory Accreditation Program
ERGI	East Ravine Groundwater Investigation
FEC	fluid electrical conductivity
FLUTe™	Flexible Liner Underground Technologies™
gpm	gallons per minute
GMP	Groundwater Monitoring Program
IM No. 3	Interim Measure Number 3
MCL	maximum contaminant level
mg/L	milligrams per liter
mg/kg	milligrams per kilogram
msl	mean sea level

NELAP	National Environmental Laboratory Accreditation Program
ORP	oxidation-reduction potential
PAH	polyaromatic hydrocarbon
PCB	polychlorinated biphenyl
PG&E	Pacific Gas and Electric Company
PVC	polyvinyl chloride
RCRA	Resource Conservation and Recovery Act of 1976
RFI/RI	RCRA facility investigation/remedial investigation
SVOC	semi-volatile organic compound
TDS	total dissolved solids
TOC	total organic carbon
TPH	total petroleum hydrocarbon
UTL	upper tolerance limit
VOC	volatile organic compound

1.0 Introduction

Pacific Gas and Electric Company (PG&E) is addressing groundwater contamination at the Topock Compressor Station located in San Bernardino County, approximately 15 miles to the southeast of Needles, California, as shown in Figure A-1. Investigative and remedial activities at the Topock Compressor Station are being performed under the Resource Conservation and Recovery Act (RCRA) corrective action process, as well as the Comprehensive Environmental Response, Compensation and Liability Act (CERCLA), under agreements with the California Environmental Protection Agency, Department of Toxic Substances Control (DTSC) and the United States Department of the Interior (DOI), respectively. PG&E has completed Volume 1 (Site Background and History), Volume 2 (Hydrogeologic Characterization and Results of Groundwater and Surface Water Investigations), and the Volume 2 Addendum of the RCRA facility investigation/remedial investigation (RFI/RI) for the Topock Compressor Station (CH2M HILL, 2007a, 2009a-b). RFI/RI Volume 3 is pending and will include final characterization data to complete the RFI/RI requirements for the Topock Compressor Station.

This report documents groundwater investigation and associated activities in the ravine area east of the Topock Compressor Station designated as Area of Concern (AOC) 10 (hereafter referred to as the East Ravine) and presents the results of investigation activities as outlined in the *Revised Work Plan for East Ravine Groundwater Investigation* (Work Plan) (CH2M HILL, 2008a). The investigation activities are collectively referred to in this report as the East Ravine groundwater investigation (ERGI).

As described in the East Ravine Work Plan, the rationale for the ERGI are related to the elevated concentrations of hexavalent chromium (Cr[VI]) that were observed sporadically in well MW-23 (Miocene conglomerate bedrock monitoring well), which is located immediately north of the East Ravine. Additionally, historic soil sampling data indicate some of the highest chromium concentrations in soils at the site have been detected in the drainage depressions in the East Ravine (areas designated AOC 10). Historical aerial photographs of this portion of the site show the presence of an impoundment within the AOC 10c subarea that contained liquids of unknown composition during several years in the 1960s (CH2M HILL, 2007a). The AOC 10c subarea, where the highest concentrations of chromium were detected in soil, is coincident with the western portion of the area identified as drilling Site A in Figure A2. DTSC and DOI have directed that additional drilling and groundwater investigation are needed to characterize the groundwater flow pathway and groundwater conditions of bedrock formations in the East Ravine and MW-23 area.

Groundwater monitoring wells were installed at eight locations during the ERGI to provide additional groundwater characterization data for the RFI/RI for the Topock site. In addition, an existing monitoring well was overdrilled and rebuilt as a multilevel well. Well installation activities began in January 2009 and continued through May 2009. Well development, sampling, borehole flow characterization, and hydraulic monitoring occurred from February through July 2009. The primary technical objectives of the ERGI were to:

- Determine whether elevated concentrations of hexavalent chromium (Cr[VI]) and other inorganic and organic constituents are present in groundwater beneath the East Ravine area.
- If elevated concentrations of Cr(VI) were confirmed in bedrock, evaluate the presence, source, and extent of the groundwater impact.
- Assess the potential for perched/shallow groundwater to occur at the base alluvium/weathered bedrock/bedrock contact underlying the East Ravine area and install perched/shallow groundwater monitoring wells, as appropriate.
- Install monitoring wells within the bedrock, as appropriate, to facilitate ongoing groundwater quality monitoring in the East Ravine area.

1.1 Approvals and Authorizations

The ERGI was executed in conformance with the following approvals and authorizations:

- DTSC conditional approval of the Work Plan (DTSC, 2008).
- Agreement to Amend Lake or Streambed Alteration Agreement (Notification No. 1600-2005-0140-R6 between the California Department of Fish and Game (CDFG) and PG&E (CDFG, 2007).
- Pre-construction and post-construction biological surveys were conducted in compliance with the *Programmatic Biological Assessment for the Pacific Gas and Electric Topock Compressor Station Remedial and Investigative Action* (CH2M HILL, 2007b).
- DOI Bureau of Land Management (BLM), United States Fish and Wildlife Service, and Bureau of Reclamation approval of the Work Plan and permission to implement (DOI, 2008).

1.2 Report Organization

This report summarizes the work conducted as part of the ERGI and presents the results of the drilling, well installation, and initial groundwater sampling. The rest of the report is organized in the following manner:

- Section 2.0 summarizes the drilling, well installation, geophysical logging, borehole characterization, hydraulic monitoring and testing, groundwater sampling, and associated field activities performed.
- Section 3.0 presents the results of the drilling investigation, including lithologic observations, borehole flow characterization, depth-discrete borehole groundwater sample data, soil sample data, initial groundwater monitoring well sample data, and hydraulic monitoring and testing data.
- Section 4.0 summarizes refinements made to the conceptual site model presented in the RFI/RI Volume No. 2 Report (RFI/RI Vol. 2) and RFI/RI Volume No. 2 Report

Addendum (CH2M HILL, 2009a-b) by incorporating the ERGI data and presents conclusions and recommendations for additional investigation.

- Section 5.0 provides a list of works cited while compiling this report.

2.0 Summary of Field Activities

This section summarizes the borehole drilling and testing, well installation, soil and groundwater sampling, and associated field activities performed in accordance with the Work Plan (CH2M HILL, 2008a). Investigation activities were initiated as Sites A and B, which were designated in the work plan as "primary" investigation locations (Figure A-2). Based on data collected from Sites A and B, the investigation was expanded, per the work plan, to Sites C, E, F, and G, which are designated in the work plan as "contingency" investigation locations. Subsequent to review of data collected from the contingency Sites C, E, F, and G, investigation activities were also conducted at contingency sites C-Alternate and E-Alternate 2. In lieu of conducting investigation activities at Site E-Alternate 1, existing well MW-23 was reconstructed to address the objectives of this investigation. Investigation was not conducted at contingency Site D.

Figure A-2 presents the general locations investigated during the ERGI as originally shown in the Work Plan and the groundwater monitoring wells installed at each location. Table A-1 presents the drilling and well installation details of each associated boring and groundwater monitoring well. Primary field tasks conducted during this investigation included:

- Site access, preparation, and compliance monitoring.
- Borehole drilling and the collection of continuous core at 12 boreholes for lithologic logging and subsequent borehole testing/well installation.
- Collection of soil samples from the initial boreholes drilled at Sites A and B.
- Borehole testing to facilitate the design of single or multilevel groundwater monitoring wells at Sites A, B, C-Alternate, and E.
- Collection and analysis of screening-level groundwater samples from the open boreholes prior to construction of the monitor wells.
- Installation and development of one or more groundwater monitoring wells completed within each borehole.
- Retrofit of an existing monitoring well (MW-23) into two nested wells within the original borehole.
- Collection of groundwater samples for laboratory analysis from each newly installed groundwater monitoring well.
- Management of investigation-derived materials.

2.1 Site Access, Preparation, and Compliance Monitoring

An onsite biologist conducted a pre-construction survey before the commencement of work and a post-construction survey following the completion work at each investigation site to assess and document compliance with the *Programmatic Biological Assessment for the Pacific*

Gas and Electric Topock Compressor Station Remedial and Investigative Action (CH2M HILL, 2007b) and Havasu National Wildlife Refuge-required conditions for well installation. The results of these surveys are provided in the *Biological Resources Completion Report for the East Ravine Groundwater Investigation, Topock Compressor Station, Needles, California* (CH2M HILL, 2009c).

The drilling sites were accessed by the approved, pre-existing routes identified in the Work Plan. No vegetation was cleared during this investigation. No listed species or nesting birds were observed during the pre-activity or post-activity surveys. All construction occurred within previously disturbed areas. No additional areas were disturbed by the activities, and no habitat loss occurred.

Representatives of DTSC, BLM, DOI, Havasu National Wildlife Refuge, the Fort Mojave, and Colorado River Indian Tribes were present during a project initiation meeting held at the Topock Compressor Station on January 13, 2009 immediately prior to the commencement of investigation activities. In addition, representatives of the Fort Mojave Indian Tribe and Colorado River Indian Tribe were present during portions of the work to observe investigation activities.

2.2 Drilling and Lithologic Logging

Drilling and lithologic logging activities were performed under the supervision of a California Professional Geologist from January through May 2009. Continuous core was collected from ground surface to the total depth drilled at each drilling location. All boreholes installed during this investigation were vertical. As presented in the Work Plan, two different drilling methods were used to advance all or portions of each borehole depending on the geology encountered and the type of core desired. One track-mounted drilling rig was modified in the field to conduct drilling by either method.

Drilling through unconsolidated materials above bedrock was accomplished with rotosonic drilling methods, which involves advancing a steel drive casing and core barrel through the subsurface using a combination of down-force, rotation, and vibration. This method was selected because it has the capability to produce a continuous core from the land surface to the target drilling depth, generates minimal drilling wastes, and provides relatively undisturbed sediment cores for observation and/or soil sample collection. Rotosonic drilling was also used to advance boreholes into consolidated bedrock when highly disturbed bedrock core was acceptable or to widen boreholes initially drilled using rotary core drilling methods.

Diamond-bit rotary core drilling methods with HQ-size tools (3.8-inch diameter) were used to drill through consolidated bedrock when relatively undisturbed bedrock core was required. This method uses a rotating, dual-barreled drill casing with a diamond bit to collect relatively undisturbed core. Fresh water, which was collected from the Colorado River during this investigation, is constantly circulated through the borehole to facilitate the drilling process. Both temporary and permanent casings were used to conduct drilling water during rotary coring activities, depending on the purpose of each borehole drilled.

A summary of details for the drilling and construction of each borehole installed during this investigation is provided in Attachment A1-1. The core obtained during this investigation was used to prepare the lithologic logs provided in Attachment A1-2 and has been retained at the site as part of the Topock core archive. Well installation rationale and details are discussed in Section 2.4. Lithology and hydrostratigraphy are discussed in Section 3.1.

2.3 Soil Sampling

Soil samples were collected from the initial boreholes drilled at Sites A and B under the field direction of DTSC and based on the approach presented in the Work Plan in January 2009. Samples were collected from the rotosonic core using the standard operating procedures established for previous phases of soil sample collection at the site.

Six soil samples were collected at Site A from unconsolidated sediments above bedrock. The shallowest sample was collected at a depth of 1.5 to 2.0 feet below ground surface (bgs) based on the observation of white powder material in the core. Five deeper samples were collected at 10-foot intervals beginning at 20 feet bgs, which is 10 feet deeper than the deepest soil sample collected in this area during the Soil Part A Phase 1 investigation (CH2M HILL, 2006a), down to 60 feet bgs. Metadiorite bedrock was encountered in this borehole at approximately 65 feet bgs, and the water table was encountered at approximately 66 feet bgs.

Three soil samples were collected at Site B. The shallowest sample (3 to 4 feet bgs) was collected at a depth within the thickness of the embankment that forms a gravel road through the area and also acts as an impediment to surface flow in the East Ravine. The second sample was collected 5 feet below the shallow sample (8 to 9 feet bgs) at a depth approximately equal to the projected base of the East Ravine, immediately below the thickness of the embankment. The deepest sample was collected 10 feet deeper (18 to 19 feet bgs) within unconsolidated sediments.

Soil samples were analyzed at an offsite California Department of Public Health Environmental Laboratory Accreditation Program (ELAP)- and National Environmental Laboratory Accreditation Program (NELAP)-certified laboratory for the analyses outlined in the Work Plan. These analyses included:

- Cr(VI) (7199/3060A).
- Title 22 Metals (6010B/7471A).
- Volatile organic compounds (VOCs) (8260B).
- Total petroleum hydrocarbons (TPH)-extractable (8015ME) and TPH-purgable (8015MP).
- Polycyclic aromatic hydrocarbons (PAHs) (8270Sim).

The results of laboratory analysis of soil samples are discussed in Section 3.4.

2.4 Monitoring Well Installation and Development

Each borehole installed during this investigation was used for the construction of a monitoring well designed to test either a single or multiple independent zones. The design of each monitoring well was established in consultation with the DTSC, DOI, and other stakeholders. Well design was based on evaluation of lithologic data (recovered core, and at some locations, borehole geophysical data), borehole flow characterization (hydrophysical data), and screening level groundwater quality data. Once installed, each well was surveyed for location, ground surface elevation, and measurement reference elevation. Well installation and development activities were conducted from January through July 2009.

The materials and methods used for installation and development of groundwater monitoring wells are presented in the following subsections. Well installation details are summarized in Table A-1. Well construction diagrams are provided in Attachment A1-3. Although work conducted at this project is exempt from the requirement to obtain well installation permits pursuant to the CERCLA permitting exemption, for completeness, well completion reports were filed with the California Department of Water Resources and San Bernardino County by the drilling company (Boart-Longyear) and are provided in Attachment A1-4.

2.4.1 Single-completion Monitoring Wells

After consultation with the agencies, single-completion monitoring wells, designed to monitor one specific interval of the borehole, were installed at Sites A, B, C, E, E-Alternate 2, F, and G (see Table A-1 for specific well names and construction details). As appropriate, each of these monitoring wells were installed and developed in accordance with the methods and procedures defined in the *Sampling, Analysis, and Field Procedures Manual, PG&E Topock Program, Revision 1, Topock Compressor Station, Needles, California* (CH2M HILL, 2005).

With the exception of monitoring well MW-57-185, all single-completion monitoring wells were constructed within 6-inch-diameter rotosonic drill casing, which was retracted as the well was constructed. Each well was constructed with threaded, 2-inch-diameter, schedule 40 polyvinyl chloride (PVC) casing and screen (0.02-inch factory slotted). Filter pack material consisting of #3 Monterey silica sand was installed around the screen and approximately 2 feet above the top of the screened interval. The screened interval was then sealed from the remainder of the borehole with approximately 5 feet of bentonite chips. Grout was installed via positive pressure tremie from the top of the bentonite seal up to near ground surface.

With the exception of monitoring wells MW-57-185, MW-58-065, and MW-57-050, each single-completion monitoring well was installed to test the shallowest saturated interval of the borehole. The interface of the alluvium and the bedrock at Sites A and B, which are locations where ponded water may have infiltrated into groundwater from surface ponding, is at a higher elevation than the water table. Therefore, monitoring wells MW-58-065 and MW-57-050 were installed above the water table to monitor groundwater that may become intermittently perched at the interface of the alluvium and the bedrock at Sites A and B, respectively.

A threaded, 3-inch schedule 40 PVC screen was initially placed in the exploratory borehole drilled into deeper bedrock at the Site B (MW-57) location to ensure the borehole remained open during geophysical testing and borehole flow characterization, as discussed in Sections 2.5 and 2.6, respectively. Based on the results of the borehole testing, it was determined that the existing condition of the borehole was adequate for long-term monitoring of the one predominant interval of groundwater inflow. The 3-inch screen, which extends from total depth (184 feet bgs) to the bottom of the permanent conductor casing (un-slotted 3-inch PVC riser extends to ground surface), was left in the MW-57 exploratory borehole and was established as monitoring well MW-57-185. Because this screen monitors groundwater in bedrock, filter pack materials were not placed in the annulus between the screen and the borehole wall. Further, an annular grout seal was not installed due to the permanent conductor casing installed from ground surface to 70 feet bgs in this borehole (see Section 2.2).

Following well construction and annular seal placement, the single-completion monitoring wells installed below the water table were developed using a combination of surging, bailing, and pumping, as appropriate. During development, temperature, pH, specific conductance, and turbidity were measured using field instruments. Well development was continued until the minimum purge volume had been removed and field water quality parameters had stabilized in ranges indicative of groundwater (i.e., different water quality signature than that from the river water used during installation). Once development was complete, screening-level groundwater samples were collected for analysis at the Interim Measure Number 3 (IM No. 3) laboratory for specific conductance, Cr(VI), and total dissolved chromium (Cr[T]) (results are discussed in Section 3.3).

2.4.2 FLUTe™ Multilevel Monitoring Wells

Following drilling, exploratory boreholes installed into deeper bedrock at Sites A, B, C-Alternate, and E were outfitted as temporary characterization wells with threaded 3-inch schedule 40 PVC screens (and un-slotted riser) over the entire saturated thickness of exposed bedrock. The 3-inch temporary screens were installed as sleeves (without annular materials) within the cored 3.8-inch open boreholes to ensure an open borehole for testing. The screen intervals of these initial characterization wells are summarized in Table A-1.

Testing data collected from each exploratory borehole was evaluated with DTSC, DOI, and other stakeholders to determine if multilevel monitoring wells were appropriate for long-term monitoring. Following the determination that exploratory boreholes at Sites A, C-Alternate, and E would require multilevel well construction (see the previous section regarding the Site B exploratory borehole), PG&E conducted an evaluation of various construction methods including packer systems, the Solinst Continuous Multi-channel Tubing system, the Waterloo Multilevel System, and the Flexible Liner Underground Technologies™ (FLUTe™) multilevel sampling system. The capabilities of each system, required monitoring intervals, and associated data objectives for each location were subsequently discussed with DTSC, DOI, and other stakeholders. It was determined that the FLUTe™ multilevel sampling system was the best solution to:

- Evaluate vertical hydraulic gradients within each borehole, as practicable.
- Evaluate vertical distribution of groundwater quality and geochemical conditions within each borehole, as practicable.
- Provide flexibility such that if additional data objectives are identified subsequent to this investigation, the existing well construction may be modified and the drilling of additional boreholes can be minimized.

FLUTe™ multilevel wells were designed to meet the following objectives:

- **Site A (MW-58-115 and MW-58-205)**: Isolate and monitor two general intervals of groundwater inflow into the borehole: approximately 95 to 115 feet bgs and 160 to 206 feet bgs (total depth).
- **Site C-alternate (MW-64-150, MW-64-205, and MW-64-260)**: Isolate and monitor three general intervals: 120 to 150 feet bgs, 175 to 205 feet bgs and 230 to 260 feet bgs (total depth). As discussed in Section 3.2, predominant intervals of groundwater inflow were not apparent during testing of this borehole. Therefore, the borehole was divided into three intervals of similar length to determine if differences in groundwater quality and hydraulics could be observed with longer-term monitoring.
- **Site E (MW-62-110 and MW-62-190)**: Isolate and monitor two general intervals of groundwater inflow into the borehole: approximately 85 to 110 feet bgs and 155 to 192 feet bgs (total depth).

Based on the monitoring intervals and objectives identified, two different FLUTe™ system designs were used. A schematic of the two FLUTe™ multilevel system designs is presented in Figure A-3. Unlike other multilevel systems, which rely on packers or sealing materials such as bentonite to create multiple sample zones, FLUTe™ uses a flexible polyurethane liner that is filled with potable water and sealed with hydrostatic pressure to create discrete sample zones (Figure A-3). At each desired sampling interval, an annular permeable helical-shaped spacer (screen) is attached to the liner material to allow water flow from the screened zone into the sampling port.

For the FLUTe™ system design at Site C-Alternate the sampling port is attached to tubing inside the flexible liner, which extends to the surface for sampling with a check valve creating a pump tube for sampling. A second tube tees off of the pump tube with a check valve to create a "U-connection" that serves as the sample tubing where groundwater samples and manual water levels are collected. A pressure transducer for each monitoring zone is permanently installed within the liner during construction below the check valves so that the transducer reads true formation pressure. However, the check valve complicates the collection of representative manual water levels for calibration of the pressure transducers installed, because the check valve prevents the water levels in the sample tubing from following dropping water levels. As a result, the collection of water levels must be timed to ensure they are collected during rising water levels (i.e., a period after purging).

The FLUTe™ system design at Site A and Site E were modified from the standard design used at Site C-Alternate to allow for the removal and installation of pressure transducers once the FLUTe™ system was installed. Instead of a "U-connection," with both a sample tube and a pump tube, a 1-inch tremie pipe is attached to the sample port with a single check valve that is only engaged by applying pressure with the sampling system deployed during sampling. This allows for the collection of representative manual water levels. This modification was not possible in the 3.8-inch borehole where more than two intervals are monitored due to the lack of borehole annular space.

The FLUTe™ system is constructed from three main components: a liner, the screen materials (called a spacer), and sample tubing (Figure A-3). The liner was constructed of urethane-coated nylon, the screen (spacer) was constructed of a nylon/polypropylene/polyester composite, and the sample tubing materials were constructed with polyvinyldiene fluoride. Based on available publication, potential byproducts from the FLUTe™ well materials include arsenic; toluene; formamide; phenol; benzoic acid; ethanol; benzoylformic acid; 1,6-dioxacyclododecane-7,12-dione; 2,2,6,6-tetramethyl,-4piperidylamino betacrotonic acid; ethyl ester; and tinuvin (Gilmore et al., 2004; Gotkowitz et al., 2004; CH2M HILL, 2006b; and Cherry et al., 2007). Based on information from the manufacturer (Keller, 2009) and observations during multiple studies, the detection of byproduct chemicals dissipate over time (Pantex, 2004; Gotkowitz et al., 2004; CH2M HILL, 2006b; Cherry et al., 2007; Kleinfelder, 2008; and Haley & Aldrich, 2009).

2.4.3 MW-23 Rebuild

In lieu of well installation using a new borehole at Site E-Alternate 1, PG&E was directed by DTSC and DOI to overdrill existing monitoring well MW-23 without deepening the borehole from its original total depth, and rebuild the well as two, nested monitoring wells within the original borehole. This work was conducted in May 2009, and was not described in the original Work Plan; however, DOI and BLM confirmed that this activity was within existing authorizations

The original MW-23 borehole was drilled to 80 feet bgs using air rotary drilling methods to create a 9.6-inch borehole within Miocene conglomerate bedrock. A 4-inch PVC monitoring well, screened from 60 to 80 feet bgs, was completed in this borehole. During the ERGI, the original MW-23 was overdrilled using 10-inch rotosonic drilling tools to create a borehole with a diameter of approximately 10.7 inches. Once the existing well materials were removed, the borehole was used for the construction of two nested monitoring wells. The deepest well was constructed with a screen extending from 75 to 80 feet bgs, and the second shallower well was constructed with a screen extending from approximately 50 to 60 feet bgs (water table).

The rebuilt nested MW-23 monitoring wells were developed using the same methods identified for the single-completion monitoring wells (Section 2.4.1).

2.5 Geophysical Logging

Geophysical logging was conducted in the exploratory boreholes at Sites A (MW-58BR) and B (MW-57BR). The geophysical logs for these drilling locations are provided in Appendices B-1 and B-2 and are discussed further in Section 3.2.1. The geophysical data collected at each location is summarized as follows:

- **Site A (MW-58BR)**: Geophysical logs, including natural gamma ray, dual induction, and caliper, were collected at Site A following the placement of the 3-inch PVC screen. Video and acoustic televiewer logs were not obtained from within the screen.
- **Site B (MW-57BR)**: Geophysical logs were collected at Site B both before and after the placement of the 3-inch PVC screen. Following borehole installation to total depth (192 feet bgs) and prior to the placement of the 3-inch PVC screen, the MW-57BR borehole collapsed, preventing geophysical logging below approximately 146 feet bgs. In addition to the natural gamma ray, dual induction, and caliper logs, video and acoustic televiewer logs were obtained from the uncased borehole above this blockage. Subsequent to the clearance of the blockage and placement of the 3-inch PVC screen,

natural gamma ray, dual induction, and caliper logs were collected to total depth (185 feet bgs due to sloughing). Video and acoustic televiewer logs were not obtained from within the screen.

2.6 Borehole Flow Characterization

Borehole flow characterization testing was conducted in each of the four exploratory boreholes installed into Miocene conglomerate bedrock (MW-62BR), metadiorite bedrock (MW-58BR and MW-64BR), or a combination of the two (MW-57BR). Borehole dilution testing (here forth referred to as hydrophysical testing or hydrophysics) was conducted by RAS, Inc. from March through May 2009. This testing method was chosen because it is can be applied for a wider range of borehole yields than other methods. Hydrophysical testing was conducted within the temporary 3-inch PVC screens placed in these open boreholes.

Hydrophysical testing uses the contrast in fluid electrical conductivity (FEC) between deionized water and groundwater in the formation to identify intervals of groundwater inflow and outflow in the borehole. The testing is conducted in two phases to characterize groundwater flow under both ambient and, subsequently, induced flow conditions. During testing under ambient flow conditions, higher FEC formation water within the borehole is replaced with deionized water (FEC near zero), taking care to maintain static water levels during emplacement of the deionized water. Following the emplacement of deionized water, the rates and depths where higher FEC groundwater flows from the formation into/ out of the borehole were logged over time using a specialized, down-hole FEC measurement tool.

Following ambient flow characterization, testing is conducted in a similar manner under induced flow conditions to increase the probability of detecting conductive intervals that may not be identified in the ambient flow condition. Due to the location of conductive intervals identified during ambient flow characterization in each of the four exploratory boreholes, induced flow testing was conducted using a submersible pump placed near the bottom of the borehole. Where constant rate pumping was not practicable due to low borehole yield, induced flow testing was conducted by removing a slug of water from the borehole and logging the FEC in the borehole during recovery. Analysis of the data collected was performed to evaluate intervals of inflow and outflow in the borehole, estimate the flow rate and hydraulic conductivity values for each of these zones, and determine the cumulative flow rate within the borehole.

Depth-specific groundwater samples were collected from intervals of interest in each borehole, as identified by the field analysis of the ambient and induced flow hydrophysical data. These samples were collected using a discrete-point sampler operated on a wire line. This sampler is cleaned and sealed at the surface, lowered to the interval of interest, and opened using a controller at the surface. Once the sampler is filled, it is closed and raised back to the surface. Samples were also collected from the pump discharge to test groundwater from the pump. Samples were analyzed for Cr(VI), Cr(T), FEC, and pH at either the onsite IM No. 3 laboratory or the certified offsite laboratory. Data obtained from the laboratory were evaluated with the hydrophysical data to calculate an estimated interval-specific analyte concentration. This screening-level water quality data were used along with other lithologic and hydraulic testing data to develop the design of monitoring wells in each exploratory borehole.

A summary of the testing activities conducted at each ERGI site and the results are discussed in Sections 3.2 and 3.3 and provided in Table A-3. The report provided by RAS, Inc., which summarizes additional details for all testing activities and final results, is provided as Attachment A2-2. Analytical results for the screening level groundwater samples are presented in Attachment A2-3.

2.7 Groundwater Monitoring Well Sampling

Following the installation and development of each groundwater monitoring well, samples were collected for analysis at an offsite, ELAP- and NELAP-certified laboratory. As defined in the Work Plan, each well installed as part of the ERGI would be initially sampled following installation and development. Then, approximately 30 days after the last well was installed, developed, and initially sampled, all ERGI groundwater wells would be sampled for a second time during one contemporaneous event. Due to the extended field implementation schedule associated with investigation at contingency investigation sites, in consultation with DTSC and DOI, the plan for the collection of groundwater samples from each newly installed monitoring well was revised. In accordance with the revised approach, initial groundwater samples were collected from each newly installed well, with the exception of FLUTe™ multilevel groundwater wells, which were installed at the end of the field implementation program (mid-July 2009). Then, once the FLUTe™ multilevel wells were installed and developed, all wells installed during this investigation were sampled during one contemporaneous event (week of July 20, 2009). The results from laboratory analysis of the samples collected during this contemporaneous event are presented in Section 3.5. The results of laboratory analysis of samples collected from ERGI wells during all collection events are presented in Tables A-4 and A-5 and Attachment A3. The results of laboratory analysis of screening level samples collected either during well development or hydraulic testing activities are presented in Sections 3.3 and 3.6, respectively.

In accordance with the revised approach to groundwater sample collection, a minimum of one sample was collected from each well for laboratory analysis of all constituents listed in Table 2 of the Work Plan (CH2M HILL, 2008a). Sample analysis included, but was not limited to, the following analyses: Cr(VI), Cr(VI), Title 22 metals, VOCs, total dissolved solids (TDS), general minerals, redox sensitive parameters, total organic carbon, and stable isotopes of oxygen.

In addition, as directed by the DTSC in a May 15, 2009 letter (DTSC, 2009), wells MW-59-100 and MW-57-070 were also sampled for dioxin/furans and organic compounds including: PAHs, polychlorinated biphenyls (PCBs), TPH, and select semi-volatile organic compounds (SVOCs). Collection of these samples was intended to further the understanding of the nature and extent of groundwater contamination in the East Ravine area in response to detections of these compounds in the Part A Soil Investigation soil samples (DTSC, 2009).

Each single-completion monitoring well (including the nested wells at location MW-23) was sampled using the methods and procedures described in the Work Plan and in the procedures, analytical methods, reporting limits, and quality control plan used for the

Topock Groundwater Monitoring Program (GMP), as described in the *Sampling, Analysis, and Field Procedures Manual, PG&E Topock Program, Revision 1, Topock Compressor Station, Needles, California* (CH2M HILL, 2005). Groundwater samples were collected using a temporary adjustable-rate, electric submersible pump. Wells were purged and sampled using the three-casing volume method to obtain representative groundwater samples. Further, field water quality parameters (temperature, pH, specific conductance, oxidation-reduction potential [ORP], dissolved oxygen, and turbidity) were measured and recorded during purging with an in-line water quality meter (within a flow cell) during each sampling event.

Exploratory boreholes outfitted with the FLUTe™ system were sampled using a nitrogen gas supply at the surface and the airlift pumping system installed with these monitoring systems and followed the manufacturer's recommended sampling procedures. Because of the low yields obtained from the FLUTe™ multilevel wells, purging and sampling using the three-casing volume method was not practicable. FLUTe™ multilevel wells were sampled by dewatering the sample interval while recording field water quality parameters, then returning to the well the following day and purging a second time to obtain sufficient sample volume for laboratory analysis.

Consistent with the *Sampling, Analysis, and Field Procedures Manual, PG&E Topock Program, Revision 1, Topock Compressor Station, Needles, California* (CH2M HILL, 2005), the sample aliquots collected for Cr(T), metals, and cations were filtered in the field. The sample aliquots collection for Cr(VI) were filtered in the laboratory prior to analysis. One field duplicate sample was collected every 10 samples during initial sample collection events and during the contemporaneous event. Further, during these events, one equipment blank was collected each day, per crew, per piece of non-dedicated equipment.

2.8 Hydraulic Testing and Monitoring

This section presents a summary of the hydraulic testing and water-level monitoring activities conducted during this investigation. Hydraulic data were collected to assist with the development of the conceptual model for the East Ravine area and, specifically, to evaluate various bedrock characteristics including hydraulic gradient, conductivity, and transmissivity. Hydraulic data were collected using slug tests, constant-rate extraction tests, and water-level monitoring equipment, as appropriate. The results of the hydraulic monitoring activities conducted during this investigation are presented in Section 3.6.

2.8.1 Slug Testing

Slug tests were conducted in monitoring wells and exploratory boreholes that did not have a yield high enough to support a constant-rate extraction test (i.e., a sustainable yield greater than one gallon per minute [gpm]). Slug tests were conducted in wells with a screen completed within approximately 20 feet of the static water level (MW-57-070, MW-60-125, MW-61-110, and MW-62-065) by instantaneously raising/lowering water levels by rapidly emplacing/removing a physical slug in April 2009. The slug used for these tests consisted of a capped section of PVC pipe filled with sand. Slug tests were conducted in exploratory boreholes MW-58BR_D (April 2009) and MW-64BR (June 2009) by rapidly removing tens of feet of hydraulic head. In this case, the water was removed by pumping with an electric submersible pump. In either testing scenario, once the water level was raised/lowered above/below the static water level in the well or borehole, the water level was monitored with a pressure transducer with data-logging capability until it recovered to within a minimum of 80 percent of the static level.

2.8.2 Constant-rate Extraction Testing

Exploratory borehole MW-57BR was the only location investigated during the ERGI that yielded enough water to sustain constant rate pumping of 1 gpm or greater with the desired water-level drawdown. Therefore, a constant-rate extraction test was conducted at this location in April 2009. During this test, the water level in the MW-57BR borehole was monitored using a pressure transducer with data-logging capability, and the pump effluent flow rate was monitored using a vortex flowmeter with a calibration range of 0.75 to 11.4 gpm. The test was conducted over a period of approximately 7 hours. The water level in the MW-57BR borehole (pumping well) and seven observation wells (MW-23, MW-57-070, MW-58BR_D, MW-59-100, MW-60-125, MW-61-110, and MW-62-065) were monitored at least 19 hours before, during, and over 24 hours following the test using pressure transducers with data-logging capability. A groundwater sample was collected from the pump effluent line near the end of the pump test for certified laboratory analysis of Cr(T) and Cr(VI).

2.8.3 Water-level Gauging and Gradient Monitoring

Well gauging was conducted to evaluate horizontal and vertical gradients within wells installed during the ERGI and existing wells in the vicinity of the East Ravine. Water-level datasets were collected in two ways: (1) collecting manual depth-to-water measurements from multiple wells in a short period of time (henceforth referred to as water-level snapshots), and (2) collecting water levels from multiple wells over time using pressure transducers with data-logging capability.

Water-level snapshots were collected at various times throughout the investigation using ERGI wells installed at that time and existing wells in the vicinity of East Ravine, as applicable (i.e., wells hydraulically impacted by ERGI activities such as well installation or development were not included in snapshots that may have been conducted during that specific time). Due to the potential influence of the Colorado River on groundwater fluctuations, each snapshot dataset was collected as quickly as possible (typically within 1 to 2 hours). Water-level snapshot datasets were collected on March 31, April 1, April 6, April 30, May 5, May 30, June 16, and July 8, 2009.

In addition to hydraulic data collection in snapshots, after each borehole, single, or multilevel monitoring well was installed and developed, pressure transducers were installed to collect water-level data in a manner consistent with existing wells at the site. Once the full ERGI monitoring well network was established, these data were used to prepare a time averaged groundwater elevation map to estimate net gradients, further evaluate horizontal and vertical gradients and to the degree of river influence, and the effects of earth tides and barometric pressure on gradients in East Ravine wells and wells in the vicinity in relation to the rest of the site.

Pressure transducers were also used to monitor East Ravine bedrock wells and wells in the vicinity of the East Ravine on two occasions where the Interim Measures extraction and injection wells were shut down in April and May 2009. The April 2009 shutdown was a planned one-week shutdown for annual maintenance of the treatment plant receiving groundwater from the extraction system. A second unexpected treatment plant shutdown occurred over approximately a 30-hour period to do additional maintenance.

2.9 Investigation-derived Waste Management

Investigation-derived waste was managed in accordance with the procedures detailed in the Work Plan. Solid and liquid wastes generated during this investigation were temporarily stored at the work area in portable tanks (liquids) and hoppers (drill cuttings). As necessary, drill cuttings were transferred to lined roll-off bins located at the equipment staging area pending characterization sampling. Similarly, purge water was transferred to the IM No. 3 groundwater treatment facility for treatment and injection in compliance with California Regional Water Quality Control Board Order No. R7-2006-0060 (2006). Incidental trash was removed from the work area daily and was transferred to a standard trash bin at the Topock Compressor Station for offsite disposal.

Approximately 30 cubic yards of drill cuttings were generated during this investigation and were stored at the staging area located at the Topock Compressor Station. Composite soil characterization samples were collected following ERGI activities. The samples were submitted to a certified laboratory for the same analyses used for disposal characterization of drill cuttings during previous drilling projects, including CAM metals (6010B), mercury, and percent moisture.

Drill cuttings from the ERGI were profiled as non-hazardous waste and were transported to an offsite disposal facility.

3.0 Investigation Results

This section presents the results of the soil, hydrogeologic, and water quality sampling and testing activities conducted for the ERGI. A discussion of the integration of these data into the Topock site hydrogeologic conceptual model is presented in Section 4.0.

3.1 Lithology and Hydrostratigraphy

A primary objective of the ERGI was to further characterize the site hydrogeologic conditions in the area of the East Ravine. As discussed in Section 2.2, continuous core was collected from ground surface to the total depth drilled at each investigation site.

Two hydrogeologic cross sections have been prepared to illustrate the drilling results and hydrogeologic data for the East Ravine area. These cross sections present the interpreted hydrostratigraphy, well screen intervals, primary lithologic contacts, and the Cr(VI) laboratory analytical results from ERGI wells sampled during the July 2009 contemporaneous event (these results further discussed in Section 3.5) from ERGI wells and select existing wells in the vicinity of the East Ravine area. The locations of these cross sections are shown in Figure A-4. Hydrogeologic cross-sections A-A′ and B-B′ are presented in Figures A-5 and A-6, respectively. A summary of the key lithologic contacts observed at each ERGI site is presented in Table A-2.

Groundwater is first encountered within the bedrock at each investigation location, with the exception of Site G (MW-59-100), where saturated alluvium was encountered above bedrock[1]. As discussed in Section 2.2, a complete lithologic log, including a description of unconsolidated sediments and bedrock, was developed for each investigation borehole. However, given the nature of the bedrock at the site, the nature of bedrock discontinuities in situ was often difficult to ascertain. Investigation results regarding permeability of bedrock within investigation boreholes are presented in Section 3.2 (results of borehole flow characterization activities) and Section 3.6 (results of hydraulic monitoring activities). For additional details including Unified Soil Classification System designation of unconsolidated core, percent recovery, estimated fractures per foot within bedrock, discontinuity description, and rock quality designations, see Attachment A1-1. The hydrogeologic and bedrock elevation data for the East Ravine area are discussed in the context of existing site wide data in Section 4.0.

3.2 Characterization of Exploratory Boreholes

As described in Section 2.5 and 2.6, geophysical and borehole flow logging were conducted at each of the four exploratory boreholes to collect additional lithologic and hydrogeologic data for consideration during the design of groundwater monitoring wells. The following subsections present the results of the activities defined in Sections 2.5 and 2.6.

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[1] Bedrock was not encountered at Site G (MW-59-100). However, based on the observation of core recovered from the bottom of the borehole, Miocene conglomerate bedrock may have been encountered within feet of the total depth drilled.

3.2.1 Geophysical Logging

Geophysical logging was conducted in Site A (MW-58BR) and B (MW-57BR) exploratory boreholes within the open borehole at MW-57BR and within the 3-inch PVC casing at MW-58BR. Geophysical logging included natural gamma ray, dual induction, and caliper logs. An acoustic televiewer log was also run at MW-57BR. Geophysical logs are provided in Attachment A2-1. The acoustic televiewer log run at MW-57BR is provided with the borehole flow characterization report in Attachment A2-2.

In general, observation of core recovered during drilling provided higher quality lithologic information than that gleaned from analysis of the geophysical logs. Further, comparison of the geophysical data to hydrophysical logs does not suggest an obvious relationship between flow intervals and geophysical response. Therefore, geophysical logging was not conducted at subsequently investigated sites (C, C-Alt, E, E-Alternative 2, F, and G).

3.2.2 Borehole Flow Characterization

Borehole flow logging was conducted using hydrophysical logging methods at each of the four exploratory boreholes to identify water-bearing intervals within the bedrock. Testing was conducted under ambient (static water level) and induced (decrease water level) flow conditions. Depth-specific groundwater samples were also collected to estimate a screening-level, interval-specific chromium concentration, which is calculated based on the hydrophysical data. A summary of the results of hydrophysical testing and laboratory analysis of depth-specific groundwater screening samples is provided in Table A-3. Additional testing details are provided in the RAS, Inc. summary report (Attachment A2-2). Attachment A2-2 includes figures (montages) summarizing the hydrophysical testing results, including the results of depth-specific samples, the estimated interval-specific concentration (observed concentrations corrected for interval-specific flow contribution), and geophysical logging. The results of the screening level, depth-specific samples collected following well development activities and during hydrophysical testing are provided as Attachment A2-3.

Ambient and induced flow characterization was conducted in all wells. Extremely low flow rates were observed during the ambient period of testing, with interval specific ambient flow rates ranging from less than 0.001 (MW-64BR) to 0.005 (MW-57BR) gpm. Interval specific flow rates observed during the induced period of testing ranged from 0.008 (MW-64BR) to 2.1 (MW-57BR) gpm. Very low rates of upflow were detected in the ambient flow condition from the deepest water-bearing intervals at Sites A (MW-58BR) and E (MW-62BR). Due to the very low interval-specific flow rates in each borehole, the development of interval-specific chromium concentrations under pumping conditions was not successful at any locations except for MW-57BR. The limitations of sample results obtained during borehole flow characterization are discussed in Section 3.3.

3.3 Screening-level Groundwater Sample Data

As described in Sections 2.4, 2.6, and 2.8, screening-level groundwater samples were collected from the pump effluent during development activities, aquifer testing, or using a depth-specific sampler during borehole characterization (during pumping and non-pumping conditions). These screening level data were evaluated by PG&E, DTSC, DOI, and other stakeholders during the field investigation to guide contingency well installation and well design criteria. Screening-level groundwater samples were analyzed for Cr(VI), Cr(T), specific conductance, and pH at either the IM No. 3 onsite laboratory and/or the offsite laboratory Advanced Technologies Laboratory. Groundwater samples obtained during well development, aquifer testing, and borehole flow characterization activities (i.e., grab samples) are considered screening-level data for a qualitative assessment of water quality conditions in the aquifer. Results of the screening-level samples are provided in Attachment A2-3.

In general, screening-level sample results for Cr(VI) and Cr(T) were greater from open boreholes than for samples collected from the FLUTe™ multilevel systems of corresponding depth. However, Cr(VI) and Cr(T) sample results from single-completion wells remained at similar concentrations throughout the ERGI (i.e., after development) when compared to screening-level data. Screening-level samples are collected from open boreholes that have not been fully purged. The samples may not be representative of the depth interval where they were collected, and the depth intervals of the screening samples generally do not match those of the completed wells. As a result, inconsistencies commonly occur between screening-level samples from open boreholes and samples from subsequently completed wells. The reasons for these inconsistencies in the ERGI investigation have not been determined. In addition, DTSC has noted that the FLUTe™ wells generally exhibit elevated concentrations of total organic carbon (TOC) in comparison to other East Ravine wells. Leaching of organic carbon from FLUTe™ liners was documented in Cherry et al. (2007). DTSC has suggested that the TOC might be leaching from the FLUTe™ well materials and altering the geochemical conditions in the aquifer so that the FLUTe™ wells could be underestimating the actual Cr(VI) concentrations in the groundwater.

FLUTe™ multilevel systems installed at Sites A (MW-58BR), and E (MW-62BR) were designed to monitor the intervals found to have the greatest flow rates during borehole flow characterization. The FLUTe ™ multilevel system installed at Site C-Alternate (MW-64BR) was designed to divide the saturated thickness of the borehole into three intervals of similar length because predominant intervals of groundwater inflow were not apparent during testing.

Following FLUTe™ multilevel installation, development, and sampling, detected concentrations of Cr(VI) and Cr(T) were just above or below the laboratory reporting limit from most mid-depth and deep well sample locations (Section 3.5). It is estimated that the higher concentrations observed during screening and borehole characterization at MW-58BR and MW-62BR under pumping conditions) were affected by the blending of higher concentration Cr(VI) and Cr(T) groundwater from shallow portions of these boreholes with generally clean deeper groundwater. Therefore, screening-level samples obtained during pumping conditions at these boreholes are not considered to represent depth-specific intervals. The MW-64BR borehole was not sampled under pumping conditions due to extremely low yield at this location.

As described in Section 2.6 and 3.2, samples were also obtained with a depth-specific sampler during non-pumping (ambient) flow conditions from open boreholes. Results of ambient depth-specific samples collected near the bottom of the MW-58BR and MW-62BR boreholes (Attachment A2-3) were less than laboratory reporting limits for both Cr(VI) and

Cr(T), which is consistent with the results of samples collected after FLUTe™ multilevel systems were installed.

Non-pumping (ambient) depth-specific samples were also obtained from the MW-64BR open borehole at locations near the water table and from approximately 50 feet and 100 feet below the water table after borehole development and before commencing borehole flow characterization activities. Cr(VI) was detected at concentrations ranging from 82 to 110 micrograms per liter (µg/L) in these screening level samples. After the FLUTe™ multilevel system was installed, Cr(VI) was not detected above the laboratory reporting limit in the shallow and deeper interval and was detected at a concentration of 5.7 µg/L (just above the laboratory reporting limit) in the middle interval (Section 3.5).

3.4 Laboratory Analysis of Soil Samples

At the direction of the DTSC, nine soil samples were collected during the ERGI at Sites A and B and were analyzed for constituents of potential concern (COPCs) identified for AOC 10 (East Ravine) in the *Draft RCRA Facility Investigation/Remedial Investigation Soil Investigation Work Plan, Part A* (CH2M HILL, 2006a). Complete sample results for soil samples collected during the ERGI are provided as Attachment A3. Sample results for PAHs, SVOCs, TPHs, and VOCs were all less than laboratory reporting limits. A summary of soil sample results for Cr(VI) and Cr(T) at Sites A and B includes:

- **Site A (MW-58 well series)**: Elevated concentrations of Cr(T) and Cr(VI) were detected in one sample collected from this location. Laboratory analysis of the shallowest soil sample, which was collected from 1.5 to 2.0 feet bgs based upon the observation of a white powder material in the core during drilling, indicated a Cr(T) and Cr(VI) concentration of 4,000 and 150 milligrams per kilogram (mg/kg), respectively. Laboratory analysis of the five deeper samples indicated Cr(T) concentrations ranging from 24 to 35 mg/kg. Further, Cr(VI) was detected at a concentration above the reporting limit in two of the five deeper samples (maximum concentration of 0.43 mg/kg).
- **Site B (MW-57 well series)**: Analysis of five samples collected at this location indicated Cr(T) concentrations ranging from 20 to 26 mg/kg. Cr(VI) was not detected above laboratory reporting limit in any samples.

Results of soil samples collected during the ERGI will be combined with results of soil samples collected during the Part A soil investigation within the East Ravine in Fall 2008 and results of soil samples collected during earlier (1999 to 2003) soil investigations within the East Ravine. Evaluation of the combined data set from these soil investigations in the East Ravine for Cr(VI), Cr(T), additional metals, and other COPCs will be provided in the forthcoming Part A soil data evaluation.

3.5 Groundwater Quality in the East Ravine Area

This section presents the groundwater analytical and field measurement results for groundwater samples collected as discussed in Section 2.7. Presentation of the results in the following subsections focuses on laboratory analysis of samples collected during the July

2009 event, during which each newly installed well was sampled over a four day period.[2] The following subsections detail the results for Cr(T), Cr(VI), and COPCs in groundwater carried forward from the RFI/RI Volume 2 and RFI/RI Volume 2 Addendum (molybdenum, selenium, and nitrate) (CH2M HILL, 2009a-b), as well as the results of key geochemical indicator parameters. No additional COPCs were identified during the ERGI.

In addition to the contemporaneous sampling event for East Ravine wells in July 2009, two East Ravine wells were included in a supplemental sampling event in May-June 2009 for analysis of additional organic constituents. These results are presented in Section 3.5.3.

Complete laboratory analytical results for constituents collected for the ERGI are provided in Appendices C-2 and C-3. Sample results for the supplementary sampling event are provided in Attachment A3.

3.5.1 Distribution of Chromium and Field Measurements

Table A-4 presents laboratory groundwater analytical results for Cr(VI) and Cr(T) and field measurements for the new ERGI wells. Figures A-7 and A-8 present Cr(VI) results for the July 2009 sampling event for the shallow and mid-depth/deep wells, respectively. These figures illustrate that, during the initial sampling event, Cr(VI) was largely limited to shallow water table wells, was absent from deep wells, and was detected in one mid-depth well (detection of 74 µg/L of Cr(VI) in the well MW-62-110). The initial sample results from newly installed wells at Topock are sometimes inconsistent with later samples. In addition, as noted above, DTSC believes that TOC in FLUTe™ wells may be contributing to underestimates of the Cr(VI) concentrations. Therefore, it should be recognized that there is uncertainty with regard to interpretation of the ERGI results at this time.

Results for surface water samples collected during July 2009 as part of the site wide river monitoring program are also posted in Figure A-7. Two new surface water sampling locations were added to the surface water monitoring program in response to Cr(VI) results for samples in East Ravine wells, and these locations have been sampled beginning in April 2009. Consistent with surface water samples collected from other monitoring locations adjacent to the Colorado River, sample results at these two new locations and previously established surface water sampling locations were less than analytical reporting limits during April and July 2009 monitoring (CH2M HILL, 2009d).

Hexavalent chromium results for the July 2009 sampling event are also posted on hydrogeologic cross-sections A-A′ and B-B′ in Figures A-5 and A-6, respectively, with field-measured ORP and specific conductance data.

3.5.2 Sample Results for other Analytes in the ERGI

In accordance with the Work Plan, groundwater samples were analyzed for additional analytes, including metals and VOCs. Sample results for molybdenum, selenium, and nitrate (identified as COPCs in the RFI/RI Vol. 2 or RFI/RI Volume 2 Addendum) are summarized in Table A-4 (CH2M HILL 2009a and 2009b). Results for these COPCs are presented in the context of results from site-wide wells in the following sections.

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[2] Groundwater samples were not collected from perched zone wells since either no water was present in the well (MW-57-050) or there was insufficient volume for sample collection (MW-58-065).

Sample results for all VOCs were below the laboratory reporting limits at all wells except for those VOCs discussed in Section 3.7.2.

3.5.2.1 Molybdenum

As described in the RFI/RI Vol. 2 and RFI/RI Vol. 2 Addendum, molybdenum was carried forward as a COPC in groundwater based on its historical use at the Topock Compressor Station and its observed distribution in groundwater (CH2M HILL, 2009a-b). There is no federal or state maximum contaminant level (MCL) established for molybdenum.

Table A-4 presents groundwater sample results for molybdenum and field parameters collected during the ERGI. Molybdenum was detected at all wells with concentrations ranging from 22 to 110 µg/L. All detected concentrations are within the range previously observed for other wells at the site. The upper tolerance limit (UTL) calculated for alluvial wells in the Topock background study was 36.3 µg/L (CH2M HILL 2009b). The maximum molybdenum concentrations in ERGI samples generally occurred from deep sample intervals where Cr(VI) was absent. As reported in the RFI/RI Volume 2 report, the highest molybdenum concentrations have normally been reported for deep alluvial wells across the site (both inside and outside of the Cr(VI) plume), but the maximum average molybdenum concentrations has historically been reported for shallow alluvial well MW-10 (average concentration of 144 µg/L) (CH2M HILL, 2009b). Because the maximum molybdenum concentrations observed in the ERGI were generally found at deep well locations where Cr(VI) is absent and upward hydraulic gradients are prevalent (see Section 3.6), it is believed that molybdenum observed at ERGI wells is most likely naturally occurring and not related to the historical use of molybdenum at the Topock Compressor Station. Additional groundwater monitoring is planned to further evaluate molybdenum distribution and occurrence due to the limited data set.

3.5.2.2 Selenium

Selenium was carried forward as a COPC in groundwater in the RFI/RI Vol. 2 report (CH2M HILL 2009a). Table A-4 presents groundwater sample results for selenium and field parameters collected during the ERGI. Selenium was detected in seven of the 16 wells sampled for the ERGI at concentrations ranging from 0.82 to 5.10 µg/L. These results are less than those historically reported for a large amount of site wells and less than the alluvial wells UTL (10.3 µg/L) calculated for the background study (CH2M HILL, 2009a). The MCL for selenium is 50 µg/L.

3.5.2.3 Nitrate

Nitrate was carried forward as a COPC in groundwater in the RFI/RI Vol. 2 report and evaluated as a COPC in the RFI/RI Vol. 2 Addendum (CH2M HILL, 2009a-b). In the ERGI, nitrate (expressed as nitrogen) ranged from to 2.90 to 9.10 milligrams per liter (mg/L) in the six (of 16) monitoring locations where it was detected. All detected concentrations are within the range previously observed for other wells at the site. Wells with detectable nitrate were generally shallow water table monitoring wells without reducing conditions present. The maximum concentration (9.1 mg/L) was reported for shallow well MW-57-70. Monitoring locations with nitrate results less than analytical reporting limits were mostly deep monitoring wells where reducing conditions are present. The California MCL for nitrate (expressed as nitrogen) is 10 mg/L. The UTL for nitrate calculated in the background study for site alluvial wells was 5.03 mg/L (expressed as nitrogen) (CH2M HILL, 2008b). As described in the RFI/RI Vol. 2 Report and RFI/RI Vol. 2 Addendum, there are several potential sources of nitrate, including concentration by lightning in rainfall, disruption of desert pavement, blasting materials from nearby quarries and roadway construction, animal grazing, and evaporative concentration in industrial wastewater.

3.5.3 Sample Results for Additional Constituents

In a May 15, 2009 letter, the DTSC directed PG&E to collect groundwater samples at wells MW-57-070 and MW-59-100 (in addition to other non-ERGI wells) for analyses not included in the Work Plan (DTSC, 2009). These samples were intended to further evaluate if COPCs identified in surface soil samples during the soil investigation Part A were also present in groundwater (DTSC, 2009). None of these additional COPCs (dioxin/furans, PAHs, PCBs, TPH, and SVOCs) was detected above laboratory reporting limits in either sample set. Samples results for GMP monitoring wells (i.e., all wells identified in the DTSC letter except MW-57-070 and MW-59-100) were presented in the *Second Quarter Performance Monitoring and Sitewide Groundwater and Surface Water Monitoring Report, PG&E Topock Compressor Station, Needles, California* (CH2M HILL, 2009d). Groundwater sample results for the supplemental sampling conducted for the ERGI are provided as Attachment A3.

3.5.4 General Geochemistry

Table A-5 presents laboratory groundwater analytical results for general chemistry parameters collected for the new ERGI wells. A review of this table demonstrates that dissolved iron and manganese are present while nitrate is absent from most deep wells. These data, along with the field parameter data for dissolved oxygen and ORP presented in Section 3.4.1, indicate the occurrence of reducing conditions at deep wells where Cr(VI) is absent. This is consistent with chromium geochemistry, with Cr(VI) reduced to the insoluble trivalent form under these conditions.

TDS data in Table A-5 illustrate that there is generally greater TDS in deeper bedrock wells, with much lower concentrations observed in shallower wells. Groundwater in the shallow bedrock of the East Ravine area is also notably less reducing than several site bedrock wells located outside of the East Ravine (MW-24BR, PGE-7BR, PGE-8), presumably due to the stronger hydraulic communication with alluvial groundwater and/or surface runoff. Similar to groundwater found within other deep bedrock wells onsite, groundwater at deep wells completed during the ERGI is presumed to be very old water given the low permeability and upward hydraulic gradients observed at these wells. As a result, it is thought that the shallow wells that have Cr(VI) present contain relatively young water and that mid-depth and deep wells generally contain older water.

Results for the stable isotopes of oxygen (oxygen, deuterium) were also evaluated by comparing the results for ERGI wells to other site wells reported in the *Performance Monitoring Report for Fourth Quarter 2008 and Annual Performance Evaluation, February 2008 through January 2009* (PMR) (CH2M HILL, 2009e). As described in the PMR report, there are three categories of groundwater evident in plotting the stable isotope data: river, industrial, and non-industrial. There may be considerable overlap between the industrial isotopic signature associated with the partly-evaporated facility water and non-industrial isotopic signature associated with natural aquifer conditions; however, these data can provide another valuable line of evidence for delineating groundwater that may have historically been impacted by industrial water.

Figure A-9 presents a plot of the stable isotope data collected during the ERGI, along with other site wells previously presented in the annual PMR report (CH2M HILL, 2009e). A review of this figure indicates that well MW-63-065 has a similar isotopic signature to Colorado River water and that alluvial well MW-59-100 has the heavy isotopic signature typical of other alluvial plume wells. The remaining bedrock wells have signatures between these two end members, with those containing elevated Cr(VI) tending to have heavier signatures than those that do not, also similar to the trend observed in the Alluvial Aquifer. Further investigation will be aimed at determining characteristics of the facility water source in the East Ravine.

3.6 Hydraulic Testing and Monitoring in the East Ravine Area

Hydraulic testing and monitoring activities in the East Ravine area included slug testing, constant rate extraction testing, water-level snapshots, and monitoring of gradients with pressure transducers. Aquifer monitoring data, including slug tests, the MW-57BR constant rate pumping test, and water-level hydrographs are provided as Attachment A4-1, A4-2, and A4-3, respectively.

Pressure transducers were also used to record hydraulic response to the planned IM No. 3 shut down of active extraction and injection wells in April and May 2009. These data were deconvoluted by the method described in Halford (2006). This method involves using the Colorado River stages, barometric pressure, and background monitoring wells as input data series to synthesize estimates of what the monitoring wells' water levels would have been with active pumping; however no response was detected in the East Ravine wells over either of these fitting periods, so these data are not presented in this section.

3.6.1 Slug Testing

Slug test data were analyzed with the software AQTSOLVE™ 3.0 created by HydroSOLVE, Inc. using manual curve matching and the Bouwer-Rice straight-line solution for an unconfined aquifer to estimate localized hydraulic properties near the test wells. Slug test results are summarized in Table A-6. The estimated hydraulic conductivities of the Miocene conglomerate and pre-Tertiary metadiorite range from 0.016 to 0.18 and 0.0011 to 1.56 feet per day, respectively, based on the slug test analyses and a constant rate pumping test. These estimates are similar to previous estimates for these units at other bedrock well locations at the Topock site (CH2M HILL, 2009a).

Neither of the bedrock formations appear to be more permeable than the other, although the lowest K observed during the ERGI was observed within the pre-tertiary metadiorite at well MW-64BR. Well MW-64BR took greater than 3 days to recover after pumping the well down to the submersible pump. Recovery curves and AQTSOLVE™ printouts of the slug tests are provided as Attachment A4-1.

3.6.2 Constant Rate Extraction Testing

On April 2, 2009, a constant rate pumping test was conducted at well MW-57BR (MW-57-185). Well MW-57BR has a 3-inch screen from 70 to 185 feet within the Miocene conglomerate and pre-tertiary metadiorite. Pumping was conducted at a rate of approximately 3 gpm over approximately a 7-hour period with steady drawdown of approximately 78 feet observed within the pumping well. Negligible (less than 0.05 foot) to no response was observed in six of the seven observation wells monitored, including the adjacent water table well (MW-57-070 screened from 55 to 70 feet below top of casing) completed within Miocene conglomerate. The greatest response detected was at MW-58BR, where approximately 0.07 foot of drawdown was observed.

The hydraulic conductivity at MW-57BR was estimated to be 0.18 feet/day, with a storativity of 0.0008 using multilayer unsteady state for Windows Version 1.60.02 (Hemker and Post, 2009). Plots of hydraulic data recorded during the MW-57BR pump test, including drawdown plots for observation wells and the Colorado River stage, are provided as Attachment A4-2. The groundwater sample collected at the end of the pump test contained a Cr(VI) concentration of 16 µg/L, consistent with other sample results for this well. Sample results are provided in Attachment A2-3.

3.6.3 Gradient Monitoring and Water-level Snapshots

Figure A-10 presents hydrographs of the MW-57, MW-58, and MW-62 well clusters completed during the ERGI. A review of this figure confirms that upward gradients are present at all three of these well clusters and that none of these bedrock wells is significantly affected by diurnal river fluctuations. These upward gradients are consistent with those historically reported for other site bedrock wells (MW-24 cluster, MW-12/MW-48) and clusters of wells completed within the alluvium that are not influenced by Interim Measures pumping (CH2M HILL, 2009a).

Additional hydrographs of all East Ravine wells are provided as Attachment A4-3. Assessment of these hydrographs confirms that except MW-63-065 (completed near the river in fractured Miocene conglomerate) most ERGI wells have a low response to river fluctuations compared to other site wells completed within the alluvium at similar distances from the Colorado River (CH2M HILL, 2009a). Representative water levels at the MW-64 cluster were difficult to obtain due to the construction design of the multilevel monitoring system installed in this borehole (see Section 2.4.2); however, upward vertical gradients are present at this cluster also (Attachment A4-3).

Water-level snapshots of wells completed within the East Ravine and neighboring wells on May 30 and July 8, 2009 are presented in Figures A-11 and A-12, respectively. These snapshots illustrate that horizontal gradients are predominantly towards the northeast, and that vertical gradients are upward at the MW-57, MW-58, and MW-62 series wells.

Figure A-13 presents water-level contours of time-averaged pressure transducer data collected for water table wells in the East Ravine and vicinity collected over the period of June 1st through July 15, 2009. Included in this figure are data for the FLUTe™ multilevel wells, which were not available during the previous water-level snapshots. Average horizontal gradients measured with pressure transducers are consistent to those measured during the water-level snapshots, with a northeasterly component to horizontal hydraulic gradients apparent in the East Ravine and surrounding area.

3.7 Data Quality Evaluation Summary

This data quality evaluation (DQE) summary assesses the data quality of analytical results for the 2009 East Ravine groundwater investigation at the PG&E Topock Compressor Station between January 14, 2009 and July 22, 2009. Samples were collected and analyzed as requested by the DTSC. The PG&E Quality Assurance Program Plan and subsequent updates (CH2M HILL, 2008c-e), individual method requirements, internal laboratory quality control criteria, guidelines from the United States Environmental Protection Agency (EPA) *Contract Laboratory National Functional Guidelines for Inorganic Data Review* (2002) and *Contract Laboratory National Functional Guidelines for Organic Data Review* (1999) were used in this assessment.

3.7.1 Data Assessment

This DQE summary covers 48 normal groundwater and water samples, 11 normal soil samples, two field duplicate groundwater samples, and one field duplicate soil sample. A summary discussion of data quality for the ERGI soil and groundwater sampling data is presented below. A complete DQE report is provided as Attachment A5 of this report. Additional details are provided in the data validation reports, which are kept in the project file and are available upon request.

- **Holding Times:** One depth discrete dissolved arsenic sample was analyzed (SW6020B) outside the recommended holding time of 180 days by approximately 12 days. The analysis was requested following expiration of the recommended holding time to clarify subsequent arsenic results that varied significantly from historical norms. The detected result was qualified as estimated and was flagged "J" All other holding times were met.

- **Method Blanks:** Method blanks were analyzed at the required frequency. No target analytes were detected at or above the reporting limit.

- **Matrix Interference:** Matrix interference has been encountered at the Topock site in selected monitoring wells that affected the sensitivity for Cr(VI) by the E218.6 and SW7199 Methods. Further details of the added laboratory procedures to address this issue are discussed in Attachment A5.

- **Matrix Spike Sample:** All matrix spike acceptance criteria were met.

- **Quantitation and Sensitivity:** Due to a demonstrated matrix effect for the Cr(VI) analyses, which is discussed in Attachment A5, the reporting limits for Method E218.6 (hexavalent chromium) for the non-detected sample results were raised by the laboratory at seven locations.

- **Equipment Blanks:** Target analytes detected in equipment blanks may indicate that field equipment was not thoroughly decontaminated and samples could have been cross-contaminated. Following the criteria in Table 6-3, Flagging Conventions – Minimum Data Evaluation Criteria for Inorganic Methods from the QAPP (CH2M HILL, 2008), the associated samples with a result less than five times the concentration of the equipment blank detect are qualified as non-detect and flagged "U". Chromium (SW6010B) was detected above the reporting limit in one equipment blank and zinc (SW6010B) was detected above the reporting limit in four equipment blanks. Three chromium results and 18 zinc results from groundwater monitoring samples were qualified as not detected at the reported concentrations and were flagged "U."

- **Internal Standard Recoveries:** All internal response factors met method acceptance criteria.
- **Calibration:** Initial and continuing calibrations were performed as required by the methods. Calibration criteria were generally met overall; exceptions to meeting calibration criteria are presented in Attachment A5.
- **Internal Standard Recoveries:** All internal response factors met method acceptance criteria.
- **Surrogate Recoveries**: Surrogate recoveries met the acceptance criteria with the following exception. One TPH-gasoline-range (SW8015B) soil sample had a slightly low biased surrogate recovery. The non-detected result was flagged "UJ" as an estimated value.
- **Matrix Spike Samples:** Matrix spike/matrix spike duplicate acceptance criteria were generally met, with the exceptions provided in Attachment A5.
- **Field Duplicates:** All field duplicate acceptance criteria were met.
- **Lab Duplicates:** The laboratory analyzed duplicate aliquots of field samples at the required frequency. The quality control acceptance criteria were met for all methods.
- **Laboratory Control Samples:** Laboratory control samples were analyzed at the required frequency and were recovered within quality control limits.
- **Chain of Custody/Sample Receipt:** Each sample was documented in a completed chain of custody and was received at the laboratory in good condition. All discrepancies identified in laboratory custody were promptly resolved.

3.7.2 Historical Discrepancies

Seven FLUTe™ wells were installed within three of the deep boreholes (MW-58BR, MW-62BR, and MW-64BR). The acetone (SW8260B), toluene (SW8260B), and arsenic (SW6020A) results from these FLUTe™ wells were found to be inconsistent with sitewide historical data. After further review of available literature and other onsite results, it was determined that the FLUTe™ well construction materials (described in Section 2.4.2.2) contained these three analytes at varying levels (Gilmore et al., 2004; Gotkowitz et al., 2004; CH2M HILL, 2006b; and Cherry et al., 2007). Therefore, the results of each of these compounds from the groundwater monitoring samples were confirmed to be unusable. These results were flagged "R" since data were demonstrated to be unusable due to deficiencies in the ability to meet quality control criteria.

Because of the elevated detections of arsenic detected from FLUTe™ wells, groundwater samples obtained from these well locations before FLUTe™ installations were also analyzed for arsenic. A minimum of two samples for each borehole (MW-58BR, MW-62BR, and MW-64BR) were analyzed, with arsenic concentrations ranging from 11 to 25 µg/L (Attachment A2-3). These results are consistent with sample results for other ERGI well samples (Attachment A3-2) and provided further justification for rejecting the arsenic data for FLUTe™ well samples.

During procurement and installation of the FLUTe™ multilevels, it was unknown that the urethane-coated fabric used to construct the FLUTe™ multilevels contains arsenic and toluene. Arsenic is applied during the manufacturing process to prevent biological growth and deterioration of the liner materials. The current organic arsenic loading rate is 0.0056 ounces per square yard for the double-coated fabric used for FLUTe™ liners. These arsenic loading rates are very common for awnings, boat covers, life preservers, and pool liners (Keller, 2009). Upon obtaining validated laboratory groundwater sample results, and after discussions with FLUTe™, it was acknowledged that the urethane-coated fabric in the FLUTe™ multilevels contains low levels of arsenic and toluene, and that detections of these analyses should be expected in initial samples collected from FLUTe™ wells (Keller, 2009). Low concentrations of acetone (up to 50 µg/L) and toluene (up to 6 µg/L) were detected; however, arsenic was detected at greater concentrations, ranging from 110 to 770 µg/L.

FLUTe™ conducted leaching tests with the urethane-coated fabric used to construct the FLUTe™ multilevels (Keller, 2009). During these tests, arsenic concentrations were relatively independent of whether the samples were leached for one or four weeks, indicating that there is a limit to the amount of arsenic that may leach from the liner materials. Arsenic concentrations in six samples collected from the leach water ranged from 26 to 511 µg/L. Over time, arsenic (and acetone and toluene) concentrations in FLUTe™ wells are expected to decrease and eventually reach levels representative of formation water (Gotkowitz et al., 2004; CH2M HILL, 2006b; and Cherry et al., 2007). Cherry et al. (2007) states:

> *The leaching of toluene, total organic carbon (TOC), and arsenic from the liner material has been documented in field systems and laboratory leach tests. These compounds are seen in the sample water to varying degrees depending upon the time and whether the prescribed purge procedure was performed.*
>
> *Toluene, which is used in the production of the urethane coating, has been found in the ground water samples at concentrations of several hundred micrograms per liter, with more typical values of 10 to 70 µg/L soon after the liner installation. The concentrations of toluene have been shown to decrease with time to near nondetectable levels after several months to a year. Concentrations of TOC in ground water obtained from FLUTe systems have ranged from ''nondetect'' to several milligrams per liter immediately following installation but typically decrease with time to less than 1 mg/L. A recent side-by-side comparison of a FLUTe system and three cluster wells showed good agreement for TOC concentrations ranging from 1 to 14 mg/L in sampling intervals at the elevations of the three well screens (T. Roeper, personal communication, 2005).*

PG&E is currently purging the FLUTe™ wells multiple times prior to each sampling event to assist with flushing out any compounds that may be leaching from the liner materials. PG&E anticipates that any issues with leaching from the FLUTe™ liners will diminish with time.

4.0 Refinements to the Topock Conceptual Site Model

This section summarizes the additions and refinements to the Topock hydrogeologic conceptual site model (CSM) that resulted from the ERGI. The investigation data and findings relevant to the Topock CSM include:

- Bedrock elevation and structure.
- Lithology of the bedrock formations.
- Hydraulic characterization of the bedrock formations.
- Groundwater gradients and flow direction.
- Groundwater quality characterization.

The refinements made to the CSM presented in the RFI/RI Report Volume 2 and Addendum (CH2M HILL 2009b-c) by incorporating the ERGI data are summarized in this section. Conclusions and recommendations for additional investigation and characterization are also presented.

4.1 Bedrock Elevation and Lithology

Additional data on the depth/elevation and the lithologic characteristics of bedrock were collected at eight drilling sites (described in Section 3.1). Figure A-14 presents the updated bedrock elevation contour map for the Topock site that incorporates the results of the ERGI. The principal change to the site bedrock map resulting from the ERGI involves the position of the bedrock/Alluvial Aquifer contact at water table elevation 456 feet above mean sea level (msl), as highlighted in Figure A-14. The ERGI drilling shows that bedrock in the area immediately northeast of the compressor station is deeper than initially mapped, and the bedrock surface forms a shallow 'embayment' adjacent to the bedrock outcrops. As a consequence, a comparatively thin interval of the Alluvial Aquifer (approximately 10 to 30 feet thick) overlies the bedrock surface in this area. The bedrock elevation and Alluvial Aquifer thickness are estimated at MW-59 based on contouring bedrock elevations in the adjacent borings and projecting the bedrock surface on a site hydrogeologic cross section (see Section 4.2.1). The boring at MW-59 was drilled to install a monitoring well at an equivalent depth as the shallow wells at MW-57 and MW-58, and did not reach bedrock.

The ERGI investigation collected detailed core of the two main bedrock formations present at the Topock site, the Miocene conglomerate and pre-Tertiary crystalline rock (metadiorite). The resulting core log information provides a more complete record of the lithologic characteristics, features, and subsurface occurrence of the bedrock formations. The new bedrock lithologic data supplement the geologic descriptions of Miocene conglomerate and pre-tertiary metadiorite that were presented in the RFI/RI Report Volume 2.

The site bedrock elevation map has been incorporated in the Topock CSM and the groundwater model. In August 2009, the site groundwater model was reconfigured to accommodate the new information on the depth, elevation, and bedrock contacts for the depth intervals and model layers for the Alluvial Aquifer.

4.2 Hydrogeologic Characterization

The new data obtained from the ERGI enhances the understanding of the hydrogeologic setting and hydraulic properties and groundwater occurrence in bedrock at the Topock site. Summarized below are the primary findings and refinements to the bedrock hydrogeologic characterization.

4.2.1 Hydrogeologic Setting of the East Ravine

A hydrogeologic cross-section presented in Figure A-15 illustrates the drilling results, hydrostratigraphy, and site setting and relationship of the Alluvial Aquifer north of the East Ravine and bedrock formations present in the East Ravine. This true-scale cross section was prepared to supplement the existing set of site cross sections issued in RFI/RI Volume 2 and Addendum reports (hence, this cross section is designated J-J′). The features illustrated include:

- The thickness of the Alluvial Aquifer ranges from over 130 feet in the MW-20 bench area (IM extraction well TW-3D) to an estimated approximately 20 feet at East Ravine well MW-59-100. Based on available drilling data, the Miocene conglomerate bedrock surface gradually rises in depth from well cluster MW-12/MW-48 southward to the East Ravine.
- Groundwater occurs in the bedrock formations underlying and south of the East Ravine. The water table in the bedrock units equilibrates to an approximate elevation similar to the water table present in the Alluvial Aquifer. This is consistent with observations for the bedrock wells that were installed prior to the ERGI. Testing and monitoring shows that groundwater in fractured bedrock is in hydraulic communication with the Alluvial Aquifer.
- The location and inferred depth of the Chemehuevi detachment fault is depicted on Cross-section J-J′. This fault is a regional geologic feature that is exposed along the base of the bedrock slope immediately south and southeast of the compressor station. Additional faults in bedrock may be present in the subsurface but are not defined by the drilling or surface mapping. As noted in Section 3.1, the MW-57BR exploratory borehole drilled at ERGI Site B (located approximately 300 feet east of Cross-section J-J′ is believed to have intersected the Chemehuevi fault at an approximate elevation of 350 feet msl.

4.2.2 Bedrock Hydraulic Characterization

Prior to the ERGI, characterization of hydraulic properties of bedrock formations was based on hydraulic tests conducted at four wells completed in metadiorite bedrock (PGE-8, PGE-7, PGE-7BR, and MW-24BR) and two wells near East Ravine completed in Miocene conglomerate (MW-23 and MW-48). The hydraulic conductivity was estimated to range from 0.0009 (PGE-07BR) to 0.09 (PGE-08) feet/day within metadiorite bedrock and from 0.0004 (MW-48) to 0.004 (MW-23) feet/day within the Miocene conglomerate (CH2M HILL, 2009a).

The hydraulic testing data obtained from the ERGI have further refined the bedrock hydraulic characterization for the Topock site. The findings and refinements from additional testing include:

- Overall, the shallow bedrock in the East Ravine area (water table interval) exhibits a low to moderate fractured rock permeability, with an average K of 0.45 feet/day (range 0.02 to 1.56 feet/day).
- Data for deeper long screen intervals in bedrock (test intervals with elevation 425 to 300 feet msl) indicate very low to low fractured rock permeability, with an average K of 0.064 foot/day (range 0.0011 to 0.18 foot/day).
- The distribution of bedrock hydraulic conductivity appears independent of the lithology, specifically, the range of permeabilities were distributed similarly in both the Miocene conglomerate and the metadiorite bedrock units. The lowest bedrock K was measured in metadiorite (0.0011 foot/day). The highest bedrock K was measured in the shallow portion of the metadiorite (1.56 feet/day).

4.2.3 Site Hydraulic Gradients and Groundwater Flow

As described in Section 3.6.3, the new groundwater elevation data from the ERGI have been integrated with other site data to refine the characterization of hydraulic gradients and groundwater flow in site bedrock. The findings and refinements from additional hydraulic data include:

- The available data indicate that groundwater hydraulic gradient is upward and northeastward (see Figure A-13).
- The monitoring well clusters installed for the ERGI provide additional data on vertical gradients at the site. Upward vertical gradients have been observed in all four of the ERGI well clusters installed (see hydrographs, Figure A-10). This finding corroborates the prior upward vertical gradient data collected at other alluvium/bedrock well clusters (MW-24B/MW-24BR and MW-12/MW-48).

It is recommended that continuous water-level monitoring continue at the new bedrock monitoring well clusters for at least one year to be able to observe seasonal changes in gradients in response to river fluctuations. This may provide insight into whether the fractured bedrock is behaving as an equivalent porous medium. As determined from the analysis of data collected from ERGI wells during a May 2009 shutdown of IM No. 3 extraction wells, these wells do not respond to IM No. 3 pumping; therefore, there is not a need for ongoing water-level monitoring of these wells to support the IM No. 3 Performance Monitoring Program.

4.3 Nature and Extent of Chromium and Other COPCs in Groundwater

Prior to the ERGI, the southern limit of the groundwater chromium plume in the Alluvial Aquifer was based on the inferred bedrock contact in the area east of the compressor station. Additionally, prior to the ERGI, Cr(VI) had been consistently detected in only one bedrock monitoring well, MW-23. The new groundwater analytical data collected in ERGI sampling in July 2009 (described in Section 3.5) have supplemented the RFI/RI groundwater quality characterization, specifically for the following areas:

- The area of the groundwater chromium plume in the Alluvial Aquifer is extended to the south relative to the pre-ERGI chromium plume characterization maps. This refinement has been incorporated in the corrective measures study/feasibility study (CMS/FS), as described in Section 2.3 of the CMS/FS Report (CH2M HILL, 2009f).
- Elevated chromium in groundwater in the East Ravine appears to be primarily in the uppermost 20 to 50 feet of the saturated bedrock. Due to the low porosity and limited fracturing present within the bedrock formations, mass of chromium in bedrock likely represents much less than one percent of the total plume mass.
- The source of chromium in bedrock groundwater in the East Ravine has not been identified based on the available data.
- In response to Cr(VI) results in samples collected from ERGI monitoring wells, two new shoreline surface water sampling locations were established as part of the sitewide river monitoring program (Figure A-7). Results of samples collected from these surface water locations were less than analytical reporting limits for both Cr(VI) and Cr(T) in April and July 2009 sampling (Figure A-7) (CH2M HILL 2009d).
- Groundwater sample results for COPCs other than Cr(VI) carried forward from the RFI/RI Vol. 2 and RFI/RI Vol. 2 Addendum are generally consistent with data for other site wells (e.g., molybdenum) or present at lower concentrations (e.g., selenium and nitrate). Since the greatest concentrations were generally found at deep wells where Cr(VI) was absent and upward hydraulic gradients are present, molybdenum detected in the ERGI wells is most likely not associated with previous use at the Topock Compressor station.

4.3.1 Groundwater Quality Characterization Data Needs

The ERGI confirmed the presence of elevated chromium in bedrock groundwater, with some concentrations above site Alluvial Aquifer background levels. The installed wells and established surface water/shoreline sampling locations have provided partial definition of the lateral and vertical extent of the chromium impact in bedrock. Additional information will be collected to enhance the understanding of the groundwater contamination in the area, and that information will be incorporated into the design of the final remedy.

The scope and rationale of additional investigation in the East Ravine area and compressor station is currently being developed with agencies and stakeholders. At this time, three main data gaps have been identified for the East Ravine that must be addressed through additional characterization:

- Identification of the source of contaminated bedrock groundwater in the East Ravine through installation of wells, including at the compressor station.
- Determination of the lateral extent of contamination.
- Determination of the vertical extent of contamination where not currently defined (e.g., at MW-60 and MW-61).

It is anticipated that East Ravine wells would be sampled quarterly for at least four quarters prior to deciding how these wells would be incorporated into the GMP. The exception to this may be MW-64, where monthly sampling is currently proposed. Having several rounds of sample data from MW-64 prior to the initiation of the second phase of the East Ravine investigation may help determine whether a step-out well is needed to define the extent of elevated Cr(VI) in the area south of MW-64. Additional investigation is also necessary to determine the source of contaminants in East Ravine groundwater. Possible sources that have been identified to date include the former cooling water discharge in Bat Cave Wash, potential infiltration of water into bedrock beneath the compressor station, and potential discharge or runoff of contaminated surface water from the compressor station into the East Ravine.

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Tables

TABLE A-1

Summary of Well Installation Details

Summary of Findings Associated with the East Ravine Groundwater Investigation

PG&E Topock Compressor Station, Needles, California

ERGI Site	Location ID	Northing	Easting	Date Installed	Location Description	Total Boring Depth	Monitoring Zone	Screen Length	Ground/Conc. Surface Elevation	TOC Elevation	Top of Screen (permanent MW)		Bottom of Screen (permanent MW)		Top of Borehole Interval (characterization)		Bottom of Borehole Interval (characterization)		Well Diameter PVC	Boring Diameter	Notes
						(ft bgs)		(feet)	(NAVD 88)	(NAVD 88)	Depth (ft bgs)	Elevation (ft MSL)	Depth (ft bgs)	Elevation (ft MSL)	Depth (ft bgs)	Elevation (ft MSL)	Depth (ft bgs)	Elevation (ft MSL)	(inch)	(inch)	
MW-23	**MW-23-060**	7616448.25	2101286.36	5/2/2009	permanent MW (nested)	80	BR - Tmc	10	504.5	504.08	50	455	60	445	--	--	--	--	2	10.7	
	MW-23-080	7616448.50	2101286.32	5/2/2009	permanent MW (nested)	80	BR - Tmc	5	504.5	504.13	75	430	80	425	--	--	--	--	2	10.7	
B	**MW-57-050**	7616384.35	2100906.35	1/21/2009	permanent MW (single completion)	50	PA - alluvial	10	508.97	508.76	40	469	50	459	--	--	--	--	2	6.3	
	MW-57-070	7616394.98	2100893.58	1/28/2009	permanent MW (single completion)	70	BR - Tmc	15	509.67	509.37	55	455	70	440	--	--	--	--	2	6.3	
	MW-57-185	7616389.44	2100899.56	2/16/2009	permanent MW (single completion)	192	BR - Tmc & pTbr	114	509.39	508.97	70	439	184	325	--	--	--	--	3	3.8	Drilled to 192' and caved to 184' during sleeve installation.
A	**MW-58-065**	7616136.25	2100607.15	2/12/2009	permanent MW (single completion)	64	PA -alluvial & pTbr	10	521.41	523.26	54	467	64	457	--	--	--	--	2	6.3	
	MW-58BR_S	7616131.91	2100612.36	2/10/2009	* exploratory borehole	115	BR - pTbr	60	521.78	523.83	--	--	--	--	55	467	115	407	3	3.8	Initial borehole 115.2' temporary 3" slotted sleeve installed for characterization and removed to deepen to 206'
	MW-58BR_D	7616131.91	2100612.36	3/27/2009	* exploratory borehole	206	BR - pTbr	152	521.78	523.83	--	--	--	--	54	468	206	316	3	3.8	Initial borehole 115.2' deepened to 206' and temporary 3" slotted sleeve installed for characterization and removed prior to FLUTe™ multi-level installation
	MW-58-115	7616131.67	2100612.13	7/8/2009	multi-level well (FLUTe™)	206	BR - pTbr	20	521.64	524.44	95	427	115	407	--	--	--	--		3.8	
	MW-58-205	7616131.80	2100612.06	7/8/2009	multi-level well (FLUTe™)	206	BR - pTbr	46	521.64	524.42	160	362	206	316	--	--	--	--		3.8	
G	**MW-59-100**	7616081.90	2100851.96	2/26/2009	permanent MW (single completion)	101	SA - alluvial	15	538.94	541.61	86	453	101	438	--	--	--	--	2	6.3	
F	**MW-60-125**	7616434.82	2100491.63	3/3/2009	permanent MW (single completion)	123	BR - pTbr	20	555.78	555.47	103	453	123	433	--	--	--	--	2	6.3	
C	**MW-61-110**	7616591.04	2100713.02	3/13/2009	permanent MW (single completion)	112	BR - pTbr	20	544.12	544.03	92	452	112	432	--	--	--	--	2	6.3	
E	**MW-62-065**	7616560.96	2101064.51	3/18/2009	permanent MW (single completion)	65	BR - Tmc	20	503.56	503.56	44.5	459	64.5	439	--	--	--	--	2	6.3	
	MW-62BR	7616551.06	2101068.31	4/22/2009	* exploratory borehole	192	BR - Tmc	127	504.6	503.96	64.5	440	191.5	313	64.5	440	191.5	313	3	3.8	Temporary 3" slotted sleeve installed for characterization and removed prior to FLUTe™multi-level installation
	MW-62-110	7616550.88	2101068.16	7/7/2009	multi-level well (FLUTe™)	192	BR - Tmc	25	504.6	504.05	85	420	110	395	--	--	--	--	--	3.8	
	MW-62-190	7616550.99	2101068.29	7/7/2009	multi-level well (FLUTe™)	192	BR - Tmc	37	504.6	504.05	155	350	192	313	--	--	--	--	--	3.8	
E-Alt2	**MW-63-065**	7616921.60	2100973.93	4/8/2009	permanent MW (single completion)	66	BR - Tmc	20	505.03	504.47	46	459	66	439	--	--	--	--	--	6.3	
C-Alt	**MW-64BR**	7616939.41	2100520.49	5/15/2009	* exploratory borehole	258	BR - pTbr	148	576.05	575.60	2	574	258	318	110	466	258	318	3	3.8	Temporary 3" slotted sleeve installed for characterization and removed prior to FLUTe™multi-level installation
	MW-64-150	7616939.26	2100520.23	7/11/2009	multi-level well (FLUTe™)	258	BR - pTbr	30	576.05	575.90	120	456	150	426	--	--	--	--	--	3.8	
	MW-64-205	7616939.51	2100520.82	7/11/2009	multi-level well (FLUTe™)	258	BR - pTbr	30	576.05	575.92	175	401	205	371	--	--	--	--	--	3.8	
	MW-64-260	7616939.75	2100520.18	7/11/2009	multi-level well (FLUTe™)	258	BR - pTbr	28	576	576	230	346	260	316	--	--	--	--	--	3.8	

Monitoring Zones:

PA = perched aquifer (unsaturated zone). Approximately 1-foot of water present in MW-58-065 screen

SA = shallow interval of Alluvial Aquifer (elevation 455 to 425' MSL)

BR = bedrock formations: including Miocene Conglomerate (Tmc) and pre-Tertiary metadiorite bedrock (pTbr).

Elevations are NAVD 88; essentially equivalent to mean sea level (MSL). Ground surface elevations rounded to 0.0 foot; screen depths rounded to whole-foot.

* denotes temporary well screen initially installed in total-drilled bedrock interval for characterization logging.
The initial long-screened characterization intervals were subsequently re-completed as multilevel monitoring wells (MLW) using the Flexible Liner Underground Technologies™ [FLUTe™] system.
The characterization "wells" (MW-58BR_S, MW-58BR_D, MW-62BR, and MW-64BR) have x-y coordinates identical to the depth-discrete MLWs, and <u>no longer exist</u> for groundwater monitoring.

TABLE A-2

Summary of Lithology Encountered During ERGI

Summary of Findings Associated with the East Ravine Groundwater Investigation

PG&E Topock Compressor Station, Needles, California

Site ID	Monitoring Wells Completed	Approximate Depth to Groundwater (ft bgs)	Total Boring Depth (ft bgs)	Start Depth (ft bgs)	End Depth (ft bgs)	Summary of Lithologic Description
A	**MW-58-065 MW-58-115 MW-58-205**	66	206	0	60	**Unconsolidated alluvium:** silt with sand and silty gravel, silty sand with gravel, and poorly graded sand with gravel.
				60	65.5	Highly weathered **metadiorite bedrock** becoming more competent toward the bottom of the interval.
				65.5	206	Competent pre-tertiary **metadiorite bedrock** (metadiorite);dusky yellowish green with intermediate (dioritic) mineralogy, and a medium grained, strong, unweathered, and massive to foliated rock mass.
B	**MW-57-050 MW-57-070 MW-57-185**	52	192	0	46	**Unconsolidated alluvium:** sandy silt with gravel and silty gravel.
				46	144.5	Competent Miocene **conglomerate bedrock** (conglomerate); yellowish red, fine- to coarse-grained, medium strong, unweathered, matrix supported and massive.
				144.5	153	Completely weathered **conglomerate bedrock** similar to that from 46 to 144.5 feet bgs, but cement has been largely replaced or removed. The conglomerate is medium strong; however, the matrix rapidly dissolved when exposed to water.
				153	154.5	**Metaconglomerate:** dark yellowish-orange, strong, and unweathered. The matrix composed of moderate reaction to hydrochloric acid (HCl) solution minerals; however, the relict conglomerate structure was still apparent.
				154.5	155.5	**Altered metadiorite bedrock:** yellowish-brown with largely felsic mineralogy; medium-grained, strong, and unweathered. No reaction to HCl solution. Portions of this interval exhibited a mylonitic texture, inferred to be associated with displacement along a portion of the Chemehuevi detachment fault.
				155.5	192	**Metadiorite bedrock:** dusky yellowish-green, with an intermediate (dioritic) mineralogy and fine- to medium-grained, strong, unweathered, and massive to foliated rock mass.
C	**MW-61-110**	87	112.5	0	63	**Unconsolidated alluvium:** poorly graded silty sand with gravel and poorly graded sand with silt and gravel.
				63	112.5	**Metadiorite bedrock:** dusky yellowish-green, hard to very hard, with intermediate (dioritic) mineralogy and fine-grained, unweathered, and massive to foliated rock mass.

TABLE A-2
Summary of Lithology Encountered During ERGI
Summary of Findings Associated with the East Ravine Groundwater Investigation
PG&E Topock Compressor Station, Needles, California

Site ID	Monitoring Wells Completed	Approximate Depth to Groundwater (ft bgs)	Total Boring Depth (ft bgs)	Start Depth (ft bgs)	End Depth (ft bgs)	Summary of Lithologic Description
C-Alt	**MW-64-150** **MW-64-205** **MW-64-260**	120	260.5	0	260.5	**Metadiorite bedrock**; grayish olive, intermediate (dioritic) mineralogy, with a strong, unweathered to slightly weathered, massive to foliated rock mass.
E	**MW-62-065** **MW-62-110** **MW-62-190**	47	191.5	0	4.5	**Unconsolidated alluvium:** silty sand.
				4.5	191.5	**Conglomerate bedrock:** reddish-brown, strong, unweathered, and massive, with a fine-grained matrix and coarse sand to gravel-sized clasts of no dominant mineralogy.
E-Alt2	**MW-63-065**	49	66	49	66	**Conglomerate bedrock** was observed from ground surface. Bedrock moderate brown, matrix supported, and friable, with a moderately to completely weathered rock mass and clasts as large as 4 centimeters.
F	**MW-60-125**	98	123	0	9	**Unconsolidated alluvium:** dark yellowish-brown silty sand.
				9	123	**Metadiorite bedrock:** grayish-green to dusky green with intermediate (dioritic) mineralogy with a medium-grained, unweathered, and massive to foliated rock mass.
G	**MW-59-100**	84	101	0	82	**Unconsolidated alluvium:** brown to yellowish-brown silty sand.
				82	101	**Unconsolidated alluvium:** dark grayish-brown and dark reddish-brown gravelly sand with appearance of completely weather conglomerate bedrock.
MW-23	**MW-23-060** **MW-23-080**	48	80	NA	NA	**Conglomerate bedrock**.

TABLE A-3

Summary of Borehole Flow Characterization Results

Summary of Findings Associated with the East Ravine Groundwater Investigation

PG&E Topock Compressor Station

		Ambient Flow Testing			**Induced Flow Testing**						**Depth-Specific GW Screening**	
					Method							
Site ID	**Borehole Tested**	**No. of Flow Zones Identified**	**Estimated Flow Rate from Entire Borehole** (GPM)	**Estimated Interval-Specific Flow** (GPM)	**Test Type**	**Avg. Flow Rate** (GPM)	**Approximate Drawdown** (FT)	**No. of Flow Zones Identified**	**Estimated Flow Rate from Entire Borehole** (GPM)	**Estimated Interval-Specific Flow Rates** (GPM)	**No. of Samples Collected**	**Range of Cr(VI) Concentrations Detected** [a] (µg/L)
A	MR-58BR_D	1	0.004	0.004	Slug Removal	--	6.8	7	0.5	0.003 - 0.27	5	ND (<1) - 83
B	MW-57BR	2	0.008	0.003 - 0.005	Constant-rate Pumping	2.1	10.3	2	2.1	0.03 - 2.1	6	13 - 36
C-Alt	MW-64BR	0	<0.001	--	Slug Removal	--	17	0	0.008	--	0	--
E	MW-62BR	1	0.01	0.01	Constant-rate Pumping	1.3	23	6	1.3	0.04 - 0.56	7	ND (<1) - 1,200

Note:

[a] Cr(VI) concentration ranges are from certified laboratory analysis of samples collected during borehole flow characterization testing. Samples collected following well development or other screening-level sample events are not included.

TABLE A-4

Groundwater Analytical Results for New ERGI Monitoring Wells, Chromium, Selenium, Molybdenum, Nitrate and Field Water Quality Parameter
Summary of Findings Associated with the East Ravine Groundwater Investigation
PG&E Topock Compressor Station

		Lab Data					Field Data						
Location	**Sample Date**	**Dissolved Chromium (µg/L)**	**Hexavalent Chromium (µg/L)**	**Selenium (µg/L)**	**Molydenum (µg/L)**	**Nitrate as Nitrogen (mg/L)**	**Specific Conductance (µS/cm)**	**Temperature (°C)**	**pH (pH units)**	**ORP (mV)**	**Dissolved Oxygen (mg/L)**	**Salinity (%)**	**Turbidity (NTU)**
MW-23-060	7/21/2009	30.0	26.0	2.70	50.0	3.90	16,400	31.3	8.43	146	4.41	0.106	30.0
MW-23-080	7/21/2009	44.0	34.0	0.82	95.0	6.30	16,900	32.7	11.0	87.9	4.99	0.109	5.00
MW-57-070	2/11/2009	720	660	ND (10)	13.0	8.00	2,910	28.2	7.30	-93.6	2.55	1.51	---
	7/21/2009	350	340	4.40	22.0	9.10	3,140	31.9	6.60	287	1.13	0.203	13.0
MW-57BR	*3/1/2009*	*14 - 35 [1]*	*13 - 36 [1]*	---	---	---	---	---	---	---	---	---	---
MW-57-185	7/20/2009	ND (4.9)	1.40	ND (2.5) J	99.0	ND (2.5)	18,300	29.7	8.19	194	0.20	0.118	2.00
MW-58BR_S	*3/5/2009*	*180 - 240 [1]*	*180 - 230 [1]*	---	---	---	---	---	---	---	---	---	---
MW-58BR_D	*5/6-8/2009*	*5.1 - 91 [1]*	*ND (1.0) - 83 [1]*	---	---	---	---	---	---	---	---	---	---
MW-58-115	7/22/2009	3.00	ND (1.0)	ND (0.5)	62.0	ND (2.5)	6,590	30.5	6.78	-319	0.27	0.37	4.10
MW-58-205	7/22/2009	6.30	ND (1.0)	ND (0.5)	51.0	ND (2.5)	16,300	29.4	7.38	-337	0.00	0.89	1.50
MW-59-100	3/18/2009	4800	4300	ND (10)	38.0	4.20	25,600	30.6	7.16	46.0	2.70	1.58	4.40
	7/22/2009	4900	5100	5.10	38.0	4.40	10,800	30.8	6.92	90.1	4.51	6.04	27.0
	7/22/2009 FD	4800	5100	ND (0.5)	39.0	4.50	---	---	---	---	---	---	---
MW-60-125	3/20/2009	840	810	ND (10)	25.0	4.40	15,500	32.6	7.44	99.0	3.46	0.88	9.20
	7/21/2009	810	780	4.20	45.0	3.30	8,200	32.5	7.24	70.6	1.01	0.53	22.0
MW-61-110	3/23/2009	670	620	ND (10)	38.0	ND (2.5)	20,000	29.9	7.52	-119	0.02	1.20	3.50
	7/21/2009	260	240	ND (0.5)	60.0	ND (2.5)	15,100	33.4	7.27	-9.6	0.23	0.0979	7.00
MW-62-065	3/27/2009	740	720	ND (10)	23.0	4.80	7,410	30.1	7.40	148	3.36	0.40	3.80
	7/22/2009	300	290	2.70	28.0	2.90	5,810	34.0	7.31	51.8	1.10	0.376	8.00
MW-62BR	*5/7-8/2009*	*3.7 - 1300 [1]*	*ND (1.0) - 1200 [1]*	---	---	---	---	---	---	---	---	---	---
MW-62-110	7/22/2009	71.0	74.0	1.40	110	ND (1.0)	8,950	29.4	8.09	-94	0.00	0.50	2.20
MW-62-190	7/22/2009	2.00	ND (1.0)	ND (0.5)	100	ND (2.5)	28,800	29.5	7.71	-305	0.14	1.80	2.00
MW-63-065	4/15/2009	2.30	ND (0.2)	ND (10)	41.0	ND (1.0)	10,900	27.1	7.08	12.0	1.27	0.61	7.10
	7/20/2009	ND (2.9)	0.54	ND (0.5)	50.0	ND (1.0)	6,650	28.2	6.49	308	0.70	0.43	21.0
	7/20/2009 FD	ND (3.0)	0.54	ND (0.5)	49.0	ND (1.0)	---	---	---	---	---	---	---
MW-64BR	*5/28/2009*	*120 - 160 [1]*	*82 - 110 [1]*	---	---	---	---	---	---	---	---	---	---
MW-64-150	7/22/2009	5.20	ND (1.0)	ND (0.5)	110	ND (1.0)	8,860	30.0	7.37	-30	0.00 R	0.49	2.10
MW-64-205	7/22/2009	17.0	5.70	ND (0.5)	93.0	ND (2.5)	14,800	29.9	7.34	26.0	0.00 R	0.88	3.50
MW-64-260	7/22/2009	4.80	ND (1.0)	ND (0.5)	85.0	ND (1.0)	10,900	29.6	7.33	29.0	0.00 R	0.60	3.10

TABLE A-4

Groundwater Analytical Results for New ERGI Monitoring Wells, Chromium, Selenium, Molybdenum, Nitrate and Field Water Quality Parameter
Summary of Findings Associated with the East Ravine Groundwater Investigation
PG&E Topock Compressor Station

NOTES:

µg/L	micrograms per liter
µS/cm	microSiemens per centimeter
°C	degree centigrade
ORP	oxidation reduction potential, results rounded off to whole point
mV	millivolts
mg/L	milligrams per liter
%	percentage
NTU	Nephelometric Turbidity Unit
ND	not detected at listed reporting limit
FD	field duplicate
---	Sample not analyzed for this parameter

[1] *ATL laboratory results from screening samples collected from open borehole prior to well construction. The range of values from multiple screening samples are shown here.*

TABLE A-5

Groundwater Analytical Results for New ERGI Monitoring Wells, General Chemistry Parameters

Summary of Findings Associated with the East Ravine Groundwater Investigation

PG&E Topock Compressor Station

		Dissolved General Metals																
Loc ID	Sample Date	Sodium (mg/L)	Potassium (mg/L)	Calcium (mg/L)	Magnesium (mg/L)	Manganese (mg/L)	Iron (mg/L)	Alkalinity, as carbonate (mg/L)	Alkalinity, bicarbonate as CaCo3 (mg/L)	Alkalinity, total as CaCO3 (mg/L)	Chloride (mg/L)	Sulfate (mg/L)	Nitrate/Nitrite as nitrogen (mg/L)	Total Dissolved Solids (mg/L)	Total Organic Carbon (mg/L)	Ammonia as nitrogen (mg/L)	Deuterium (0/00)	Oxygen 18 (0/00)
MW-23-060	21-Jul-09	2700	100	830	49.0	ND (0.01)	ND (0.04)	ND (5.0)	28.0	28.0	5500	540	3.90	11000	1.60	ND (0.1)	-75.3	-8.96
MW-23-080	21-Jul-09	2900	94.0	900	0.19	ND (0.01)	ND (0.04)	25.0	ND (5.0)	140	5400	650	6.30	11000	1.70	ND (0.1)	-73.4	-8.67
MW-57-070	11-Feb-09	110	11.0	340	24.0	0.031	ND (0.5)	ND (5.0) J	81.0	81.0	710	130 J	8.00	1700	1.60	ND (0.1)	-64.5	-8.58
MW-57-070	21-Jul-09	110	12.0	420	28.0	0.086	ND (0.04)	ND (5.0) J	75.0	75.0	840	100	9.10	2000	1.30	ND (0.1)	-65.9	-9.29
MW-57-185	20-Jul-09	3600	66.0	330	3.30	1.10	ND (0.04)	6.30	20.0	26.0	6100	680	ND (2.5)	11000	0.57	ND (0.1)	-79.1	-10.3
MW-58-115	22-Jul-09	1700	47.0	610	33.0	2.50	0.13	ND (5.0) J	43.0	43.0	4000	550	ND (2.5)	7800	17.0 J	ND (0.1)	-77.5	-10.4
MW-58-205	22-Jul-09	1100	33.0	470	25.0	0.31	0.057	ND (5.0)	45.0	45.0	2800	490	ND (2.5)	5700	18.0 J	ND (0.1)	-76.9	-10.5
MW-59-100	18-Mar-09	1500	46.0	870	31.0	2.40	ND (1.0)	ND (5.0)	110	110	3300 J	760 J	4.20	7800	3.40	ND (0.5)	-62.4	-7.84
MW-59-100	22-Jul-09	1300	55.0	830	26.0	0.29	ND (0.04)	ND (5.0)	110	110	3500	750	4.40	7500	ND (0.6) J	ND (0.1)	-63	-8.4
MW-59-100	22-Jul-09 FD	1300	51.0	820	25.0	0.29	ND (0.04)	ND (5.0)	110	110	3500	750	4.50	7500	0.80 J	ND (0.1)	-62.4	-7.79
MW-60-125	20-Mar-09	1500 J	39.0	450 J	29.0	0.12	ND (0.5)	ND (5.0)	58.0	58.0	2500	450 J	4.40	5400	1.20	ND (0.5)	-70.5	-9.28
MW-60-125	21-Jul-09	1100	41.0	480	29.0	0.14	ND (0.04)	ND (5.0)	77.0	77.0	2600	390	3.30	5200	0.42	ND (0.1)	-72.7	-9.51
MW-61-110	23-Mar-09	2800	58.0	510	22.0	0.70	ND (1.0)	ND (5.0) J	52.0	52.0	4700	620 J	ND (2.5)	9100	3.30	ND (0.5)	-75.7	-9.86
MW-61-110	21-Jul-09	2700	73.0	630	23.0	0.82	ND (0.04)	ND (5.0)	51.0	51.0	5200	640	ND (2.5)	9600	1.90	0.15	-76.5	-10
MW-62-065	27-Mar-09	1400	29.0	200	24.0	0.037	ND (0.5)	ND (5.0) J	110	110	1900	400	4.80	3800	2.70	ND (0.5)	-67	-8.91
MW-62-065	22-Jul-09	860	36.0	200	25.0	0.062	ND (0.04)	ND (5.0)	120	120	1600	360	2.90	3600	0.95 J	0.12	-70.6	-9.75
MW-62-110	22-Jul-09	1400	35.0	150	7.00	0.44	ND (0.04)	ND (5.0)	74.0	74.0	2500	450	ND (1.0)	5000	25.0 J	ND (0.1)	-70.5	-9.27
MW-62-190	22-Jul-09	3500	62.0	350	14.0	2.20	0.055	ND (5.0)	49.0	49.0	6300	690	ND (2.5)	11000	58.0 J	ND (0.1)	-79.4	-10.6
MW-63-065	15-Apr-09	1200	26.0	150	21.0	0.52	ND (0.5)	ND (5.0) J	200	200	1500	540 J	ND (1.0)	3400	6.40	ND (0.1)	---	---
MW-63-065	20-Jul-09	1200	33.0	200	21.0	0.24	ND (0.04)	ND (5.0)	210	210	1800	570	ND (1.0)	4100	0.69	ND (0.1)	-98	-12
MW-63-065	20-Jul-09 FD	1200	32.0	200	21.0	0.23	ND (0.04)	ND (5.0)	210	210	1700	560	ND (1.0)	4100	ND (1.2)	ND (0.1)	-98.3	-12.4
MW-64-150	22-Jul-09	1400	36.0	230	15.0	0.47	0.05	ND (5.0)	57.0	57.0	2600	450	ND (1.0)	5100	16.0 J	0.20	-78.2	-10.2
MW-64-205	22-Jul-09	2100	47.0	330	15.0	0.27	ND (0.04)	ND (5.0)	54.0	54.0	4500	580	ND (2.5)	8000	19.0 J	0.14	-77.8	-9.73
MW-64-260	22-Jul-09	1600	41.0	270	17.0	0.33	0.13	ND (5.0)	66.0	66.0	3200	470	ND (1.0)	6200	25.0 J	0.18	-78.7	-9.91

NOTES:

FD	field duplicate
ND	not detected at listed reporting limit
mg/L	milligrams per liter
0/00	differences from global standard in parts per thousand
J	concentration estimated by laboratory or data validation

TABLE A-6
Slug Testing Results Summary
Summary of Findings Associated with the East Ravine Groundwater Investigation, PG&E Topock Compressor Station, Needles, California

Well Location	**Lithology Tested**	**Initial Displacement (feet)**	**Estimated Hydraulic Conductivity (feet/day)**
MW-57-070	Miocene conglomerate	4.15	0.18
MW-58BR (206-feet total depth)	Pre-tertiary metadiorite	105.7	0.012
MW-60-110	Pre-tertiary metadiorite	7.05	0.059
MW-61-125	Pre-tertiary metadiorite	6.05	1.56
MW-62-065	Miocene conglomerate	5.2	0.016
MW-64BR	Pre-tertiary metadiorite	124.2	0.0011

Figures

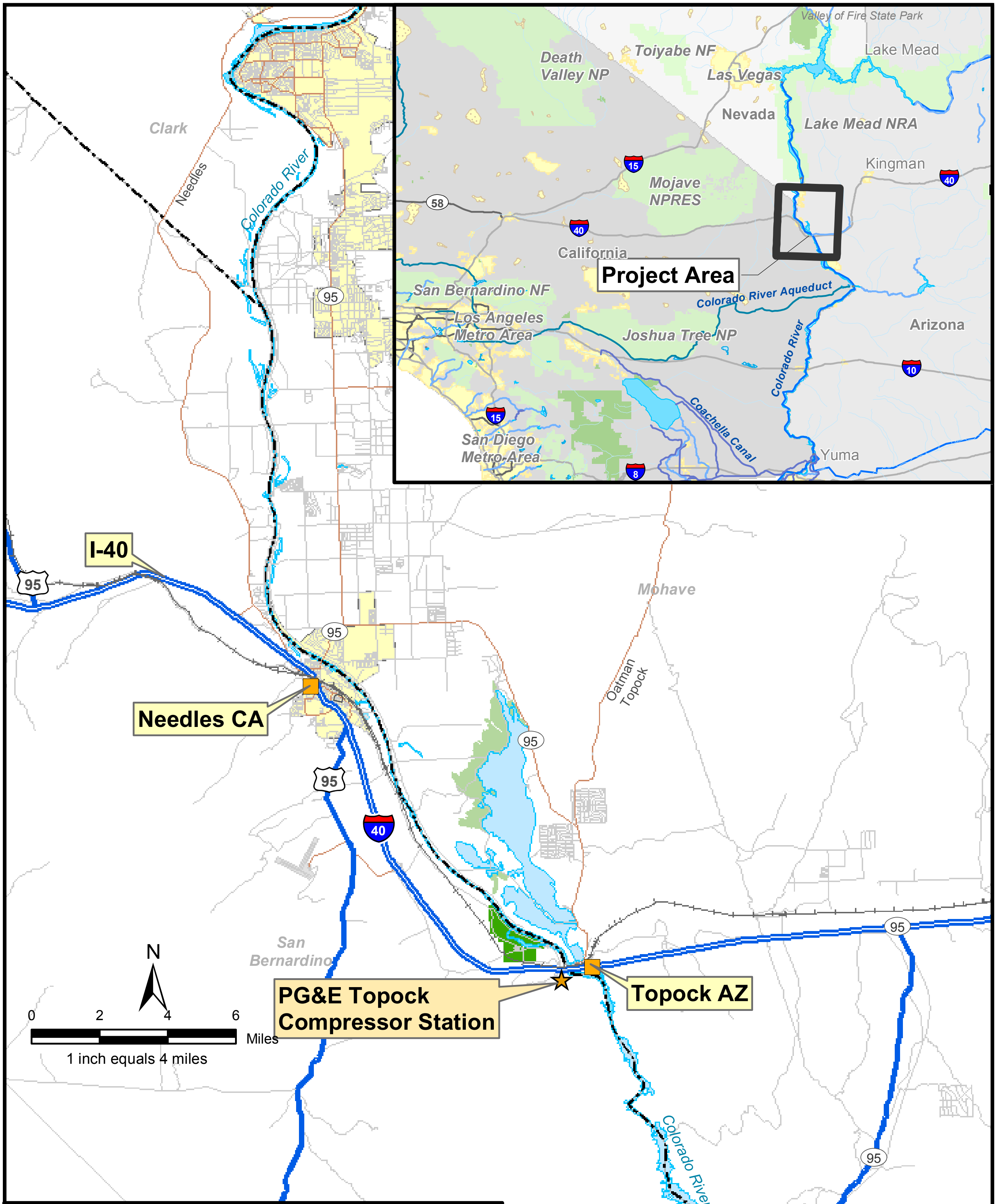

FIGURE A-1
SITE LOCATION MAP

FINAL GROUNDWATER CORRECTIVE MEASURES STUDY/
FEASIBILITY STUDY REPORT FOR SWMU 1/AOC 1 and AOC 10
PG&E TOPOCK COMPRESSOR STATION
NEEDLES, CALIFORNIA

CH2MHILL

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FIGURE A-2
LOCATION OF EAST RAVINE GROUNDWATER INVESTIGATION SITES

FINAL GROUNDWATER CORRECTIVE MEASURES STUDY/
FEASIBILITY STUDY REPORT FOR SWMU 1/AOC 1 and AOC 10
PG&E TOPOCK COMPRESSOR STATION
NEEDLES, CALIFORNIA

CH2MHILL

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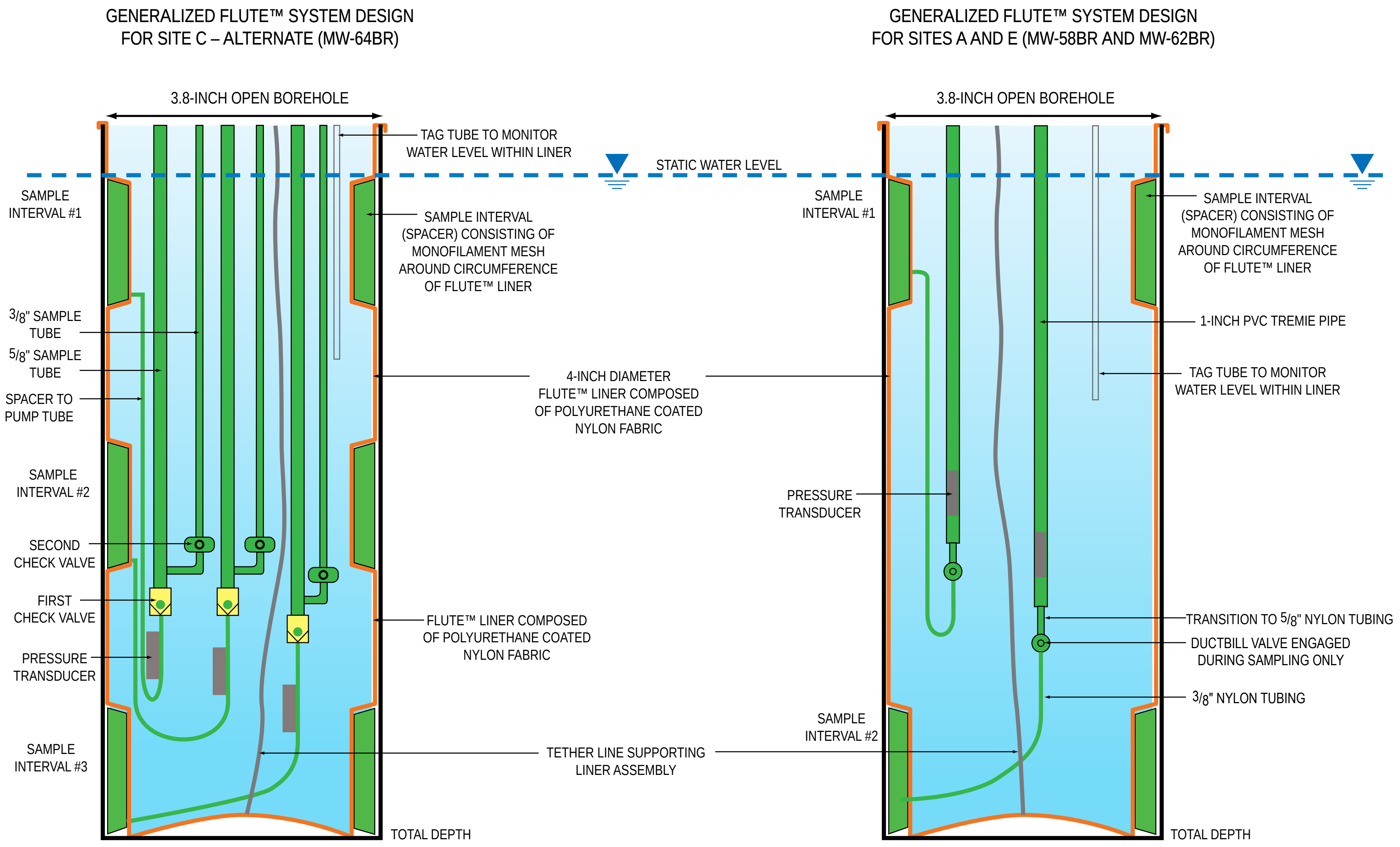


ABBREVIATIONS:
FT = FEET
BGS = BELOW GROUND SURFACE
" = INCH

NOTE: NOT TO SCALE. SEE APPENDIX A-2 FOR MORE COMPLETE WELL CONSTRUCTION INFORMATION.

FIGURE A-3
FLEXIBLE LINER UNDERGROUND TECHNOLOGIES™ (FLUTE™) MULTILEVEL MONITORING SYSTEM
FINAL GROUNDWATER CORRECTIVE MEASURES STUDY/
FEASIBILITY STUDY REPORT FOR SWMU 1/AOC 1 and AOC 10
PG&E TOPOCK COMPRESSOR STATION
NEEDLES, CALIFORNIA

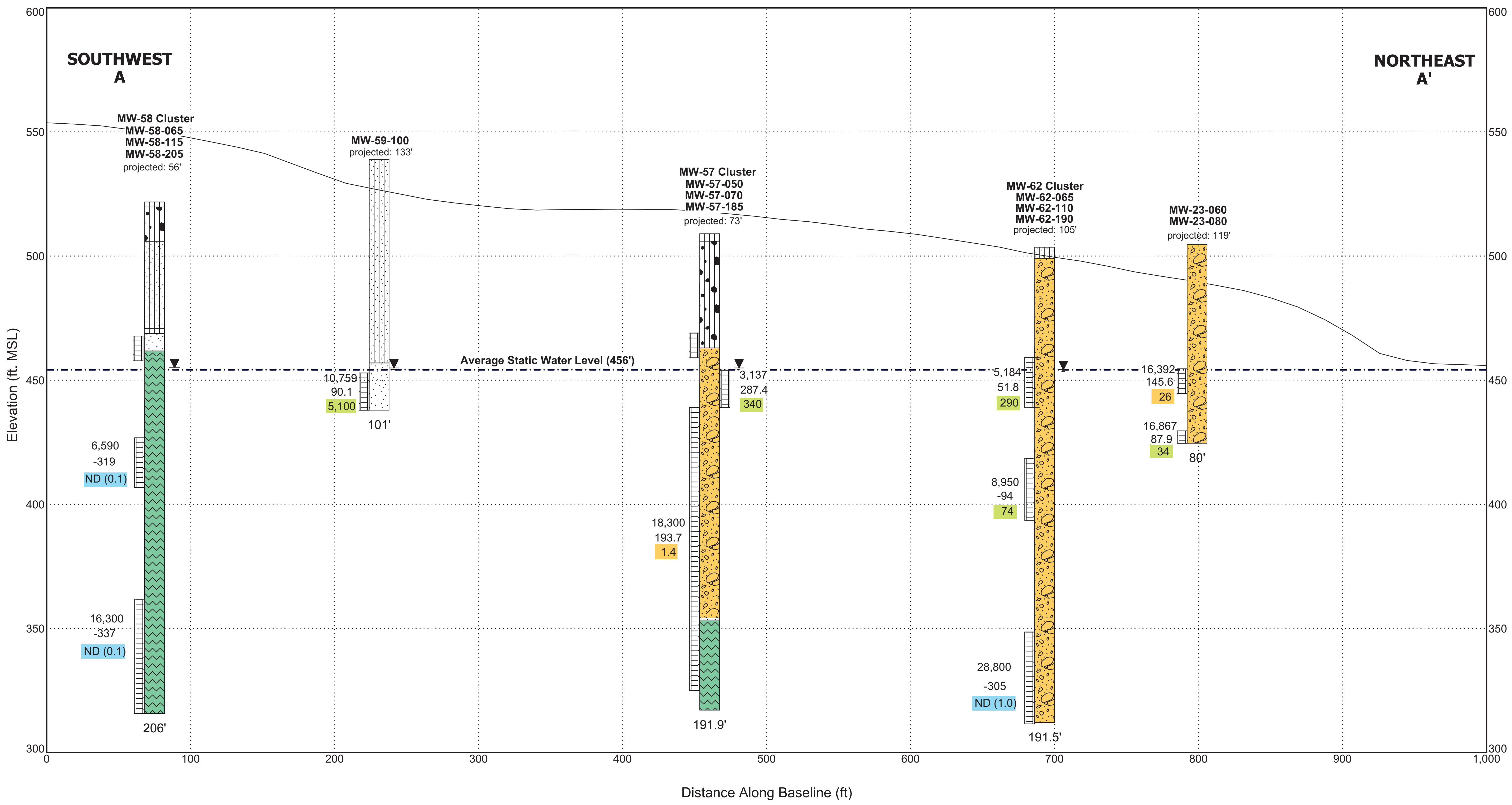
CH2MHILL

FIGURE A-4
LOCATION OF HYDROGEOLOGIC CROSS-SECTIONS

FINAL GROUNDWATER CORRECTIVE MEASURES STUDY/
FEASIBILITY STUDY REPORT FOR SWMU 1/AOC 1 and AOC 10
PG&E TOPOCK COMPRESSOR STATION
NEEDLES, CALIFORNIA

CH2MHILL

\\ZINFANDEL\PROJ\PACIFICGASELECTRICCO\TOPOCKPROGRAM\GIS\MAPFILES\2009\ERGI\ERGI_XSECTION.MXD PJOYCE1 7/30/2009 15:07:31

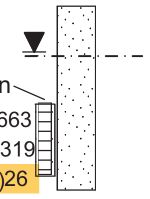


Cr(IV) Concentrations

🟦 Not detected at analytical reporting limit

🟧 Concentrations between reporting limit and 32 ug/L

🟩 Concentrations > 32 ug/L



average water level
well screen
Conductivity (uS/cm) 663
Oxidation Reduction Potential - ORP (mV) -319
Hexavalent Chromium - Cr(IV) Concentration (ug/L) 26
boring depth (feet bgs) 103'

Project Number: 382653.FP.04.FW

LITHOLOGY GRAPHICS Bedrock Formations

▥ Silt
▥ Silty Gravel
▨ Conglomerate
▥ Silty Sand
▨ Metadiorite
▨ Poorly Graded Sand

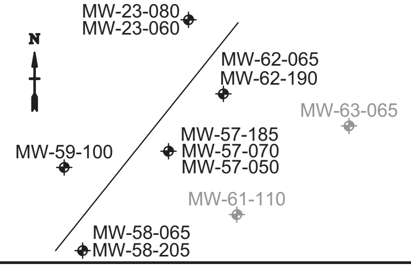
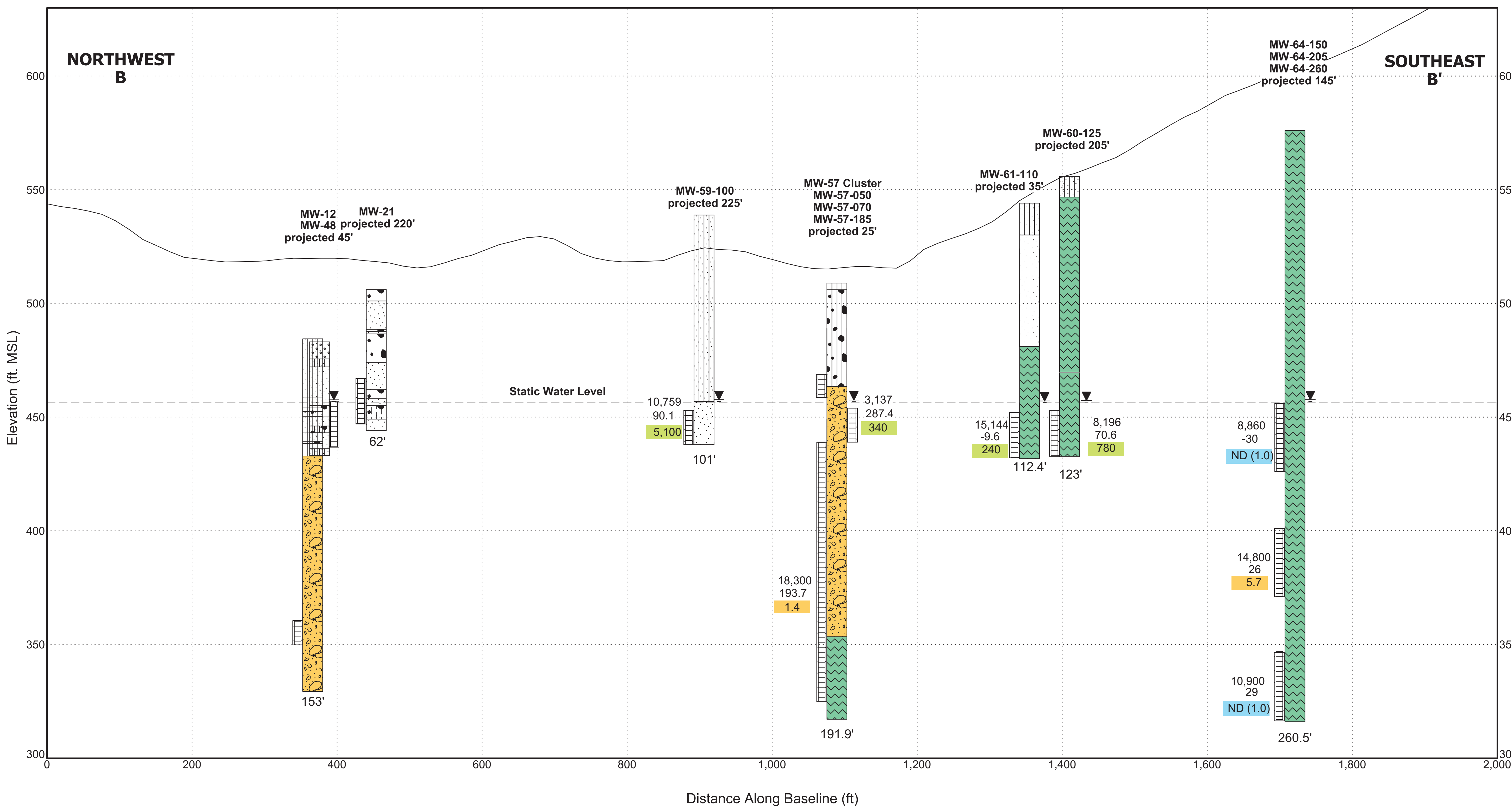


FIGURE A-5
HEXAVALENT CHROMIUM DISTRIBUTION HYDROGEOLOGIC SECTION A-A'

FINAL GROUNDWATER CORRECTIVE MEASURES
STUDY/FEASIBILITY STUDY REPORT FOR SWMU
1/AOC 1 and AOC 10
PG&E TOPOCK COMPRESSOR STATION
NEEDLES, CALIFORNIA

CH2MHILL

11X17STICKLOG_ERGI GEOTECH_ERGI_PROJECT.GPJ CH2M GEOTECH-REVISED.GDT 8/21/09



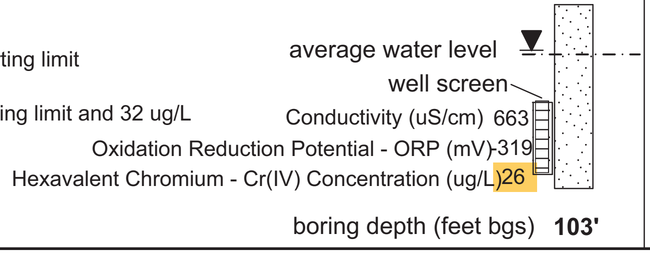
11X17STICKLOG_ERGI_GEOTECH_ERGI_PROJECT.GPJ CH2M GEOTECH-REVISED.GDT 6/24/09

Cr(IV) Concentrations

🟦 Not detected at analytical reporting limit

🟧 Concentrations between reporting limit and 32 ug/L

🟩 Concentrations > 32 ug/L



Project Number: 382653.FP.04.FW

LITHOLOGY GRAPHICS

- ▥ Silty Sand
- ▨ Poorly Graded Gravel with Silt
- ▨ Poorly Graded Gravel
- ▨ Well-Graded Sand
- ▨ Poorly Graded Sand
- ▥ Silt
- ▥ Silty Gravel

Bedrock Formations

- 🟩 Metadiorite
- 🟧 Conglomerate

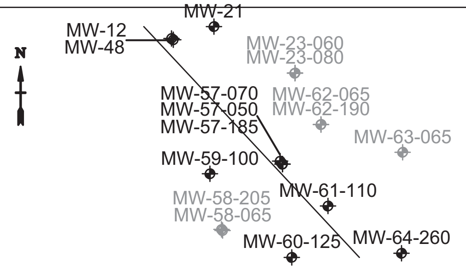


FIGURE A-6
HEXAVALENT CHROMIUM DISTRIBUTION HYDROGEOLOGIC SECTION B-B'

FINAL GROUNDWATER CORRECTIVE MEASURES
STUDY/ FEASIBILITY STUDY REPORT FOR SWMU
1/AOC 1 AND AOC 10
PG&E TOPOCK COMPRESSOR STATION
NEEDLES, CALIFORNIA

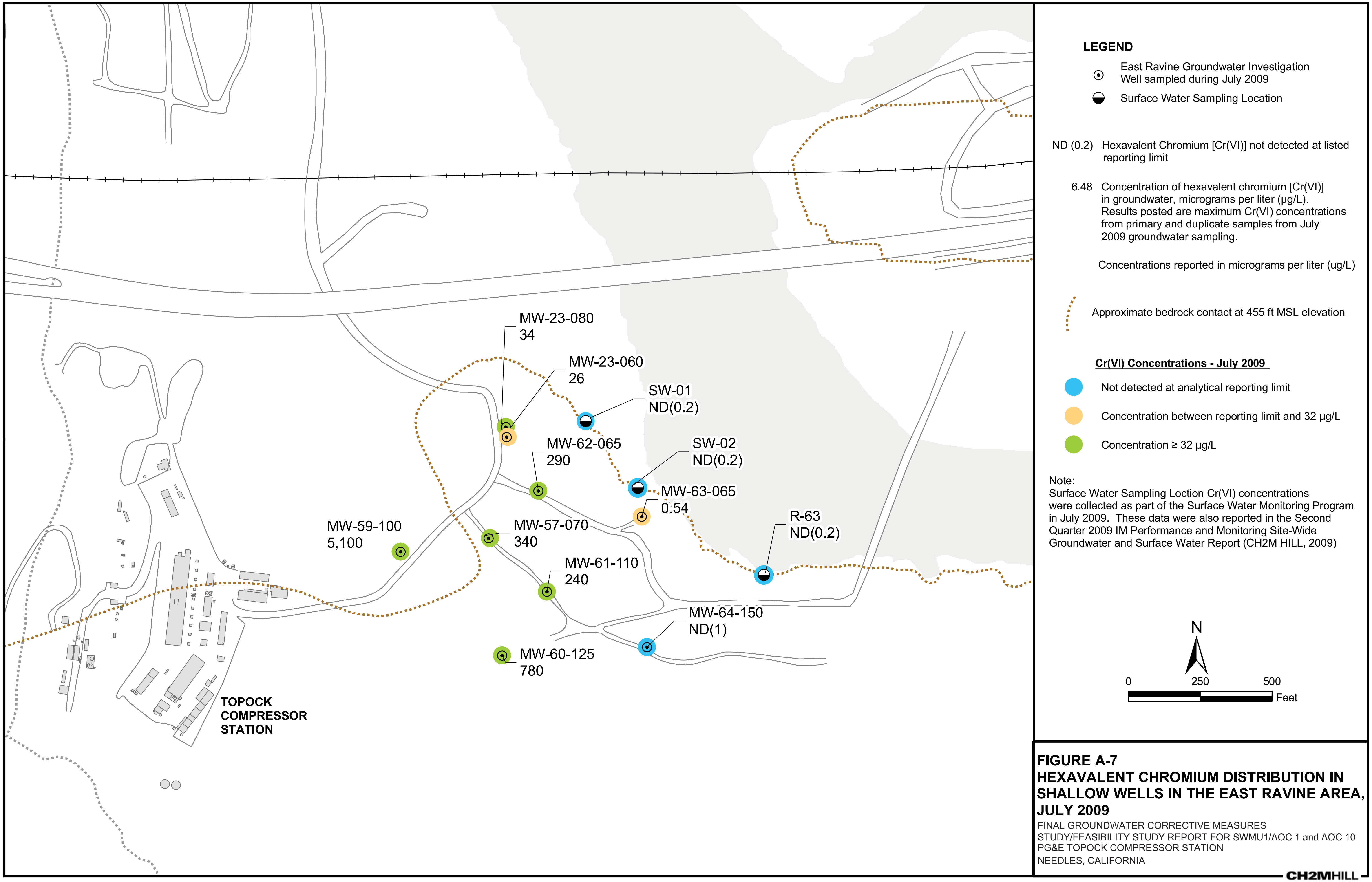


FIGURE A-7
HEXAVALENT CHROMIUM DISTRIBUTION IN SHALLOW WELLS IN THE EAST RAVINE AREA, JULY 2009

FINAL GROUNDWATER CORRECTIVE MEASURES
STUDY/FEASIBILITY STUDY REPORT FOR SWMU1/AOC 1 and AOC 10
PG&E TOPOCK COMPRESSOR STATION
NEEDLES, CALIFORNIA

CH2MHILL

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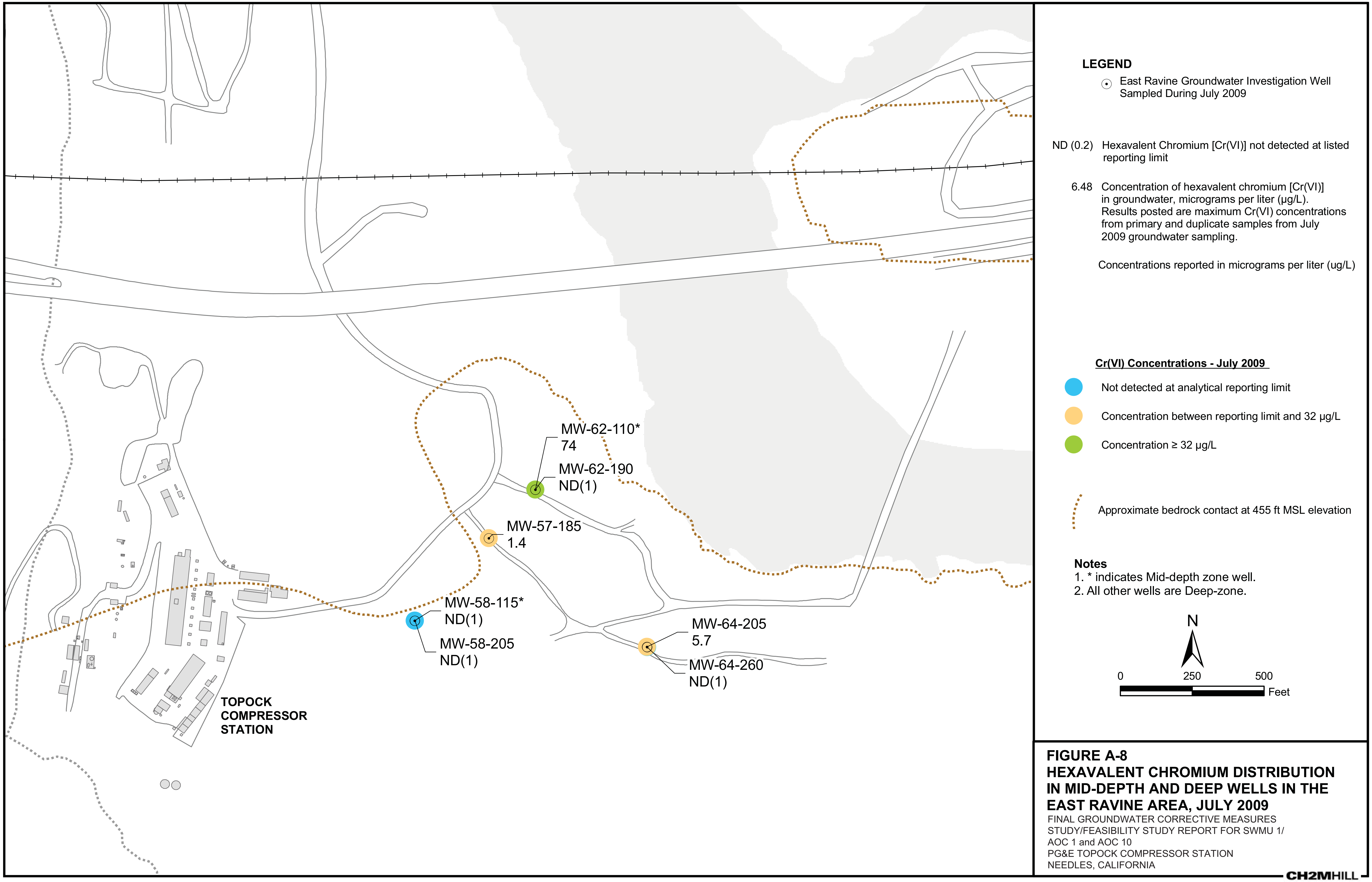


FIGURE A-8
HEXAVALENT CHROMIUM DISTRIBUTION IN MID-DEPTH AND DEEP WELLS IN THE EAST RAVINE AREA, JULY 2009

FINAL GROUNDWATER CORRECTIVE MEASURES
STUDY/FEASIBILITY STUDY REPORT FOR SWMU 1/
AOC 1 and AOC 10
PG&E TOPOCK COMPRESSOR STATION
NEEDLES, CALIFORNIA

CH2MHILL

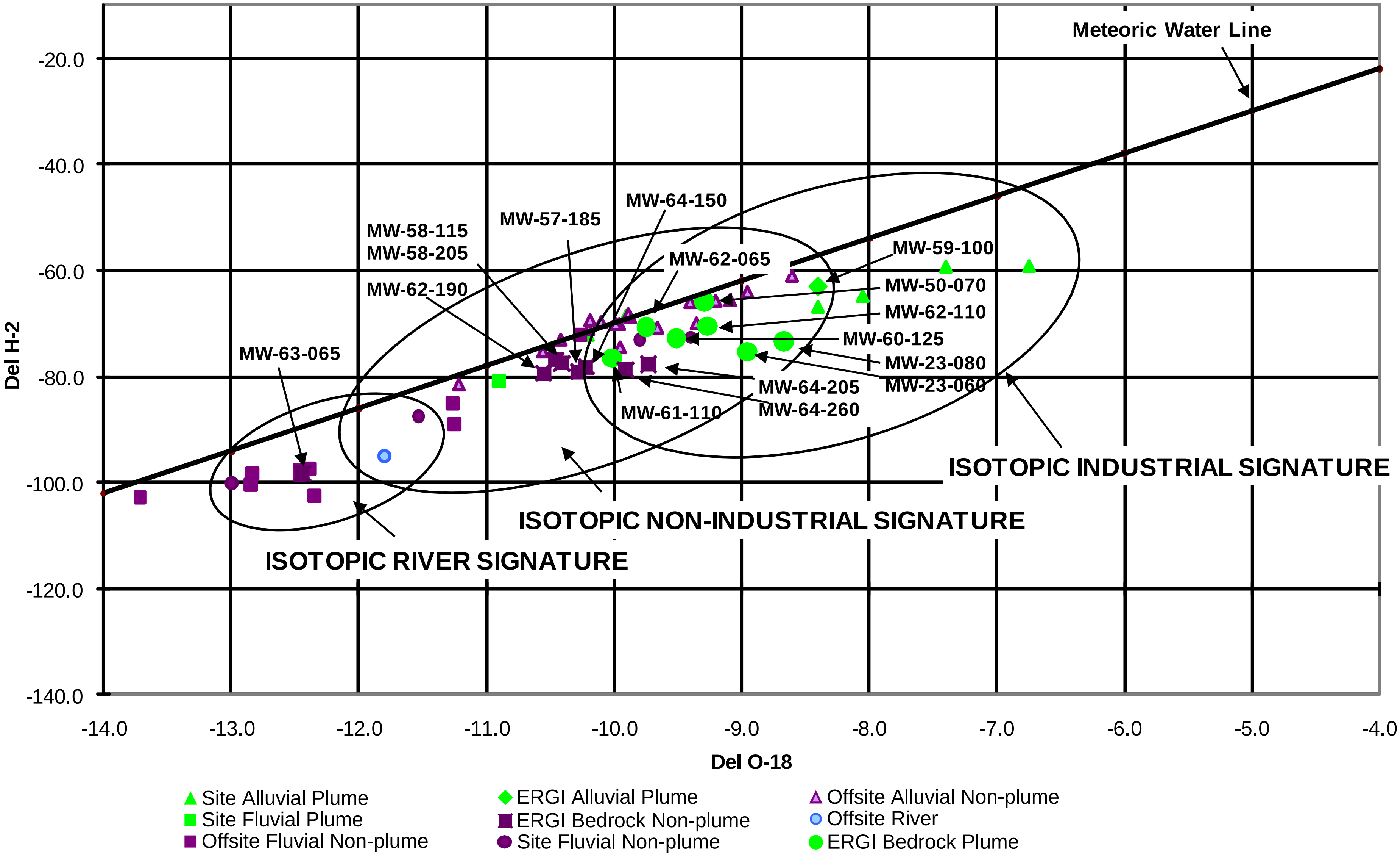


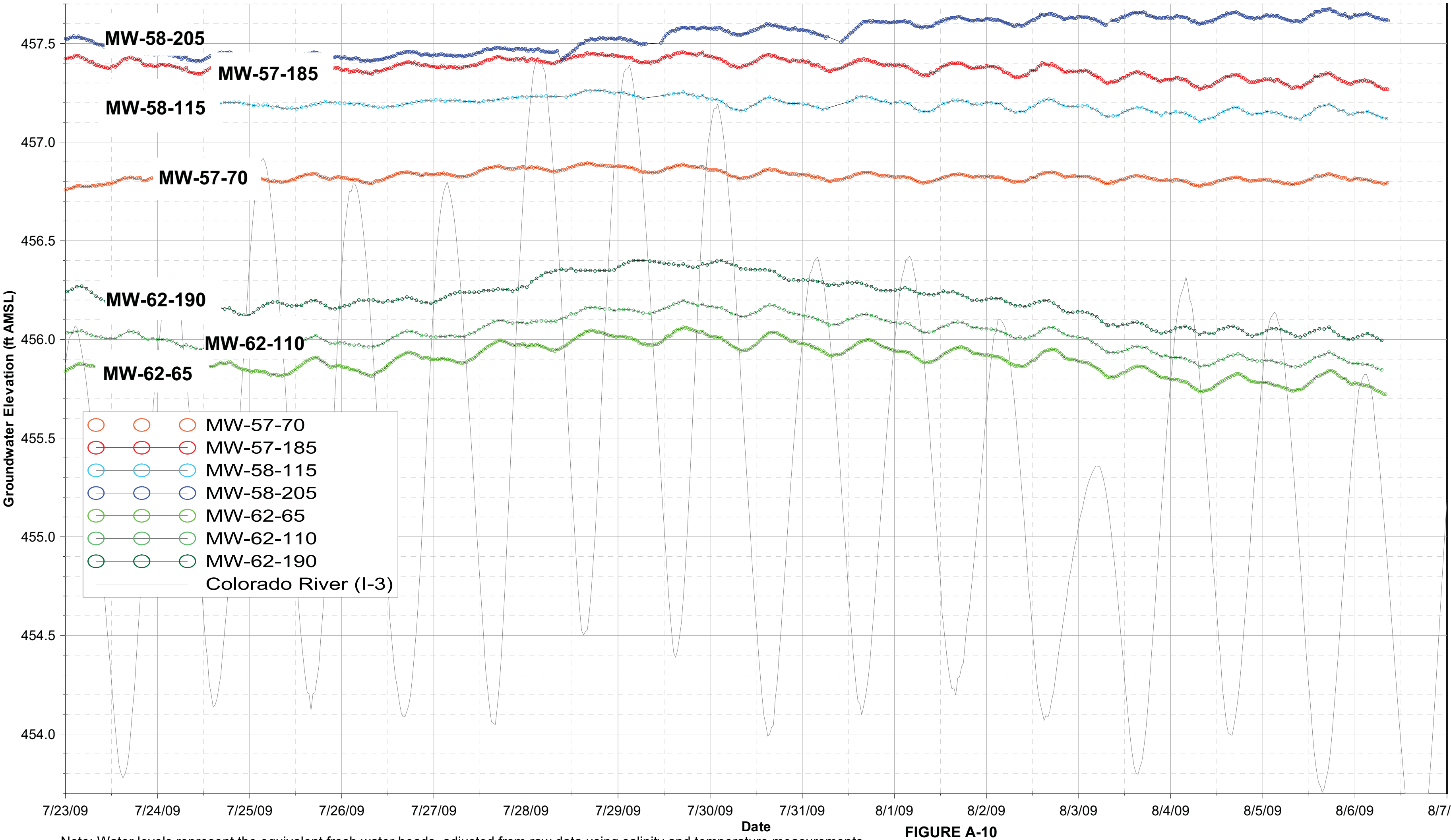
FIGURE A-9
STABLE ISOTOPES OF OXYGEN AND DEUTERIUM

FINAL GROUNDWATER CORRECTIVE MEASURES STUDY/FEASIBILITY STUDY
REPORT FOR SWMU 1/AOC 1 and AOC 10
PG&E TOPOCK COMPRESSOR STATION
NEEDLES, CALIFORNIA

Note: All East Ravine Groundwater Investigation (ERGI) wells are completed in bedrock except MW-59-100. Data for wells not completed during the ERGI were prevoiusly reported in the Performance Monitoring Report for Fourth Quarter 2008 and Annual Performance Evaluation using averaged data for February 2008 through January 2009 (CH2M HILL, 2009c).

CH2MHILL

ES092009003BAO_Fig_3-6_StableIsotopes_v2.ai_111109_lho

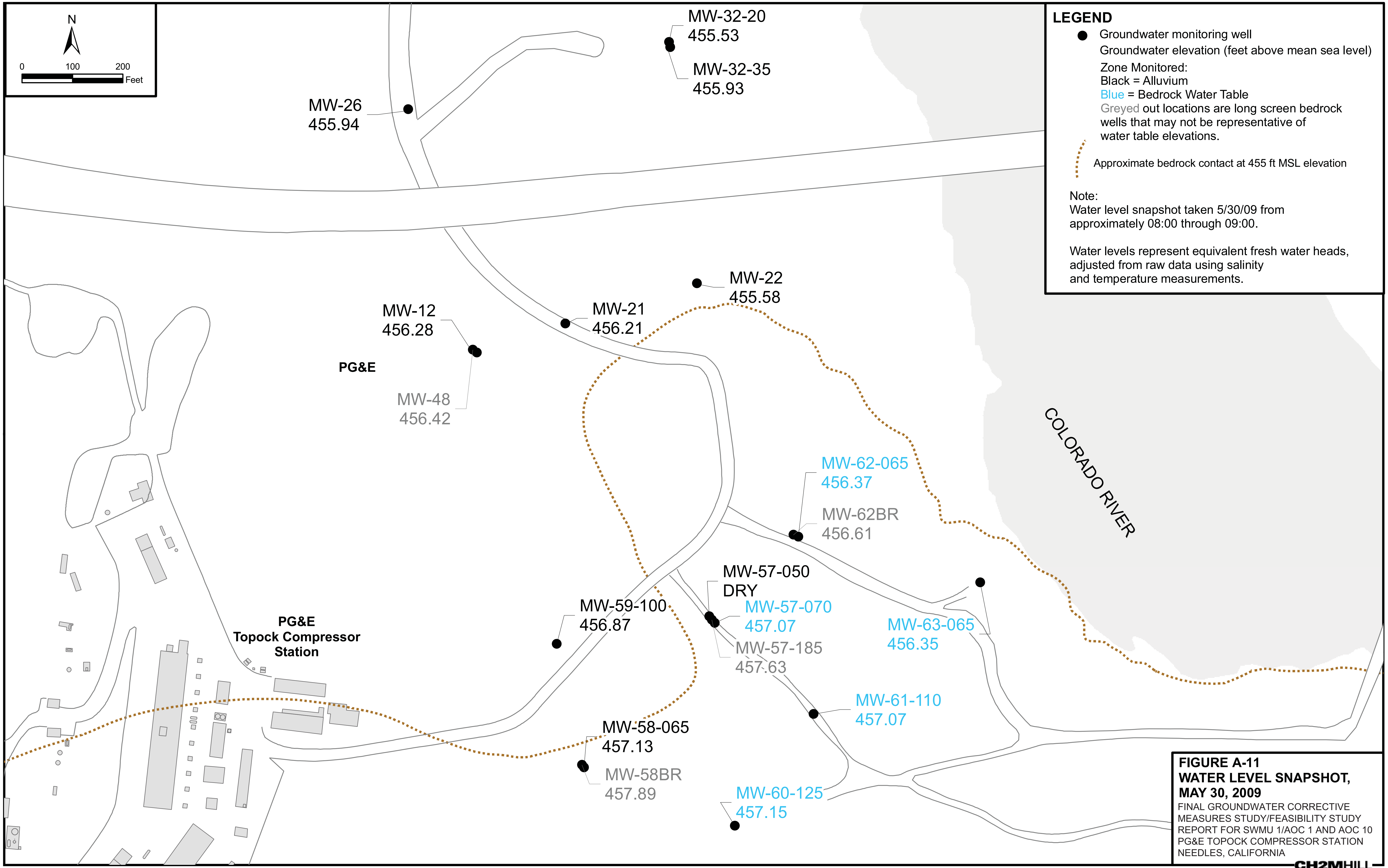


Note: Water levels represent the equivalent fresh water heads, adjusted from raw data using salinity and temperature measurements.
Data subject to review.

FIGURE A-10
MW-57, MW-58, AND MW-62 WELL CLUSTER
WATER LEVEL HYDROGRAPHS
FINAL GROUNDWATER CORRECTIVE MEASURES STUDY/FEASIBILITY STUDY
REPORT FOR SWMU 1/AOC 1 AND AOC 10
PG&E TOPOCK COMPRESSOR STATION, NEEDLES, CALIFORNIA

CH2MHILL

\\zinfandel\proj\PacificGasElectricCo\TopockProgram\Project_2009FieldActivities\ERGI\Reporting\EGRI_Report\PG&E_DRAFT\Figures\Raw_Files



LEGEND

● Groundwater monitoring well

Groundwater elevation (feet above mean sea level)

Zone Monitored:
Black = Alluvium
Blue = Bedrock Water Table
Greyed out locations are long screen bedrock
wells that may not be representative of
water table elevations.

Approximate bedrock contact at 455 ft MSL elevation

Note:
Water level snapshot taken 5/30/09 from
approximately 08:00 through 09:00.

Water levels represent equivalent fresh water heads,
adjusted from raw data using salinity
and temperature measurements.

FIGURE A-11
WATER LEVEL SNAPSHOT,
MAY 30, 2009
FINAL GROUNDWATER CORRECTIVE
MEASURES STUDY/FEASIBILITY STUDY
REPORT FOR SWMU 1/AOC 1 AND AOC 10
PG&E TOPOCK COMPRESSOR STATION
NEEDLES, CALIFORNIA

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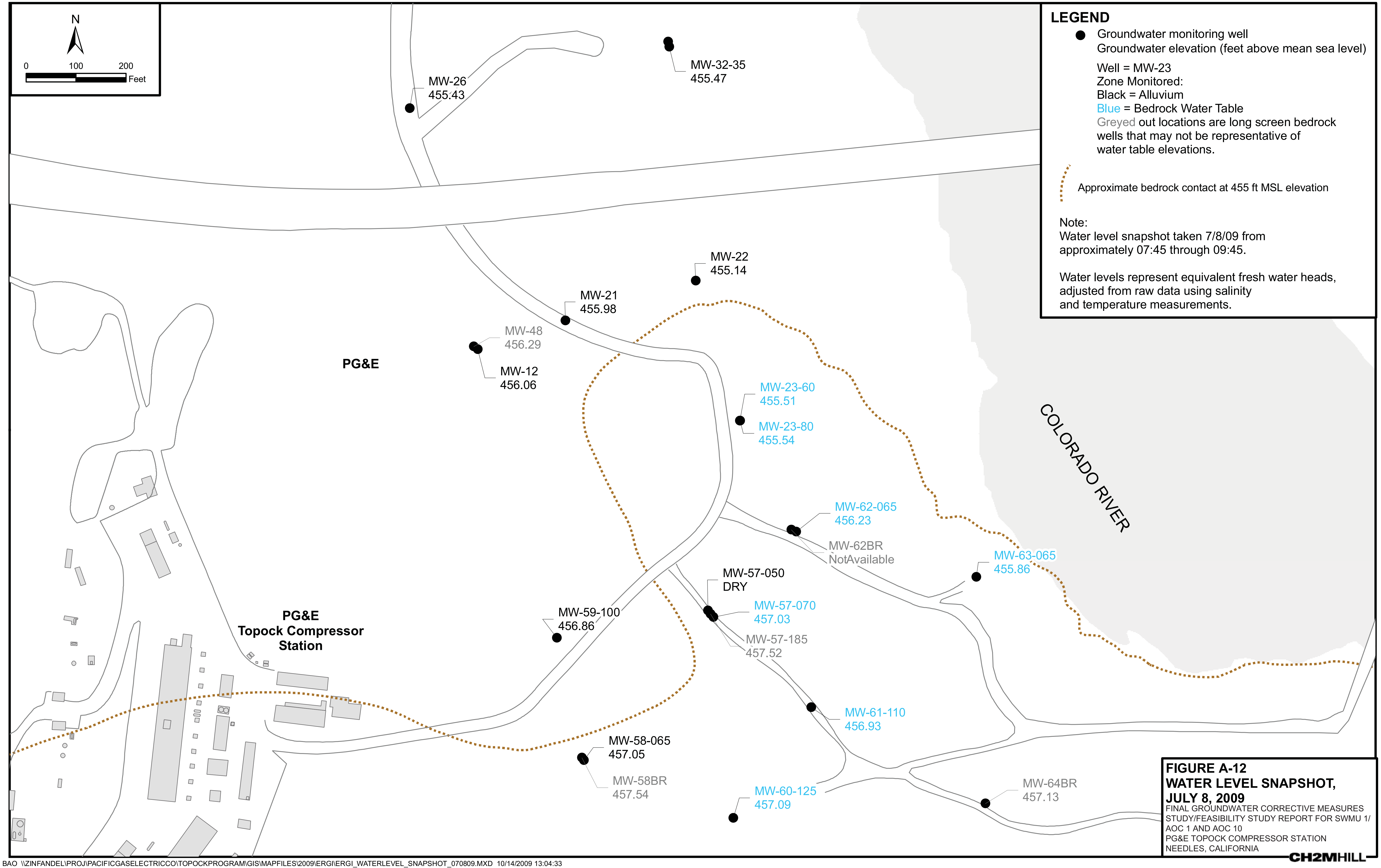

LEGEND

● Groundwater monitoring well
Groundwater elevation (feet above mean sea level)

Well = MW-23
Zone Monitored:
Black = Alluvium
Blue = Bedrock Water Table
Greyed out locations are long screen bedrock wells that may not be representative of water table elevations.

Approximate bedrock contact at 455 ft MSL elevation

Note:
Water level snapshot taken 7/8/09 from approximately 07:45 through 09:45.

Water levels represent equivalent fresh water heads, adjusted from raw data using salinity and temperature measurements.

FIGURE A-12
WATER LEVEL SNAPSHOT,
JULY 8, 2009
FINAL GROUNDWATER CORRECTIVE MEASURES
STUDY/FEASIBILITY STUDY REPORT FOR SWMU 1/
AOC 1 AND AOC 10
PG&E TOPOCK COMPRESSOR STATION
NEEDLES, CALIFORNIA

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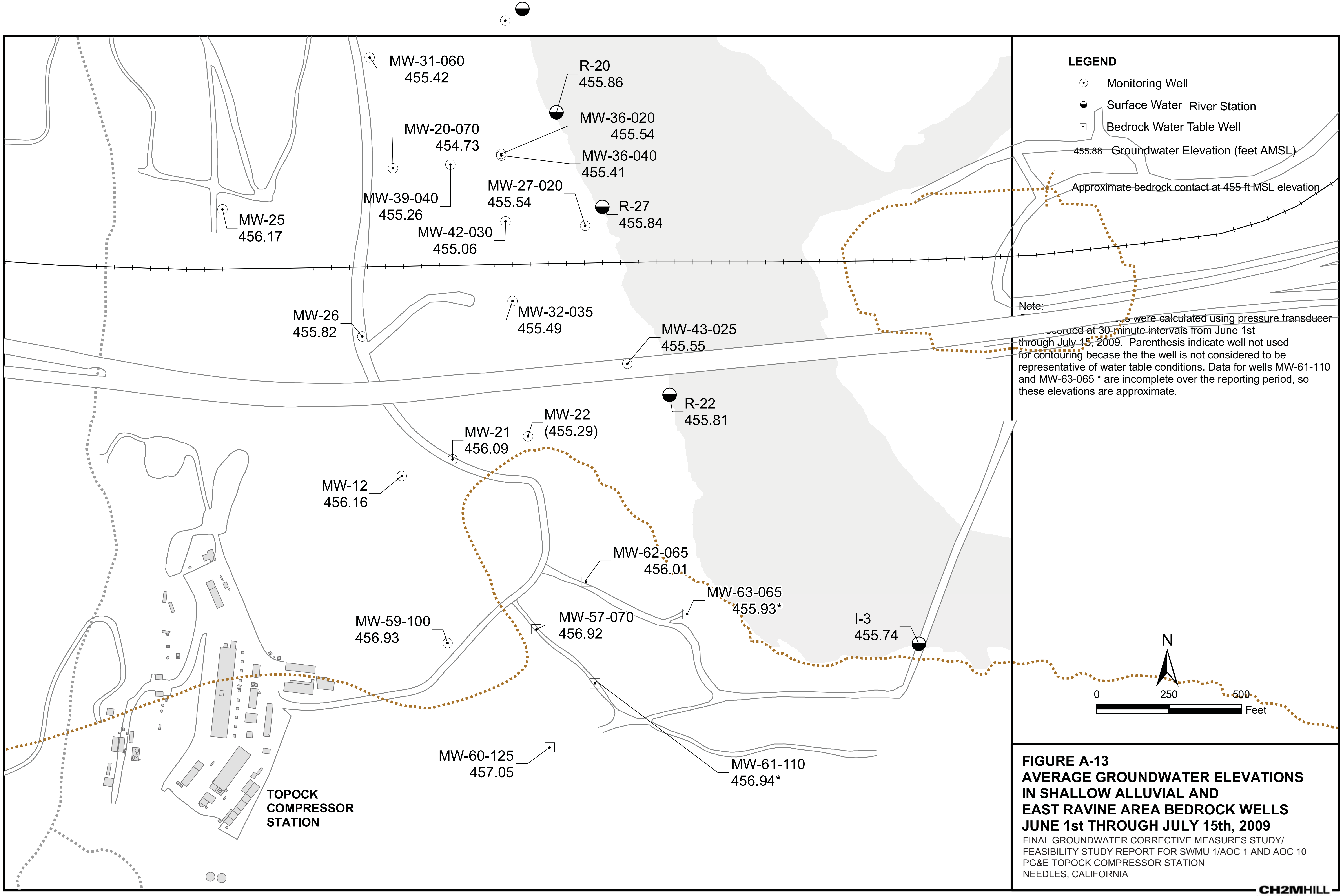

Note:
[illegible] were calculated using pressure transducer [illegible]corded at 30-minute intervals from June 1st through July 15, 2009. Parenthesis indicate well not used for contouring becase the the well is not considered to be representative of water table conditions. Data for wells MW-61-110 and MW-63-065 * are incomplete over the reporting period, so these elevations are approximate.

FIGURE A-13
AVERAGE GROUNDWATER ELEVATIONS IN SHALLOW ALLUVIAL AND EAST RAVINE AREA BEDROCK WELLS JUNE 1st THROUGH JULY 15th, 2009

FINAL GROUNDWATER CORRECTIVE MEASURES STUDY/
FEASIBILITY STUDY REPORT FOR SWMU 1/AOC 1 AND AOC 10
PG&E TOPOCK COMPRESSOR STATION
NEEDLES, CALIFORNIA

CH2MHILL

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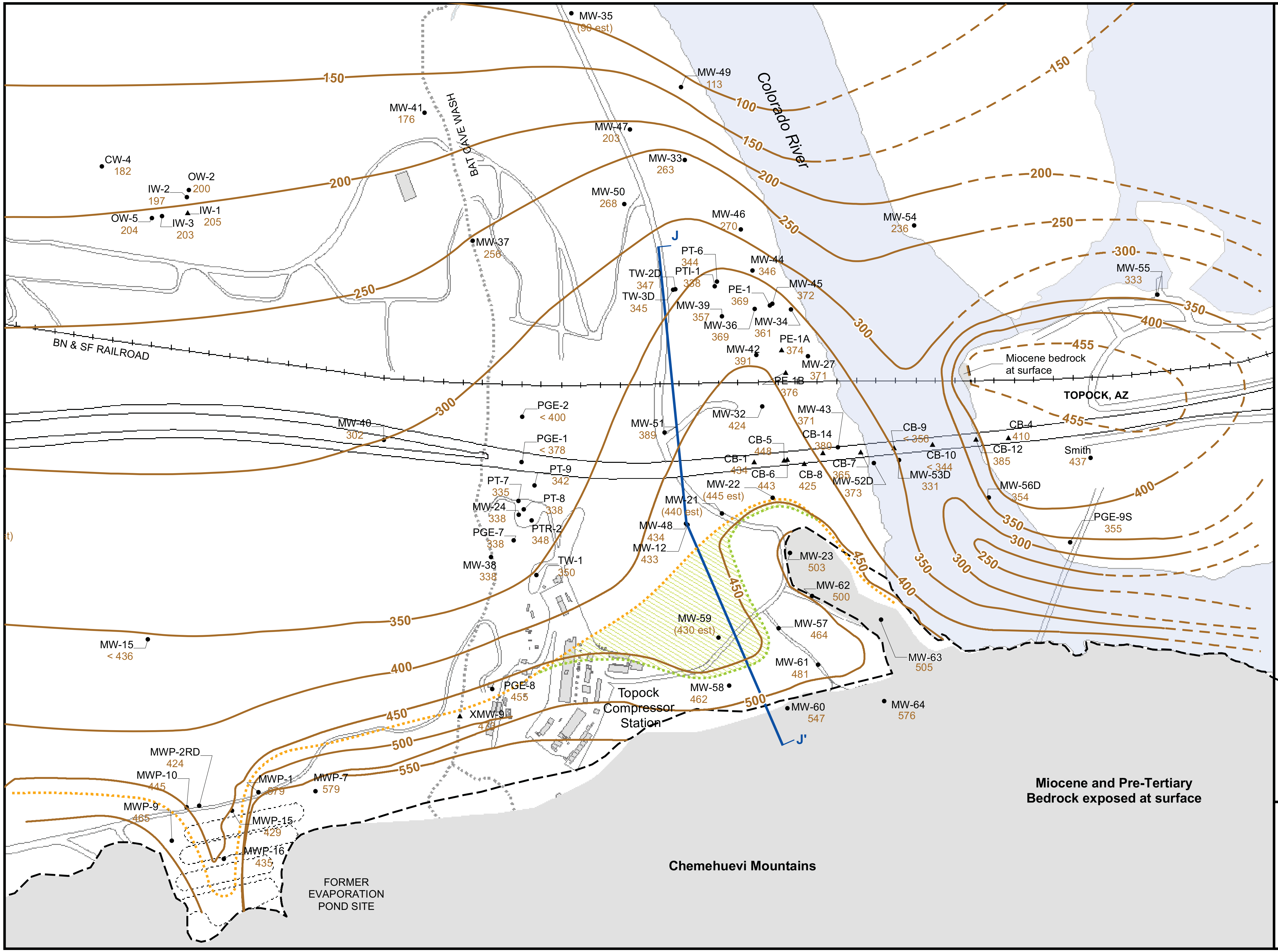

N

0 250 500 750 Feet

LEGEND

MW-41 ● 177	Elevation of Bedrock in feet above mean sea level (MSL)
(326 est)	Bedrock elevation estimated from cross-section
< 240	Bedrock elevation deeper than elevation of total depth of boring (data posted for selected locations)
350	Bedrock elevation contour (feet MSL)
	Contours are dashed where inferred from USGS seismic surveys and extended beyond drilling locations.
	Approximate bedrock / Alluvial Aquifer contact at elevation 456 ft MSL before 2009 East Ravine drilling
	Approximate bedrock / Alluvial Aquifer contact at elevation 456 ft MSL after East Ravine drilling.
	Hydrogeologic cross-section

Notes:

The bedrock structure map has been updated July 2009 with drilling data from 2009 East Ravine groundwater investigation.

FIGURE A-14
UPDATED BEDROCK STRUCTURE CONTOUR MAP

FINAL GROUNDWATER CORRECTIVE
MEASURES STUDY/FEASIBILITY STUDY
REPORT FOR SWMU 1/AOC 1 AND AOC 10
PG&E TOPOCK COMPRESSOR STATION
NEEDLES, CALIFORNIA

CH2MHILL

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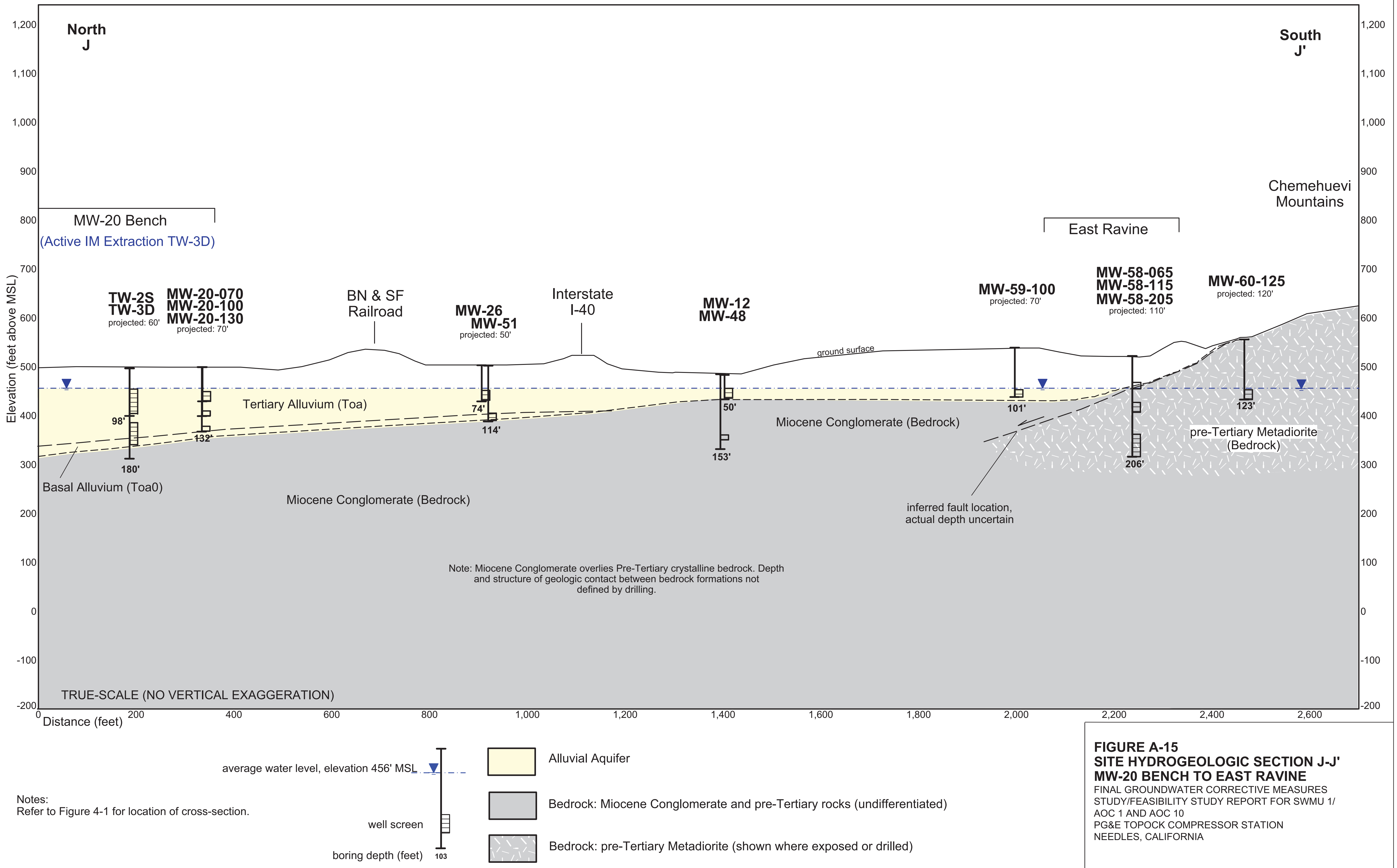

Notes:
Refer to Figure 4-1 for location of cross-section.

FIGURE A-15
SITE HYDROGEOLOGIC SECTION J-J'
MW-20 BENCH TO EAST RAVINE
FINAL GROUNDWATER CORRECTIVE MEASURES
STUDY/FEASIBILITY STUDY REPORT FOR SWMU 1/
AOC 1 AND AOC 10
PG&E TOPOCK COMPRESSOR STATION
NEEDLES, CALIFORNIA

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Attachment A1
Drilling and Well Construction Records
(This attachment is provided on CD-ROM)

Attachment A1-1
Borehole Construction Narrative

Attachment A1-1
Borehole Construction Narrative

The following bullets provide a summary of the drilling activities conducted to facilitate lithologic and hydrogeologic characterization, and well installation at each ERGI investigation site:

- Site A (MW-58 well series) – Two boreholes were advanced at Site A. An initial exploratory borehole was advanced to 115 feet bgs using a combination of rotosonic and rotary core drilling. To facilitate rotary coring and segregate the deeper portion of the borehole, a permanent 6-inch poly vinyl chloride (PVC) conductor casing was installed to 65.5 ft bgs and sealed with Portland cement grout. Subsequent to testing the 115-foot borehole, it was deepened to a final total depth of 206 feet bgs. Based lithologic and hydraulic data collected from the initial borehole, a second borehole was installed to 64 feet bgs for well installation.
- Site B (MW-57 well series) – Three boreholes were advanced at Site B. An initial exploratory borehole was advance to 192 feet bgs using a combination of rotosonic and rotary core drilling. To facilitate rotary coring and segregate the deeper portion of the borehole, a permanent 5-inch PVC conductor casing was installed to 70 feet bgs and sealed with Portland cement grout. Based on lithologic and hydraulic data collected from the initial borehole, two additional boreholes were installed to 50 and 70 feet bgs for well installation.
- Site C (MW-61-110) – One borehole was advanced at Site C to a total depth of 112 feet bgs for well installation. The borehole was initially advanced to 68 feet bgs using rotosonic drilling methods. The rotosonic casing was then used as a temporary conductor casing to facilitate rotary core drilling, which was used to advance the borehole to total depth. The cored borehole was then over-drilled from 68 feet bgs to total depth using rotosonic methods to facilitate well installation.
- Site C-Alternate (MW-64 well series) – One borehole was advanced at Site C-Alternate to a total depth of 260.5 feet bgs. The borehole was initially drilled 20 feet bgs using rotosonic drilling for the installation of a permanent 6-inch PVC conductor casing (sealed with Portland cement grout). Rotary core drilling was then used to advance the borehole to total depth.
- Site D – No borings were installed at Site D.
- Site E (MW-62 well series) – Two boreholes were advanced at Site E. The initial borehole was advanced to a total depth of 75 feet bgs for well installation. This borehole was initially advanced to 21 feet bgs using rotosonic drilling, and then to total depth with rotary core drilling using the rotosonic casing as a temporary conductor casing. The cored borehole was then over-drilled from 21 feet bgs to total depth using rotosonic methods to facilitate well installation. The second borehole was initially advanced to 75

feet bgs using rotosonic drilling for the installation of a permanent 6-inch PVC conductor casing (sealed with Portland cement grout). The boring was then advanced to a total depth of 191.5 feet bgs using rotary core drilling.

- Site E-Alternate 1 (MW-23 re-build) – No borings were installed at Site E-Alternate 1. In lieu of installing a new boring at this location, nearby existing monitoring well MW-23 was re-built to address the objectives of this investigation. MW-23 was over-drilled using rotosonic drilling to facilitate well re-installation within the pre-existing borehole.
- Site E-Alternate 2 (MW-63-065) – One borehole was advanced at Site E-Alternate 2 to a total depth of 66 feet bgs for well installation. The borehole was initially advanced to 30 feet bgs using rotosonic drilling methods. The rotosonic casing was then used as a temporary conductor casing to facilitate rotary core drilling, which was used to advance the borehole to total depth. The cored borehole was then over-drilled from 30 feet bgs to total depth using rotosonic methods to facilitate well installation.
- Site F (MW-60-125) – One borehole was advanced at Site F to a total depth of 123 feet bgs for well installation. The borehole was initially advanced to 86.5 feet bgs using rotosonic drilling methods. The rotosonic casing was then used as a temporary conductor casing to facilitate rotary core drilling, which was used to advance the borehole to total depth. The cored borehole was then over-drilled from 86.5 feet bgs to total depth using rotosonic methods to facilitate well installation.
- Site G (MW-59-100) – One borehole was advanced at Site G to a total depth of 101 feet bgs for well installation. This borehole was installed using only rotosonic drilling.

Attachment A1-2
Borehole Drilling Logs

PROJECT NUMBER:	BORING NUMBER:
382653.FP.04.FW	**MW-57** SHEET 1 OF 11

SOIL BORING LOG

PROJECT : PG&E Topock - ERGI
LOCATION : Site B (2100899.6 N, 7616389.4 E)
ELEVATION : 509.0 ft
DRILLING CONTRACTOR : Boart Longyear (D. Roberts)
DRILLING EQUIPMENT AND METHOD : Track-mounted Rig, Rotosonic drill head and tools
ORIENTATION : Vertical
WATER LEVELS : Approx. 52 ft BGS
START : 1/14/2009
END : 1/20/2009
LOGGER : A. Brewster (Northstar)

DEPTH BELOW EXISTING GRADE (ft)	INTERVAL (ft)	RECOVERY (in)	LAB SAMPLE	USCS CODE/ LITHOLOGY	SOIL DESCRIPTION SOIL NAME, USCS GROUP SYMBOL, COLOR, MOISTURE CONTENT, RELATIVE DENSITY OR CONSISTENCY, SOIL STRUCTURE, MINERALOGY	COMMENTS DEPTH OF CASING, DRILLING RATE, DRILLING FLUID LOSS, TESTS, AND INSTRUMENTATION
		COMPLETE		ML	**Sandy Silt With Gravel (ML)** 0.0-3.0' - dark brown, (7.5YR 3/3), dry, loose, 20% gravel, 30% sand, 50% fines, angular gravel, poorly graded, no dominant mineralogy, matrix-supported, max clast size = 10 mm	Boring initially drilled to 70' bgs using Rotosonic tools up to 10-in in diameter. Permanent 5-in PVC conductor casing installed from ground surface to 70' bgs (portland cement grout). Boring drilled from 70' bgs to total depth of 192' bgs using diamond bit rotary core tools (HQ-size, 3.8-in diameter)
	3.0 4.0		10:10	GM	**Silty Gravel (GM)** 3.0-46.0' - dark brown, (7.5YR 3/3), dry, loose, 40% gravel, 20% sand, 40% fines, angular gravel, poorly graded, no dominant mineralogy, matrix-supported, max clast size = 100 mm	
5						
	8.0 9.0		11:00, 14:00 (FD)			
10						
15						
	18.0 19.0		11:10			
20						

PROJECT NUMBER:	BORING NUMBER:
382653.FP.04.FW	MW-57 SHEET 2 OF 11

SOIL BORING LOG

PROJECT : PG&E Topock - ERGI
LOCATION : Site B (2100899.6 N, 7616389.4 E)
ELEVATION : 509.0 ft
DRILLING CONTRACTOR : Boart Longyear (D. Roberts)
DRILLING EQUIPMENT AND METHOD : Track-mounted Rig, Rotosonic drill head and tools
ORIENTATION : Vertical
WATER LEVELS : Approx. 52 ft BGS
START : 1/14/2009
END : 1/20/2009
LOGGER : A. Brewster (Northstar)

DEPTH BELOW EXISTING GRADE (ft)	INTERVAL (ft)	RECOVERY (in)	LAB SAMPLE	USCS CODE/ LITHOLOGY	SOIL DESCRIPTION SOIL NAME, USCS GROUP SYMBOL, COLOR, MOISTURE CONTENT, RELATIVE DENSITY OR CONSISTENCY, SOIL STRUCTURE, MINERALOGY	SYMBOLIC LOG	COMMENTS DEPTH OF CASING, DRILLING RATE, DRILLING FLUID LOSS, TESTS, AND INSTRUMENTATION
		COMPLETE			**Silty Gravel (GM)** 3.0-46.0' - dark brown, (7.5YR 3/3), dry, loose, 40% gravel, 20% sand, 40% fines, angular gravel, poorly graded, no dominant mineralogy, matrix-supported, max clast size = 100 mm		
25							
30				GM			
35							
40							

PROJECT NUMBER:	BORING NUMBER:
382653.FP.04.FW	MW-57 SHEET 3 OF 11

SOIL BORING LOG

PROJECT : PG&E Topock - ERGI

LOCATION : Site B (2100899.6 N, 7616389.4 E)

ELEVATION : 509.0 ft

DRILLING CONTRACTOR : Boart Longyear (D. Roberts)

DRILLING EQUIPMENT AND METHOD : Track-mounted Rig, Rotosonic drill head and tools

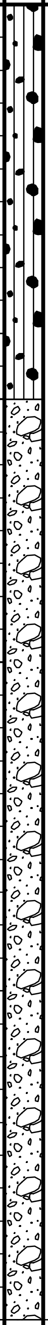
ORIENTATION : Vertical

WATER LEVELS : Approx. 52 ft BGS

START : 1/14/2009

END : 1/20/2009

LOGGER : A. Brewster (Northstar)

DEPTH BELOW EXISTING GRADE (ft)	INTERVAL (ft)	RECOVERY (in)	LAB SAMPLE	USCS CODE/ LITHOLOGY	SOIL DESCRIPTION SOIL NAME, USCS GROUP SYMBOL, COLOR, MOISTURE CONTENT, RELATIVE DENSITY OR CONSISTENCY, SOIL STRUCTURE, MINERALOGY	SYMBOLIC LOG	COMMENTS DEPTH OF CASING, DRILLING RATE, DRILLING FLUID LOSS, TESTS, AND INSTRUMENTATION
45		COMPLETE		GM	**Silty Gravel (GM)** 3.0-46.0' - dark brown, (7.5YR 3/3), dry, loose, 40% gravel, 20% sand, 40% fines, angular gravel, poorly graded, no dominant mineralogy, matrix-supported, max clast size = 100 mm		
50 55 60				Tmc	**Conglomerate (Tmc)** 46.0-145.5' - bedrock is consolidated. Drilling method pulverizes most of the core. Intact portions of core are yellowish red (5YR 4/6), dry, matrix-supported conglomerate with no dominant clast mineralogy		

PROJECT NUMBER:	BORING NUMBER:
382653.FP.04.FW	MW-57 SHEET 4 OF 11

SOIL BORING LOG

PROJECT : PG&E Topock - ERGI
LOCATION : Site B (2100899.6 N, 7616389.4 E)
ELEVATION : 509.0 ft
DRILLING CONTRACTOR : Boart Longyear (D. Roberts)
DRILLING EQUIPMENT AND METHOD : Track-mounted Rig, Rotosonic drill head and tools
ORIENTATION : Vertical
WATER LEVELS : Approx. 52 ft BGS
START : 1/14/2009
END : 1/20/2009
LOGGER : A. Brewster (Northstar)

DEPTH BELOW EXISTING GRADE (ft)	INTERVAL (ft)	RECOVERY (in)	LAB SAMPLE	USCS CODE/ LITHOLOGY	SOIL DESCRIPTION SOIL NAME, USCS GROUP SYMBOL, COLOR, MOISTURE CONTENT, RELATIVE DENSITY OR CONSISTENCY, SOIL STRUCTURE, MINERALOGY	SYMBOLIC LOG	COMMENTS DEPTH OF CASING, DRILLING RATE, DRILLING FLUID LOSS, TESTS, AND INSTRUMENTATION
		COMPLETE			**Conglomerate (Tmc)** 46.0-145.5' - bedrock is consolidated. Drilling method pulverizes most of the core. Intact portions of core are yellowish red (5YR 4/6), dry, matrix-supported conglomerate with no dominant clast mineralogy		
65				Tmc			
70	70.0				Begin rock coring from 70.0 ft bgs See the next page for the rock core log.		Boring by Rotosonic completed 1/14/09. Install permanent 5-in diameter PVC conductor casing (portland cement grout). Begin rotary core drilling at 70.0' bgs.
75							
80							

CH2MHILL

PROJECT NUMBER:	BORING NUMBER:
382653.FP.04.FW	MW-57 SHEET 5 OF 11

ROCK CORE LOG

PROJECT : PG&E Topock - ERGI
LOCATION : Site B (2100899.6 N, 7616389.4 E)
ELEVATION : 509.0 ft
DRILLING CONTRACTOR : Boart Longyear (D. Roberts)
CORING EQUIPMENT AND METHOD : Track-mounted Rig, LF-70 Drill Head and HQ-sized tools (diamond bit)
ORIENTATION : Vertical
WATER LEVELS : Approx. 52 ft BGS
START : 1/14/2009
END : 1/20/2009
LOGGER : A. Brewster (Northstar)

DEPTH AND ELEVATION BELOW SURFACE (ft)	CORE RUN, LENGTH, AND RECOVERY (%)	DISCONTINUITIES: R Q D (%)	DISCONTINUITIES: FRACTURES PER FOOT	DISCONTINUITIES: DESCRIPTION — DEPTH, TYPE, ORIENTATION, ROUGHNESS, PLANARITY, INFILLING MATERIAL AND THICKNESS, SURFACE STAINING, AND TIGHTNESS	SYMBOLIC LOG	LITHOLOGY — ROCK TYPE, COLOR, MINERALOGY, TEXTURE, HARDNESS, WEATHERING, AND ROCK MASS CHARACTERISTICS	COMMENTS — SIZE AND DEPTH OF CASING, FLUID LOSS, CORING RATE AND SMOOTHNESS, CAVING ROD DROPS, TEST RESULTS, ETC.
	70.0 R1 5.3 ft 0%	0	NR			**No Recovery** 70-75.3'	
75	75.3						R1 = 23.0 min
	R2 9.5 ft 103%	100	0 0 0 0 0 0 0 0 0 0			**Conglomerate (Tmc)** 75.3-145.5' - light brown, (5YR 5/6), no dominant clast mineralogy, fine to coarse grained, medium strong (R3), unweathered, matrix-supported, massive	
80							
85	84.8						Added Approx. 50 gallons of water
	R3 10 ft 100%	100	0 0 0 0 0				
90							

PROJECT NUMBER: 382653.FP.04.FW

BORING NUMBER: MW-57

SHEET 6 OF 11

ROCK CORE LOG

PROJECT : PG&E Topock - ERGI

LOCATION : Site B (2100899.6 N, 7616389.4 E)

ELEVATION : 509.0 ft

DRILLING CONTRACTOR : Boart Longyear (D. Roberts)

CORING EQUIPMENT AND METHOD : Track-mounted Rig, LF-70 Drill Head and HQ-sized tools (diamond bit)

ORIENTATION : Vertical

WATER LEVELS : Approx. 52 ft BGS

START : 1/14/2009

END : 1/20/2009

LOGGER : A. Brewster (Northstar)

DEPTH AND ELEVATION BELOW SURFACE (ft)	CORE RUN, LENGTH, AND RECOVERY (%)	R Q D (%)	DISCONTINUITIES FRACTURES PER FOOT	DISCONTINUITIES DESCRIPTION DEPTH, TYPE, ORIENTATION, ROUGHNESS, PLANARITY, INFILLING MATERIAL AND THICKNESS, SURFACE STAINING, AND TIGHTNESS	SYMBOLIC LOG	LITHOLOGY ROCK TYPE, COLOR, MINERALOGY, TEXTURE, HARDNESS, WEATHERING, AND ROCK MASS CHARACTERISTICS	COMMENTS SIZE AND DEPTH OF CASING, FLUID LOSS, CORING RATE AND SMOOTHNESS, CAVING ROD DROPS, TEST RESULTS, ETC.
			0			**Conglomerate (Tmc)** 75.3-145.5' - light brown, (5YR 5/6), no dominant clast mineralogy, fine to coarse grained, medium strong (R3), unweathered, matrix-supported, massive	
			0				
			0				
			0				
95	94.8		0				Added approx. 25 gallons of water. R3 = 10.0 min
			0				
			0				
			0				
			1	98.5, 99.0' - Joint, 35 deg, rough, undulating, reddish staining, tight		98.5-98.7' - slightly weathered	
100	R4 10 ft 100%	70	1				
			0				
			0				
			0				
			>10	103.0-105.0' - Multiple breaks, difficult to ascertain if jointed or caused by drilling.			
105	104.8		>10				R4 = 10.5 min
			0				
			0				
			0				
			0				
110	R5 10 ft 100%	97	0				

PROJECT NUMBER:	BORING NUMBER:
382653.FP.04.FW	**MW-57** SHEET 7 OF 11

ROCK CORE LOG

PROJECT : PG&E Topock - ERGI

LOCATION : Site B (2100899.6 N, 7616389.4 E)

ELEVATION : 509.0 ft

DRILLING CONTRACTOR : Boart Longyear (D. Roberts)

CORING EQUIPMENT AND METHOD : Track-mounted Rig, LF-70 Drill Head and HQ-sized tools (diamond bit)

ORIENTATION : Vertical

WATER LEVELS : Approx. 52 ft BGS

START : 1/14/2009

END : 1/20/2009

LOGGER : A. Brewster (Northstar)

DEPTH AND ELEVATION BELOW SURFACE (ft)	CORE RUN, LENGTH, AND RECOVERY (%)	DISCONTINUITIES R Q D (%)	FRACTURES PER FOOT	DESCRIPTION: DEPTH, TYPE, ORIENTATION, ROUGHNESS, PLANARITY, INFILLING MATERIAL AND THICKNESS, SURFACE STAINING, AND TIGHTNESS	SYMBOLIC LOG	LITHOLOGY: ROCK TYPE, COLOR, MINERALOGY, TEXTURE, HARDNESS, WEATHERING, AND ROCK MASS CHARACTERISTICS	COMMENTS: SIZE AND DEPTH OF CASING, FLUID LOSS, CORING RATE AND SMOOTHNESS, CAVING ROD DROPS, TEST RESULTS, ETC.
			0			**Conglomerate (Tmc)** 75.3-145.5' - light brown, (5YR 5/6), no dominant clast mineralogy, fine to coarse grained, medium strong (R3), unweathered, matrix-supported, massive	
			0				
			0				
			1	113.1' - Joint, 35 deg, rough, undulating, reddish staining, tight			
115	114.8		0				Added approx. 25 gallons of water. R5 = 12.5 min
			0				
			0				
			0				
			0				
120	R6 10 ft 100%	100	1	119.3' - Joint, 35 deg, rough, planar, reddish staining, tight			
			0				
			0				
			0				
			0				
125	124.8		0				R6 = 14.0 min
			0				
			0				
			0				
			0				
130	R7 9.9 ft 100%	100	0				

CH2MHILL

PROJECT NUMBER:	BORING NUMBER:
382653.FP.04.FW	MW-57 SHEET 8 OF 11

ROCK CORE LOG

PROJECT : PG&E Topock - ERGI

LOCATION : Site B (2100899.6 N, 7616389.4 E)

ELEVATION : 509.0 ft

DRILLING CONTRACTOR : Boart Longyear (D. Roberts)

CORING EQUIPMENT AND METHOD : Track-mounted Rig, LF-70 Drill Head and HQ-sized tools (diamond bit)

ORIENTATION : Vertical

WATER LEVELS : Approx. 52 ft BGS

START : 1/14/2009

END : 1/20/2009

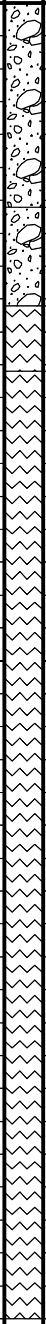
LOGGER : A. Brewster (Northstar)

DEPTH AND ELEVATION BELOW SURFACE (ft)	CORE RUN, LENGTH, AND RECOVERY (%)	DISCONTINUITIES R Q D (%)	FRACTURES PER FOOT	DESCRIPTION DEPTH, TYPE, ORIENTATION, ROUGHNESS, PLANARITY, INFILLING MATERIAL AND THICKNESS, SURFACE STAINING, AND TIGHTNESS	SYMBOLIC LOG	LITHOLOGY ROCK TYPE, COLOR, MINERALOGY, TEXTURE, HARDNESS, WEATHERING, AND ROCK MASS CHARACTERISTICS	COMMENTS SIZE AND DEPTH OF CASING, FLUID LOSS, CORING RATE AND SMOOTHNESS, CAVING ROD DROPS, TEST RESULTS, ETC.
			0			**Conglomerate (Tmc)** 75.3-145.5' - light brown, (5YR 5/6), no dominant clast mineralogy, fine to coarse grained, medium strong (R3), unweathered, matrix-supported, massive	
			0				
			0				
			1	133' - Joint, 35 deg, rough, planar, < 1 mm calcite infilling, reddish staining, tight (likely caused by drilling)			
135	134.7		0				R7 = 15.0 min
			1	135' - Joint, 60 deg, rough, undulating, < 2 mm calcite infilling, reddish staining, tight			
			0				
			1	137.1' - Joint, 35 deg, rough, undulating, reddish staining, minor yellow staining, tight			
			0				
140	R8 10.1 ft 100%	100	0				
			0				
			1	141' - Joint, 80 deg, rough, undulating, reddish staining, tight (likely caused by drilling)			
			0				
			0				
145	144.8		1	144' - Joint, 45 deg, rough, stepped, reddish staining, tightness uncertain			R8 = 14.5 min
			0			145.5-153.1' - moderate reddish orange, (10R 6/6), no dominant clast mineralogy, fine to coarse grained, medium strong (R3), completely weathered, matrix-supported, foliated	Conglomerate from 144.5.-153.1 is altered. The matrix of the rock rapidly dissolves on contact with water as evident from the outer portion of the recovered core exposed to drilling fluids and fragments of core intentionally submersed in water.
			0				
			0	146.8-152.6' - Multiple fractures caused by drilling. Preferential clevage 25 to 35 deg, undulating, slickensided, no infill, reddish staining			
			0				
150	R9 10.1 ft 99%	98	0				

PROJECT NUMBER:	BORING NUMBER:
382653.FP.04.FW	MW-57 SHEET 9 OF 11

ROCK CORE LOG

PROJECT : PG&E Topock - ERGI
LOCATION : Site B (2100899.6 N, 7616389.4 E)
ELEVATION : 509.0 ft
DRILLING CONTRACTOR : Boart Longyear (D. Roberts)
CORING EQUIPMENT AND METHOD : Track-mounted Rig, LF-70 Drill Head and HQ-sized tools (diamond bit)
ORIENTATION : Vertical
WATER LEVELS : Approx. 52 ft BGS
START : 1/14/2009
END : 1/20/2009
LOGGER : A. Brewster (Northstar)



DEPTH AND ELEVATION BELOW SURFACE (ft)	CORE RUN, LENGTH, AND RECOVERY (%)	R Q D (%)	FRACTURES PER FOOT	DISCONTINUITIES DESCRIPTION: DEPTH, TYPE, ORIENTATION, ROUGHNESS, PLANARITY, INFILLING MATERIAL AND THICKNESS, SURFACE STAINING, AND TIGHTNESS	LITHOLOGY: ROCK TYPE, COLOR, MINERALOGY, TEXTURE, HARDNESS, WEATHERING, AND ROCK MASS CHARACTERISTICS	COMMENTS: SIZE AND DEPTH OF CASING, FLUID LOSS, CORING RATE AND SMOOTHNESS, CAVING ROD DROPS, TEST RESULTS, ETC.
			0		**Conglomerate (Tmc)** 145.5-153.1' - moderate reddish orange, (10R 6/6), no dominant clast mineralogy, fine to coarse grained, medium strong (R3), completely weathered, matrix-supported, foliated	
			0			
			0			
			0	153.5, 154.5' - Mechanical break, 35 deg, undulating to planar, brownish with black staining, no infill, slickensided, tight	**Metaconglomerate (Tmc)** 153.1-154.6' - dark yellowish orange, (10YR 6/6), strong (R4), unweathered, massive, moderate HCl reaction, conglomerate matrix has been largely replaced with minerals that have a moderate reaction with HCl, however relict conglomerate structure is apparent.	
	154.9		0	154.6-155.6' - Fracture zone, healed fractures with random orientation		R9 = 17.5 min
155			>10			
	R10 4.8 ft 100%		0		**Altered Metadiorite (pTbr)** 154.6-155.6' - moderate yellowish brown, (10YR 5/4), largely felsic mineralogy, medium grained, strong (R4), unweathered, no HCL reaction, portions of this interval exhibit mylonitic texture	
		58	0			
			1	158.2' - Joint, 60 deg dip along multiple planes, rough, undulating, < 1 mm calcite infilling covering 50% of one plane, yellowish staining, tightness uncertain	**Metadiorite (pTbr)** 155.6-191.9' - dusky yellowish green, (10GY 3/2), intermediate (dioritic) mineralogy, fine to medium grained, strong (R4), unweathered, massive to foliated	General Note: The metadiorite bedrock exhibits many small healed fractures (1-3 mm) of somewhat random orientation. These healed fractures create weaknesses in the rock. It can be difficult to determine if the metadiorite is jointed in-situ, or if the discontinuities are caused by the drilling method. Intervals with fracture per foot counts >10 are likely caused by drilling.
	159.7		0			
160			0			
	R11 4.7 ft 100%		>10	160.9-164.2' - Fracture zone, reddish staining, yellow staining from 162.3-164.2'		
		51	>10			
			>10			R10 = 23.0 min
	164.4		0			R11 = 13.3 min
165			0			
	R12 4.6 ft 100%	53	1	166.1' - Mechanical break, near 90 deg, calcite infilling, calcite healed fracture, most likely induced by drilling	166.8-167.0' - slightly weathered	
			0	167.7-170.0' - Mechanical break (6), 35 deg and 45 deg, calcite infilling, along calcite healed fractures, likely induced by drilling		
	169.0		0			
			0			R12 = 19.3 min
170						

CH2MHILL

PROJECT NUMBER:	BORING NUMBER:	
382653.FP.04.FW	MW-57	SHEET 10 OF 11

ROCK CORE LOG

PROJECT : PG&E Topock - ERGI
LOCATION : Site B (2100899.6 N, 7616389.4 E)
ELEVATION : 509.0 ft
DRILLING CONTRACTOR : Boart Longyear (D. Roberts)
CORING EQUIPMENT AND METHOD : Track-mounted Rig, LF-70 Drill Head and HQ-sized tools (diamond bit)
ORIENTATION : Vertical
WATER LEVELS : Approx. 52 ft BGS
START : 1/14/2009
END : 1/20/2009
LOGGER : A. Brewster (Northstar)

DEPTH AND ELEVATION BELOW SURFACE (ft)	CORE RUN, LENGTH, AND RECOVERY (%)	DISCONTINUITIES R Q D (%)	FRACTURES PER FOOT	DESCRIPTION: DEPTH, TYPE, ORIENTATION, ROUGHNESS, PLANARITY, INFILLING MATERIAL AND THICKNESS, SURFACE STAINING, AND TIGHTNESS	LITHOLOGY: ROCK TYPE, COLOR, MINERALOGY, TEXTURE, HARDNESS, WEATHERING, AND ROCK MASS CHARACTERISTICS	COMMENTS: SIZE AND DEPTH OF CASING, FLUID LOSS, CORING RATE AND SMOOTHNESS, CAVING ROD DROPS, TEST RESULTS, ETC.
	R13 4.8 ft 100%		0		**Metadiorite (pTbr)** 155.6-191.9' - dusky yellowish green, (10GY 3/2), intermediate (dioritic) mineralogy, fine to medium grained, strong (R4), unweathered, massive to foliated	Last 1.5' = 2-3x faster drill rate
		69	0			
			>10	172.2-173.8' - Fracture zone, reddish staining		
	173.8 R14 0.5 ft 100%		>10			R13 = 25.3 min
	174.3	0	1	174.4' - Joint, 30 deg, smooth, undulating, < 1 mm calcite infilling, reddish staining, tight		R14 = 7.5 min
175	R15 3.4 ft 100%		0	175.2' - Mechanical break, 35 deg, < 2 mm calcite infilling, along calcite healed fracture		@ 175' bgs: drill rate increases
		71	1	176.6' - Joint, 60 deg, rough, undulating, reddish staining, tight		
	177.7		1	177.3' - Joint, 30 deg, rough, undulating, < 1 mm calcite infilling, reddish staining, tight		R15 = 17.0 min
			0			
	R16 4.2 ft 100%		1	179.1' - Joint, 20 deg, rough, undulating, < 1 mm calcite infilling, reddish staining, tight		
180		100	1	180' - Joint, 30 deg, rough, undulating, minor reddish staining, tight		
	181.9		1	181.2' - Joint, 25 deg, rough, undulating, < 1 mm calcite infilling, reddish and black staining, tight		R16 = 15.5 min
			1	182.1, 189.6' - Joint (2), 10 deg, smooth, undulating, < 1 mm clay infilling, reddish staining, tight, clay infilling is dark-reddish brown		
			0			
			0			
185			0			
	R17 10 ft 100%		0	185.8 - 186.0' - Multiple breaks, likely induced by drilling		
		92	0			
			1			
190			0			

PROJECT NUMBER:	BORING NUMBER:
382653.FP.04.FW	MW-57 SHEET 11 OF 11

ROCK CORE LOG

PROJECT : PG&E Topock - ERGI
LOCATION : Site B (2100899.6 N, 7616389.4 E)
ELEVATION : 509.0 ft
DRILLING CONTRACTOR : Boart Longyear (D. Roberts)
CORING EQUIPMENT AND METHOD : Track-mounted Rig, LF-70 Drill Head and HQ-sized tools (diamond bit)
ORIENTATION : Vertical
WATER LEVELS : Approx. 52 ft BGS
START : 1/14/2009
END : 1/20/2009
LOGGER : A. Brewster (Northstar)

DEPTH AND ELEVATION BELOW SURFACE (ft)	CORE RUN, LENGTH, AND RECOVERY (%)	DISCONTINUITIES R Q D (%)	 FRACTURES PER FOOT	 DESCRIPTION DEPTH, TYPE, ORIENTATION, ROUGHNESS, PLANARITY, INFILLING MATERIAL AND THICKNESS, SURFACE STAINING, AND TIGHTNESS	SYMBOLIC LOG	LITHOLOGY ROCK TYPE, COLOR, MINERALOGY, TEXTURE, HARDNESS, WEATHERING, AND ROCK MASS CHARACTERISTICS	COMMENTS SIZE AND DEPTH OF CASING, FLUID LOSS, CORING RATE AND SMOOTHNESS, CAVING ROD DROPS, TEST RESULTS, ETC.
	191.9		0 0			**Metadiorite (pTbr)** 155.6-191.9' - dusky yellowish green, (10GY 3/2), intermediate (dioritic) mineralogy, fine to medium grained, strong (R4), unweathered, massive to foliated	R17 = 35.5 min
						End Drilling on 1/20/2009 Total Borehole Depth: 191.9 ft bgs	
195							
200							
205							
210							

PROJECT NUMBER:	BORING NUMBER:
382653.FP.04.FW	MW-58 SHEET 1 OF 11

SOIL BORING LOG

PROJECT : PG&E Topock - ERGI
LOCATION : Site A (2100612.1 N, 7616131.8 E)
ELEVATION : 521.8 ft
DRILLING CONTRACTOR : Boart Longyear (D. Roberts)
DRILLING EQUIPMENT AND METHOD : Track-mounted Rig, Rotosonic drill head and tools
ORIENTATION : Vertical
WATER LEVELS : Approx. 66 ft BGS
START : 1/29/2009
END : 3/27/2009
LOGGER : A. Brewster (Northstar)

DEPTH BELOW EXISTING GRADE (ft)	INTERVAL (ft)	RECOVERY (in)	LAB SAMPLE	USCS CODE/ LITHOLOGY	SOIL DESCRIPTION: SOIL NAME, USCS GROUP SYMBOL, COLOR, MOISTURE CONTENT, RELATIVE DENSITY OR CONSISTENCY, SOIL STRUCTURE, MINERALOGY	SYMBOLIC LOG	COMMENTS: DEPTH OF CASING, DRILLING RATE, DRILLING FLUID LOSS, TESTS, AND INSTRUMENTATION
	1.5 2.0	COMPLETE	14:00	ML	**Silt With Sand(ML)** 0.0-2.0' - brown, (7.5YR 4/4), dry, loose, 0% gravel, 20% sand, 80% fines, sand is angular to subangular, poorly graded, no dominant mineralogy		Boring initially drilled to 65.5' bgs using Rotosonic tools up to 10-in in diameter. Permanent 6-in PVC conductor casing installed from ground surface to 65.5' bgs (portland cement grout). Boring drilled from 65.5' bgs to an initial total depth of 115' bgs using diamond bit rotary core tools (HQ-size, 3.8-in diameter). Following testing, boring was deepend to a total depth of 206' bgs using rotary core tools.
5 10 15				GM	**Silty Gravel With Sand(GM)** 2.0-17.0' - brown, (7.5YR 4/3), dry, loose, 40% gravel, 30% sand, 30% fines, gravel is angular to subangular, poorly graded, no dominant mineralogy, matrix supported, max clast size = 90 mm.		
20	19.0 20.0		14:50	SM	**Silty Sand With Gravel(SM)** 16.0-51.0' - brown, (7.5YR 4/3), dry, loose, 15% gravel, 60% sand, 25% fines, gravel is angular to subrounded, poorly graded, no dominant mineralogy, matrix supported, max clast size = 100 mm		

CH2MHILL

PROJECT NUMBER: 382653.FP.04.FW

BORING NUMBER: MW-58 **SHEET** 2 **OF** 11

SOIL BORING LOG

PROJECT : PG&E Topock - ERGI
LOCATION : Site A (2100612.1 N, 7616131.8 E)
ELEVATION : 521.8 ft
DRILLING CONTRACTOR : Boart Longyear (D. Roberts)
DRILLING EQUIPMENT AND METHOD : Track-mounted Rig, Rotosonic drill head and tools
ORIENTATION : Vertical
WATER LEVELS : Approx. 66 ft BGS
START : 1/29/2009
END : 3/27/2009
LOGGER : A. Brewster (Northstar)

DEPTH BELOW EXISTING GRADE (ft)	INTERVAL (ft)	RECOVERY (in)	LAB SAMPLE	USCS CODE/ LITHOLOGY	SOIL DESCRIPTION SOIL NAME, USCS GROUP SYMBOL, COLOR, MOISTURE CONTENT, RELATIVE DENSITY OR CONSISTENCY, SOIL STRUCTURE, MINERALOGY	SYMBOLIC LOG	COMMENTS DEPTH OF CASING, DRILLING RATE, DRILLING FLUID LOSS, TESTS, AND INSTRUMENTATION
		COMPLETE			**Silty Sand With Gravel (SM)** 16.0-51.0' - brown, (7.5YR 4/3), dry, loose, 15% gravel, 60% sand, 25% fines, gravel is angular to subrounded, poorly graded, no dominant mineralogy, matrix supported, max clast size = 100 mm		
25							
	29.0		15:10				
30	30.0			SM			
35							
	39.0		16:30				
40	40.0						

CH2MHILL

PROJECT NUMBER:	BORING NUMBER:
382653.FP.04.FW	MW-58 SHEET 3 OF 11

SOIL BORING LOG

PROJECT : PG&E Topock - ERGI
LOCATION : Site A (2100612.1 N, 7616131.8 E)
ELEVATION : 521.8 ft
DRILLING CONTRACTOR : Boart Longyear (D. Roberts)
DRILLING EQUIPMENT AND METHOD : Track-mounted Rig, Rotosonic drill head and tools
ORIENTATION : Vertical
WATER LEVELS : Approx. 66 ft BGS
START : 1/29/2009
END : 3/27/2009
LOGGER : A. Brewster (Northstar)

DEPTH BELOW EXISTING GRADE (ft)	INTERVAL (ft)	RECOVERY (in)	LAB SAMPLE	USCS CODE/ LITHOLOGY	SOIL DESCRIPTION SOIL NAME, USCS GROUP SYMBOL, COLOR, MOISTURE CONTENT, RELATIVE DENSITY OR CONSISTENCY, SOIL STRUCTURE, MINERALOGY	SYMBOLIC LOG	COMMENTS DEPTH OF CASING, DRILLING RATE, DRILLING FLUID LOSS, TESTS, AND INSTRUMENTATION
45 50	49.0 50.0	COMPLETE	17:10	SM	**Silty Sand With Gravel(SM)** 16.0-51.0' - brown, (7.5YR 4/3), dry, loose, 15% gravel, 60% sand, 25% fines, gravel is angular to subrounded, poorly graded, no dominant mineralogy, matrix supported, max clast size = 100 mm		
				ML	**Silt (ML)** 51.0-53.0' - dark brown, (7.5YR 3/2), dry, stiff, 0% gravel, 0% sand, 100% fines, no apparent structure, max clast size = 20 mm. Occurrence of lenses of white clayey silt up to 10 mm thick, cohesive.		
55 60	59.0 60.0		17:30	SP	**Poorly Graded Sand With Grave(SP)** 53.0-60.0' - dark yellowish brown, (10YR 4/6), dry, loose to medium dense, 30% gravel, 65% sand, 5% fines, sand is fine to medium grained, subangular to subrounded, poorly graded, no dominant mineralogy, matrix supported, max clast size = 30 mm.		Total depth of Rotosonic boring is 65.5 ft bgs. Install permanent 6-in conductor casing (portland cement grout). See rock core log for 60.0-65.5 lithlologic description.
					Begin rock coring from 65.5 ft bgs See the next page for the rock core log.		

PROJECT NUMBER:	BORING NUMBER:	
382653.FP.04.FW	MW-58	SHEET 4 OF 11

ROCK CORE LOG

PROJECT : PG&E Topock - ERGI
LOCATION : Site A (2100612.1 N, 7616131.8 E)
ELEVATION : 521.8 ft
DRILLING CONTRACTOR : Boart Longyear (D. Roberts)
CORING EQUIPMENT AND METHOD : Track-mounted Rig, LF-70 Drill Head and HQ-sized tools (diamond bit)
ORIENTATION : Vertical
WATER LEVELS : Approx. 66 ft BGS
START : 1/29/2009
END : 3/27/2009
LOGGER : A. Brewster (Northstar)

DEPTH AND ELEVATION BELOW SURFACE (ft)	CORE RUN, LENGTH, AND RECOVERY (%)	DISCONTINUITIES R Q D (%)	FRACTURES PER FOOT	DESCRIPTION DEPTH, TYPE, ORIENTATION, ROUGHNESS, PLANARITY, INFILLING MATERIAL AND THICKNESS, SURFACE STAINING, AND TIGHTNESS	SYMBOLIC LOG	LITHOLOGY ROCK TYPE, COLOR, MINERALOGY, TEXTURE, HARDNESS, WEATHERING, AND ROCK MASS CHARACTERISTICS	COMMENTS SIZE AND DEPTH OF CASING, FLUID LOSS, CORING RATE AND SMOOTHNESS, CAVING ROD DROPS, TEST RESULTS, ETC.
	60.0					**Metadiorite (pTbr)** 60.0-62.0' - Metadiorite.Highly weathered.	
						Metadiorite (pTbr) 62.0-65.5' - Metadiorite. Rock is competent, but shattered and partially pulverized by Rotosonic drilling method.	
65							
	65.5 R1 3 ft 100%	13	>10 >10 >10	65.5-70.0' - core recovered, but largely broken by drilling.		**Metadiorite (pTbr)** 65.5-206.0' - dusky yellowish green, (10GY 3/2), intermediate (dioritic) mineralogy, medium grained, strong (R4), unweathered, massive to foliated	65.5': Begin rotary core drilling General Note: The metadiorite bedrock exhibits many small healed fractures (1-3 mm) of somewhat random orientation. These healed fractures create weaknesses in the rock. It can be difficult to determine if the metadiorite is jointed in-situ, or if the discontinuities are caused by the drilling method. Intervals with fracture per foot counts >10 are likely caused by drilling.
	68.5 R2 1 ft 100%	0	1	68.5' - Joint, 50 deg, rough, undulating, < 1 mm calcite infilling, no staining, tight			
	69.5 R3 0.5 ft 100%	0	>10				
70	70.0 R4 5.5 ft 95%	100	1 0	70.9' - Joint, 30 deg, rough, undulating, < 1 mm calcite infilling, no staining, tight			
			3 1	72.2' - Joint, 35 deg, rough, undulating, < 1 mm calcite infilling, no staining, tight 72.7' - Joint (2), 40 deg and 60 deg, rough, undulating, < 1 mm calcite infilling, yellowish staining on 40 deg face, tight			R1 = 11.5 min R2 = 13.2 min R3 = 8.0 min
75			0	73.9' - Joint, 40 deg, rough, undulating, yellowish silty infill (< 1 mm) and < 1 mm calcite infilling, yellowish staining, tight			
	75.5 R5 8.5 ft 100%	67	3 0	75.2' - Joint, 40 deg, rough, undulating, < 1 mm calcite infilling, no staining, tight 75.7, 76.0' - Joint, 60 deg, rough, undulating, < 1 mm calcite infilling, no staining, tight			R4 = 23.3 min
			1	77.2' - Joint, 60 deg, rough, undulating, < 1 mm calcite infilling, no staining, tight			
80			2 2	78.3' - Joint, 40 deg, rough, stepped, no staining, tight 78.8' - Joint, 60 deg, rough, undulating, no staining, tight			

CH2MHILL

PROJECT NUMBER:	BORING NUMBER:	
382653.FP.04.FW	MW-58	SHEET 5 OF 11

ROCK CORE LOG

PROJECT : PG&E Topock - ERGI

LOCATION : Site A (2100612.1 N, 7616131.8 E)

ELEVATION : 521.8 ft

DRILLING CONTRACTOR : Boart Longyear (D. Roberts)

CORING EQUIPMENT AND METHOD : Track-mounted Rig, LF-70 Drill Head and HQ-sized tools (diamond bit)

ORIENTATION : Vertical

WATER LEVELS : Approx. 66 ft BGS

START : 1/29/2009

END : 3/27/2009

LOGGER : A. Brewster (Northstar)

DEPTH AND ELEVATION BELOW SURFACE (ft)	CORE RUN, LENGTH, AND RECOVERY (%)	DISCONTINUITIES			SYMBOLIC LOG	LITHOLOGY	COMMENTS
		R Q D (%)	FRACTURES PER FOOT	DESCRIPTION DEPTH, TYPE, ORIENTATION, ROUGHNESS, PLANARITY, INFILLING MATERIAL AND THICKNESS, SURFACE STAINING, AND TIGHTNESS		ROCK TYPE, COLOR, MINERALOGY, TEXTURE, HARDNESS, WEATHERING, AND ROCK MASS CHARACTERISTICS	SIZE AND DEPTH OF CASING, FLUID LOSS, CORING RATE AND SMOOTHNESS, CAVING ROD DROPS, TEST RESULTS, ETC.
	84.0		1 >10 2 1	79.3, 79.6' - Joint, 40 deg, rough, undulating, no staining, tight 80.4' - Joint, 15 deg, rough, undulating, some red staining, tight 81.1' - Joint, 15 deg, rough, undulating, < 0.5 mm calcite infilling, no staining, tight 81.4-82.1' - Fracture zone, rough, undulating, < 1 mm calcite infilling, no staining, tight, 60 deg dip at 82.1' 82.5-84.0' - Joint, near 90 deg, rough, undulating, < 2 mm calcite infilling, no staining, tight		**Metadiorite (pTbr)** 65.5-206.0' - dusky yellowish green, (10GY 3/2), intermediate (dioritic) mineralogy, medium grained, strong (R4), unweathered, massive to foliated	R5 = 39.2 min
85	R6 1.5 ft 100% 85.5	80	1 2	84.9' - Joint, 25 deg, rough, undulating, < 1 mm calcite infilling, no staining, tight 85.3, 85.5' - Joint, 40 deg, rough, stepped, < 0.5 mm calcite infilling, no staining, tight			R6 = 4.5 min
90	R7 4.4 ft 100% 89.9	32	>10 >10 >10 >10	86' - Joint, 10 deg, rough, undulating, < 1 mm calcite infilling, no staining, tight 86.4' - Joint, 40 deg, rough, undulating, < 1 mm calcite infilling, yellowish staining, tight, 86.4-88.9' multiple fractures, rough, undulating, minor calcite growth (< 1 mm), some yellowish staining, tight. 60 deg dip at 88.9'.			R7 = 19.6 min
	R8 4.5 ft 100% 94.4	51	>10 2 2 >10	90.3' - Joint, 30 deg, rough, undulating, no staining, tight 90.5-90.9' - Fracture zone, rough, undulating, no staining, tight, 60 deg dip at 90.9' 91.3' - Joint, 60 deg, rough, undulating, reddish staining, tight 91.5' - Joint, 30 deg, rough, undulating, reddish staining, tight 92.4' - Joint, 10 deg, rough, undulating, calcite infilling, no staining, tight 92.8' - Joint, 40 deg, rough, undulating, reddish staining, tight 93.4-93.9' - Fracture zone, rough, undulating, brownish-grey microcrystalline infill (< 1 mm), reddish-yellow staining, tight, no reaction to HCl			R8 = 30.5 min
95	R9 1 ft 100% 95.4	33	>10	94.6-97.8' - Multiple healed fractures, rough, undulating, > 3 mm black infill, some rust-colored staining, tight.			R9 = 4.5 min
100	R10 4.6 ft 100% 100.0	17	>10 >10 >10 >10 >10	96.1' - Joint, 40 deg, rough, undulating, < 1 mm calcite infilling, no staining, tight 97.0, 97.9' - Joint, 60 deg, rough, undulating, no staining, tight 97.9-100.0' - Fracture zone, rough, undulating, < 1 mm black infill, reddish staining			R10 = 23.3 min

CH2MHILL

PROJECT NUMBER:	BORING NUMBER:
382653.FP.04.FW	MW-58 SHEET 6 OF 11

ROCK CORE LOG

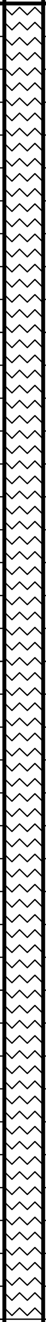
PROJECT : PG&E Topock - ERGI
LOCATION : Site A (2100612.1 N, 7616131.8 E)
ELEVATION : 521.8 ft
DRILLING CONTRACTOR : Boart Longyear (D. Roberts)
CORING EQUIPMENT AND METHOD : Track-mounted Rig, LF-70 Drill Head and HQ-sized tools (diamond bit)
ORIENTATION : Vertical
WATER LEVELS : Approx. 66 ft BGS
START : 1/29/2009
END : 3/27/2009
LOGGER : A. Brewster (Northstar)

DEPTH AND ELEVATION BELOW SURFACE (ft)	CORE RUN, LENGTH, AND RECOVERY (%)	DISCONTINUITIES: R Q D (%)	DISCONTINUITIES: FRACTURES PER FOOT	DISCONTINUITIES: DESCRIPTION — DEPTH, TYPE, ORIENTATION, ROUGHNESS, PLANARITY, INFILLING MATERIAL AND THICKNESS, SURFACE STAINING, AND TIGHTNESS	SYMBOLIC LOG	LITHOLOGY: ROCK TYPE, COLOR, MINERALOGY, TEXTURE, HARDNESS, WEATHERING, AND ROCK MASS CHARACTERISTICS	COMMENTS: SIZE AND DEPTH OF CASING, FLUID LOSS, CORING RATE AND SMOOTHNESS, CAVING ROD DROPS, TEST RESULTS, ETC.
			1	100.4' - Joint, 40 deg, rough, undulating, no staining, tight		**Metadiorite (pTbr)** 65.5-206.0' - dusky yellowish green, (10GY 3/2), intermediate (dioritic) mineralogy, medium grained, strong (R4), unweathered, massive to foliated	
			0				
	R11 5.5 ft 100%		0				
		100	2	103.1' - Joint, 20 deg, rough, undulating, < 0.5 mm calcite infilling, no staining, tight			
105			1	103.9' - Joint, 40 deg, rough, undulating, < 0.5 mm calcite infilling, no staining, tight 104.2' - Joint, 40 deg, rough, undulating, < 0.5 mm calcite infilling, some red staining, tight			
	105.5		0				R11 = 21.9 min
			1	106.4' - Joint, 40 deg, rough, undulating, no staining, tight			
			0				
			>10	108.3-108.7' - Fracture zone, rough, undulating, no staining, tight			
110	R12 9.7 ft 100%		0				
		79	0				
			1	111.1' - Joint, 30 deg, rough, undulating, no staining, tight			
			0				
			1	113' - Joint, 60 deg, rough, undulating, < 1 mm calcite infilling, reddish staining, tight			
115			2	114.1' - Joint, 40 deg, rough, undulating, < 2 mm calcite infilling, no staining, tight 114.7' - Joint, 15 deg, rough, undulating, < 1 mm calcite infilling, reddish staining, tight			R12 = 36.7 min
	115.2		1	115.3, 116.7, 116.8' - Joint, 35 deg, rough, undulating, < 2 mm calcite infilling, no staining, tight			Drilling to 115.2 ft bgs ends on 2/4/2009, following testing, drilling resumes on 3/25/2009.
			2				
			0				
			1	118.5' - Joint, 55 deg, rough, undulating, < 5 mm calcite infilling, no staining, tight			
120			0				

PROJECT NUMBER:	BORING NUMBER:
382653.FP.04.FW	MW-58 SHEET 7 OF 11

ROCK CORE LOG

PROJECT : PG&E Topock - ERGI
LOCATION : Site A (2100612.1 N, 7616131.8 E)
ELEVATION : 521.8 ft
DRILLING CONTRACTOR : Boart Longyear (D. Roberts)
CORING EQUIPMENT AND METHOD : Track-mounted Rig, LF-70 Drill Head and HQ-sized tools (diamond bit)
ORIENTATION : Vertical
WATER LEVELS : Approx. 66 ft BGS
START : 1/29/2009
END : 3/27/2009
LOGGER : A. Brewster (Northstar)

DEPTH AND ELEVATION BELOW SURFACE (ft)	CORE RUN, LENGTH, AND RECOVERY (%)	DISCONTINUITIES R Q D (%)	DISCONTINUITIES FRACTURES PER FOOT	DISCONTINUITIES DESCRIPTION: DEPTH, TYPE, ORIENTATION, ROUGHNESS, PLANARITY, INFILLING MATERIAL AND THICKNESS, SURFACE STAINING, AND TIGHTNESS	SYMBOLIC LOG	LITHOLOGY: ROCK TYPE, COLOR, MINERALOGY, TEXTURE, HARDNESS, WEATHERING, AND ROCK MASS CHARACTERISTICS	COMMENTS: SIZE AND DEPTH OF CASING, FLUID LOSS, CORING RATE AND SMOOTHNESS, CAVING ROD DROPS, TEST RESULTS, ETC.
	R13 10.8 ft 100%	100	1	120.7' - Joint, 35 deg, rough, undulating, < 2 mm calcite infilling, no staining, tight		**Metadiorite (pTbr)** 65.5-206.0' - dusky yellowish green, (10GY 3/2), intermediate (dioritic) mineralogy, medium grained, strong (R4), unweathered, massive to foliated	
			0				
			0				
			2	123.4, 123.5' - Joint, 35 deg and 45 deg, rough, undulating, < 1 mm calcite infilling, no staining, tight			
125			1	124.5' - Joint, 70 deg, rough, undulating, < 1 mm calcite infilling, no staining, moderately tight			
	126.0		0				R13 = 25.1 min
			0				
			1	127.2' - Joint, 65 deg, rough, undulating, < 2.5-inch dark reddish brown (10R 3/4) consolidated fine sediment infilling, no staining, tight			
	R14 6.5 ft 100%		0				
130		65	0				
			>10	130.2-132.5' - Fracture zone, rough, undulating to stepped, < 2 mm calcite infilling, reddish staining, no dominant orientation		130.2-132.5' - slightly weathered	
			>10				
	132.5		>10				R14 = 20.3 min
	R15 3.7 ft 100%		0				
135		100	0				
			1	135.7' - Joint, 15 deg, rough, undulating, < 1 mm calcite infilling, no staining, tight			
	136.2		0				R15 = 14.5 min
			0				
			0				
140			0				

PROJECT NUMBER: **382653.FP.04.FW**

BORING NUMBER: **MW-58** SHEET 8 OF 11

ROCK CORE LOG

PROJECT : PG&E Topock - ERGI

LOCATION : Site A (2100612.1 N, 7616131.8 E)

ELEVATION : 521.8 ft

DRILLING CONTRACTOR : Boart Longyear (D. Roberts)

CORING EQUIPMENT AND METHOD : Track-mounted Rig, LF-70 Drill Head and HQ-sized tools (diamond bit)

ORIENTATION : Vertical

WATER LEVELS : Approx. 66 ft BGS

START : 1/29/2009

END : 3/27/2009

LOGGER : A. Brewster (Northstar)

DEPTH AND ELEVATION BELOW SURFACE (ft)	CORE RUN, LENGTH, AND RECOVERY (%)	DISCONTINUITIES: R Q D (%)	DISCONTINUITIES: FRACTURES PER FOOT	DISCONTINUITIES: DESCRIPTION: DEPTH, TYPE, ORIENTATION, ROUGHNESS, PLANARITY, INFILLING MATERIAL AND THICKNESS, SURFACE STAINING, AND TIGHTNESS	SYMBOLIC LOG	LITHOLOGY: ROCK TYPE, COLOR, MINERALOGY, TEXTURE, HARDNESS, WEATHERING, AND ROCK MASS CHARACTERISTICS	COMMENTS: SIZE AND DEPTH OF CASING, FLUID LOSS, CORING RATE AND SMOOTHNESS, CAVING ROD DROPS, TEST RESULTS, ETC.
	R16 10.2 ft 100%		0			**Metadiorite (pTbr)** 65.5-206.0' - dusky yellowish green, (10GY 3/2), intermediate (dioritic) mineralogy, medium grained, strong (R4), unweathered, massive to foliated	
		100	0				
			0				
			1				
			1	143.9, 144.6' - Joint, 40 deg, rough, undulating to stepped, < 5 mm calcite infilling, no staining, moderately tight			
145			3	145.1, 145.3, 145.5' - Joint, 40 deg, rough, undulating, < 5 mm calcite infilling, reddish staining, tight to moderately tight			
	146.4		0				R16 = 33.0 min
			1	147.4' - Joint, 40 deg, rough, undulating, < 1 mm calcite infilling, no staining, tight			
			2	148.1, 148.3, 149.6' - Joint, 65 deg, rough, undulating, < 5 mm calcite infilling, reddish staining, tight			
			1				
150	R17 9.8 ft 100%		1	150.1, 152.9, 153.4, 154.5' - Joint, 25, 25, 25, and 65 deg, rough, undulating, < 1 mm calcite infilling, no staining, tight			
		90	0				
			1				
			1				
			1				
155			1	155.0, 156.1, 156.4, 156.7' - Joint, 30 deg, rough, undulating, < 1 mm calcite infilling, dark red to black staining, tight			
	156.2		3				R17 = 37.8 min
			0				
			1	158.5' - Joint, 85 deg, rough, undulating, < 1 mm calcite infilling, reddish staining, tight			
			0				
160							

PROJECT NUMBER:	BORING NUMBER:
382653.FP.04.FW	MW-58 SHEET 9 OF 11

ROCK CORE LOG

PROJECT : PG&E Topock - ERGI

LOCATION : Site A (2100612.1 N, 7616131.8 E)

ELEVATION : 521.8 ft

DRILLING CONTRACTOR : Boart Longyear (D. Roberts)

CORING EQUIPMENT AND METHOD : Track-mounted Rig, LF-70 Drill Head and HQ-sized tools (diamond bit)

ORIENTATION : Vertical

WATER LEVELS : Approx. 66 ft BGS

START : 1/29/2009

END : 3/27/2009

LOGGER : A. Brewster (Northstar)

DEPTH AND ELEVATION BELOW SURFACE (ft)	CORE RUN, LENGTH, AND RECOVERY (%)	DISCONTINUITIES R Q D (%)	FRACTURES PER FOOT	DESCRIPTION DEPTH, TYPE, ORIENTATION, ROUGHNESS, PLANARITY, INFILLING MATERIAL AND THICKNESS, SURFACE STAINING, AND TIGHTNESS	SYMBOLIC LOG	LITHOLOGY ROCK TYPE, COLOR, MINERALOGY, TEXTURE, HARDNESS, WEATHERING, AND ROCK MASS CHARACTERISTICS	COMMENTS SIZE AND DEPTH OF CASING, FLUID LOSS, CORING RATE AND SMOOTHNESS, CAVING ROD DROPS, TEST RESULTS, ETC.
	R18 10 ft 100%		0			**Metadiorite (pTbr)** 65.5-206.0' - dusky yellowish green, (10GY 3/2), intermediate (dioritic) mineralogy, medium grained, strong (R4), unweathered, massive to foliated	
		80	0				
			0				
			0				
165			>10	164.5-166.7' - Fracture zone, rough, undulating, < 1 mm calcite infilling, reddish staining, no dominant orientation, moderately tight			
	166.2		>10				
			>10				R18 = 39.0 min
			1	167.4' - Joint, 65 deg, rough, undulating, < 3 mm calcite infilling, no staining, moderately tight			
	R19 7 ft 100%		>10	168.2-169.0' - Fracture zone, rough, undulating, < 5 mm calcite infilling, no staining, no dominant orientation, tight			
170		57	1	169.5, 170.5' - Joint, 65 deg, rough, undulating, < 3 mm calcite infilling, no staining, tight			
			1				
			1	171.5' - Joint, 30 deg, rough, undulating, < 1 mm calcite infilling, reddish staining, tight		171.7-172.2' - medium to coarse grained	
	173.2		>10	171.7-178.0' - Fracture zone, rough, undulating, reddish staining, tight		172.2-177.4' - yellowish gray, (5Y 8/1), largely felsic mineralogy, fine grained, unweathered	
	R20 2 ft 100%		>10				R19 = 38.0 min
175	175.2	40	>10				
	R21 2 ft 100%		>10				R20 = 11.3 min
	177.2	20	>10				
			>10			177.4-179.4' - light grey (N7), largely felsic mineralogy, coarse grained, unweathered	R21 = 12.2 min
	R22 4.3 ft 100%		3	178.1, 178.3, 178.7' - Joint, 45, 45, 85 deg, rough, undulating, < 1 mm fine-grained white sediment/silt (no reaction to HCl) infilling, no staining, moderately tight			
180		81	1			179.4' - fine grained	

PROJECT NUMBER:	BORING NUMBER:
382653.FP.04.FW	**MW-58** SHEET 10 OF 11

ROCK CORE LOG

PROJECT : PG&E Topock - ERGI
LOCATION : Site A (2100612.1 N, 7616131.8 E)
ELEVATION : 521.8 ft
DRILLING CONTRACTOR : Boart Longyear (D. Roberts)
CORING EQUIPMENT AND METHOD : Track-mounted Rig, LF-70 Drill Head and HQ-sized tools (diamond bit)
ORIENTATION : Vertical
WATER LEVELS : Approx. 66 ft BGS
START : 1/29/2009
END : 3/27/2009
LOGGER : A. Brewster (Northstar)

DEPTH AND ELEVATION BELOW SURFACE (ft)	CORE RUN, LENGTH, AND RECOVERY (%)	DISCONTINUITIES			SYMBOLIC LOG	LITHOLOGY	COMMENTS
		R Q D (%)	FRACTURES PER FOOT	DESCRIPTION DEPTH, TYPE, ORIENTATION, ROUGHNESS, PLANARITY, INFILLING MATERIAL AND THICKNESS, SURFACE STAINING, AND TIGHTNESS		ROCK TYPE, COLOR, MINERALOGY, TEXTURE, HARDNESS, WEATHERING, AND ROCK MASS CHARACTERISTICS	SIZE AND DEPTH OF CASING, FLUID LOSS, CORING RATE AND SMOOTHNESS, CAVING ROD DROPS, TEST RESULTS, ETC.
			1	179.7, 180.7' - Joint, 60 deg, rough, undulating, < 1 mm calcite infilling, reddish staining, tight		**Metadiorite (pTbr)** 65.5-206.0' - dusky yellowish green, (10GY 3/2), intermediate (dioritic) mineralogy, medium grained, strong (R4), unweathered, massive to foliated	
	181.5		>10	181.2-181.5' - Fracture zone, rough, undulating, reddish staining, no dominant orientation, tight			R22 = 24.0 min
			0			182.3-183.2' - coarse grained	
	R23 4.5 ft 100%	100	0				
185			3	184.0, 184.1, 184.5' - Joint, 60 deg, rough, undulating, < 3 mm white silt/clay infilling (no HCl reaction, greasy when wet), no staining, tight		184.5-185.0' - increase in felsic minerals	
	186.0		1	185.6, 186.8, 186.9' - Joint, 25, 25, and 55 deg, rough, undulating, < 2 mm calcite infilling, no staining, tight			R23 = 17.8 min
			2				
			>10	187.2-187.9' - Fracture zone, rough, undulating, < 1 mm calcite infilling, reddish staining, no dominant orientation, moderately tight		187.0-195.2' - medium grained	
	R24 6.5 ft 100%		3	188.3, 2 at 188.7' - Joint, 60, 85, and 85 deg, rough, undulating, < 1 mm calcite infilling, rusty staining, tight			
190		62	2	189.1, 189.6, 190.3' - Joint, 75, 15, and 75 deg, rough, undulating, < 2 mm calcite infilling, rusty staining, moderately tight			
			1				
			>10	191.5-192.5' - Fracture zone, rough, undulating, rusty staining, no dominant orientation, tight			
	192.5		>10				R24 = 39.0 min
	R25 3.5 ft 100%		1	193.3, 194.1, 194.3, 194.7' - Joint, 25 deg, rough to smooth, undulating, rusty staining, tight			
195		57	3				
	196.0		>10	195.0-198.8' - Fracture zone, rough, undulating, reddish staining, no dominant orientation, tight		195.2-197.3' - yellowish grey (5Y 8/1), largely felsic minerals, fine grained, unweathered	R25 = 13.0 min
	R26 2.6 ft 100%		>10				
		23	>10				
	198.6		>10	198.1, 199.4, 199.7' - Joint, 30 deg, rough, stepped to undulating, < 1 mm calcite infilling, reddish staining, tight			R26 = 17.7 min
200			3				

CH2MHILL

PROJECT NUMBER:	BORING NUMBER:
382653.FP.04.FW	MW-58 SHEET 11 OF 11

ROCK CORE LOG

PROJECT : PG&E Topock - ERGI

LOCATION : Site A (2100612.1 N, 7616131.8 E)

ELEVATION : 521.8 ft

DRILLING CONTRACTOR : Boart Longyear (D. Roberts)

CORING EQUIPMENT AND METHOD : Track-mounted Rig, LF-70 Drill Head and HQ-sized tools (diamond bit)

ORIENTATION : Vertical

WATER LEVELS : Approx. 66 ft BGS

START : 1/29/2009

END : 3/27/2009

LOGGER : A. Brewster (Northstar)

DEPTH AND ELEVATION BELOW SURFACE (ft)	CORE RUN, LENGTH, AND RECOVERY (%)	DISCONTINUITIES R Q D (%)	DISCONTINUITIES FRACTURES PER FOOT	DISCONTINUITIES DESCRIPTION: DEPTH, TYPE, ORIENTATION, ROUGHNESS, PLANARITY, INFILLING MATERIAL AND THICKNESS, SURFACE STAINING, AND TIGHTNESS	SYMBOLIC LOG	LITHOLOGY: ROCK TYPE, COLOR, MINERALOGY, TEXTURE, HARDNESS, WEATHERING, AND ROCK MASS CHARACTERISTICS	COMMENTS: SIZE AND DEPTH OF CASING, FLUID LOSS, CORING RATE AND SMOOTHNESS, CAVING ROD DROPS, TEST RESULTS, ETC.
	R27 4.4 ft 100% 203.0	39	3 0 >10	200.1, 200.6, 200.9' - Joint, 60, 30, and 30 deg, rough, undulating to stepped, < 1 mm calcite infilling, reddish staining, moderately tight 202.0-206.0' - Fracture zone, rough, undulating to stepped, < 3 mm calcite infilling, reddish staining, moderately tight		**Metadiorite (pTbr)** 199.1-206.0' - greenish gray, (5GY 6/1), intermediate (dioritic) mineralogy, medium grained, strong (R4), unweathered, massive to foliated	R27 = 27.0 min
205	R28 3 ft 100% 206.0	17	>10 >10 >10				
						End Drilling on 3/27/2009 Total Borehole Depth: 206.0 ft bgs	
210							
215							
220							

PROJECT NUMBER:	BORING NUMBER:
382653.FP.04.FW	MW-59 SHEET 1 OF 6

SOIL BORING LOG

PROJECT : PG&E Topock - ERGI
LOCATION : Site G (2100852.0 N, 7616081.9 E)
ELEVATION : 538.9 ft
DRILLING CONTRACTOR : Boart Longyear (D. Roberts)
DRILLING EQUIPMENT AND METHOD : Track-mounted Rig, Rotosonic drill head and tools
ORIENTATION : Vertical
WATER LEVELS : Approx. 84 ft BGS
START : 2/25/2009
END : 2/26/2009
LOGGER : A. Brewster (Northstar)

DEPTH BELOW EXISTING GRADE (ft)	INTERVAL (ft)	RECOVERY (in)	LAB SAMPLE	USCS CODE/ LITHOLOGY	SOIL DESCRIPTION: SOIL NAME, USCS GROUP SYMBOL, COLOR, MOISTURE CONTENT, RELATIVE DENSITY OR CONSISTENCY, SOIL STRUCTURE, MINERALOGY	SYMBOLIC LOG	COMMENTS: DEPTH OF CASING, DRILLING RATE, DRILLING FLUID LOSS, TESTS, AND INSTRUMENTATION
		COMPLETE			**Silty Sand (SM)** 0-82.0' - brown, (10YR 4/3), dry, loose, 10% gravel, 75% sand, 15% fines, angular to subangular, poor to moderate grading, matrix supported, max clast size = 80 mm.		Target depth of boring is 15 feet past static water level.
					3.5-18.5' - yellowish brown, (10YR 5/4)		
5							
10				SM			
15							
					18.5-71.0' brown, (10YR 4/3)		
20							

CH2MHILL

PROJECT NUMBER: 382653.FP.04.FW

BORING NUMBER: MW-59 SHEET 2 OF 6

SOIL BORING LOG

PROJECT : PG&E Topock - ERGI
LOCATION : Site G (2100852.0 N, 7616081.9 E)
ELEVATION : 538.9 ft
DRILLING CONTRACTOR : Boart Longyear (D. Roberts)
DRILLING EQUIPMENT AND METHOD : Track-mounted Rig, Rotosonic drill head and tools
ORIENTATION : Vertical
WATER LEVELS : Approx. 84 ft BGS
START : 2/25/2009
END : 2/26/2009
LOGGER : A. Brewster (Northstar)

DEPTH BELOW EXISTING GRADE (ft)	INTERVAL (ft)	RECOVERY (in)	LAB SAMPLE	USCS CODE/ LITHOLOGY	SOIL DESCRIPTION	SYMBOLIC LOG	COMMENTS
					SOIL NAME, USCS GROUP SYMBOL, COLOR, MOISTURE CONTENT, RELATIVE DENSITY OR CONSISTENCY, SOIL STRUCTURE, MINERALOGY		DEPTH OF CASING, DRILLING RATE, DRILLING FLUID LOSS, TESTS, AND INSTRUMENTATION
		COMPLETE			**Silty Sand (SM)** 0-82.0' - brown from 18.5', (10YR 4/3), dry, loose, 10% gravel, 75% sand, 15% fines, angular to subangular, poor to moderate grading, matrix supported, max clast size = 80 mm.		
25							
30				SM			
35							
40							

CH2MHILL

PROJECT NUMBER:	BORING NUMBER:
382653.FP.04.FW	MW-59 SHEET 3 OF 6

SOIL BORING LOG

PROJECT : PG&E Topock - ERGI
LOCATION : Site G (2100852.0 N, 7616081.9 E)
ELEVATION : 538.9 ft
DRILLING CONTRACTOR : Boart Longyear (D. Roberts)
DRILLING EQUIPMENT AND METHOD : Track-mounted Rig, Rotosonic drill head and tools
ORIENTATION : Vertical
WATER LEVELS : Approx. 84 ft BGS
START : 2/25/2009
END : 2/26/2009
LOGGER : A. Brewster (Northstar)

DEPTH BELOW EXISTING GRADE (ft)	INTERVAL (ft)	RECOVERY (in)	LAB SAMPLE	USCS CODE/ LITHOLOGY	SOIL DESCRIPTION SOIL NAME, USCS GROUP SYMBOL, COLOR, MOISTURE CONTENT, RELATIVE DENSITY OR CONSISTENCY, SOIL STRUCTURE, MINERALOGY	SYMBOLIC LOG	COMMENTS DEPTH OF CASING, DRILLING RATE, DRILLING FLUID LOSS, TESTS, AND INSTRUMENTATION
45 50 55 60		COMPLETE		SM	**Silty Sand (SM)** 0-82.0' - brown from 18.5', (10YR 4/3), dry, loose, 10% gravel, 75% sand, 15% fines, angular to subangular, poor to moderate grading, matrix supported, max clast size = 80 mm.		

CH2MHILL

PROJECT NUMBER:	BORING NUMBER:
382653.FP.04.FW	MW-59 SHEET 4 OF 6

SOIL BORING LOG

PROJECT : PG&E Topock - ERGI
LOCATION : Site G (2100852.0 N, 7616081.9 E)
ELEVATION : 538.9 ft
DRILLING CONTRACTOR : Boart Longyear (D. Roberts)
DRILLING EQUIPMENT AND METHOD : Track-mounted Rig, Rotosonic drill head and tools
ORIENTATION : Vertical
WATER LEVELS : Approx. 84 ft BGS
START : 2/25/2009
END : 2/26/2009
LOGGER : A. Brewster (Northstar)

DEPTH BELOW EXISTING GRADE (ft)	INTERVAL (ft)	RECOVERY (in)	LAB SAMPLE	USCS CODE/ LITHOLOGY	SOIL DESCRIPTION SOIL NAME, USCS GROUP SYMBOL, COLOR, MOISTURE CONTENT, RELATIVE DENSITY OR CONSISTENCY, SOIL STRUCTURE, MINERALOGY	SYMBOLIC LOG	COMMENTS DEPTH OF CASING, DRILLING RATE, DRILLING FLUID LOSS, TESTS, AND INSTRUMENTATION
		COMPLETE			**Silty Sand (SM)** 0-82.0' - brown from 18.5', (10YR 4/3), dry, loose, 10% gravel, 75% sand, 15% fines, angular to subangular, poor to moderate grading, matrix supported, max clast size = 80 mm.		
65							
70				SM			
					71.0-82.0' brown, (7.5YR 4/3)		
75							
80							

PROJECT NUMBER:	BORING NUMBER:	
382653.FP.04.FW	MW-59	SHEET 5 OF 6

SOIL BORING LOG

PROJECT : PG&E Topock - ERGI
LOCATION : Site G (2100852.0 N, 7616081.9 E)
ELEVATION : 538.9 ft
DRILLING CONTRACTOR : Boart Longyear (D. Roberts)
DRILLING EQUIPMENT AND METHOD : Track-mounted Rig, Rotosonic drill head and tools
ORIENTATION : Vertical
WATER LEVELS : Approx. 84 ft BGS
START : 2/25/2009
END : 2/26/2009
LOGGER : A. Brewster (Northstar)

DEPTH BELOW EXISTING GRADE (ft)	INTERVAL (ft)	RECOVERY (in)	LAB SAMPLE	USCS CODE/ LITHOLOGY	SOIL DESCRIPTION SOIL NAME, USCS GROUP SYMBOL, COLOR, MOISTURE CONTENT, RELATIVE DENSITY OR CONSISTENCY, SOIL STRUCTURE, MINERALOGY	SYMBOLIC LOG	COMMENTS DEPTH OF CASING, DRILLING RATE, DRILLING FLUID LOSS, TESTS, AND INSTRUMENTATION
		COMPLETE		SM	**Silty Sand (SM)** 0-82.0' - brown from 71.0', (7.5YR 4/3), dry, loose, 10% gravel, 75% sand, 15% fines, angular to subangular, poor to moderate grading, matrix supported, max clast size = 80 mm.		
					Poorly Graded Sand With Gravel (SP) 82.0-101.0' - dark brown, (10YR 3/3), dry, loose to medium dense, 40% gravel, 60% sand, 0% fines, subangular to subrounded, poorly graded, matrix supported, max clast size = 50 mm. 83.0' - moist 84.0' - saturated		
85							
90				SP			
95					95.0' - very dark greyish brown (10YR 3/3)		
					97.5' - a mixture of very dark greyish brown, (10YR 3/2), and dark reddish brown, (5YR 3/4)		
100							

PROJECT NUMBER:	BORING NUMBER:
382653.FP.04.FW	MW-59 SHEET 6 OF 6

SOIL BORING LOG

PROJECT : PG&E Topock - ERGI LOCATION : Site G (2100852.0 N, 7616081.9 E)

ELEVATION : 538.9 ft DRILLING CONTRACTOR : Boart Longyear (D. Roberts)

DRILLING EQUIPMENT AND METHOD : Track-mounted Rig, Rotosonic drill head and tools ORIENTATION : Vertical

WATER LEVELS : Approx. 84 ft BGS START : 2/25/2009 END : 2/26/2009 LOGGER : A. Brewster (Northstar)

DEPTH BELOW EXISTING GRADE (ft)	INTERVAL (ft)	RECOVERY (in)	LAB SAMPLE	USCS CODE/ LITHOLOGY	SOIL DESCRIPTION SOIL NAME, USCS GROUP SYMBOL, COLOR, MOISTURE CONTENT, RELATIVE DENSITY OR CONSISTENCY, SOIL STRUCTURE, MINERALOGY	SYMBOLIC LOG	COMMENTS DEPTH OF CASING, DRILLING RATE, DRILLING FLUID LOSS, TESTS, AND INSTRUMENTATION
		COMPLETE		SP	**Poorly Graded Sand With Gravel (SP)** 82.0-101.0' - mixture of very dark greyish brown, (10YR 3/2), and dark reddish brown, (5YR 3/4), from 97.0', loose to medium dense, 40% gravel, 60% sand, 0% fines, subangular to subrounded, poorly graded, saturated from 84.0', matrix supported, max clast size = 50 mm. End Drilling on 2/26/2009 Total Borehole Depth: 101.0 ft bgs		
105							
110							
115							
120							

PROJECT NUMBER: 382653.FP.04.FW	BORING NUMBER: MW-60 SHEET 1 OF 7

SOIL BORING LOG

PROJECT : PG&E Topock - ERGI
LOCATION : Site F (2100491.6 N, 7616434.8 E)
ELEVATION : 555.8 ft
DRILLING CONTRACTOR : Boart Longyear (D. Roberts)
DRILLING EQUIPMENT AND METHOD : Track-mounted Rig, Rotosonic drill head and tools
ORIENTATION : Vertical
WATER LEVELS : Approx. 98 ft BGS
START : 2/27/2009
END : 3/3/2009
LOGGER : A. Brewster (Northstar)

DEPTH BELOW EXISTING GRADE (ft)	INTERVAL (ft)	RECOVERY (in)	LAB SAMPLE	USCS CODE/ LITHOLOGY	SOIL DESCRIPTION SOIL NAME, USCS GROUP SYMBOL, COLOR, MOISTURE CONTENT, RELATIVE DENSITY OR CONSISTENCY, SOIL STRUCTURE, MINERALOGY	SYMBOLIC LOG	COMMENTS DEPTH OF CASING, DRILLING RATE, DRILLING FLUID LOSS, TESTS, AND INSTRUMENTATION
5		COMPLETE		SM	**Silty Sand (SM)** 0.0-9.0' - dark yellowish brown, (10YR 4/4), dry, loose, 15% gravel, 60% sand, 25% fines, angular to subangular, poorly graded, no dominant mineralogy, matrix supported, max clast size = 60 mm.		Boring initially drilled to 86.5' bgs using Rotosonic tools up to 6-in in diameter. 6-in conductor casing then used as a temporary conductor casing to facilitate rotary core drilling. Boring drilled from 86.5' bgs to a total depth of 123.0' bgs using diamond bit rotary core tools (HQ-size, 3.8-in diameter), and then overdrilled to total depth using 6-in Rotosonic tools.
10 15				pTbr	**Metadiorite (pTbr)** 9.0-86.5' - bedrock is consolidated. Drilling method pulverizes most of the core. Intact portions of core are described, as appropriate.		
20					16.0-26.0'- greyish green (5G 5/2), fine grained, some calcite infill (1 mm max) and reddish staining observed on fracture surfaces		

PROJECT NUMBER:	BORING NUMBER:
382653.FP.04.FW	MW-60 SHEET 2 OF 7

SOIL BORING LOG

PROJECT : PG&E Topock - ERGI
LOCATION : Site F (2100491.6 N, 7616434.8 E)
ELEVATION : 555.8 ft
DRILLING CONTRACTOR : Boart Longyear (D. Roberts)
DRILLING EQUIPMENT AND METHOD : Track-mounted Rig, Rotosonic drill head and tools
ORIENTATION : Vertical
WATER LEVELS : Approx. 98 ft BGS
START : 2/27/2009
END : 3/3/2009
LOGGER : A. Brewster (Northstar)

DEPTH BELOW EXISTING GRADE (ft)	INTERVAL (ft)	RECOVERY (in)	LAB SAMPLE	USCS CODE/ LITHOLOGY	SOIL DESCRIPTION: SOIL NAME, USCS GROUP SYMBOL, COLOR, MOISTURE CONTENT, RELATIVE DENSITY OR CONSISTENCY, SOIL STRUCTURE, MINERALOGY	SYMBOLIC LOG	COMMENTS: DEPTH OF CASING, DRILLING RATE, DRILLING FLUID LOSS, TESTS, AND INSTRUMENTATION
		COMPLETE			**Metadiorite (pTbr)** 16.0-26.0'- greyish green (5G 5/2), fine grained, some calcite infill (1 mm max) and reddish staining observed on fracture surfaces		
25							
					26.0-35.0'- dusky yellowish green (10GY 3/2), fine grained, some calcite infill (1 mm max) and reddish staining observed on fracture surfaces		
30				pTbr			
35							
					36.0-73.0'- dusky green (5G 3/2), fine grained, no infill, very little reddish staining on fracture surfaces		
40							

PROJECT NUMBER:	BORING NUMBER:
382653.FP.04.FW	MW-60 SHEET 3 OF 7

SOIL BORING LOG

PROJECT : PG&E Topock - ERGI
LOCATION : Site F (2100491.6 N, 7616434.8 E)
ELEVATION : 555.8 ft
DRILLING CONTRACTOR : Boart Longyear (D. Roberts)
DRILLING EQUIPMENT AND METHOD : Track-mounted Rig, Rotosonic drill head and tools
ORIENTATION : Vertical
WATER LEVELS : Approx. 98 ft BGS
START : 2/27/2009
END : 3/3/2009
LOGGER : A. Brewster (Northstar)

DEPTH BELOW EXISTING GRADE (ft)	INTERVAL (ft)	RECOVERY (in)	LAB SAMPLE	USCS CODE/ LITHOLOGY	SOIL DESCRIPTION SOIL NAME, USCS GROUP SYMBOL, COLOR, MOISTURE CONTENT, RELATIVE DENSITY OR CONSISTENCY, SOIL STRUCTURE, MINERALOGY	SYMBOLIC LOG	COMMENTS DEPTH OF CASING, DRILLING RATE, DRILLING FLUID LOSS, TESTS, AND INSTRUMENTATION
		COMPLETE			**Metadiorite (pTbr)** 36.0-73.0'- dusky green (5G 3/2), fine grained, no infill, very little reddish staining on fracture surfaces		
45							
50				pTbr			
55							
60							

CH2MHILL

PROJECT NUMBER:	BORING NUMBER:	
382653.FP.04.FW	MW-60	SHEET 4 OF 7

SOIL BORING LOG

PROJECT : PG&E Topock - ERGI
LOCATION : Site F (2100491.6 N, 7616434.8 E)
ELEVATION : 555.8 ft
DRILLING CONTRACTOR : Boart Longyear (D. Roberts)
DRILLING EQUIPMENT AND METHOD : Track-mounted Rig, Rotosonic drill head and tools
ORIENTATION : Vertical
WATER LEVELS : Approx. 98 ft BGS
START : 2/27/2009
END : 3/3/2009
LOGGER : A. Brewster (Northstar)

DEPTH BELOW EXISTING GRADE (ft)	INTERVAL (ft)	RECOVERY (in)	LAB SAMPLE	USCS CODE/ LITHOLOGY	SOIL DESCRIPTION SOIL NAME, USCS GROUP SYMBOL, COLOR, MOISTURE CONTENT, RELATIVE DENSITY OR CONSISTENCY, SOIL STRUCTURE, MINERALOGY	SYMBOLIC LOG	COMMENTS DEPTH OF CASING, DRILLING RATE, DRILLING FLUID LOSS, TESTS, AND INSTRUMENTATION
		COMPLETE			**Metadiorite (pTbr)** 36.0-73.0'- dusky green (5G 3/2), fine grained, no infill, very little reddish staining on fracture surfaces		
65							
70				pTbr			
					73.0-86.5'- dusky green (5G 3/2) rock mass with very light grey (N8) mottling, medium grained, calcite infill and reddish staining on fracture surfaces		73.0-86.5'- Nearly 100% of core recovered is intact.
75							
80							

PROJECT NUMBER:	BORING NUMBER:
382653.FP.04.FW	**MW-60** SHEET 5 OF 7

SOIL BORING LOG

PROJECT : PG&E Topock - ERGI
LOCATION : Site F (2100491.6 N, 7616434.8 E)
ELEVATION : 555.8 ft
DRILLING CONTRACTOR : Boart Longyear (D. Roberts)
DRILLING EQUIPMENT AND METHOD : Track-mounted Rig, Rotosonic drill head and tools
ORIENTATION : Vertical
WATER LEVELS : Approx. 98 ft BGS
START : 2/27/2009
END : 3/3/2009
LOGGER : A. Brewster (Northstar)

DEPTH BELOW EXISTING GRADE (ft)	INTERVAL (ft)	RECOVERY (in)	LAB SAMPLE	USCS CODE/ LITHOLOGY	SOIL DESCRIPTION SOIL NAME, USCS GROUP SYMBOL, COLOR, MOISTURE CONTENT, RELATIVE DENSITY OR CONSISTENCY, SOIL STRUCTURE, MINERALOGY	SYMBOLIC LOG	COMMENTS DEPTH OF CASING, DRILLING RATE, DRILLING FLUID LOSS, TESTS, AND INSTRUMENTATION
85	86.5	COMPLETE		pTbr	73.0-86.5'- dusky green (5G 3/2) rock mass with very light grey (N8) mottling, medium grained, calcite infill and reddish staining on fracture surfaces		Total depth of initial Rotosonic boring is 86.5 ft bgs. Begin rotary core drilling.
90 95 100					Begin rock coring from 86.5 ft bgs See the next page for the rock core log.		

CH2MHILL

PROJECT NUMBER:	BORING NUMBER:
382653.FP.04.FW	MW-60 SHEET 6 OF 7

ROCK CORE LOG

PROJECT : PG&E Topock - ERGI

LOCATION : Site F (2100491.6 N, 7616434.8 E)

ELEVATION : 555.8 ft

DRILLING CONTRACTOR : Boart Longyear (D. Roberts)

CORING EQUIPMENT AND METHOD : Track-mounted Rig, LF-70 Drill Head and HQ-sized tools (diamond bit)

ORIENTATION : Vertical

WATER LEVELS : Approx. 98 ft BGS

START : 2/27/2009

END : 3/3/2009

LOGGER : A. Brewster (Northstar)

DEPTH AND ELEVATION BELOW SURFACE (ft)	CORE RUN, LENGTH, AND RECOVERY (%)	DISCONTINUITIES: R Q D (%)	DISCONTINUITIES: FRACTURES PER FOOT	DISCONTINUITIES: DESCRIPTION: DEPTH, TYPE, ORIENTATION, ROUGHNESS, PLANARITY, INFILLING MATERIAL AND THICKNESS, SURFACE STAINING, AND TIGHTNESS	SYMBOLIC LOG	LITHOLOGY: ROCK TYPE, COLOR, MINERALOGY, TEXTURE, HARDNESS, WEATHERING, AND ROCK MASS CHARACTERISTICS	COMMENTS: SIZE AND DEPTH OF CASING, FLUID LOSS, CORING RATE AND SMOOTHNESS, CAVING ROD DROPS, TEST RESULTS, ETC.
	86.5		>10	86.5-89.5' - Fracture zone, rough, undulating, < 1 mm calcite infilling, reddish staining, no dominant orientation		**Metadiorite (pTbr)** 86.5-123.0' - dusky green, (5G 3/2), intermediate (dioritic) mineralogy, medium grained, unweathered, massive to foliated	General Note: The metadiorite bedrock exhibits many small healed fractures (1-3 mm) of somewhat random orientation. These healed fractures create weaknesses in the rock. It can be difficult to determine if the metadiorite is jointed in-situ, or if the discontinuities are caused by the drilling method. Intervals with fracture per foot counts >10 are likely caused by drilling. R1 = 23.0 min
	R1 3 ft 100%	0	>10				
			>10				
	89.5		>10	89.5-96.5' - Fracture zone, 30 deg, rough, undulating, < 1 mm calcite infilling, reddish staining, tight			
90			2				
			2				
	R2 7 ft 100%	53	3			92.0' - fine grained	
			2				
			>10				
95			>10				
	96.5		0				R2 = 36.0 min
			1	97' - Joint, 60 deg, rough, undulating, < 1 mm calcite infilling, reddish staining, tight			
			0				
			1				
100			1	100' - Joint, 60 deg, rough, undulating, < 1 mm calcite infilling, no staining, tight 100.5-105.0' - Fracture zone, 30 deg and 60 deg, rough, undulating, < 1 mm calcite infilling, reddish staining, rusty staining at 102.5' and 103.6', tight.			
	R3 9.9 ft 100%	48	2				
			1				
			1				
			1			104.5' - medium grained	
105			0				
	106.4						R3 = 50.0 min

CH2MHILL

PROJECT NUMBER:	BORING NUMBER:
382653.FP.04.FW	MW-60 SHEET 7 OF 7

ROCK CORE LOG

PROJECT : PG&E Topock - ERGI LOCATION : Site F (2100491.6 N, 7616434.8 E)

ELEVATION : 555.8 ft DRILLING CONTRACTOR : Boart Longyear (D. Roberts)

CORING EQUIPMENT AND METHOD : Track-mounted Rig, LF-70 Drill Head and HQ-sized tools (diamond bit) ORIENTATION : Vertical

WATER LEVELS : Approx. 98 ft BGS START : 2/27/2009 END : 3/3/2009 LOGGER : A. Brewster (Northstar)

DEPTH AND ELEVATION BELOW SURFACE (ft)	CORE RUN, LENGTH, AND RECOVERY (%)	DISCONTINUITIES: R Q D (%)	DISCONTINUITIES: FRACTURES PER FOOT	DISCONTINUITIES: DESCRIPTION: DEPTH, TYPE, ORIENTATION, ROUGHNESS, PLANARITY, INFILLING MATERIAL AND THICKNESS, SURFACE STAINING, AND TIGHTNESS	SYMBOLIC LOG	LITHOLOGY: ROCK TYPE, COLOR, MINERALOGY, TEXTURE, HARDNESS, WEATHERING, AND ROCK MASS CHARACTERISTICS	COMMENTS: SIZE AND DEPTH OF CASING, FLUID LOSS, CORING RATE AND SMOOTHNESS, CAVING ROD DROPS, TEST RESULTS, ETC.
	R4 6 ft 100%	90	1			**Metadiorite (pTbr)** 86.5-123.0' - dusky green, (5G 3/2), intermediate (dioritic) mineralogy, medium grained, unweathered, massive to foliated	
			1	107.5' - Joint, 70 deg, rough, undulating, < 1 mm calcite infilling, reddish staining, tight			
			0				
			0				
110			0			110.5' - coarse grained	
			0				
112.4	R5 3.6 ft 100%	0	1	112.0-115.0' - Fracture zone or mechanical break, 30 deg and 60 deg, < 1 mm calcite infilling, rusty-reddish staining, tight, likely mechanical breaks along healed joints		112.0' - fine grained	R4 = 33.0 min
			1			113.5' - yellow-orange staining	
			1				
115			>10	115.0-116.0' - Fracture zone, rough, undulating, no staining, no dominant orientation			
116.0	R6 7 ft 100%	77	1	116.0-123.0' - Fracture zone, 30 deg, rough, undulating, < 0.05 mm calcite infilling, no staining, tight			R5 = 45.0 min
			1				
			2				
			1				
120			0				
			1			121.0-122.0' - yellow-orange staining	
			1				R6 = 31.0 min
123.0						End Drilling on 3/3/2009 Total Borehole Depth: 123.0 ft bgs	
125							

PROJECT NUMBER:	BORING NUMBER:
382653.FP.04.FW	**MW-61** SHEET 1 OF 7

SOIL BORING LOG

PROJECT : PG&E Topock - ERGI
LOCATION : Site C (2100713.0 N, 7616591.0 E)
ELEVATION : 544.1 ft
DRILLING CONTRACTOR : Boart Longyear (D. Roberts)
DRILLING EQUIPMENT AND METHOD : Track-mounted Rig, Rotosonic drill head and tools
ORIENTATION : Vertical
WATER LEVELS : Approx. 87 ft BGS
START : 3/4/2009
END : 3/12/2009
LOGGER : A. Brewster (Northstar)

DEPTH BELOW EXISTING GRADE (ft)	INTERVAL (ft)	RECOVERY (in)	LAB SAMPLE	USCS CODE/ LITHOLOGY	SOIL DESCRIPTION SOIL NAME, USCS GROUP SYMBOL, COLOR, MOISTURE CONTENT, RELATIVE DENSITY OR CONSISTENCY, SOIL STRUCTURE, MINERALOGY	SYMBOLIC LOG	COMMENTS DEPTH OF CASING, DRILLING RATE, DRILLING FLUID LOSS, TESTS, AND INSTRUMENTATION
		COMPLETE		SM	**Silty Sand With Gravel (SM)** 0.0-14.0' - dark brown, (7.5YR 3/3), dry, loose, 30% gravel, 50% sand, 20% fines, sand is angular to subangular, poorly graded, no dominant mineralogy, matrix supported, max clast size = 40 mm		Boring initially drilled to 68.0' bgs using Rotosonic tools up to 6-in in diameter. 6-in Rotosonic casing then used as a temporary conductor casing to facilitate the rotary core drilling. Boring drilled from 68.0' bgs to a total depth of 112.4' bgs using diamond bit rotary core tools (HQ-size, 3.8-in diameter) and then overdrilled to total depth using 6-in Rotosonic tools.
5							
10							
				SP-SM	**Poorly Graded Sand With Silt And Gravel (SP-SM)** 14.0-63.0' - dark brown, (7.5YR 3/3), dry, loose, 20% gravel, 70% sand, 10% fines, sand is angular to subangular, poorly graded, no dominant mineralogy, matrix supported, max clast size = 50 mm		
15							
20							

PROJECT NUMBER:	BORING NUMBER:
382653.FP.04.FW	**MW-61** SHEET 2 OF 7

SOIL BORING LOG

PROJECT : PG&E Topock - ERGI
LOCATION : Site C (2100713.0 N, 7616591.0 E)
ELEVATION : 544.1 ft
DRILLING CONTRACTOR : Boart Longyear (D. Roberts)
DRILLING EQUIPMENT AND METHOD : Track-mounted Rig, Rotosonic drill head and tools
ORIENTATION : Vertical
WATER LEVELS : Approx. 87 ft BGS
START : 3/4/2009
END : 3/12/2009
LOGGER : A. Brewster (Northstar)

DEPTH BELOW EXISTING GRADE (ft)	INTERVAL (ft)	RECOVERY (in)	LAB SAMPLE	USCS CODE/ LITHOLOGY	SOIL DESCRIPTION SOIL NAME, USCS GROUP SYMBOL, COLOR, MOISTURE CONTENT, RELATIVE DENSITY OR CONSISTENCY, SOIL STRUCTURE, MINERALOGY	SYMBOLIC LOG	COMMENTS DEPTH OF CASING, DRILLING RATE, DRILLING FLUID LOSS, TESTS, AND INSTRUMENTATION
		COMPLETE			**Poorly Graded Sand With Silt And Gravel (SP-SM)** 14.0-63.0' - dark brown, (7.5YR 3/3), dry, loose, 20% gravel, 70% sand, 10% fines, sand is angular to subangular, poorly graded, no dominant mineralogy, matrix supported, max clast size = 50 mm		
25							
30				SP-SM			
35							
40							

PROJECT NUMBER:	BORING NUMBER:
382653.FP.04.FW	MW-61 SHEET 3 OF 7

SOIL BORING LOG

PROJECT : PG&E Topock - ERGI
LOCATION : Site C (2100713.0 N, 7616591.0 E)
ELEVATION : 544.1 ft
DRILLING CONTRACTOR : Boart Longyear (D. Roberts)
DRILLING EQUIPMENT AND METHOD : Track-mounted Rig, Rotosonic drill head and tools
ORIENTATION : Vertical
WATER LEVELS : Approx. 87 ft BGS
START : 3/4/2009
END : 3/12/2009
LOGGER : A. Brewster (Northstar)

DEPTH BELOW EXISTING GRADE (ft)	INTERVAL (ft)	RECOVERY (in)	LAB SAMPLE	USCS CODE/ LITHOLOGY	SOIL DESCRIPTION SOIL NAME, USCS GROUP SYMBOL, COLOR, MOISTURE CONTENT, RELATIVE DENSITY OR CONSISTENCY, SOIL STRUCTURE, MINERALOGY	SYMBOLIC LOG	COMMENTS DEPTH OF CASING, DRILLING RATE, DRILLING FLUID LOSS, TESTS, AND INSTRUMENTATION
		COMPLETE			**Poorly Graded Sand With Silt And Gravel (SP-SM)** 14.0-63.0' - dark brown, (7.5YR 3/3), dry, loose, 20% gravel, 70% sand, 10% fines, sand is angular to subangular, poorly graded, no dominant mineralogy, matrix supported, max clast size = 50 mm		
45							
50				SP-SM			
55							
60							

CH2MHILL

PROJECT NUMBER:	BORING NUMBER:
382653.FP.04.FW	MW-61 SHEET 4 OF 7

SOIL BORING LOG

PROJECT : PG&E Topock - ERGI
LOCATION : Site C (2100713.0 N, 7616591.0 E)
ELEVATION : 544.1 ft
DRILLING CONTRACTOR : Boart Longyear (D. Roberts)
DRILLING EQUIPMENT AND METHOD : Track-mounted Rig, Rotosonic drill head and tools
ORIENTATION : Vertical
WATER LEVELS : Approx. 87 ft BGS
START : 3/4/2009
END : 3/12/2009
LOGGER : A. Brewster (Northstar)

DEPTH BELOW EXISTING GRADE (ft)	INTERVAL (ft)	RECOVERY (in)	LAB SAMPLE	USCS CODE/ LITHOLOGY	SOIL DESCRIPTION SOIL NAME, USCS GROUP SYMBOL, COLOR, MOISTURE CONTENT, RELATIVE DENSITY OR CONSISTENCY, SOIL STRUCTURE, MINERALOGY	SYMBOLIC LOG	COMMENTS DEPTH OF CASING, DRILLING RATE, DRILLING FLUID LOSS, TESTS, AND INSTRUMENTATION
		COMPLETE		SP-SM	**Poorly Graded Sand With Silt And Gravel (SP-SM)** 14.0-63.0' - dark brown, (7.5YR 3/3), dry, loose, 20% gravel, 70% sand, 10% fines, sand is angular to subangular, poorly graded, no dominant mineralogy, matrix supported, max clast size = 50 mm		
65	68.0			pTbr	**Metadiorite (pTbr)** 63.0-112.4' - bedrock is consolidated. Drilling method pulverizes most of the core.		Total depth of initial Rotosonic boring is 68.0 ft bgs. Begin rotary core drilling.
70 75 80					Begin rock coring from 68.0 ft bgs See the next page for the rock core log.		

PROJECT NUMBER:	BORING NUMBER:
382653.FP.04.FW	**MW-61** SHEET 5 OF 7

ROCK CORE LOG

PROJECT : PG&E Topock - ERGI
LOCATION : Site C (2100713.0 N, 7616591.0 E)
ELEVATION : 544.1 ft
DRILLING CONTRACTOR : Boart Longyear (D. Roberts)
CORING EQUIPMENT AND METHOD : Track-mounted Rig, LF-70 Drill Head and HQ-sized tools (diamond bit)
ORIENTATION : Vertical
WATER LEVELS : Approx. 87 ft BTOC
START : 3/4/2009
END : 3/12/2009
LOGGER : A. Brewster (Northstar)

DEPTH AND ELEVATION BELOW SURFACE (ft)	CORE RUN, LENGTH, AND RECOVERY (%)	DISCONTINUITIES			SYMBOLIC LOG	LITHOLOGY	COMMENTS
		R Q D (%)	FRACTURES PER FOOT	DESCRIPTION: DEPTH, TYPE, ORIENTATION, ROUGHNESS, PLANARITY, INFILLING MATERIAL AND THICKNESS, SURFACE STAINING, AND TIGHTNESS		ROCK TYPE, COLOR, MINERALOGY, TEXTURE, HARDNESS, WEATHERING, AND ROCK MASS CHARACTERISTICS	SIZE AND DEPTH OF CASING, FLUID LOSS, CORING RATE AND SMOOTHNESS, CAVING ROD DROPS, TEST RESULTS, ETC.
	68.0		0			**Metadiorite (pTbr)** 63.0-112.4' - dusky yellowish green, (10GY 3/2), intermediate (dioritic) mineralogy, fine grained, hard to very hard, unweathered, massive to foliated, pale greenish yellow (10YR 8/2) banding throughout	General Note: The metadiorite bedrock exhibits many small healed fractures (1-3 mm) of somewhat random orientation. These healed fractures create weaknesses in the rock. It can be difficult to determine if the metadiorite is jointed in-situ, or if the discontinuities are caused by the drilling method. Intervals with fracture per foot counts >10 are likely caused by drilling.
			>10	69.3-69.6' and 70.4-70.6' - Fracture zone, rough, undulating, < 1 mm calcite infilling, reddish staining, tight, no dominant orientation (two at 60 deg)			
70			>10				
	R1 7 ft 100%	53	0				
			1	72.5' - Joint, 30 deg, rough, undulating, < 5 mm calcite infilling, some reddish staining, tight			
			>10	73.6-74.0' - Fracture zone, rough, undulating, < 1 mm calcite infilling, no staining, moderately tight, no dominant orientation			
			1	74.4, 75.3' - Joint, 60 deg, rough, undulating, < 3 mm calcite infilling, reddish staining, tight			R1 = 17.0 min
75	75.0		1				
			0			76.0' - yellow-orange staining	
			1	77.9, 78.4, 79.5, 80.9' - Joint, 60 deg, rough, undulating, < 3 mm calcite infilling, some reddish staining, tight			
			1				
	R2 9.3 ft 100%	86	1				
80			1				
			>10	81.8-82.0' - Fracture zone, rough, undulating, no staining, infill by calcite (primary) and dark greyish black material (< 3 mm), moderately tight, no dominant orientation		81.0-94.5' - dusky yellow green, (5GY 5/2)	
			1	82.5' - Joint, 80 deg, rough, undulating, calcite (< 1 mm) and dark greyish black material (< 2 mm), no staining, moderately tight			
			>10	83.5-84.6' - Fracture zone, < 1 mm calcite infilling, no staining, tight, no dominant orientation			R2 = 33.0 min
	84.3		>10				
85			1	85.5, 86.4, 86.5, 87.4' - Joint, rough, undulating, < 5 mm calcite infilling, prominent reddish staining, 45, 80, 80, and 10 deg respectively, tight			
	R3 6 ft 100%		2				
		57	1			87.0' - yellow-orange staining	

CH2MHILL

PROJECT NUMBER: 382653.FP.04.FW

BORING NUMBER: MW-61 SHEET 6 OF 7

ROCK CORE LOG

PROJECT : PG&E Topock - ERGI

LOCATION : Site C (2100713.0 N, 7616591.0 E)

ELEVATION : 544.1 ft

DRILLING CONTRACTOR : Boart Longyear (D. Roberts)

CORING EQUIPMENT AND METHOD : Track-mounted Rig, LF-70 Drill Head and HQ-sized tools (diamond bit)

ORIENTATION : Vertical

WATER LEVELS : Approx. 87 ft BTOC

START : 3/4/2009

END : 3/12/2009

LOGGER : A. Brewster (Northstar)

DEPTH AND ELEVATION BELOW SURFACE (ft)	CORE RUN, LENGTH, AND RECOVERY (%)	DISCONTINUITIES R Q D (%)	FRACTURES PER FOOT	DESCRIPTION DEPTH, TYPE, ORIENTATION, ROUGHNESS, PLANARITY, INFILLING MATERIAL AND THICKNESS, SURFACE STAINING, AND TIGHTNESS	LITHOLOGY ROCK TYPE, COLOR, MINERALOGY, TEXTURE, HARDNESS, WEATHERING, AND ROCK MASS CHARACTERISTICS	COMMENTS SIZE AND DEPTH OF CASING, FLUID LOSS, CORING RATE AND SMOOTHNESS, CAVING ROD DROPS, TEST RESULTS, ETC.
			0		**Metadiorite (pTbr)** 63.0-112.4' - dusky yellow green, (5GY 5/2), intermediate (dioritic) mineralogy, fine grained, hard to very hard, unweathered, massive to foliated, pale greenish yellow (10YR 8/2) banding throughout 89.0-94.5' - medium grained	
90			0			
	90.3		1			R3 = 12.5 min
			1	90.9' - Joint, 20 deg, rough, undulating, < 1 mm calcite infilling, prominent reddish staining, tight		
	R4 4.2 ft 100%	71	>10	91.9' - Joint, 80 deg, rough, undulating, calcite (< 3 mm) and dark greyish black material (< 1 mm), no staining, tight		
			>10	92.2-93.4' - Fracture zone, rough, undulating, primary calcite infill, secondary reddish staining, tertiary dark greyish-black infill, tight, no dominant orientation		
95	94.5		2	94.2, 94.5, 95.6, 96.4' - Joint, rough, undulating, < 1 mm calcite infilling, reddish staining, 60, 30, 60, and 30 deg (respectively), tight	94.5-109.2' - dusky yellowish green, (10GY 3/2), fine grained	R4 = 11.8 min
			1			
			1			
			>10	97.0-97.7' - Fracture zone, no staining, < 1 mm dark greyish-black infill, tight, no dominant orientation		
			0			
100	R5 10 ft 100%	90	1	99.4, 101.2, 101.8, 102.5, 103.3' - Joint, rough, undulating, < 1 mm calcite infilling, some reddish staining, 40, 40, 10, 40, and 60 deg (respectively), tight		
			0			
			2			
			1			
			1			
105	104.5		0			R5 = 30.0 min
			1	105.4, 106.2, 106.7' - Joint, 10 deg, rough, undulating, < 5 mm calcite infilling, some reddish staining, tight		
	R6 4.7 ft 100%	94	2			
			0			

CH2MHILL

PROJECT NUMBER:	BORING NUMBER:	
382653.FP.04.FW	MW-61	SHEET 7 OF 7

ROCK CORE LOG

PROJECT : PG&E Topock - ERGI
LOCATION : Site C (2100713.0 N, 7616591.0 E)
ELEVATION : 544.1 ft
DRILLING CONTRACTOR : Boart Longyear (D. Roberts)
CORING EQUIPMENT AND METHOD : Track-mounted Rig, LF-70 Drill Head and HQ-sized tools (diamond bit)
ORIENTATION : Vertical
WATER LEVELS : Approx. 87 ft BTOC
START : 3/4/2009
END : 3/12/2009
LOGGER : A. Brewster (Northstar)

DEPTH AND ELEVATION BELOW SURFACE (ft)	CORE RUN, LENGTH, AND RECOVERY (%)	DISCONTINUITIES			SYMBOLIC LOG	LITHOLOGY	COMMENTS
		R Q D (%)	FRACTURES PER FOOT	DESCRIPTION DEPTH, TYPE, ORIENTATION, ROUGHNESS, PLANARITY, INFILLING MATERIAL AND THICKNESS, SURFACE STAINING, AND TIGHTNESS		ROCK TYPE, COLOR, MINERALOGY, TEXTURE, HARDNESS, WEATHERING, AND ROCK MASS CHARACTERISTICS	SIZE AND DEPTH OF CASING, FLUID LOSS, CORING RATE AND SMOOTHNESS, CAVING ROD DROPS, TEST RESULTS, ETC.
	109.2		1	108.1, 109.2, 109.9, 110.3, 111.8' - Joint, 60, 40, 10, 20, and 30 deg (respectively), rough, undulating to stepped, calcite growth (< 1 mm), reddish to dark reddish staining, tight.		**Metadiorite (pTbr)** 63.0-112.4' - dusky yellowish green, (10GY 3/2), intermediate (dioritic) mineralogy, fine grained, hard to very hard, unweathered, massive to foliated, pale greenish yellow (10YR 8/2) banding throughout 109.2-112.4' - greyish pink, (5R 8/2), coarse grained, greyish pink, (5R 8/2), coarse grained	R6 = 24.0 min
110	R7 3.2 ft 100%	100	2				
			1				
			1				
	112.4		0			End Drilling on 3/12/2009 Total Borehole Depth: 112.4 ft bgs	R7 = 22.0 min
115							
120							
125							

CH2MHILL	PROJECT NUMBER: 382653.FP.04.FW	BORING NUMBER: MW-62 SHEET 1 OF 11

SOIL BORING LOG

PROJECT : PG&E Topock - ERGI
LOCATION : Site E (2101068.3 N, 7616551.0 E)
ELEVATION : 503.6 ft
DRILLING CONTRACTOR : Boart Longyear (D. Roberts)
DRILLING EQUIPMENT AND METHOD : Track-mounted Rig, Rotosonic drill head and tools
ORIENTATION : Vertical
WATER LEVELS : Approx. 47 ft BGS
START : 3/14/2009
END : 4/22/2009
LOGGER : A. Brewster/C. Kreller (Northstar)

DEPTH BELOW EXISTING GRADE (ft)	INTERVAL (ft)	RECOVERY (in)	LAB SAMPLE	USCS CODE/ LITHOLOGY	SOIL DESCRIPTION: SOIL NAME, USCS GROUP SYMBOL, COLOR, MOISTURE CONTENT, RELATIVE DENSITY OR CONSISTENCY, SOIL STRUCTURE, MINERALOGY	SYMBOLIC LOG	COMMENTS: DEPTH OF CASING, DRILLING RATE, DRILLING FLUID LOSS, TESTS, AND INSTRUMENTATION
		COMPLETE		SM	**Silty Sand (SM)** 0.0-4.5' - dark yellowish brown, (10YR 4/4), dry, loose, 5% gravel, 80% sand, 15% fines, angular to subangular, poorly graded, no dominant mineralogy, matrix supported, max clast size = 30 mm		This log is the combination of two adjacent boreholes. Boring initially drilled to 21.0' bgs using Rotosonic tools up to 6-in in diameter. 6-in Rotosonic casing then used as temporary conductor casing to facilitate rotary core drilling. Boring drilled from 21.0' bgs to a total depth of 65.0' bgs using diamond bit rotary core tools (HQ-size, 3.8-in diameter) and then overdrilled to total depth using 6-in Rotosonic tools. Adjacent borehole (approximately 10' southeast) was drilled to 75' bgs using Rotosonic tools up to 10-in diameter. Permanent 6-in PVC conductor casing installed from ground surface to 75' bgs (portland cement grout). Boring drilled from 75' bgs to a total depth of 191.5' bgs using diamond bit rotary core tools (HQ-size, 3.8-in diameter).
5				Tmc	**Conglomerate (Tmc)** 4.5-21.0' - reddish brown, (5YR 4/4), dry, consolidated, no dominant clast mineralogy. Drilling method pulverizes most of the core.		
10							
15							
20							

PROJECT NUMBER:	BORING NUMBER:	
382653.FP.04.FW	MW-62	SHEET 2 OF 11

SOIL BORING LOG

PROJECT : PG&E Topock - ERGI | LOCATION : Site E (2101068.3 N, 7616551.0 E)

ELEVATION : 503.6 ft | DRILLING CONTRACTOR : Boart Longyear (D. Roberts)

DRILLING EQUIPMENT AND METHOD : Track-mounted Rig, Rotosonic drill head and tools | ORIENTATION : Vertical

WATER LEVELS : Approx. 47 ft BGS | START : 3/14/2009 | END : 4/22/2009 | LOGGER : A. Brewster/C. Kreller (Northstar)

DEPTH BELOW EXISTING GRADE (ft)	INTERVAL (ft)	RECOVERY (in)	LAB SAMPLE	USCS CODE/ LITHOLOGY	SOIL DESCRIPTION SOIL NAME, USCS GROUP SYMBOL, COLOR, MOISTURE CONTENT, RELATIVE DENSITY OR CONSISTENCY, SOIL STRUCTURE, MINERALOGY	SYMBOLIC LOG	COMMENTS DEPTH OF CASING, DRILLING RATE, DRILLING FLUID LOSS, TESTS, AND INSTRUMENTATION
	21.0	COMPLETE		Tmc			Total depth of Rotosonic boring is 21.0 ft bgs. Begin rotary core drilling.
					Begin rock coring from 21.0 ft bgs See the next page for the rock core log.		
25							
30							
35							
40							

PROJECT NUMBER:	BORING NUMBER:
382653.FP.04.FW	MW-62 SHEET 3 OF 11

ROCK CORE LOG

PROJECT : PG&E Topock - ERGI
LOCATION : Site E (2101068.3 N, 7616551.0 E)
ELEVATION : 503.6 ft
DRILLING CONTRACTOR : Boart Longyear (D. Roberts)
CORING EQUIPMENT AND METHOD : Track-mounted Rig, LF-70 Drill Head and HQ-sized tools (diamond bit)
ORIENTATION : Vertical
WATER LEVELS : Approx. 47 ft BGS
START : 3/14/2009
END : 4/22/2009
LOGGER : A. Brewster/C. Kreller (Northstar)

DEPTH AND ELEVATION BELOW SURFACE (ft)	CORE RUN, LENGTH, AND RECOVERY (%)	DISCONTINUITIES R Q D (%)	DISCONTINUITIES FRACTURES PER FOOT	DISCONTINUITIES DESCRIPTION: DEPTH, TYPE, ORIENTATION, ROUGHNESS, PLANARITY, INFILLING MATERIAL AND THICKNESS, SURFACE STAINING, AND TIGHTNESS	SYMBOLIC LOG	LITHOLOGY: ROCK TYPE, COLOR, MINERALOGY, TEXTURE, HARDNESS, WEATHERING, AND ROCK MASS CHARACTERISTICS	COMMENTS: SIZE AND DEPTH OF CASING, FLUID LOSS, CORING RATE AND SMOOTHNESS, CAVING ROD DROPS, TEST RESULTS, ETC.
	21.0		0			**Conglomerate(Tmc)** 21.0-64.5' - moderate reddish brown, (10R 4/6), no dominant clast mineralogy, strong (R4), hard, unweathered, fine matrix, coarse sand to coarse gravel sized clasts, massive	
			0				
	R1 5.5 ft 18%	0	0				
			0				
25			0				
	26.5		0				R1 = run time not available
			0				
			0				
			0				
30	R2 8 ft 28%	0	0				
			0				
			0				
			0				
	34.5		0				R2 = 45.0 min
35			0				
			0				
			0				
			1	38.4' - Joint, 40 deg, rough, undulating, no staining, moderately tight			
	R3 10 ft 100%	83	0				
40			0				

PROJECT NUMBER:	BORING NUMBER:
382653.FP.04.FW	MW-62 SHEET 4 OF 11

ROCK CORE LOG

PROJECT : PG&E Topock - ERGI
LOCATION : Site E (2101068.3 N, 7616551.0 E)
ELEVATION : 503.6 ft
DRILLING CONTRACTOR : Boart Longyear (D. Roberts)
CORING EQUIPMENT AND METHOD : Track-mounted Rig, LF-70 Drill Head and HQ-sized tools (diamond bit)
ORIENTATION : Vertical
WATER LEVELS : Approx. 47 ft BGS
START : 3/14/2009
END : 4/22/2009
LOGGER : A. Brewster/C. Kreller (Northstar)

DEPTH AND ELEVATION BELOW SURFACE (ft)	CORE RUN, LENGTH, AND RECOVERY (%)	DISCONTINUITIES R Q D (%)	DISCONTINUITIES FRACTURES PER FOOT	DISCONTINUITIES DESCRIPTION DEPTH, TYPE, ORIENTATION, ROUGHNESS, PLANARITY, INFILLING MATERIAL AND THICKNESS, SURFACE STAINING, AND TIGHTNESS	SYMBOLIC LOG	LITHOLOGY ROCK TYPE, COLOR, MINERALOGY, TEXTURE, HARDNESS, WEATHERING, AND ROCK MASS CHARACTERISTICS	COMMENTS SIZE AND DEPTH OF CASING, FLUID LOSS, CORING RATE AND SMOOTHNESS, CAVING ROD DROPS, TEST RESULTS, ETC.
			0			**Conglomerate(Tmc)** 21.0-64.5' - moderate reddish brown, (10R 4/6), no dominant clast mineralogy, strong (R4), hard, unweathered, fine matrix, coarse sand to coarse gravel sized clasts, massive	
			1	42.8' - Joint, 60 deg, rough, undulating, no staining, moderately tight			
			0				
45	44.5		0				R3 = 27.0 min
			0				
			0				
	R4 7 ft 100%	61	0				
			0				
50			1	49' - Joint, 30 deg, rough, undulating to stepped, reddish staining, tight			
			0				
	51.5		0				R4= 34.8 min
	R5 3 ft 70%	63	0				
			0				
55	54.5		0				R5 = 5.0 min
			0				
			0				
			0				
	R6 8.3 ft 100%	65	0				
60			0				
			0				

CH2MHILL

PROJECT NUMBER: 382653.FP.04.FW

BORING NUMBER: MW-62 **SHEET** 5 **OF** 11

ROCK CORE LOG

PROJECT : PG&E Topock - ERGI

LOCATION : Site E (2101068.3 N, 7616551.0 E)

ELEVATION : 503.6 ft

DRILLING CONTRACTOR : Boart Longyear (D. Roberts)

CORING EQUIPMENT AND METHOD : Track-mounted Rig, LF-70 Drill Head and HQ-sized tools (diamond bit)

ORIENTATION : Vertical

WATER LEVELS : Approx. 47 ft BGS

START : 3/14/2009

END : 4/22/2009

LOGGER : A. Brewster/C. Kreller (Northstar)

DEPTH AND ELEVATION BELOW SURFACE (ft)	CORE RUN, LENGTH, AND RECOVERY (%)	DISCONTINUITIES R Q D (%)	FRACTURES PER FOOT	DESCRIPTION: DEPTH, TYPE, ORIENTATION, ROUGHNESS, PLANARITY, INFILLING MATERIAL AND THICKNESS, SURFACE STAINING, AND TIGHTNESS	SYMBOLIC LOG	LITHOLOGY: ROCK TYPE, COLOR, MINERALOGY, TEXTURE, HARDNESS, WEATHERING, AND ROCK MASS CHARACTERISTICS	COMMENTS: SIZE AND DEPTH OF CASING, FLUID LOSS, CORING RATE AND SMOOTHNESS, CAVING ROD DROPS, TEST RESULTS, ETC.
			1	61.6' - Joint, 45 deg, rough, undulating, no staining, tight		**Conglomerate(Tmc)** 21.0-64.5' - moderate reddish brown, (10R 4/6), no dominant clast mineralogy, strong (R4), hard, unweathered, fine matrix, coarse sand to coarse gravel sized clasts, massive	R6 = 26.9 min
	62.8		0				
	R7 1.7 ft 100%	35	0				R7 = 3.7 min
	64.5		0				
65	COMPLETE					**Conglomerate(Tmc)** 64.5-75.0' - Rotosonic drilling method pulverizes core.	
70							
75	75.0 R1 1 ft 0% 76.0					**Conglomerate(Tmc)** 75.0-191.5' - moderate brown, (5YR 4/4), no dominant clast mineralogy, strong (R4), unweathered, fine matrix, coarse sand to coarse gravel sized clasts, massive	R1= 4.0 min
			0				
			0				
			0				
80			0				
			0				

CH2MHILL

PROJECT NUMBER:	BORING NUMBER:
382653.FP.04.FW	MW-62 SHEET 6 OF 11

ROCK CORE LOG

PROJECT : PG&E Topock - ERGI
LOCATION : Site E (2101068.3 N, 7616551.0 E)
ELEVATION : 503.6 ft
DRILLING CONTRACTOR : Boart Longyear (D. Roberts)
CORING EQUIPMENT AND METHOD : Track-mounted Rig, LF-70 Drill Head and HQ-sized tools (diamond bit)
ORIENTATION : Vertical
WATER LEVELS : Approx. 47 ft BGS
START : 3/14/2009
END : 4/22/2009
LOGGER : A. Brewster/C. Kreller (Northstar)

DEPTH AND ELEVATION BELOW SURFACE (ft)	CORE RUN, LENGTH, AND RECOVERY (%)	DISCONTINUITIES R Q D (%)	FRACTURES PER FOOT	DESCRIPTION DEPTH, TYPE, ORIENTATION, ROUGHNESS, PLANARITY, INFILLING MATERIAL AND THICKNESS, SURFACE STAINING, AND TIGHTNESS	SYMBOLIC LOG	LITHOLOGY ROCK TYPE, COLOR, MINERALOGY, TEXTURE, HARDNESS, WEATHERING, AND ROCK MASS CHARACTERISTICS	COMMENTS SIZE AND DEPTH OF CASING, FLUID LOSS, CORING RATE AND SMOOTHNESS, CAVING ROD DROPS, TEST RESULTS, ETC.
	R2 10 ft 65%	0	0			**Conglomerate(Tmc)** 75.0-191.5' - moderate brown, (5YR 4/4), no dominant clast mineralogy, strong (R4), unweathered, fine matrix, coarse sand to coarse gravel sized clasts, massive	
85			NR				R2 = 80 min
	86.0						
90	R3 10 ft 40%	40	NR				
			0				
			0				
			1	94.6' - Joint, 30 deg, rough, planar, < 1 mm calcite infilling, reddish staining, tight			
95			0				
	96.0		0				R3 = 10 min
			0				
			0				
100			0				
			1				

PROJECT NUMBER:	BORING NUMBER:
382653.FP.04.FW	MW-62 SHEET 7 OF 11

ROCK CORE LOG

PROJECT : PG&E Topock - ERGI

LOCATION : Site E (2101068.3 N, 7616551.0 E)

ELEVATION : 503.6 ft

DRILLING CONTRACTOR : Boart Longyear (D. Roberts)

CORING EQUIPMENT AND METHOD : Track-mounted Rig, LF-70 Drill Head and HQ-sized tools (diamond bit)

ORIENTATION : Vertical

WATER LEVELS : Approx. 47 ft BGS

START : 3/14/2009

END : 4/22/2009

LOGGER : A. Brewster/C. Kreller (Northstar)

DEPTH AND ELEVATION BELOW SURFACE (ft)	CORE RUN, LENGTH, AND RECOVERY (%)	DISCONTINUITIES: R Q D (%)	DISCONTINUITIES: FRACTURES PER FOOT	DISCONTINUITIES: DESCRIPTION: DEPTH, TYPE, ORIENTATION, ROUGHNESS, PLANARITY, INFILLING MATERIAL AND THICKNESS, SURFACE STAINING, AND TIGHTNESS	SYMBOLIC LOG	LITHOLOGY: ROCK TYPE, COLOR, MINERALOGY, TEXTURE, HARDNESS, WEATHERING, AND ROCK MASS CHARACTERISTICS	COMMENTS: SIZE AND DEPTH OF CASING, FLUID LOSS, CORING RATE AND SMOOTHNESS, CAVING ROD DROPS, TEST RESULTS, ETC.
		60	1	100.7' - Joint, 50 deg, rough, undulating, reddish staining, tight 101.2' - Joint, 20 deg, rough, undulating, reddish staining, tight		**Conglomerate(Tmc)** 75.0-191.5' - moderate brown, (5YR 4/4), no dominant clast mineralogy, strong (R4), unweathered, fine matrix, coarse sand to coarse gravel sized clasts, massive	
	R4 10 ft 80%		0				
			0				
105			0				
	106.0		0				R4 = 20 min
			0				
			0				
			0				
110			0				
	R5 10 ft 100%	100	0				
			0				
			0				
			0				
115			0				
	116.0		0				R5 = 20 min
			0				
			0				
			0				
120			0				
			0				

CH2MHILL

PROJECT NUMBER:	BORING NUMBER:
382653.FP.04.FW	**MW-62** SHEET 8 OF 11

ROCK CORE LOG

PROJECT : PG&E Topock - ERGI
LOCATION : Site E (2101068.3 N, 7616551.0 E)
ELEVATION : 503.6 ft
DRILLING CONTRACTOR : Boart Longyear (D. Roberts)
CORING EQUIPMENT AND METHOD : Track-mounted Rig, LF-70 Drill Head and HQ-sized tools (diamond bit)
ORIENTATION : Vertical
WATER LEVELS : Approx. 47 ft BGS
START : 3/14/2009
END : 4/22/2009
LOGGER : A. Brewster/C. Kreller (Northstar)

DEPTH AND ELEVATION BELOW SURFACE (ft)	CORE RUN, LENGTH, AND RECOVERY (%)	DISCONTINUITIES R Q D (%)	FRACTURES PER FOOT	DESCRIPTION DEPTH, TYPE, ORIENTATION, ROUGHNESS, PLANARITY, INFILLING MATERIAL AND THICKNESS, SURFACE STAINING, AND TIGHTNESS	SYMBOLIC LOG	LITHOLOGY ROCK TYPE, COLOR, MINERALOGY, TEXTURE, HARDNESS, WEATHERING, AND ROCK MASS CHARACTERISTICS	COMMENTS SIZE AND DEPTH OF CASING, FLUID LOSS, CORING RATE AND SMOOTHNESS, CAVING ROD DROPS, TEST RESULTS, ETC.
		100	0			**Conglomerate(Tmc)** 76.0-191.5' - moderate brown, (5YR 4/4), no dominant clast mineralogy, strong (R4), unweathered, fine matrix, coarse sand to coarse gravel sized clasts, massive	
	R6 10 ft 100%		0				
			0				
			0				
125	126.0		0				R6 = 20 min
			0			126.0' - moderate brown, (5YR 3/4), matrix supported, friable, moderately weathered	
			0				
			0				
			0				
130	R7 10 ft 80%	100	0				
			0				
			0				
			0				
			0				
135	136.0		0				R7 = 25 min
			0				
			0				
			0				
			0				
140			0				

PROJECT NUMBER: **382653.FP.04.FW**

BORING NUMBER: **MW-62** SHEET 9 OF 11

ROCK CORE LOG

PROJECT : PG&E Topock - ERGI
LOCATION : Site E (2101068.3 N, 7616551.0 E)
ELEVATION : 503.6 ft
DRILLING CONTRACTOR : Boart Longyear (D. Roberts)
CORING EQUIPMENT AND METHOD : Track-mounted Rig, LF-70 Drill Head and HQ-sized tools (diamond bit)
ORIENTATION : Vertical
WATER LEVELS : Approx. 47 ft BGS
START : 3/14/2009
END : 4/22/2009
LOGGER : A. Brewster/C. Kreller (Northstar)

DEPTH AND ELEVATION BELOW SURFACE (ft)	CORE RUN, LENGTH, AND RECOVERY (%)	DISCONTINUITIES R Q D (%)	FRACTURES PER FOOT	DESCRIPTION: DEPTH, TYPE, ORIENTATION, ROUGHNESS, PLANARITY, INFILLING MATERIAL AND THICKNESS, SURFACE STAINING, AND TIGHTNESS	SYMBOLIC LOG	LITHOLOGY: ROCK TYPE, COLOR, MINERALOGY, TEXTURE, HARDNESS, WEATHERING, AND ROCK MASS CHARACTERISTICS	COMMENTS: SIZE AND DEPTH OF CASING, FLUID LOSS, CORING RATE AND SMOOTHNESS, CAVING ROD DROPS, TEST RESULTS, ETC.
		100	0			**Conglomerate(Tmc)** 76.0-191.5' - moderate brown, (5YR 3/4), from 126.0', no dominant clast mineralogy, matrix supported and friable from 126.0', moderately weathered from 126.0'	
	R8 10 ft 100%		0				
			0				
			0				
145	146.0		0				R8 = 20 min
			0				146.0-156.0' add 300 gallons of water
			0				
			0				
			0				
150	R9 10 ft 100%	100	0				
			0				
			0				
			0				
			0				
155	156.0		0			155.5' - moderate brown (5YR 4/4)	R9 = 20 min
			0				
	R10 4 ft 100%	100	0				
			0				
			0				R10 = 7 min
160	160.0 R11 1 ft 50% 161.0	100	0				R11 = 5 min

CH2MHILL

PROJECT NUMBER:	BORING NUMBER:
382653.FP.04.FW	MW-62 SHEET 10 OF 11

ROCK CORE LOG

PROJECT : PG&E Topock - ERGI LOCATION : Site E (2101068.3 N, 7616551.0 E)

ELEVATION : 503.6 ft DRILLING CONTRACTOR : Boart Longyear (D. Roberts)

CORING EQUIPMENT AND METHOD : Track-mounted Rig, LF-70 Drill Head and HQ-sized tools (diamond bit) ORIENTATION : Vertical

WATER LEVELS : Approx. 47 ft BGS START : 3/14/2009 END : 4/22/2009 LOGGER : A. Brewster/C. Kreller (Northstar)

DEPTH AND ELEVATION BELOW SURFACE (ft)	CORE RUN, LENGTH, AND RECOVERY (%)	DISCONTINUITIES R Q D (%)	FRACTURES PER FOOT	DESCRIPTION DEPTH, TYPE, ORIENTATION, ROUGHNESS, PLANARITY, INFILLING MATERIAL AND THICKNESS, SURFACE STAINING, AND TIGHTNESS	LITHOLOGY ROCK TYPE, COLOR, MINERALOGY, TEXTURE, HARDNESS, WEATHERING, AND ROCK MASS CHARACTERISTICS	COMMENTS SIZE AND DEPTH OF CASING, FLUID LOSS, CORING RATE AND SMOOTHNESS, CAVING ROD DROPS, TEST RESULTS, ETC.
	R12 1 ft 162.0 100%	100	0		**Conglomerate(Tmc)** 76.0-191.5' - moderate brown, (5YR 4/4), no dominant clast mineralogy, strong (R4), unweathered, fine matrix, coarse sand to coarse gravel sized clasts, massive	R12 = 10 min
	R13 4 ft 90% 166.0	100	0			
			0			
			0			Add 300 gallons of water.
165			0			R13 = 15 min
	R14 10 ft 100% 176.0	100	0			
			0			
			0		168.0-169.0' - slightly weathered	
			0			
170			0			
			0			
			0			
			0			
			0			
175			0			R14 = 20 min
			0			
			1	177' - Joint, 80 deg, rough, planar, < 1 mm calcite infilling, reddish staining, tight		
			0			
			1	179.5' - Joint, 40 deg, rough, planar, < 1 mm calcite infilling, no staining, tight		
180			0			

PROJECT NUMBER:	BORING NUMBER:
382653.FP.04.FW	**MW-62** SHEET 11 OF 11

ROCK CORE LOG

PROJECT : PG&E Topock - ERGI

LOCATION : Site E (2101068.3 N, 7616551.0 E)

ELEVATION : 503.6 ft

DRILLING CONTRACTOR : Boart Longyear (D. Roberts)

CORING EQUIPMENT AND METHOD : Track-mounted Rig, LF-70 Drill Head and HQ-sized tools (diamond bit)

ORIENTATION : Vertical

WATER LEVELS : Approx. 47 ft BGS

START : 3/14/2009

END : 4/22/2009

LOGGER : A. Brewster/C. Kreller (Northstar)

DEPTH AND ELEVATION BELOW SURFACE (ft)	CORE RUN, LENGTH, AND RECOVERY (%)	DISCONTINUITIES R Q D (%)	FRACTURES PER FOOT	DESCRIPTION DEPTH, TYPE, ORIENTATION, ROUGHNESS, PLANARITY, INFILLING MATERIAL AND THICKNESS, SURFACE STAINING, AND TIGHTNESS	SYMBOLIC LOG	LITHOLOGY ROCK TYPE, COLOR, MINERALOGY, TEXTURE, HARDNESS, WEATHERING, AND ROCK MASS CHARACTERISTICS	COMMENTS SIZE AND DEPTH OF CASING, FLUID LOSS, CORING RATE AND SMOOTHNESS, CAVING ROD DROPS, TEST RESULTS, ETC.
	R15 10 ft 100%	95	0			**Conglomerate(Tmc)** 76.0-191.5' - moderate brown, (5YR 4/4), no dominant clast mineralogy, strong (R4), unweathered, fine matrix, coarse sand to coarse gravel sized clasts, massive	
			0				
			0				
185			0				
	186.0		0				R15 = 20 min
			0				
			0				
	R16 5.5 ft 100%	100	0				
190			0				
			0				
	191.5		0			End Drilling on 4/22/2009 Total Borehole Depth: 191.5 ft bgs	R16 = 8 min
195							
200							

PROJECT NUMBER:	BORING NUMBER:
382653.FP.04.FW	MW-63 SHEET 1 OF 4

ROCK CORE LOG

PROJECT : PG&E Topock - ERGI

LOCATION : Site E - Alternate 2 (2100973.9 N, 7616921.6 E)

ELEVATION : 505.0 ft

DRILLING CONTRACTOR : Boart Longyear (D. Roberts)

CORING EQUIPMENT AND METHOD : Track-mounted Rig, Rotosonic and LF-70 Drill Head and HQ-sized tools (diamond bit)

ORIENTATION : Vertical

WATER LEVELS : Approx. 48 ft BGS

START : 4/6/2009

END : 4/8/2009

LOGGER : R. Tweidt (Northstar)

DEPTH AND ELEVATION BELOW SURFACE (ft)	CORE RUN, LENGTH, AND RECOVERY (%)	DISCONTINUITIES R Q D (%)	DISCONTINUITIES FRACTURES PER FOOT	DISCONTINUITIES DESCRIPTION DEPTH, TYPE, ORIENTATION, ROUGHNESS, PLANARITY, INFILLING MATERIAL AND THICKNESS, SURFACE STAINING, AND TIGHTNESS	SYMBOLIC LOG	LITHOLOGY ROCK TYPE, COLOR, MINERALOGY, TEXTURE, HARDNESS, WEATHERING, AND ROCK MASS CHARACTERISTICS	COMMENTS SIZE AND DEPTH OF CASING, FLUID LOSS, CORING RATE AND SMOOTHNESS, CAVING ROD DROPS, TEST RESULTS, ETC.
						**Conglomerate(Tmc)** 0.0-30.0' - reddish brown, (5YR 4/4), dry, consolidated. Drilling method pulverizes most of core.	Boring initially drilled to 30.0 ft bgs on 4/6/2009 by Rotosonic tools up to 6-in in diameter. 6-in Rotosonic casing then used as a temporary conductor casing to facilitate rotary core drilling. Boring drilled from 30.0' bgs to total depth of 66.0' bgs using diamond bit rotary core tools (HQ-size, 3.8-in diameter) and then overdrilled to total depth using 6-in Rotosonic tools.
5							
10							
15							
20							

PROJECT NUMBER:	BORING NUMBER:
382653.FP.04.FW	MW-63 SHEET 2 OF 4

ROCK CORE LOG

PROJECT : PG&E Topock - ERGI
LOCATION : Site E - Alternate 2 (2100973.9 N, 7616921.6 E)
ELEVATION : 505.0 ft
DRILLING CONTRACTOR : Boart Longyear (D. Roberts)
CORING EQUIPMENT AND METHOD : Track-mounted Rig, Rotosonic and LF-70 Drill Head and HQ-sized tools (diamond bit)
ORIENTATION : Vertical
WATER LEVELS : Approx. 48 ft BGS
START : 4/6/2009
END : 4/8/2009
LOGGER : R. Tweidt (Northstar)

DEPTH AND ELEVATION BELOW SURFACE (ft)	CORE RUN, LENGTH, AND RECOVERY (%)	DISCONTINUITIES R Q D (%)	DISCONTINUITIES FRACTURES PER FOOT	DISCONTINUITIES DESCRIPTION: DEPTH, TYPE, ORIENTATION, ROUGHNESS, PLANARITY, INFILLING MATERIAL AND THICKNESS, SURFACE STAINING, AND TIGHTNESS	SYMBOLIC LOG	LITHOLOGY: ROCK TYPE, COLOR, MINERALOGY, TEXTURE, HARDNESS, WEATHERING, AND ROCK MASS CHARACTERISTICS	COMMENTS: SIZE AND DEPTH OF CASING, FLUID LOSS, CORING RATE AND SMOOTHNESS, CAVING ROD DROPS, TEST RESULTS, ETC.
						**Conglomerate(Tmc)** 0.0-30.0' - reddish brown, (5YR 4/4), dry, consolidated. Drilling method pulverizes most of core.	
25							
30	30.0						
	R1 6 ft 43%	0	NA	30.0-66.0' - poor rock quality and low recovery percentages. Difficult to assess natural discontinuities in core recovered. Fractures per foot not assessed (NA).		**Conglomerate(Tmc)** 30.0-66.0' - moderate brown, (5YR 3/4), no dominant clast mineralogy, strong to very weak (R4 to R1), moderately weathered to completely weathered, friable intervals, matrix supported, max clast size = 40 mm 34.0' - strong (R4), slightly weathered, max clast size = 50mm	
35							
	36.0						R1 = 26 min
40							

PROJECT NUMBER:	BORING NUMBER:
382653.FP.04.FW	MW-63 SHEET 3 OF 4

ROCK CORE LOG

PROJECT : PG&E Topock - ERGI
LOCATION : Site E - Alternate 2 (2100973.9 N, 7616921.6 E)
ELEVATION : 505.0 ft
DRILLING CONTRACTOR : Boart Longyear (D. Roberts)
CORING EQUIPMENT AND METHOD : Track-mounted Rig, Rotosonic and LF-70 Drill Head and HQ-sized tools (diamond bit)
ORIENTATION : Vertical
WATER LEVELS : Approx. 48 ft BGS
START : 4/6/2009
END : 4/8/2009
LOGGER : R. Tweidt (Northstar)

DEPTH AND ELEVATION BELOW SURFACE (ft)	CORE RUN, LENGTH, AND RECOVERY (%)	DISCONTINUITIES			SYMBOLIC LOG	LITHOLOGY	COMMENTS
		R Q D (%)	FRACTURES PER FOOT	DESCRIPTION DEPTH, TYPE, ORIENTATION, ROUGHNESS, PLANARITY, INFILLING MATERIAL AND THICKNESS, SURFACE STAINING, AND TIGHTNESS		ROCK TYPE, COLOR, MINERALOGY, TEXTURE, HARDNESS, WEATHERING, AND ROCK MASS CHARACTERISTICS	SIZE AND DEPTH OF CASING, FLUID LOSS, CORING RATE AND SMOOTHNESS, CAVING ROD DROPS, TEST RESULTS, ETC.
45	R2 10 ft 20% 46.0	0	NA	30.0-66.0' - poor rock quality and low recovery percentages. Difficult to assess natural discontinuities in core recovered. Fractures per foot not assessed (NA).		**Conglomerate(Tmc)** 30.0-66.0' - moderate brown, (5YR 3/4), no dominant clast mineralogy, strong to very weak (R4 to R1), moderately weathered to completely weathered, friable intervals, matrix supported, max clast size = 40 mm 44.0-46.0' - medium strong (R3), moderately weathered	R2 = 24 min
	R3 3 ft 83% 49.0	14	NA			46.0-47.0' - slightly weathered, max clast size = 30 mm 47.0-49.0' - completely weathered	R3 = 18 min
50 55	R4 7 ft 50% 56.0	34	NA			52.5-56.5' - slightly weathered, max clast size = 25 mm	Added approx. 15 gallons of water R4 = 42 min
	R5 3 ft 87% 59.0	35	NA			56.5-57.0' - moderately weathered 57.0-58.0' - slightly weathered, clasts are more fine grained, max clast size = 20 mm	R5 = 17 min
60	R6 1.5 ft 100%	40	NA				

PROJECT NUMBER:	BORING NUMBER:
382653.FP.04.FW	MW-63 SHEET 4 OF 4

ROCK CORE LOG

PROJECT : PG&E Topock - ERGI

LOCATION : Site E - Alternate 2 (2100973.9 N, 7616921.6 E)

ELEVATION : 505.0 ft

DRILLING CONTRACTOR : Boart Longyear (D. Roberts)

CORING EQUIPMENT AND METHOD : Track-mounted Rig, Rotosonic and LF-70 Drill Head and HQ-sized tools (diamond bit)

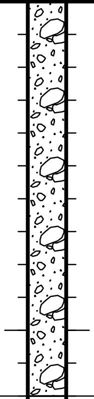
ORIENTATION : Vertical

WATER LEVELS : Approx. 48 ft BGS

START : 4/6/2009

END : 4/8/2009

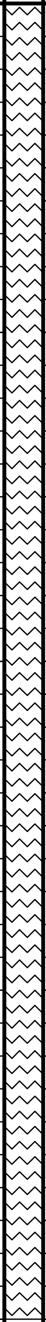
LOGGER : R. Tweidt (Northstar)

DEPTH AND ELEVATION BELOW SURFACE (ft)	CORE RUN, LENGTH, AND RECOVERY (%)	DISCONTINUITIES R Q D (%)	FRACTURES PER FOOT	DESCRIPTION DEPTH, TYPE, ORIENTATION, ROUGHNESS, PLANARITY, INFILLING MATERIAL AND THICKNESS, SURFACE STAINING, AND TIGHTNESS	SYMBOLIC LOG	LITHOLOGY ROCK TYPE, COLOR, MINERALOGY, TEXTURE, HARDNESS, WEATHERING, AND ROCK MASS CHARACTERISTICS	COMMENTS SIZE AND DEPTH OF CASING, FLUID LOSS, CORING RATE AND SMOOTHNESS, CAVING ROD DROPS, TEST RESULTS, ETC.
	60.5			30.0-66.0' - poor rock quality and low recovery percentages. Difficult to assess natural discontinuities in core recovered. Fractures per foot not assessed (NA).		**Conglomerate(Tmc)** 30.0-66.0' - moderate brown, (5YR 3/4), no dominant clast mineralogy, strong to very weak (R4 to R1), moderately weathered to completely weathered, friable intervals, matrix supported, max clast size = 40 mm	R6 = 15 min
	R7 2.5 ft 88%	32	NA				R7 = 23 min
	63.0						
65	R8 3 ft 87%	18	NA				R8 = 29 min
	66.0					End Drilling on 4/8/2009 Total Borehole Depth: 66.0 ft bgs	
70							
75							
80							

PROJECT NUMBER:	BORING NUMBER:
382653.FP.04.FW	MW-64 SHEET 1 OF 14

ROCK CORE LOG

PROJECT : PG&E Topock - ERGI
LOCATION : Site C - Alternate (2100520.2 N, 7616939.8 E)
ELEVATION : 576.0 ft
DRILLING CONTRACTOR : Boart Longyear (D. Roberts)
CORING EQUIPMENT AND METHOD : Track-mounted Rig, LF-70 Drill Head and HQ-sized tools (diamond bit)
ORIENTATION : Vertical
WATER LEVELS : Approx. 119 ft BGS
START : 5/3/2009
END : 5/15/2009
LOGGER : B. Pelletier (Northstar)

DEPTH AND ELEVATION BELOW SURFACE (ft)	CORE RUN, LENGTH, AND RECOVERY (%)	DISCONTINUITIES R Q D (%)	DISCONTINUITIES FRACTURES PER FOOT	DISCONTINUITIES DESCRIPTION: DEPTH, TYPE, ORIENTATION, ROUGHNESS, PLANARITY, INFILLING MATERIAL AND THICKNESS, SURFACE STAINING, AND TIGHTNESS	SYMBOLIC LOG	LITHOLOGY: ROCK TYPE, COLOR, MINERALOGY, TEXTURE, HARDNESS, WEATHERING, AND ROCK MASS CHARACTERISTICS	COMMENTS: SIZE AND DEPTH OF CASING, FLUID LOSS, CORING RATE AND SMOOTHNESS, CAVING ROD DROPS, TEST RESULTS, ETC.
5 10 15						**Metadiorite (pTbr)** 0-20.0' - dark greenish gray, (6Y 5/4), fine to medium grained, consolidated. Drilling method pulverizes most of the core.	Boring initially drilled to 20.0 ft bgs by Rotosonic tools up to 10-in in diameter. Permanent 6-in PVC conductor casing installed from ground surface to 20 ft bgs (portland cement grout). Boring drilled from 20.0' bgs to total depth of 260.5' bgs using diamond bit rotary core tools (HQ-size, 3.8-in diameter).
20	20.0						Total depth of Rotosonic boring is 20.0 ft bgs. Install permanent 6-in conductor casing (portland cement grout). Begin rotary core drilling.

PROJECT NUMBER:	BORING NUMBER:
382653.FP.04.FW	MW-64-260 SHEET 2 OF 14

ROCK CORE LOG

PROJECT : PG&E Topock - ERGI

LOCATION : Site C - Alternate (2100520.2 N, 7616939.8 E)

ELEVATION : 576.0 ft

DRILLING CONTRACTOR : Boart Longyear (D. Roberts)

CORING EQUIPMENT AND METHOD : Track-mounted Rig, LF-70 Drill Head and HQ-sized tools (diamond bit)

ORIENTATION : Vertical

WATER LEVELS : Approx. 119 ft BGS

START : 5/3/2009

END : 5/15/2009

LOGGER : B. Pelletier (Northstar)

DEPTH AND ELEVATION BELOW SURFACE (ft)	CORE RUN, LENGTH, AND RECOVERY (%)	R Q D (%)	FRACTURES PER FOOT	DISCONTINUITIES DESCRIPTION: DEPTH, TYPE, ORIENTATION, ROUGHNESS, PLANARITY, INFILLING MATERIAL AND THICKNESS, SURFACE STAINING, AND TIGHTNESS	SYMBOLIC LOG	LITHOLOGY: ROCK TYPE, COLOR, MINERALOGY, TEXTURE, HARDNESS, WEATHERING, AND ROCK MASS CHARACTERISTICS	COMMENTS: SIZE AND DEPTH OF CASING, FLUID LOSS, CORING RATE AND SMOOTHNESS, CAVING ROD DROPS, TEST RESULTS, ETC.
			2			**Metadiorite (pTbr)** 20.0-26.6' - dusky yellow green, (5GY 5/2), intermediate (dioritic) mineralogy, fine to medium grained, strong (R4), unweathered, massive to foliated	General Note: The metadiorite bedrock exhibits many small healed fractures (1-3 mm) of somewhat random orientation. These healed fractures create weaknesses in the rock. It can be difficult to determine if the metadiorite is jointed in-situ, or if the discontinuities are caused by the drilling method. Intervals with fracture per foot counts >10 are likely caused by drilling.
			1				
	R1 5.5 ft 77%	90	>10	22.5' - Joint, >60 deg, iron staining, weathered			
			>5	23.5' - Joint, >60 deg, no staining			
25			2				
	25.5		>10				
	R2 1.1 ft 80%	20					R1 = 32.0 min
	26.6		>10			26.6-35.7' - grayish olive, (10Y 4/2), medium grained, rare serpentine replacement along fractures	R2 = 18.0 min
			2	27.5' - Joint, 30 deg, 1-2 mm calcite infilling, no staining, relatively straight, tight			
			5	28.8' - Joint, >60 deg, rough, undulating, calcite infilling, iron staining			
30			8				
	R3 8.9 ft 94%	55	3				
			>10				
			2				
			2	33' - Joint, > 60 deg, multiple fractures, dark brown staining			
35			2				
	35.5		3	35' - Joint, >60 deg, multiple fractures, some near 90 deg			R3 = 38.0 min
			3	36' - Joint, 25 deg, < 2 mm calcite infilling, staining, straight		35.7-40.0' - grayish olive, (10Y 4/2), medium to coarse grained, strong (R4), common calcite replacement, rare foliations	
			3	37.7' - Multiple joints, undulating, heavy staining			
			5	38.5' - Joint, 35 deg, straight			
40			6	39' - Fracture zone, calcite and silica infilling, no staining			

CH2MHILL

PROJECT NUMBER:	BORING NUMBER:
382653.FP.04.FW	**MW-64** SHEET 3 OF 14

ROCK CORE LOG

PROJECT : PG&E Topock - ERGI
LOCATION : Site C - Alternate (2100520.2 N, 7616939.8 E)
ELEVATION : 576.0 ft
DRILLING CONTRACTOR : Boart Longyear (D. Roberts)
CORING EQUIPMENT AND METHOD : Track-mounted Rig, LF-70 Drill Head and HQ-sized tools (diamond bit)
ORIENTATION : Vertical
WATER LEVELS : Approx. 119 ft BGS
START : 5/3/2009
END : 5/15/2009
LOGGER : B. Pelletier (Northstar)

DEPTH AND ELEVATION BELOW SURFACE (ft)	CORE RUN, LENGTH, AND RECOVERY (%)	DISCONTINUITIES: R Q D (%)	FRACTURES PER FOOT	DESCRIPTION: DEPTH, TYPE, ORIENTATION, ROUGHNESS, PLANARITY, INFILLING MATERIAL AND THICKNESS, SURFACE STAINING, AND TIGHTNESS	SYMBOLIC LOG	LITHOLOGY: ROCK TYPE, COLOR, MINERALOGY, TEXTURE, HARDNESS, WEATHERING, AND ROCK MASS CHARACTERISTICS	COMMENTS: SIZE AND DEPTH OF CASING, FLUID LOSS, CORING RATE AND SMOOTHNESS, CAVING ROD DROPS, TEST RESULTS, ETC.
	R4 10 ft 100%	85	8	40' - Fracture zone, 60 deg and near 90 deg, calcite infilling, rare staining, some chlorite infill?		**Metadiorite (pTbr)** 40-65.3' - grayish olive, (10Y 4/2), intermediate (dioritic) mineralogy, medium to coarse grained, strong (R4), unweathered, massive to foliated	
			5				
			4				
			7				
			8	44.5' - multiple fractures as above			
45	45.5		6				R4 = 25.0 min
	R5 8 ft 90%	82	4	46.5' - Joint, 60 deg, multiple smaller undulating joints, calcite infill, common iron staining			
			6				
			>10	48' - Fracture zone, near 90 deg, common fine fractures (< 1 mm), predominately high angle			
			>10	49' - Joint, 60 deg, 1-2 mm calcite infilling			
50			8	50' - Fracture zone, common staining			
			>10	51.0-53.0' - Fracture zone, near 90 deg, undulating, moderate iron staining			
			8			52.0' - moderate foliation, silica and calcite replacement	
	53.5		6	53.0-55.0' - microfractures, undulating			R5 = 47.0 min
	R6 1.8 ft 90%	85	6				
55	55.3		6				R6 = 18.0 min
	R7 5.7 ft 95%	42	8				
			>10				
			>10	58' - Fracture zone, strong iron staining, heavy calcite and silica replacement			
60			8				

CH2MHILL

PROJECT NUMBER:	BORING NUMBER:
382653.FP.04.FW	MW-64 SHEET 4 OF 14

ROCK CORE LOG

PROJECT : PG&E Topock - ERGI
LOCATION : Site C - Alternate (2100520.2 N, 7616939.8 E)
ELEVATION : 576.0 ft
DRILLING CONTRACTOR : Boart Longyear (D. Roberts)
CORING EQUIPMENT AND METHOD : Track-mounted Rig, LF-70 Drill Head and HQ-sized tools (diamond bit)
ORIENTATION : Vertical
WATER LEVELS : Approx. 119 ft BGS
START : 5/3/2009
END : 5/15/2009
LOGGER : B. Pelletier (Northstar)

DEPTH AND ELEVATION BELOW SURFACE (ft)	CORE RUN, LENGTH, AND RECOVERY (%)	DISCONTINUITIES R Q D (%)	FRACTURES PER FOOT	DESCRIPTION: DEPTH, TYPE, ORIENTATION, ROUGHNESS, PLANARITY, INFILLING MATERIAL AND THICKNESS, SURFACE STAINING, AND TIGHTNESS	SYMBOLIC LOG	LITHOLOGY: ROCK TYPE, COLOR, MINERALOGY, TEXTURE, HARDNESS, WEATHERING, AND ROCK MASS CHARACTERISTICS	COMMENTS: SIZE AND DEPTH OF CASING, FLUID LOSS, CORING RATE AND SMOOTHNESS, CAVING ROD DROPS, TEST RESULTS, ETC.
	61.0		6			**Metadiorite (pTbr)** 60-65.3' - grayish olive, (10Y 4/2), medium to coarse grained, foliated	R7 = 28.0 min
	R8 4.5 ft 95%	70	8			61' - massive	
			8				
			>10				
			8	64' - multiple small (< 1mm) fractures			
65	65.5 R9 8.3 ft 94%	39	8			65.3-105.0' - grayish olive, (10Y 4/2), to light olive, (10Y 5/4), medium grained, strong (R4), unweathered to slightly weathered	R8 = 11.0 min
			8	66.5' - Joint, >60 deg, undulating, no staining, tight			
			8				
			>10				
			>10				
70			>10	70' - Fracture zone, rough, undulating, no staining, tight			
			8				
			8				
	73.8 R10 1.5 ft 100%	37	6	73' - Fracture, 20 deg, smooth, brown staining, tight			R9 = 24.0 min
			8				
75	75.3 R11 6.7 ft 93%	30	>10				R10 = 22.0 min
			>10	76' - Fracture zone, rough, undulating, stained		76.0' - slightly weathered	
			8	77.0-79.0' - Fracture zone, healed with silica		77.0-79.0' - foliated	
			>10				
			8				
80							

CH2MHILL

PROJECT NUMBER: 382653.FP.04.FW

BORING NUMBER: MW-64

SHEET 5 OF 14

ROCK CORE LOG

PROJECT : PG&E Topock - ERGI

LOCATION : Site C - Alternate (2100520.2 N, 7616939.8 E)

ELEVATION : 576.0 ft

DRILLING CONTRACTOR : Boart Longyear (D. Roberts)

CORING EQUIPMENT AND METHOD : Track-mounted Rig, LF-70 Drill Head and HQ-sized tools (diamond bit)

ORIENTATION : Vertical

WATER LEVELS : Approx. 119 ft BGS

START : 5/3/2009

END : 5/15/2009

LOGGER : B. Pelletier (Northstar)

DEPTH AND ELEVATION BELOW SURFACE (ft)	CORE RUN, LENGTH, AND RECOVERY (%)	DISCONTINUITIES: R Q D (%)	DISCONTINUITIES: FRACTURES PER FOOT	DISCONTINUITIES: DESCRIPTION: DEPTH, TYPE, ORIENTATION, ROUGHNESS, PLANARITY, INFILLING MATERIAL AND THICKNESS, SURFACE STAINING, AND TIGHTNESS	SYMBOLIC LOG	LITHOLOGY: ROCK TYPE, COLOR, MINERALOGY, TEXTURE, HARDNESS, WEATHERING, AND ROCK MASS CHARACTERISTICS	COMMENTS: SIZE AND DEPTH OF CASING, FLUID LOSS, CORING RATE AND SMOOTHNESS, CAVING ROD DROPS, TEST RESULTS, ETC.
			>10	80.0-82.0' - Fracture zone, calcite infilling		**Metadiorite (pTbr)** 80.0-105.0' - grayish olive, (10Y 4/2), to light olive, (10Y 5/4), intermediate (dioritic) mineralogy, medium grained, strong (R4), unweathered to slightly weathered, massive to foliated	
	82.0		>10				R11 = 23.0 min
	R12 3.3 ft 92%	73	8				
			8	83.5' - Fracture, 60 deg, calcite infilling, staining			
85	85.3		8	84.5' - Fracture zone, calcite infilling, staining			R12 = 14.0 min
	R13 8.7 ft 97%	73	6				
			6	86.0-88.0' - Fractures (3), 40 deg, smooth, minor infilling, some staining, tight			
			8				
			8				
90			8	89' - Fracture zone, rough, undulating			
			8				
			>10				
			>10	92.0-94.0' - Heavily fractured chlorite (?) rich fluid replacement, mostly healed, strong iron staining			
	94.0		>10				R13 = 36.0 min
95	R14 1.3 ft 80% 95.3	10	>10				
	R15 5 ft 90%	42	2	95' - Fracture zone, undulating, staining			R14 = 4.0 min
			>10				
			>10				
			8				
100			>10	99.0-100.5' - Fracture zone, staining		99.0-100.5' - medium strong (R3)	

PROJECT NUMBER:	BORING NUMBER:
382653.FP.04.FW	MW-64 SHEET 6 OF 14

ROCK CORE LOG

PROJECT : PG&E Topock - ERGI
LOCATION : Site C - Alternate (2100520.2 N, 7616939.8 E)
ELEVATION : 576.0 ft
DRILLING CONTRACTOR : Boart Longyear (D. Roberts)
CORING EQUIPMENT AND METHOD : Track-mounted Rig, LF-70 Drill Head and HQ-sized tools (diamond bit)
ORIENTATION : Vertical
WATER LEVELS : Approx. 119 ft BGS
START : 5/3/2009
END : 5/15/2009
LOGGER : B. Pelletier (Northstar)

		DISCONTINUITIES				LITHOLOGY	COMMENTS
				DESCRIPTION			
DEPTH AND ELEVATION BELOW SURFACE (ft)	CORE RUN, LENGTH, AND RECOVERY (%)	R Q D (%)	FRACTURES PER FOOT	DEPTH, TYPE, ORIENTATION, ROUGHNESS, PLANARITY, INFILLING MATERIAL AND THICKNESS, SURFACE STAINING, AND TIGHTNESS	SYMBOLIC LOG	ROCK TYPE, COLOR, MINERALOGY, TEXTURE, HARDNESS, WEATHERING, AND ROCK MASS CHARACTERISTICS	SIZE AND DEPTH OF CASING, FLUID LOSS, CORING RATE AND SMOOTHNESS, CAVING ROD DROPS, TEST RESULTS, ETC.
	100.3		>10			**Metadiorite (pTbr)** 100.0-105.0' - grayish olive, (10Y 4/2), to light olive, (10Y 5/4), intermediate (dioritic) mineralogy, medium grained, strong (R4), unweathered to slightly weathered, massive to foliated	R15 = 21.0 min
			8				
	R16 5 ft 84%	20	>10	102.0-105.3' - Fracture zone, rough, undulating, < 1 mm infilling, heavy staining			
			>10				
105			>10				
	105.3		8	105.3-108.0' - Fracture zone, rough, undulating, little to none infilling, staining		105.0-260.0' - grayish olive, (10Y 4/2), intermediate (dioritic) mineralogy, medium to coarse grained, strong (R4), unweathered to slightly weathered, massive to foliated	R16 = 27.0 min
			8				
	R17 5.7 ft 96%		8				
		29	>10	108.0-111.0' - Fracture zone, little to none infilling, rock fragmented			
110			>10				
	111.0		>10				R17 = 15.5 min
	R18 2.5 ft 80%		8	111' - Fracture zone, staining			
		20	8				
	113.5 R19 1.8 ft 77%		>10			113.5' - medium strong (R3)	R18 = 26.0 min
115		0	>10				
	115.3		6	115.0-118.0' - Minor fracturing, some infill, mostly tight, weak staining		115.0' - medium to coarse grained, strong (R4)	R19 = 6.0 min
			6				
			8				
	R20 8.2 ft 98%		>10	118.0-120.0' - Fractures (3), 80-90 deg, weak staining, tight			
120		55	>10				

PROJECT NUMBER: **382653.FP.04.FW**	BORING NUMBER: **MW-64**	SHEET 7 OF 14

ROCK CORE LOG

PROJECT : PG&E Topock - ERGI

LOCATION : Site C - Alternate (2100520.2 N, 7616939.8 E)

ELEVATION : 576.0 ft

DRILLING CONTRACTOR : Boart Longyear (D. Roberts)

CORING EQUIPMENT AND METHOD : Track-mounted Rig, LF-70 Drill Head and HQ-sized tools (diamond bit)

ORIENTATION : Vertical

WATER LEVELS : Approx. 119 ft BGS

START : 5/3/2009

END : 5/15/2009

LOGGER : B. Pelletier (Northstar)

DEPTH AND ELEVATION BELOW SURFACE (ft)	CORE RUN, LENGTH, AND RECOVERY (%)	DISCONTINUITIES R Q D (%)	DISCONTINUITIES FRACTURES PER FOOT	DISCONTINUITIES DESCRIPTION: DEPTH, TYPE, ORIENTATION, ROUGHNESS, PLANARITY, INFILLING MATERIAL AND THICKNESS, SURFACE STAINING, AND TIGHTNESS	LITHOLOGY: ROCK TYPE, COLOR, MINERALOGY, TEXTURE, HARDNESS, WEATHERING, AND ROCK MASS CHARACTERISTICS	COMMENTS: SIZE AND DEPTH OF CASING, FLUID LOSS, CORING RATE AND SMOOTHNESS, CAVING ROD DROPS, TEST RESULTS, ETC.
			8		**Metadiorite (pTbr)** 105.0-260.0' - grayish olive, (10Y 4/2), intermediate (dioritic) mineralogy, medium to coarse grained, strong (R4), unweathered to slightly weathered, massive to foliated	
			8	121.5-123.0' - Fracture zone, smooth, 2-3 mm infilling	121.5-123.0' - medium strong (R3), foliated	
			>10			
	123.5 R21 1.8 ft 100%	75	8		123.0' - strong (R4)	R20 = 32.0 min
125			8	124' - Fracture zone, near 90 deg, rough, undulating, tight, healed		
	125.3 R22 4.7 ft 93%	10	>10	125.3-127.0' - Fracture zone, < 1 mm calcite infilling, heavy staining, some voids		R21 = 4.5 min
			>10			
			>10		127.0' - medium strong (R3)	
			>10			
130	130.0		>10			R22 = 37.0 min
	R23 3.5 ft 86%	9	>10	130' - Highly fractured	130.0' - foliated	
			>10			
			>10			R23 = 21.0 min
	133.5 R24 1.8 ft 55%	0	>10	133.5' - As above	133.5-135.3' - medium strong (R3)	
135	135.3		>10			
	R25 2.7 ft 93%	15	>10		135.3' - strong (R4)	R24 = 11.5 min
			>10	136' - Fractures (2), 30 deg and vertical, rough, undulating, < 2 mm calcite infilling, most fractures healed		
	138.0		>10			R25 = 21.0 min
			>10	138' - Fractures (2), 70 deg and 20 deg, rough, abundant microfractures		
140			>10			

PROJECT NUMBER:	BORING NUMBER:
382653.FP.04.FW	MW-64 SHEET 8 OF 14

ROCK CORE LOG

PROJECT : PG&E Topock - ERGI
LOCATION : Site C - Alternate (2100520.2 N, 7616939.8 E)
ELEVATION : 576.0 ft
DRILLING CONTRACTOR : Boart Longyear (D. Roberts)
CORING EQUIPMENT AND METHOD : Track-mounted Rig, LF-70 Drill Head and HQ-sized tools (diamond bit)
ORIENTATION : Vertical
WATER LEVELS : Approx. 119 ft BGS
START : 5/3/2009
END : 5/15/2009
LOGGER : B. Pelletier (Northstar)

DEPTH AND ELEVATION BELOW SURFACE (ft)	CORE RUN, LENGTH, AND RECOVERY (%)	DISCONTINUITIES: R Q D (%)	DISCONTINUITIES: FRACTURES PER FOOT	DISCONTINUITIES: DESCRIPTION: DEPTH, TYPE, ORIENTATION, ROUGHNESS, PLANARITY, INFILLING MATERIAL AND THICKNESS, SURFACE STAINING, AND TIGHTNESS	SYMBOLIC LOG	LITHOLOGY: ROCK TYPE, COLOR, MINERALOGY, TEXTURE, HARDNESS, WEATHERING, AND ROCK MASS CHARACTERISTICS	COMMENTS: SIZE AND DEPTH OF CASING, FLUID LOSS, CORING RATE AND SMOOTHNESS, CAVING ROD DROPS, TEST RESULTS, ETC.
	R26 4.2 ft 71%	0	>10			**Metadiorite (pTbr)** 105.0-260.0' - grayish olive, (10Y 4/2), intermediate (dioritic) mineralogy, medium to coarse grained, strong (R4), unweathered to slightly weathered, massive to foliated 142.0' - coarse grained	
			>10				
	142.2		>10	142' - Fracture zone, rough, strong fe/cl staining			R26 = 22.0 min
	R27 3.1 ft 97%	56	>10	143' - Fractures (2), 45 deg, smooth, < 2 mm silica infilling, abundant microfractures			
145			>10				
	145.3		>10	145.0-146.0' - Fractures (2), 40 deg, smooth, stepped, silica infilling		145.3' - foliated	R27 = 7.0 min
			8	146.5' - Fracture zone, undulating, chlorite infilling, tight			
			8				
	R28 7.7 ft 99%		6				
150		95	6				
			8				
			8	151' - Fracture, 85 deg, rough, undulating			
	153.0		0	152' - Multiple tight fractures			R28 = 34.0 min
	R29 2.3 ft 100%		0	153' - Fracture, 60 deg			
155		96	0				
	155.3		1	155' - Fracture, 60 deg, rough, stepped, < 3 mm silica infilling			R29 = 9.0 min
			2	156' - Joint, 30 deg, rough, undulating, < 1 mm calcite infilling, iron staining, tight 156.2' - As above			
			0				
	R30 7.4 ft 100%		3	158.0, 158.2, 158.7' - As above			
160		69	6				

PROJECT NUMBER:	BORING NUMBER:
382653.FP.04.FW	MW-64 SHEET 9 OF 14

ROCK CORE LOG

PROJECT : PG&E Topock - ERGI
LOCATION : Site C - Alternate (2100520.2 N, 7616939.8 E)
ELEVATION : 576.0 ft
DRILLING CONTRACTOR : Boart Longyear (D. Roberts)
CORING EQUIPMENT AND METHOD : Track-mounted Rig, LF-70 Drill Head and HQ-sized tools (diamond bit)
ORIENTATION : Vertical
WATER LEVELS : Approx. 119 ft BGS
START : 5/3/2009
END : 5/15/2009
LOGGER : B. Pelletier (Northstar)

DEPTH AND ELEVATION BELOW SURFACE (ft)	CORE RUN, LENGTH, AND RECOVERY (%)	DISCONTINUITIES: R Q D (%)	DISCONTINUITIES: FRACTURES PER FOOT	DISCONTINUITIES: DESCRIPTION: DEPTH, TYPE, ORIENTATION, ROUGHNESS, PLANARITY, INFILLING MATERIAL AND THICKNESS, SURFACE STAINING, AND TIGHTNESS	SYMBOLIC LOG	LITHOLOGY: ROCK TYPE, COLOR, MINERALOGY, TEXTURE, HARDNESS, WEATHERING, AND ROCK MASS CHARACTERISTICS	COMMENTS: SIZE AND DEPTH OF CASING, FLUID LOSS, CORING RATE AND SMOOTHNESS, CAVING ROD DROPS, TEST RESULTS, ETC.
			>10	160' - Highly fractured		**Metadiorite (pTbr)** 105.0-260.0' - grayish olive, (10Y 4/2), intermediate (dioritic) mineralogy, medium to coarse grained, strong (R4), unweathered to slightly weathered, massive to foliated	
			>10				
	162.7		>10				R30 = 40.0 min
	R31 2.6 ft 100%		>10				
		65	2	163.8, 164.4, 164.6' - Joint, 30 deg, rough, undulating, < 1 mm calcite infilling, iron staining, moderately tight			
165	165.3		4	165.1, 165.2, 165.3, 165.4' - Joint, 10, 10, 10, and 30 deg, rough, undulating, < 1 mm calcite infilling, iron staining, tight to moderately tight			R31 = 5.0 min
			2	166.1, 166.6' - Joint, 30 deg, rough, undulating, no staining, moderately tight			
	R32 5.4 ft 100%		3	167.3, 167.5, 167.8' - Joint, 30, 30, and 60 deg, rough, undulating to stepped, iron staining, tight to moderately tight			
		72	2	168.1, 168.7, 169.6' - Joint, 30, 10, and 30 deg, rough, undulating to stepped, some iron staining, tight			
			1				
170	170.7		>10	170' - Fracture zone, < 2 mm calcite infilling, iron staining			R32 = 27.0 min
			3	171.0, 171.2, 171.9' - Joint, 10, 30, and 30 deg, rough, undulating to stepped, < 2 mm calcite infilling, iron staining, tight			
	R33 4.6 ft 100%		>10	172.5' - Highly fractured, < 5 mm calcite infilling, some iron staining			
		61	>10				
			2	174.0, 174.6' - Joint, 10 deg and 30 deg, rough, undulating, some iron staining, tight		174.5' - fine grained, unweathered, foliated	
175	175.3		>10	175' - Highly fractured		175.0-177.0' - grayish olive green, (5GY 3/2)	R33 = 18.0 min
			0				
			0			177.0' - dusky yellowish green, (10GY 3/2)	
	R34 8 ft 100%		0			178.5' - medium to coarse grained, foliated	
180		86	2	179.2, 179.6' - Joint, 30 deg, rough, undulating, no staining, tight			

PROJECT NUMBER:	BORING NUMBER:
382653.FP.04.FW	MW-64 SHEET 10 OF 14

ROCK CORE LOG

PROJECT : PG&E Topock - ERGI
LOCATION : Site C - Alternate (2100520.2 N, 7616939.8 E)
ELEVATION : 576.0 ft
DRILLING CONTRACTOR : Boart Longyear (D. Roberts)
CORING EQUIPMENT AND METHOD : Track-mounted Rig, LF-70 Drill Head and HQ-sized tools (diamond bit)
ORIENTATION : Vertical
WATER LEVELS : Approx. 119 ft BGS
START : 5/3/2009
END : 5/15/2009
LOGGER : B. Pelletier (Northstar)

DEPTH AND ELEVATION BELOW SURFACE (ft)	CORE RUN, LENGTH, AND RECOVERY (%)	DISCONTINUITIES R Q D (%)	DISCONTINUITIES FRACTURES PER FOOT	DISCONTINUITIES DESCRIPTION: DEPTH, TYPE, ORIENTATION, ROUGHNESS, PLANARITY, INFILLING MATERIAL AND THICKNESS, SURFACE STAINING, AND TIGHTNESS	SYMBOLIC LOG	LITHOLOGY: ROCK TYPE, COLOR, MINERALOGY, TEXTURE, HARDNESS, WEATHERING, AND ROCK MASS CHARACTERISTICS	COMMENTS: SIZE AND DEPTH OF CASING, FLUID LOSS, CORING RATE AND SMOOTHNESS, CAVING ROD DROPS, TEST RESULTS, ETC.
			2	180.1, 180.8' - Joint, 30 deg, rough, undulating, no staining, tight		**Metadiorite (pTbr)** 105.0-260.0' - dusky yellowish green, (10GY 3/2), intermediate (dioritic) mineralogy, medium to coarse grained, strong (R4), unweathered to slightly weathered, massive to foliated	
			1	181.3' - Joint, 30 deg, rough, stepped, no staining, tight			
			3	182.1, 182.4, 182.9, 183.3' - Joint, 30, 30, 30, and 10 deg, rough, undulating to stepped, no staining, tight			
	183.3 R35 1.3 ft 100%	100	1				R34 = 45.0 min
	184.6		0				R35 = 6.0 min
185	R36 2.9 ft 100%	90	1	185.3' - Joint, 10 deg, smooth, undulating to slickenslided, blackish staining, tight			
			0				
	187.5		>10	187' - Fracture zone, < 5 mm calcite infilling, some greenish staining			R36 = 8.0 min
			1	188.5' - Joint, 60 deg, rough, undulating, < 2 mm calcite infilling, iron staining, tight		188.5' - greenish staining	
			1	189.2' - Joint, 60 deg, smooth to slickenslided, undulating to planar, < 5 mm calcite infilling, iron staining, some blackish staining, tight			
190	R37 7.3 ft 100%	82	0				
			>10	191.5' - Fracture zone, < 1 mm calcite infilling, some reddish and blackish staining			
			1	192.6, 193.6' - Joint, 60 deg, rough to smooth, undulating, < 1 mm calcite infilling, some greenish staining, tight			
			1				
	194.8		>10	194.2' - Highly fractured, greenish staining		194.2' - greenish staining	R37 = 24.0 min
195			0				
			1	196.5' - Joint, 80 deg, rough, undulating, < 1 mm calcite infilling, some greenish staining, tight		196.0' - greenish staining	
			1	197.4' - Joint, 30 deg, rough, stepped, < 2 mm calcite infilling, no staining, moderately tight		197.0' - greenish staining	
			0				
200	R38 10.2 ft 100%		0				

CH2MHILL

PROJECT NUMBER:	BORING NUMBER:	
382653.FP.04.FW	MW-64	SHEET 11 OF 14

ROCK CORE LOG

PROJECT : PG&E Topock - ERGI

LOCATION : Site C - Alternate (2100520.2 N, 7616939.8 E)

ELEVATION : 576.0 ft

DRILLING CONTRACTOR : Boart Longyear (D. Roberts)

CORING EQUIPMENT AND METHOD : Track-mounted Rig, LF-70 Drill Head and HQ-sized tools (diamond bit)

ORIENTATION : Vertical

WATER LEVELS : Approx. 119 ft BGS

START : 5/3/2009

END : 5/15/2009

LOGGER : B. Pelletier (Northstar)

DEPTH AND ELEVATION BELOW SURFACE (ft)	CORE RUN, LENGTH, AND RECOVERY (%)	DISCONTINUITIES			SYMBOLIC LOG	LITHOLOGY	COMMENTS
		R Q D (%)	FRACTURES PER FOOT	DESCRIPTION DEPTH, TYPE, ORIENTATION, ROUGHNESS, PLANARITY, INFILLING MATERIAL AND THICKNESS, SURFACE STAINING, AND TIGHTNESS		ROCK TYPE, COLOR, MINERALOGY, TEXTURE, HARDNESS, WEATHERING, AND ROCK MASS CHARACTERISTICS	SIZE AND DEPTH OF CASING, FLUID LOSS, CORING RATE AND SMOOTHNESS, CAVING ROD DROPS, TEST RESULTS, ETC.
		87	0			**Metadiorite (pTbr)** 200.0-260.0' - dusky yellowish green, (10GY 3/2), intermediate (dioritic) mineralogy, medium to coarse grained, strong (R4), unweathered to slightly weathered, massive to foliated 201.0' - dusky green, (5G 3/2)	
			>10	201.3' - Highly fractured, < 5 mm calcite infilling, iron staining			
			0				
			1	203.1' - Joint, 30 deg, rough, undulating, no staining, moderately tight			
205	205.0		>10	204.2' - Fracture zone, some iron staining			R38 = 28.0 min
		98	0			205.5' - 12 mm felsic vein, 30 deg to 40 deg dips	
			0				
			0			207.7' - 50 mm felsic vein, 30 deg to 40 deg dips	
	R39 8 ft 80%		0			208.9' - 8 mm felsic vein, 30 deg to 40 deg dips	
210			0				
			0				
			0			211.2' - felsic vein, 70 deg dip	
	213.0		0			212.0' - dusky yellowish green, (10GY 3/2)	R39 = 32.0 min
	R40 2 ft 100%	0	>10	213.0-215.0' - Highly fractured, no infill, some greenish staining			
215	215.0		>10				R40 = 8.0 min
			0			215.0-218.5' - fine to medium grained	
			0				
			0				
			0			218.5-222.0' - medium to coarse grained, coarse feldspar phenocrysts (12 mm max), no foliation	
220			1				

CH2MHILL

PROJECT NUMBER:	BORING NUMBER:
382653.FP.04.FW	MW-64 SHEET 12 OF 14

ROCK CORE LOG

PROJECT : PG&E Topock - ERGI

LOCATION : Site C - Alternate (2100520.2 N, 7616939.8 E)

ELEVATION : 576.0 ft

DRILLING CONTRACTOR : Boart Longyear (D. Roberts)

CORING EQUIPMENT AND METHOD : Track-mounted Rig, LF-70 Drill Head and HQ-sized tools (diamond bit)

ORIENTATION : Vertical

WATER LEVELS : Approx. 119 ft BGS

START : 5/3/2009

END : 5/15/2009

LOGGER : B. Pelletier (Northstar)

DEPTH AND ELEVATION BELOW SURFACE (ft)	CORE RUN, LENGTH, AND RECOVERY (%)	DISCONTINUITIES R Q D (%)	FRACTURES PER FOOT	DESCRIPTION: DEPTH, TYPE, ORIENTATION, ROUGHNESS, PLANARITY, INFILLING MATERIAL AND THICKNESS, SURFACE STAINING, AND TIGHTNESS	SYMBOLIC LOG	LITHOLOGY: ROCK TYPE, COLOR, MINERALOGY, TEXTURE, HARDNESS, WEATHERING, AND ROCK MASS CHARACTERISTICS	COMMENTS: SIZE AND DEPTH OF CASING, FLUID LOSS, CORING RATE AND SMOOTHNESS, CAVING ROD DROPS, TEST RESULTS, ETC.
	R41 10 ft 100%	98	0	219.5' - Joint, 80 deg, smooth, undulating, < 2 mm calcite infilling, iron staining, greenish staining, light blue staining, tight		219.5-220.0' - presence of light-blue colored staining on fracture surfaces **Metadiorite (pTbr)** 220.0-260.0' - dusky yellowish green, (10GY 3/2), intermediate (dioritic) mineralogy, medium to coarse grained, strong (R4), unweathered to slightly weathered, massive to foliated	
			0				
			2	222.0, 222.3' - Joint, 60 deg and 30 deg, rough, undulating, < 2 mm calcite infilling, greenish staining, tight			
			>10	223.0, 223.3' - Joint, 60 deg, rough, undulating, < 1 mm calcite infilling, no staining, tight 223.5-224.4' - Highly fractured			
225	225.0		>10				R41 = 28.0 min
	R42 7.4 ft 100%	82	0			225.0' - dusky green, (5G 3/2), foliated 225.0-226.0' - bands of felsic minerals, 10 to 60 deg dips, 10 mm max	
			1				
			2	226.8, 227.4' - Joint, 80 deg and 60 deg, rough to smooth, undulating, < 1 mm calcite infilling, iron staining, tight 227.6, 228.1' - Joint, 30 deg, rough, undulating, < 1 mm calcite infilling, no staining, moderately tight			
			2				
			0	228.9' - Joint, 40 deg, smooth, undulating, some iron staining, tight		229.0' - fine grained	
230			2			230.0' - medium to coarse grained	
			0	230.6, 230.9' - Joint, 30 deg and 60 deg, rough, undulating, < 1 mm talc infilling, no staining, tight to moderately tight		230.6' - felsic vein, 60 deg dip, 25 mm max	
	232.4		>10	232' - Highly fractured, < 2 mm calcite infilling, no staining 232.4' - Highly fractured			R42 = 27.0 min
	R43 2.6 ft 8%	0	>10				
235	235.0		>10				R43 = 7.0 min
	R44 5 ft 40%	18	>10	235' - Highly fractured			
			>10				
			>10				
			>10				
240	240.0		>10				R44 = 20.0 min

CH2MHILL

PROJECT NUMBER: 382653.FP.04.FW

BORING NUMBER: MW-64 SHEET 13 OF 14

ROCK CORE LOG

PROJECT : PG&E Topock - ERGI
LOCATION : Site C - Alternate (2100520.2 N, 7616939.8 E)
ELEVATION : 576.0 ft
DRILLING CONTRACTOR : Boart Longyear (D. Roberts)
CORING EQUIPMENT AND METHOD : Track-mounted Rig, LF-70 Drill Head and HQ-sized tools (diamond bit)
ORIENTATION : Vertical
WATER LEVELS : Approx. 119 ft BGS
START : 5/3/2009
END : 5/15/2009
LOGGER : B. Pelletier (Northstar)

DEPTH AND ELEVATION BELOW SURFACE (ft)	CORE RUN, LENGTH, AND RECOVERY (%)	DISCONTINUITIES R Q D (%)	FRACTURES PER FOOT	DESCRIPTION: DEPTH, TYPE, ORIENTATION, ROUGHNESS, PLANARITY, INFILLING MATERIAL AND THICKNESS, SURFACE STAINING, AND TIGHTNESS	SYMBOLIC LOG	LITHOLOGY: ROCK TYPE, COLOR, MINERALOGY, TEXTURE, HARDNESS, WEATHERING, AND ROCK MASS CHARACTERISTICS	COMMENTS: SIZE AND DEPTH OF CASING, FLUID LOSS, CORING RATE AND SMOOTHNESS, CAVING ROD DROPS, TEST RESULTS, ETC.
	R45 2 ft 100%		>10	240' - Highly fractured		**Metadiorite (pTbr)** 240.0-260.0' - dusky green, (5G 3/2), intermediate (dioritic) mineralogy, medium to coarse grained, strong (R4), unweathered to slightly weathered, massive to foliated	
	242.0	30	0				R45 = 5.0 min
			>10				
	R46 3 ft 70%	57	1	243.6' - Joint, 60 deg, rough, undulating, < 2 mm talc infilling, no staining, loose			
245	245.0		0				R46 = 4.0 min
			>10			245.0-246.0' - largely felsic mineralogy	
	R47 3.7 ft 100%	57	2	246.4, 246.8' - Joint, 30 deg, rough, undulating to stepped, < 2 mm calcite infilling, no staining, loose			
			>10	247.0-249.0' - Highly fractured 247.3-247.6' - Multiple parallel joints, 40 deg, rough to smooth, undulating, < 1 mm calcite infilling, tight			
	248.7		>10	248.8' - Joint, 60 deg, rough, undulating, < 5 mm calcite infilling, no staining, moderately tight		248.0' - quartz based silt infill	R47 = 10.0 min
250			0				
			0				
	R48 6.3 ft 100%	94	2	251.4, 251.7' - Joint, 10 deg and 30 deg, rough, undulating, < 2 mm calcite infilling, no staining, moderately tight			
			0			252.8-253.8' - felsic veins, 20 mm max, 10 to 30 deg dips	
			0				
255	255.0		0				R48 = 9.0 min
			0				
			0				
	R49 5.5 ft 100%	100	0				
			1	258.0, 259.5, 259.9' - Joint, 30 deg, rough, undulating, no staining, tight			
260			2				

PROJECT NUMBER:	BORING NUMBER:
382653.FP.04.FW	MW-64 SHEET 14 OF 14

ROCK CORE LOG

PROJECT : PG&E Topock - ERGI

LOCATION : Site C - Alternate (2100520.2 N, 7616939.8 E)

ELEVATION : 576.0 ft

DRILLING CONTRACTOR : Boart Longyear (D. Roberts)

CORING EQUIPMENT AND METHOD : Track-mounted Rig, LF-70 Drill Head and HQ-sized tools (diamond bit)

ORIENTATION : Vertical

WATER LEVELS : Approx. 119 ft BGS

START : 5/3/2009

END : 5/15/2009

LOGGER : B. Pelletier (Northstar)

DEPTH AND ELEVATION BELOW SURFACE (ft)	CORE RUN, LENGTH, AND RECOVERY (%)	DISCONTINUITIES R Q D (%)	FRACTURES PER FOOT	DESCRIPTION DEPTH, TYPE, ORIENTATION, ROUGHNESS, PLANARITY, INFILLING MATERIAL AND THICKNESS, SURFACE STAINING, AND TIGHTNESS	SYMBOLIC LOG	LITHOLOGY ROCK TYPE, COLOR, MINERALOGY, TEXTURE, HARDNESS, WEATHERING, AND ROCK MASS CHARACTERISTICS	COMMENTS SIZE AND DEPTH OF CASING, FLUID LOSS, CORING RATE AND SMOOTHNESS, CAVING ROD DROPS, TEST RESULTS, ETC.
	260.5						R49 = 8.0 min
						End Drilling on 5/15/2009 Total Borehole Depth: 260.5 ft bgs	
265							
270							
275							
280							

Attachment A1-3
Monitoring Well Construction Logs

WELL COMPLETION DIAGRAM

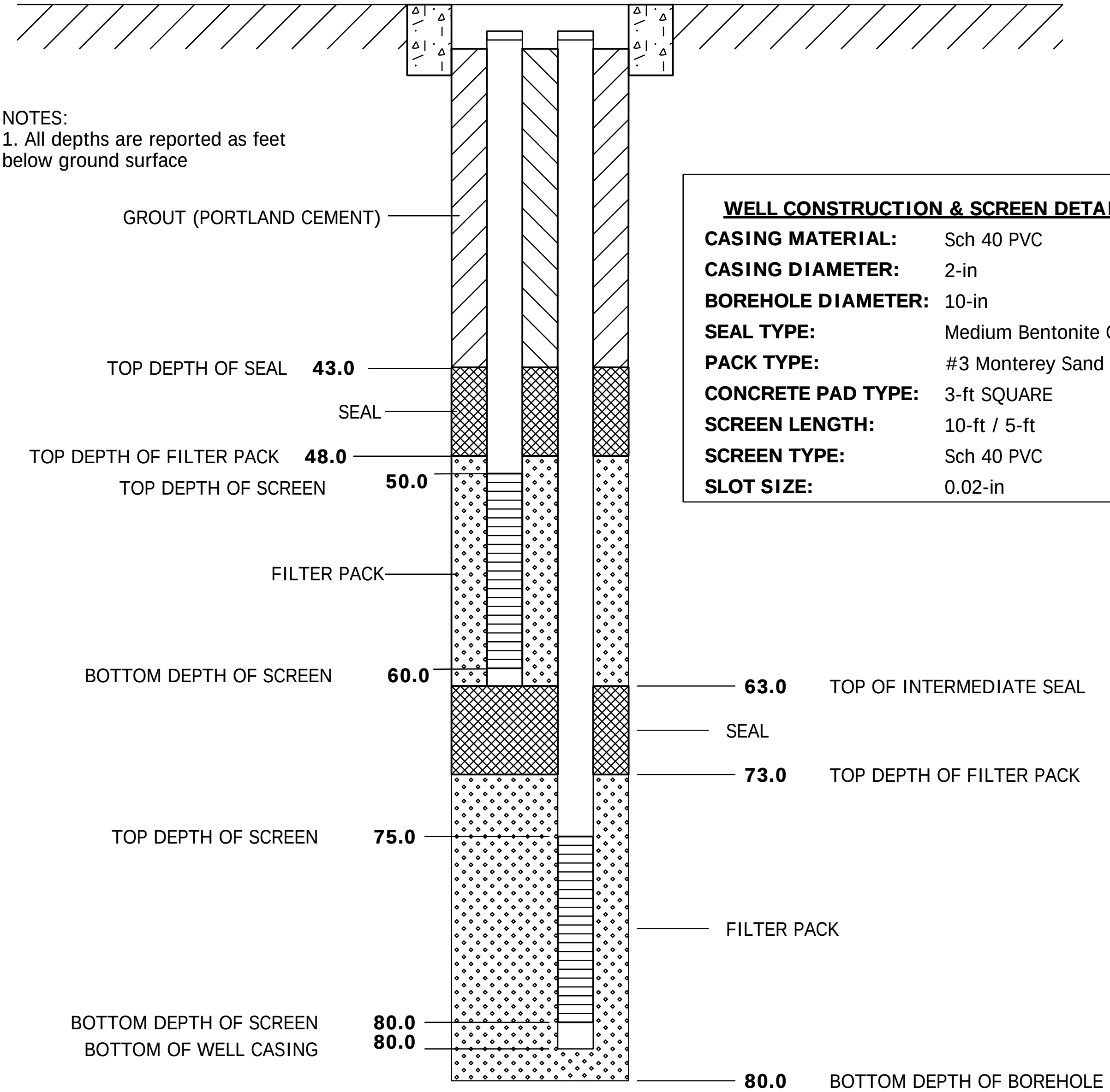
PROJECT NO: 382653.FP.04.FW	**PROJECT:** PG&E Topock - ERGI	**WELL NO:** ***MW-23-060*** ***MW-23-080***

LOCATION: Former MW-23

DRILLING CONTRACTOR: Boart Longyear (D. Roberts)	**DRILLING START:** 4/30/2009
DRILLING METHOD: Rotosonic	**DRILLING END:** 5/2/2009
LOGGER: B. Pelletier (Northstar)	**WELL COMPLETION DATE:** 5/2/2009
GROUND SURFACE ELEVATION (NAVD 88): 504.6 ft AMSL	**GENERAL REMARKS:** Existing monitoring well MW-23 was over-drilled and reconstructed within the same borehole as two nested monitoring wells
NORTHING (CCS NAD 83 Z 5): 2101286.32 **EASTING (CCS NAD 83 Z 5):** 7616448.50	

12-in DIAMETER WELL VAULT (FLUSH WITH GRADE)

NOTES:
1. All depths are reported as feet below ground surface



WELL CONSTRUCTION & SCREEN DETAILS

CASING MATERIAL:	Sch 40 PVC
CASING DIAMETER:	2-in
BOREHOLE DIAMETER:	10-in
SEAL TYPE:	Medium Bentonite Chips
PACK TYPE:	#3 Monterey Sand
CONCRETE PAD TYPE:	3-ft SQUARE
SCREEN LENGTH:	10-ft / 5-ft
SCREEN TYPE:	Sch 40 PVC
SLOT SIZE:	0.02-in

WELL DIAGRAM IS NOT TO SCALE

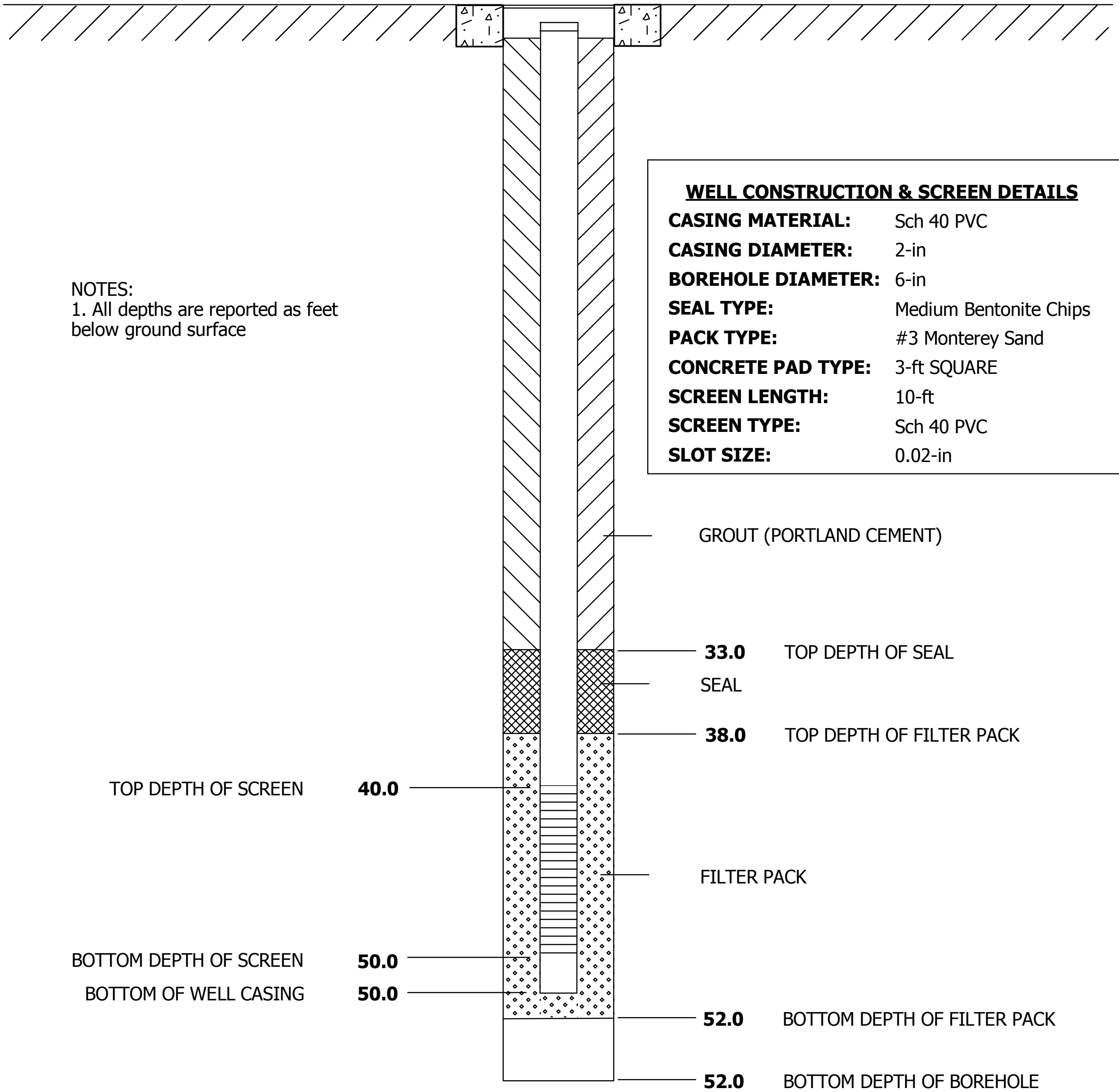
WELL COMPLETION DIAGRAM

PROJECT NO: 382653.FP.04.FW	**PROJECT:** PG&E Topock - ERGI	**WELL NO:** ***MW-57-050***

LOCATION: Site B

DRILLING CONTRACTOR: Boart Longyear (D. Roberts)	**DRILLING START:** 1/21/2009
DRILLING METHOD: Rotosonic	**DRILLING END:** 1/21/2009
LOGGER: A. Brewster (Northstar)	**WELL COMPLETION DATE:** 1/21/2009
GROUND SURFACE ELEVATION (NAVD 88): 508.97 ft AMSL	**GENERAL REMARKS:** Alias during field work: MW-57S
NORTHING (CCS NAD 83 Z 5): 2100906.35 **EASTING (CCS NAD 83 Z 5):** 7616384.35	

12-IN DIAMETER WELL VAUDT (FLUSH WITH GRADE)



WELL CONSTRUCTION & SCREEN DETAILS

CASING MATERIAL:	Sch 40 PVC
CASING DIAMETER:	2-in
BOREHOLE DIAMETER:	6-in
SEAL TYPE:	Medium Bentonite Chips
PACK TYPE:	#3 Monterey Sand
CONCRETE PAD TYPE:	3-ft SQUARE
SCREEN LENGTH:	10-ft
SCREEN TYPE:	Sch 40 PVC
SLOT SIZE:	0.02-in

NOTES:
1. All depths are reported as feet below ground surface

WELL DIAGRAM IS NOT TO SCALE

WELL COMPLETION DIAGRAM

PROJECT NO: 382653.FP.04.FW

PROJECT: PG&E Topock - ERGI

WELL NO: *MW-57-070*

LOCATION: Site B

DRILLING CONTRACTOR: Boart Longyear (D. Roberts)

DRILLING START: 1/28/2009

DRILLING METHOD: Rotosonic

DRILLING END: 1/28/2009

LOGGER: A. Brewster (Northstar)

WELL COMPLETION DATE: 1/28/2009

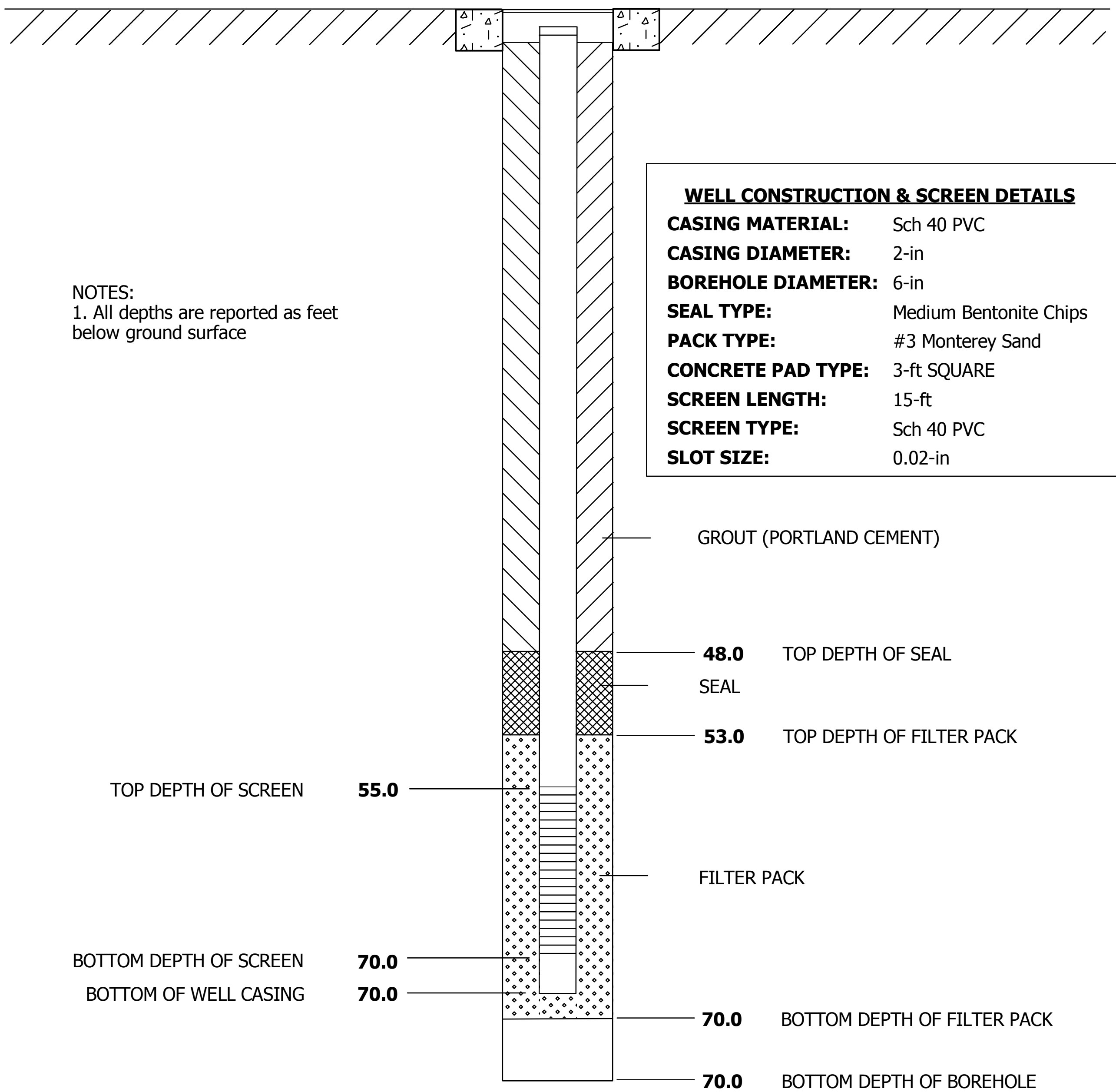
GROUND SURFACE ELEVATION (NAVD 88): 508.97 ft AMSL

GENERAL REMARKS: Alias during field work: MW-57M

NORTHING (CCS NAD 83 Z 5): 2100893.58

EASTING (CCS NAD 83 Z 5): 7616394.98

12-IN DIAMETER WELL VAULT (FLUSH WITH GRADE)



NOTES:
1. All depths are reported as feet below ground surface

WELL CONSTRUCTION & SCREEN DETAILS

CASING MATERIAL:	Sch 40 PVC
CASING DIAMETER:	2-in
BOREHOLE DIAMETER:	6-in
SEAL TYPE:	Medium Bentonite Chips
PACK TYPE:	#3 Monterey Sand
CONCRETE PAD TYPE:	3-ft SQUARE
SCREEN LENGTH:	15-ft
SCREEN TYPE:	Sch 40 PVC
SLOT SIZE:	0.02-in

WELL DIAGRAM IS NOT TO SCALE

CH2MHILL

WELL COMPLETION DIAGRAM

PROJECT NO: 382653.FP.04.FW

PROJECT: PG&E Topock - ERGI

WELL NO: *MW-57-185*

LOCATION: Site B

DRILLING CONTRACTOR: Boart Longyear (D. Roberts)

DRILLING START: 1/14/2009

DRILLING METHOD: Rotosonic / Rotary Core (HQ)

DRILLING END: 1/20/2009

LOGGER: A. Brewster (Northstar)

WELL COMPLETION DATE: 2/16/2009

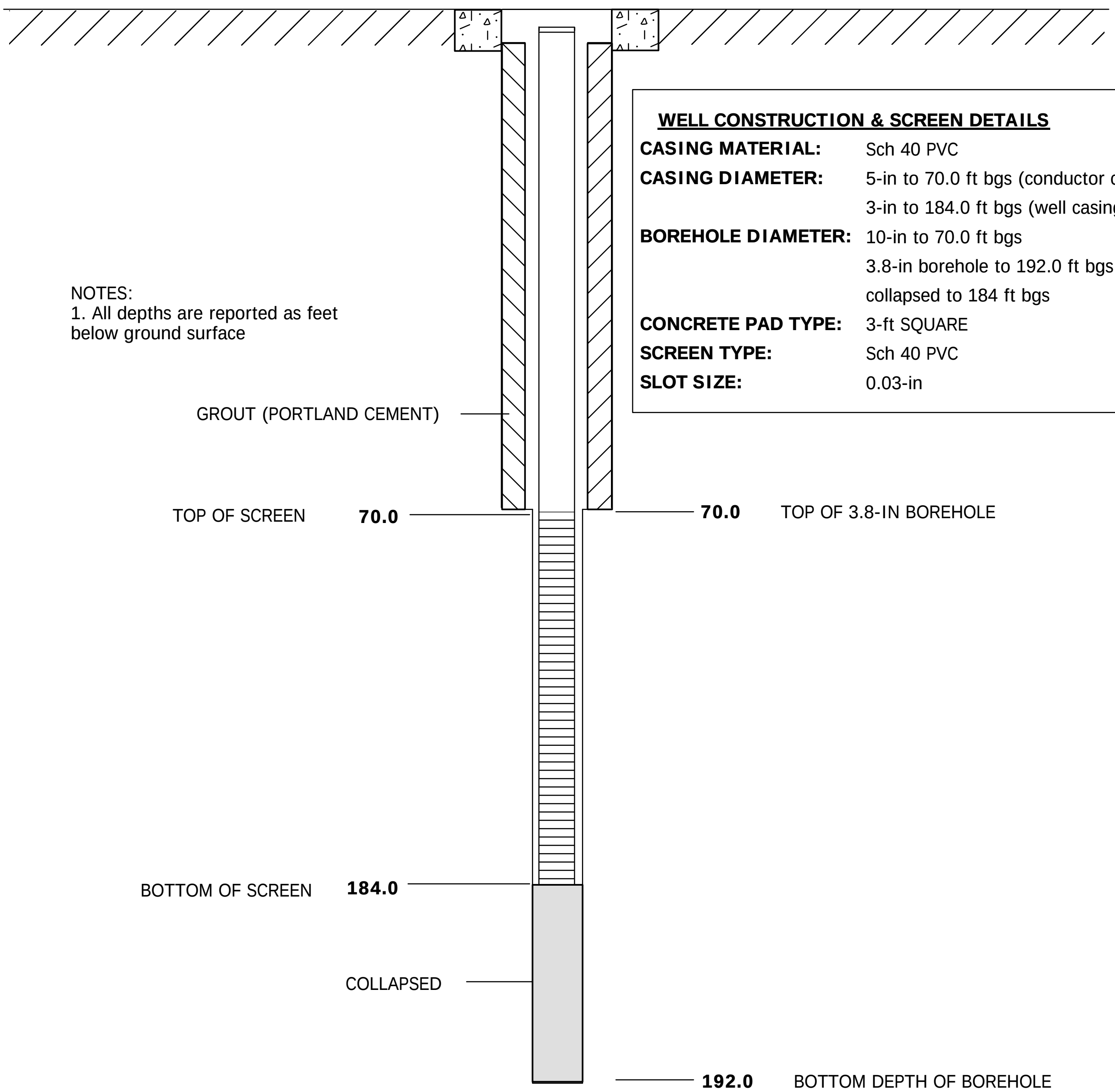
GROUND SURFACE ELEVATION (NAVD 88): 508.97 ft AMSL

GENERAL REMARKS: Alias during field work: MW-57BR

NORTHING (CCS NAD 83 Z 5): 2100899.56

EASTING (CCS NAD 83 Z 5): 7616389.44

12-IN DIAMETER WELL VAULT (FLUSH WITH GRADE)



WELL CONSTRUCTION & SCREEN DETAILS

CASING MATERIAL:	Sch 40 PVC
CASING DIAMETER:	5-in to 70.0 ft bgs (conductor casing) 3-in to 184.0 ft bgs (well casing)
BOREHOLE DIAMETER:	10-in to 70.0 ft bgs 3.8-in borehole to 192.0 ft bgs collapsed to 184 ft bgs
CONCRETE PAD TYPE:	3-ft SQUARE
SCREEN TYPE:	Sch 40 PVC
SLOT SIZE:	0.03-in

NOTES:
1. All depths are reported as feet below ground surface

WELL DIAGRAM IS NOT TO SCALE

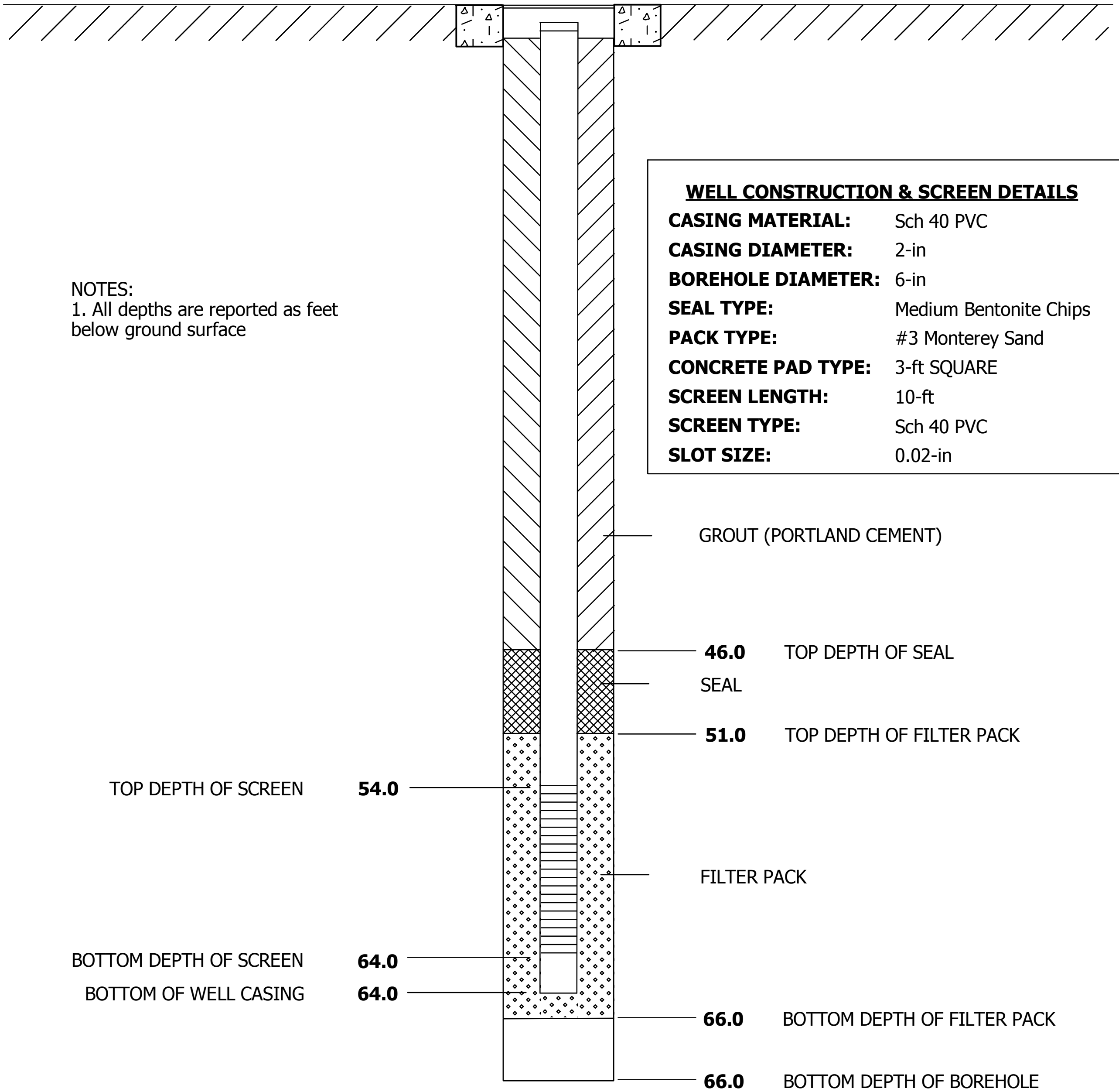
WELL COMPLETION DIAGRAM

PROJECT NO: 382653.FP.04.FW	**PROJECT:** PG&E Topock - ERGI	**WELL NO:** ***MW-58-065***

LOCATION: Site A

DRILLING CONTRACTOR: Boart Longyear (D. Roberts)	**DRILLING START:** 2/11/2009
DRILLING METHOD: Rotosonic	**DRILLING END:** 2/12/2009
LOGGER: A. Brewster (Northstar)	**WELL COMPLETION DATE:** 2/12/2009
GROUND SURFACE ELEVATION (NAVD 88): 521.41 ft AMSL	**GENERAL REMARKS:** Alias during field work: MW-58S
NORTHING (CCS NAD 83 Z 5): 2100607.15 **EASTING (CCS NAD 83 Z 5):** 7616136.25	

12-IN DIAMETER WELL VAULT (FLUSH WITH GRADE)



NOTES:
1. All depths are reported as feet below ground surface

WELL CONSTRUCTION & SCREEN DETAILS

CASING MATERIAL:	Sch 40 PVC
CASING DIAMETER:	2-in
BOREHOLE DIAMETER:	6-in
SEAL TYPE:	Medium Bentonite Chips
PACK TYPE:	#3 Monterey Sand
CONCRETE PAD TYPE:	3-ft SQUARE
SCREEN LENGTH:	10-ft
SCREEN TYPE:	Sch 40 PVC
SLOT SIZE:	0.02-in

GROUT (PORTLAND CEMENT)

46.0 TOP DEPTH OF SEAL

SEAL

51.0 TOP DEPTH OF FILTER PACK

TOP DEPTH OF SCREEN **54.0**

FILTER PACK

BOTTOM DEPTH OF SCREEN **64.0**

BOTTOM OF WELL CASING **64.0**

66.0 BOTTOM DEPTH OF FILTER PACK

66.0 BOTTOM DEPTH OF BOREHOLE

WELL DIAGRAM IS NOT TO SCALE

WELL COMPLETION DIAGRAM

PROJECT NO: 382653.FP.04.FW

PROJECT: PG&E Topock - ERGI

WELL NO's: ***MW-58-115***
MW-58-205

LOCATION: Site A

DRILLING CONTRACTOR: Boart Longyear (D. Roberts)

DRILLING START: 1/29/2009

DRILLING METHOD: Rotosonic

DRILLING END: 2/12/2009

LOGGER: A. Brewster (Northstar) and I. Wood

WELL COMPLETION DATE: 7/8/2009

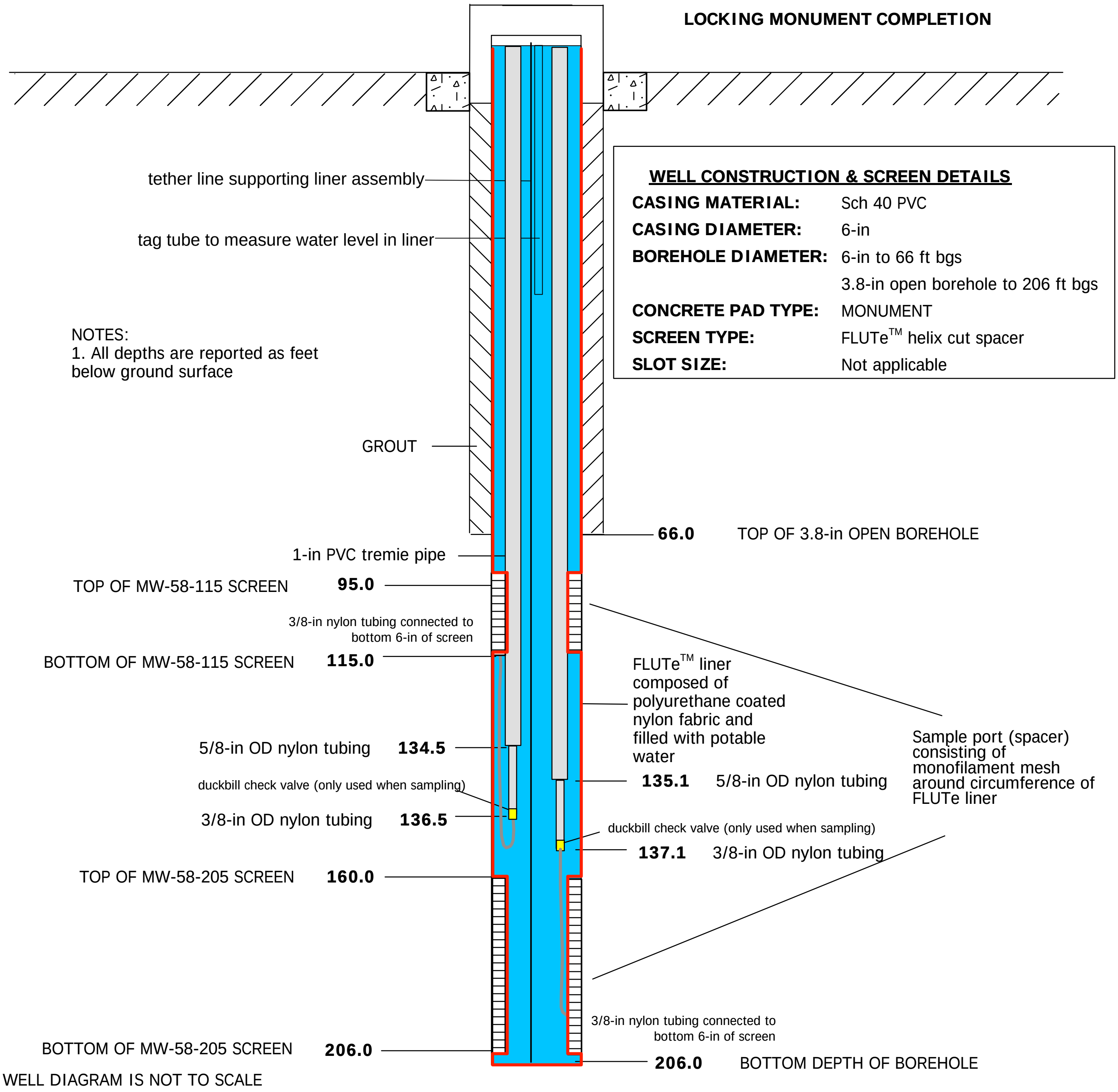
GROUND SURFACE ELEVATION (NAVD 88): 521.78 ft AMSL

NORTHING (CCS NAD 83 Z 5): 2100612.06

EASTING (CCS NAD 83 Z 5): 7616131.80

GENERAL REMARKS: 4-inch diameter, 2-port Guelph Water FLUTe™ multi-level system with helical screens installed into open 3.8-inch HQ borehole

LOCKING MONUMENT COMPLETION



NOTES:
1. All depths are reported as feet below ground surface

WELL CONSTRUCTION & SCREEN DETAILS

CASING MATERIAL:	Sch 40 PVC
CASING DIAMETER:	6-in
BOREHOLE DIAMETER:	6-in to 66 ft bgs 3.8-in open borehole to 206 ft bgs
CONCRETE PAD TYPE:	MONUMENT
SCREEN TYPE:	FLUTe™ helix cut spacer
SLOT SIZE:	Not applicable

WELL DIAGRAM IS NOT TO SCALE

FLUTe™ Flexible Liner Underground Technologies, Ltd. L.C.
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505-455-1300, www.flut.com

As-Built Information

Job # 968-1

General:

Job Description:	206' 4"dia. 2 Port Guelph Water FLUTe
Customer:	CH2M Hill
Location:	155 Grand Ave. Suite 1000 Oakland, CA 94612
Well Designation:	MW-58BR
Hole Depth:	206'
Water Table:	67'
Drilling Method:	N/A
Casing Information:	N/A
Installation Method:	Water eversion
Bubbler / Tag:	67'

Liner:

Material:	210d Orange d/c 2 sleeve
Diameter:	4"
Material Above Casing:	3'
Unverted Material:	4'
Rough Fabrication Legnth:	216'
Termination:	End Seal Knot
Knot Diameter Allowance:	2"
Markings on Liner:	Ink stamp indicating FLUTe TOC & FLUTe Job# 968-1
Spacer Design:	2 Material helix cut spacer Design (orange mesh) and Mylar

Spacer #	**Spacer Bottom [ft]**	**Spacer Top [ft]**
1	115'	95'
2	206'	160'

Tubing & Ports:							
Tubing In Bundle:			NYLON				
Tubing In Sleeves:			NYLON				
Bubbler Details:			1/4 NYLON				
Port Design:			Superthane feed thru				
Port Locations:			6" @ bottom of spacer				
Vent Design:			1/4 Superthane feed thru w/ 3/8 tygon tubing connected to duct				
Vent Location:			210'				
Pump Assembly:							
Port #:	**Transducer Serial #:**	**Transducer Pressure Rating [psi]:**	**Diaphragm Depth [ft. btoc]**	**Cable Serial #:**	**Cable Length [ft.]**	**5/8 x 3/8**	**3/8 x 1/4**
1						134'.5"	136'.5"
2						135'	137'

Other Info:

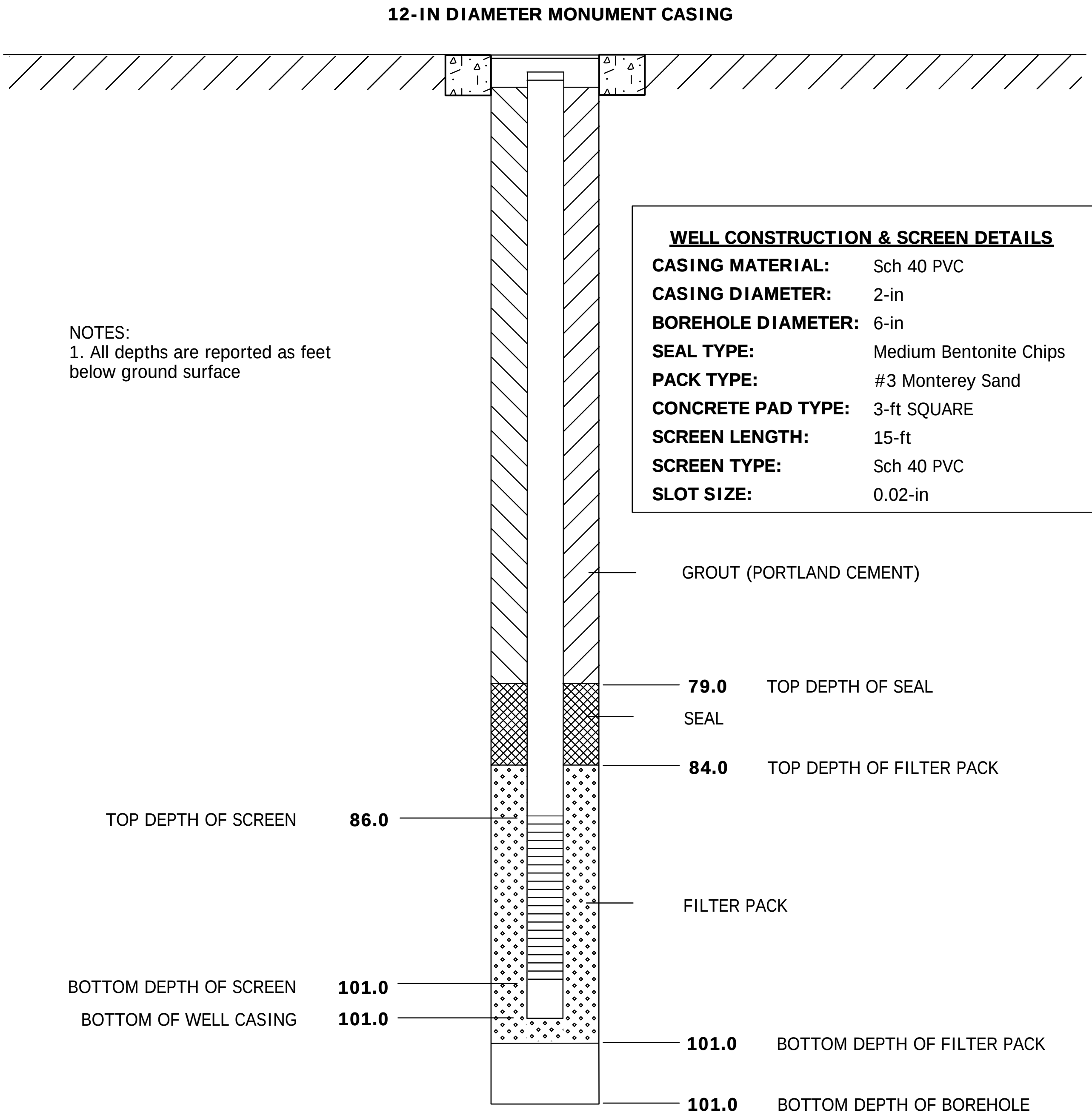
Transducer Type:	N/A
Kellum Design:	1" Friction Kellum wrap Below Unions 1" Webbing with blue hig
Kellum Locations:	1st kellum @ 18' btoc: others every 40 there after
Tether:	1/4"
Marking on Tubing:	Port #'s and color code
Marking on Cables:	Port #'S
Bundle Sheating:	White 2.25" starting @ 134'
Marks on Bundle:	E.P. markings @ every 40'
Pump Tube:	216'
Reel / Packaging:	SF FLUTe
Casing Adapter Info:	ABQ FLUTe
Wellhead Info:	ABQ FLUTe
Vent Tube:	n/a
Clamps:	ABQ FLUTe
Shipped Via:	ABQ FLUTe
Other Notes:	Port # 1 Protrudes @ 134'.5"' Top Of Tube @ 131" W/ red caps
	Port # 2 Protrudes @ 135' Top Of Tube @ 133' W/ red caps

WELL COMPLETION DIAGRAM

PROJECT NO: 382653.FP.04.FW	**PROJECT:** PG&E Topock - ERGI	**WELL NO:** ***MW-59-100***

LOCATION: Site G

DRILLING CONTRACTOR: Boart Longyear (D. Roberts)	**DRILLING START:** 2/25/2009
DRILLING METHOD: Rotosonic	**DRILLING END:** 2/26/2009
LOGGER: A. Brewster (Northstar)	**WELL COMPLETION DATE:** 2/26/2009
GROUND SURFACE ELEVATION (NAVD 88): 538.94 ft AMSL	**GENERAL REMARKS:** Alias during field work: MW-59
NORTHING (CCS NAD 83 Z 5): 2100851.96 **EASTING (CCS NAD 83 Z 5):** 7616081.90	



NOTES:
1. All depths are reported as feet below ground surface

WELL CONSTRUCTION & SCREEN DETAILS

CASING MATERIAL:	Sch 40 PVC
CASING DIAMETER:	2-in
BOREHOLE DIAMETER:	6-in
SEAL TYPE:	Medium Bentonite Chips
PACK TYPE:	#3 Monterey Sand
CONCRETE PAD TYPE:	3-ft SQUARE
SCREEN LENGTH:	15-ft
SCREEN TYPE:	Sch 40 PVC
SLOT SIZE:	0.02-in

WELL DIAGRAM IS NOT TO SCALE

WELL COMPLETION DIAGRAM

PROJECT NO: 382653.FP.04.FW
PROJECT: PG&E Topock - ERGI
WELL NO: ***MW-60-125***

LOCATION: Site F

DRILLING CONTRACTOR: Boart Longyear (D. Roberts)
DRILLING START: 2/27/2009

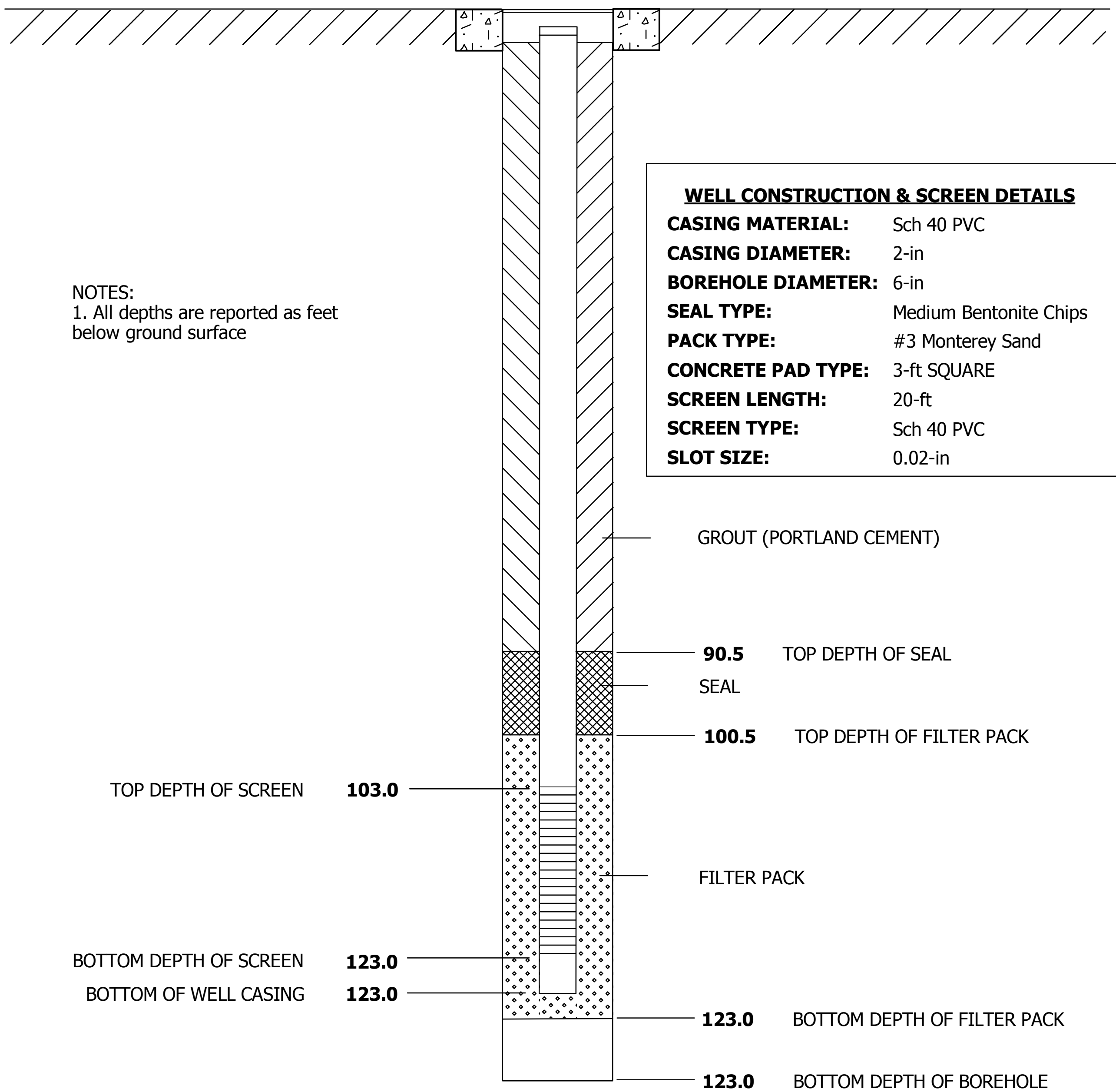
DRILLING METHOD: Rotary Core (HQ) - Rotosonic overdrill
DRILLING END: 3/3/2009

LOGGER: A. Brewster (Northstar)
WELL COMPLETION DATE: 3/3/2009

GROUND SURFACE ELEVATION (NAVD 88): 555.78 ft AMSL
GENERAL REMARKS: Alias during field work: MW-60

NORTHING (CCS NAD 83 Z 5): 2100491.63
EASTING (CCS NAD 83 Z 5): 7616434.82

12-IN DIAMETER WELL VAULT (FLUSH WITH GRADE)



NOTES:
1. All depths are reported as feet below ground surface

WELL CONSTRUCTION & SCREEN DETAILS

CASING MATERIAL:	Sch 40 PVC
CASING DIAMETER:	2-in
BOREHOLE DIAMETER:	6-in
SEAL TYPE:	Medium Bentonite Chips
PACK TYPE:	#3 Monterey Sand
CONCRETE PAD TYPE:	3-ft SQUARE
SCREEN LENGTH:	20-ft
SCREEN TYPE:	Sch 40 PVC
SLOT SIZE:	0.02-in

WELL DIAGRAM IS NOT TO SCALE

WELL COMPLETION DIAGRAM

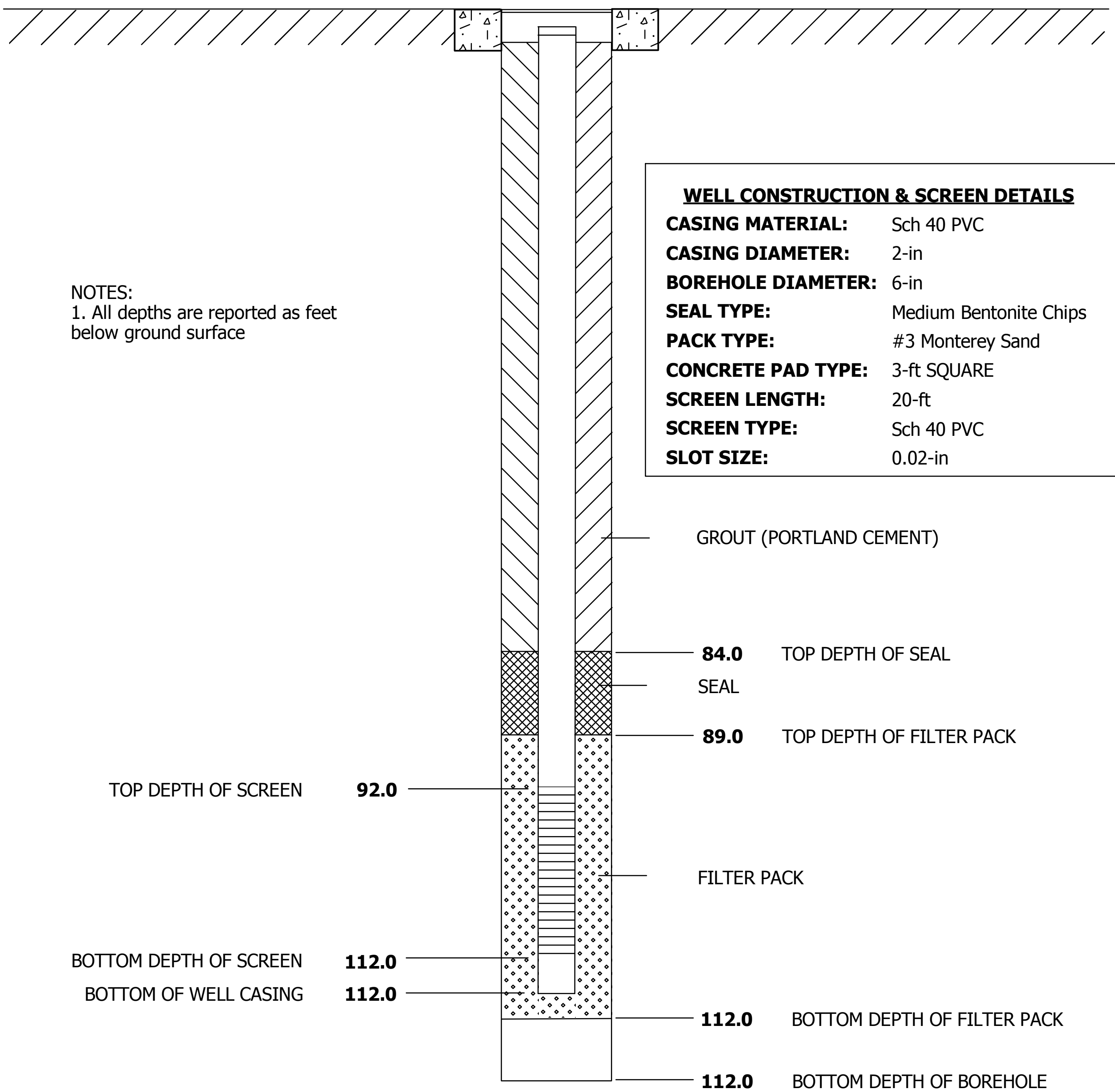
PROJECT NO: 382653.FP.04.FW	**PROJECT:** PG&E Topock - ERGI	**WELL NO:** ***MW-61-110***

LOCATION: Site C

DRILLING CONTRACTOR: Boart Longyear (D. Roberts)	**DRILLING START:** 3/4/2009
DRILLING METHOD: Rotary Core (HQ) - Rotosonic overdrill	**DRILLING END:** 3/13/2009
LOGGER: A. Brewster (Northstar)	**WELL COMPLETION DATE:** 3/13/2009
GROUND SURFACE ELEVATION (NAVD 88): 544.12 ft AMSL	**GENERAL REMARKS:** Alias during field work: MW-61

NORTHING (CCS NAD 83 Z 5):	**EASTING (CCS NAD 83 Z 5):**
2100713.02	7616591.04

12-IN DIAMETER WELL VAULT (FLUSH WITH GRADE)



WELL CONSTRUCTION & SCREEN DETAILS

CASING MATERIAL:	Sch 40 PVC
CASING DIAMETER:	2-in
BOREHOLE DIAMETER:	6-in
SEAL TYPE:	Medium Bentonite Chips
PACK TYPE:	#3 Monterey Sand
CONCRETE PAD TYPE:	3-ft SQUARE
SCREEN LENGTH:	20-ft
SCREEN TYPE:	Sch 40 PVC
SLOT SIZE:	0.02-in

NOTES:
1. All depths are reported as feet below ground surface

WELL DIAGRAM IS NOT TO SCALE

CH2MHILL

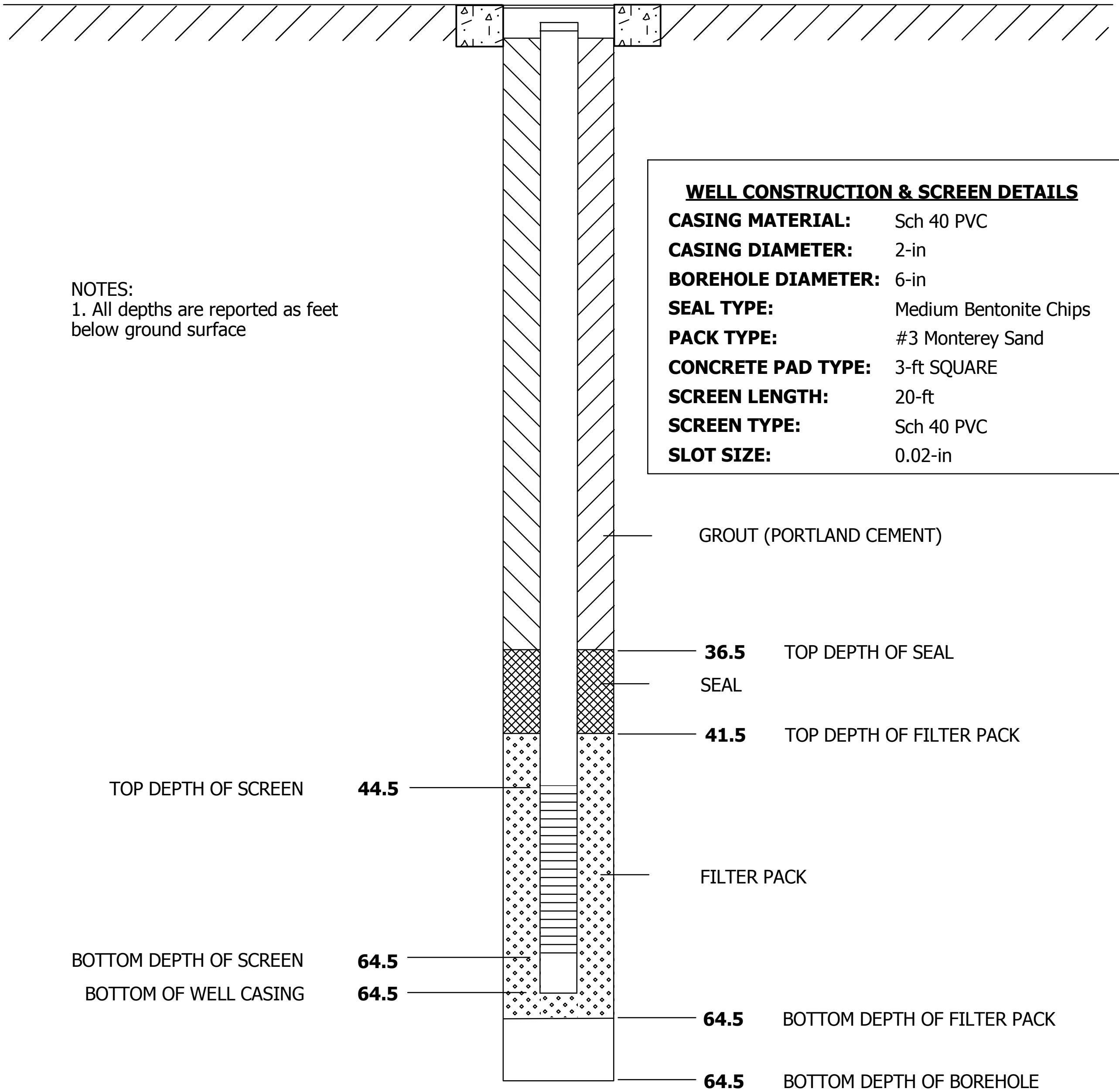
WELL COMPLETION DIAGRAM

PROJECT NO: 382653.FP.04.FW	**PROJECT:** PG&E Topock - ERGI	**WELL NO:** ***MW-62-065***

LOCATION: Site E

DRILLING CONTRACTOR: Boart Longyear (D. Roberts)	**DRILLING START:** 3/14/2009
DRILLING METHOD: Rotary Core (HQ) - Rotosonic overdrill	**DRILLING END:** 3/18/2009
LOGGER: A. Brewster (Northstar)	**WELL COMPLETION DATE:** 3/18/2009
GROUND SURFACE ELEVATION (NAVD 88): 503.55 ft AMSL	**GENERAL REMARKS:** Alias during field work: MW-62
NORTHING (CCS NAD 83 Z 5): 2101064.51 **EASTING (CCS NAD 83 Z 5):** 7616560.96	

12-IN DIAMETER WELL VAULT (FLUSH WITH GRADE)



WELL CONSTRUCTION & SCREEN DETAILS

CASING MATERIAL:	Sch 40 PVC
CASING DIAMETER:	2-in
BOREHOLE DIAMETER:	6-in
SEAL TYPE:	Medium Bentonite Chips
PACK TYPE:	#3 Monterey Sand
CONCRETE PAD TYPE:	3-ft SQUARE
SCREEN LENGTH:	20-ft
SCREEN TYPE:	Sch 40 PVC
SLOT SIZE:	0.02-in

NOTES:
1. All depths are reported as feet below ground surface

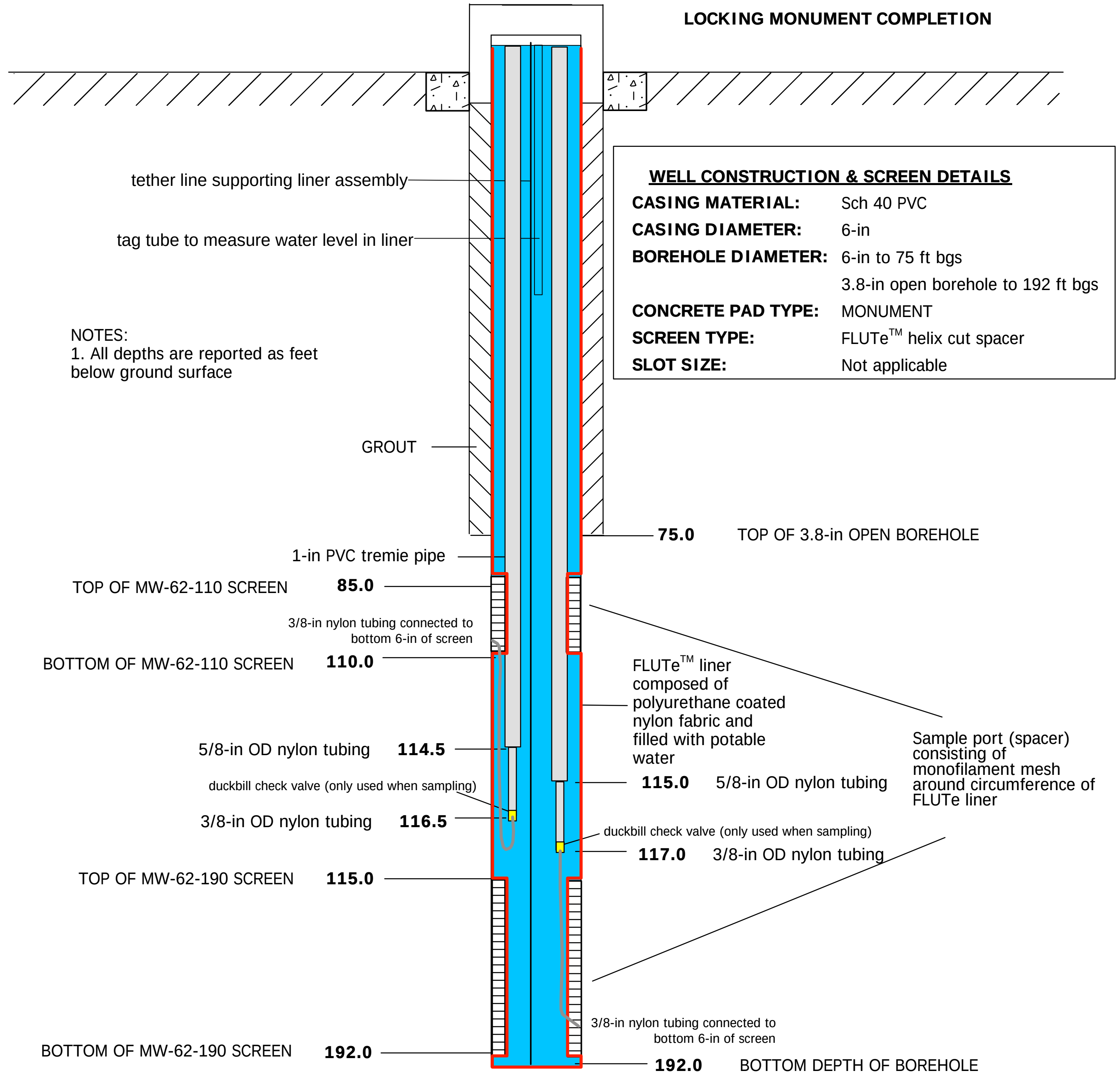
WELL DIAGRAM IS NOT TO SCALE

WELL COMPLETION DIAGRAM

PROJECT NO: 382653.FP.04.FW	**PROJECT:** PG&E Topock - ERGI	**WELL NO's:** ***MW-62-110*** ***MW-62-190***

LOCATION: Site E

DRILLING CONTRACTOR: Boart Longyear (D. Roberts)	**DRILLING START:** 3/14/2009
DRILLING METHOD: Rotosonic	**DRILLING END:** 3/18/2009
LOGGER: A. Brewster (Northstar) and I. Wood	**WELL COMPLETION DATE:** 7/7/2009
GROUND SURFACE ELEVATION (NAVD 88): 504.05 ft AMSL	**GENERAL REMARKS:** 4-inch diameter, 2-port Guelph Water FLUTe™ multi-level system with helical screens installed into open 3.8-inch HQ borehole
NORTHING (CCS NAD 83 Z 5): 2101068.16 **EASTING (CCS NAD 83 Z 5):** 7616550.88	



NOTES:
1. All depths are reported as feet below ground surface

WELL CONSTRUCTION & SCREEN DETAILS

CASING MATERIAL:	Sch 40 PVC
CASING DIAMETER:	6-in
BOREHOLE DIAMETER:	6-in to 75 ft bgs 3.8-in open borehole to 192 ft bgs
CONCRETE PAD TYPE:	MONUMENT
SCREEN TYPE:	FLUTe™ helix cut spacer
SLOT SIZE:	Not applicable

WELL DIAGRAM IS NOT TO SCALE

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505-455-1300, www.flut.com

As-Built Information

Job # 968-2

General:

Job Description:	192' 4"dia. 2 Port Guelph Water FLUTe
Customer:	CH2M Hill
Location:	155 Grand Ave. Suite 1000 Oakland, CA 94612
Well Designation:	MW-62BR
Hole Depth:	192'
Water Table:	47'
Drilling Method:	N/A
Casing Information:	N/A
Installation Method:	Water eversion
Bubbler / Tag:	47'

Liner:

Material:	210d Orange d/c 2 sleeve
Diameter:	4"
Material Above Casing:	3'
Uneverted Material:	4'
Rough Fabrication Legnth:	202'
Termination:	End Seal Knot
Knot Diameter Allowance:	2"
Markings on Liner:	Ink stamp indicating FLUTe TOC & FLUTe Job# 968-2
Spacer Design:	2 Material helix cut spacer Design (orange mesh) and Mylar

Spacer #	**Spacer Bottom [ft]**	**Spacer Top [ft]**
1	110'	85'
2	192'	155'

Tubing & Ports:

Tubing In Bundle: NYLON
Tubing In Sleeves: NYLON
Bubbler Details: 1/4 NYLON
Port Design: Superthane feed thru
Port Locations: 6" @ bottom of spacer
Vent Design: 1/4 Superthane feed thru w/ 3/8 tygon tubing connected to duct
Vent Location: 202'

Pump Assembly:

Port #:	Transducer Serial #:	Transducer Pressure Rating [psi]:	Diaphragm Depth [ft. btoc]	Cable Serial #:	Cable Length [ft.]	5/8 x 3/8	3/8 x 1/4
1						114'.5"	116'.5"
2						115'	117'

Other Info:		
Transducer Type:	N/A	
Kellum Design:	1" Friction Kellum wrap Below Unions 1" Webbing with blue hig	
Kellum Locations:	1st kellum @ 18' btoc: others every 40 there afte	
Tether:	1/4"	
Marking on Tubing:	Port #'s and color code	
Marking on Cables:	Port #'S	
Bundle Sheating:	White 2.25" starting @ 1	116'
Marks on Bundle:	E.P. markings @ every 40'	
Pump Tube:	202'	
Reel / Packaging:	SF FLUTe	
Casing Adapter Info:	ABQ FLUTe	
Wellhead Info:	ABQ FLUTe	
Vent Tube:	n/a	
Clamps:	ABQ FLUTe	
Shipped Via:	ABQ FLUTe	
Other Notes:	Port # 1 Protrudes @ 114'.5"' Top Of Tube @ 111" W/ red cap	
	Port # 2 Protrudes @ 115' Top Of Tube @ 113' W/ red cap	

WELL COMPLETION DIAGRAM

PROJECT NO: 382653.FP.04.FW

PROJECT: PG&E Topock - ERGI

WELL NO: ***MW-63-065***

LOCATION: Site E - Alternate 2

DRILLING CONTRACTOR: Boart Longyear (D. Roberts)

DRILLING START: 4/6/2009

DRILLING METHOD: Rotary Core (HQ) - Rotosonic overdrill

DRILLING END: 4/8/2009

LOGGER: R. Tweidt (Northstar)

WELL COMPLETION DATE: 4/8/2009

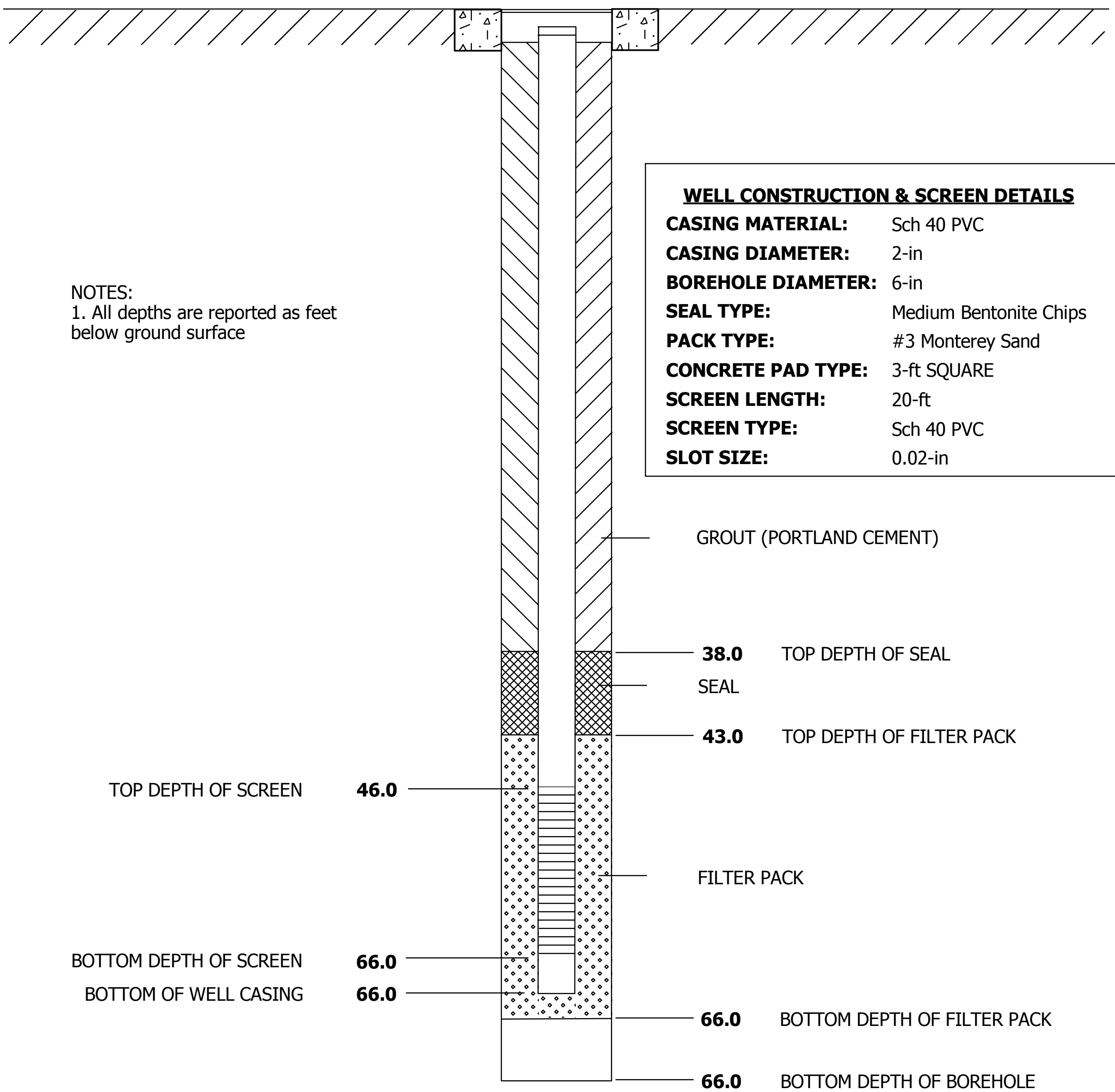
GROUND SURFACE ELEVATION (NAVD 88): 505.03 ft AMSL

GENERAL REMARKS: Alias during field work: MW-63

NORTHING (CCS NAD 83 Z 5): 2100973.93

EASTING (CCS NAD 83 Z 5): 7616921.60

12-IN DIAMETER WELL VAULT (FLUSH WITH GRADE)



WELL CONSTRUCTION & SCREEN DETAILS

CASING MATERIAL:	Sch 40 PVC
CASING DIAMETER:	2-in
BOREHOLE DIAMETER:	6-in
SEAL TYPE:	Medium Bentonite Chips
PACK TYPE:	#3 Monterey Sand
CONCRETE PAD TYPE:	3-ft SQUARE
SCREEN LENGTH:	20-ft
SCREEN TYPE:	Sch 40 PVC
SLOT SIZE:	0.02-in

NOTES:
1. All depths are reported as feet below ground surface

GROUT (PORTLAND CEMENT)

38.0 TOP DEPTH OF SEAL

SEAL

43.0 TOP DEPTH OF FILTER PACK

TOP DEPTH OF SCREEN **46.0**

FILTER PACK

BOTTOM DEPTH OF SCREEN **66.0**

BOTTOM OF WELL CASING **66.0**

66.0 BOTTOM DEPTH OF FILTER PACK

66.0 BOTTOM DEPTH OF BOREHOLE

WELL DIAGRAM IS NOT TO SCALE

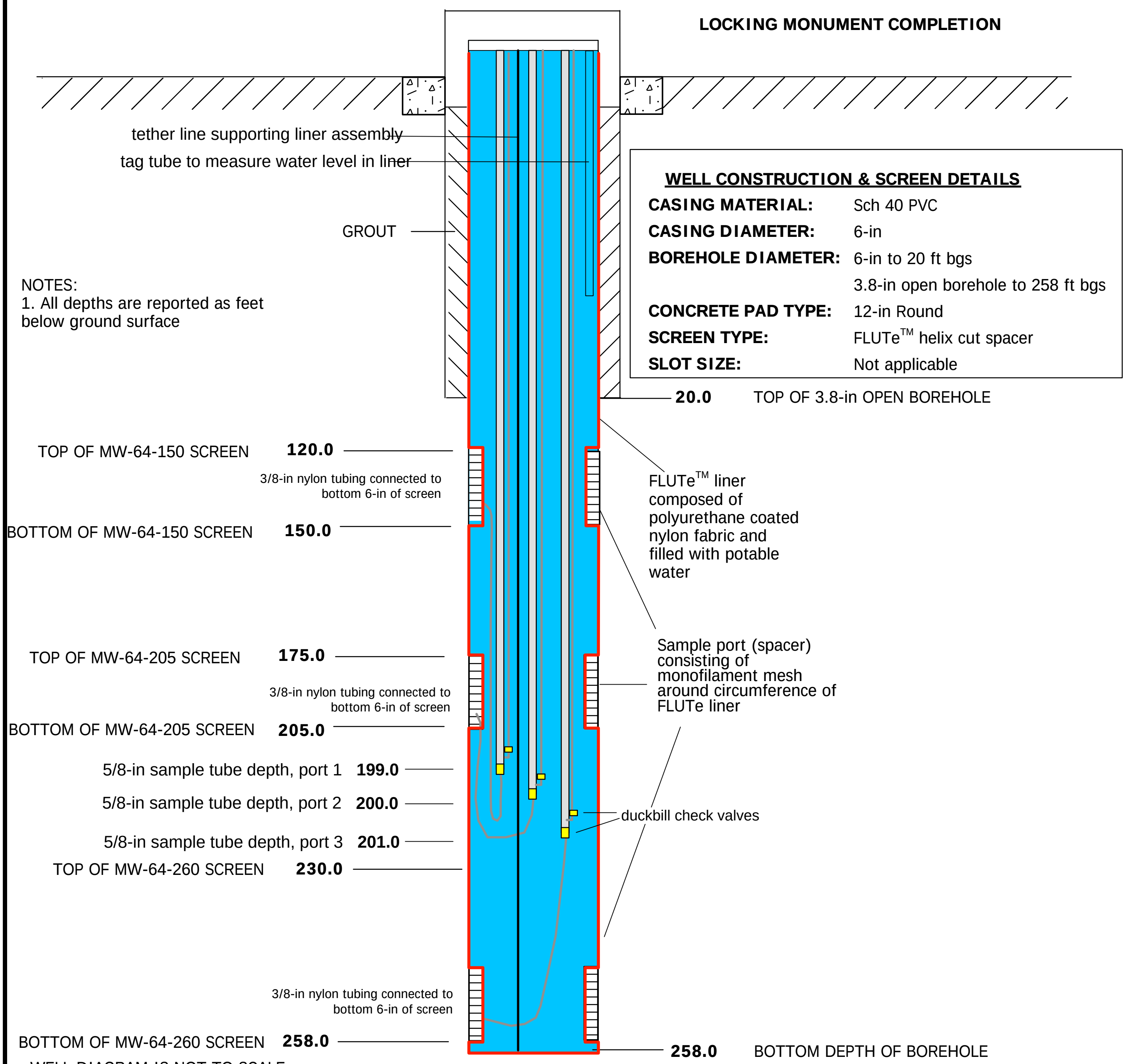
WELL COMPLETION DIAGRAM

PROJECT NO: 382653.FP.04.FW	**PROJECT:** PG&E Topock - ERGI	**WELL NO's:** ***MW-64-150*** ***MW-64-205*** ***MW-64-260***

LOCATION: Site C - Alternate

DRILLING CONTRACTOR: Boart Longyear (D. Roberts)	**DRILLING START:** 4/6/2009
DRILLING METHOD: Rotosonic	**DRILLING END:** 4/8/2009
LOGGER: A. Brewster (Northstar) and I. Wood	**WELL COMPLETION DATE:** 7/11/2009
GROUND SURFACE ELEVATION (NAVD 88): 575.92 ft AMSL	**GENERAL REMARKS:** 4-inch diameter, 3-port Guelph Water FLUTe™ multi-level system with helical screens installed into open 3.8-inch HQ borehole
NORTHING (CCS NAD 83 Z 5): 2100520.82 / **EASTING (CCS NAD 83 Z 5):** 7616939.51	

LOCKING MONUMENT COMPLETION



NOTES:
1. All depths are reported as feet below ground surface

WELL CONSTRUCTION & SCREEN DETAILS

CASING MATERIAL:	Sch 40 PVC
CASING DIAMETER:	6-in
BOREHOLE DIAMETER:	6-in to 20 ft bgs 3.8-in open borehole to 258 ft bgs
CONCRETE PAD TYPE:	12-in Round
SCREEN TYPE:	FLUTe™ helix cut spacer
SLOT SIZE:	Not applicable

WELL DIAGRAM IS NOT TO SCALE

FLUTe™ Flexible Liner Underground Technologies, Ltd. L.C.
For a medley of innovative designs
6 Easy St., Santa Fe, NM 87506
505-455-1300, www.flut.com

As-Built Information

Job # 968-3

General:

Job Description:	258' 4"dia. 3 Port Water FLUTe
Customer:	CH2M Hill
Location:	155 Grand Ave. Suite 1000 Oakland, CA 94612
Well Designation:	MW-64BR
Hole Depth:	258'
Water Table:	120'
Drilling Method:	N/A
Casing Information:	N/A
Installation Method:	Water eversion
Bubbler / Tag:	120'

Liner:

Material:	210d Orange d/c 2 sleeve
Diameter:	4"
Material Above Casing:	3'
Unverted Material:	4'
Rough Fabrication Legnth:	268'
Termination:	End Seal Knot
Knot Diameter Allowance:	2"
Markings on Liner:	Ink stamp indicating FLUTe TOC & FLUTe Job# 968-3
Spacer Design:	2 Material helix cut spacer Design (orange mesh) and Mylar

Spacer #	**Spacer Bottom [ft]**	**Spacer Top [ft]**
1	150'	120'
2	205'	175'
3	258'	230'

Tubing & Ports:

Tubing In Bundle:	NYLON & PVDF
Tubing In Sleeves:	NYLON & PVDF
Bubbler Details:	1/4 NYLON
Port Design:	Superthane feed thru
Port Locations:	6" @ bottom of spacer
Vent Design:	1/4 Superthane feed thru w/ 3/8 tygon tubing connected to duct
Vent Location:	262'

Pump Assembly:

Port #:	Transducer Serial #:	Transducer Pressure Rating [psi]:	Diaphragm Depth [ft. btoc]	Cable Serial #:	Cable Length [ft.]	Brass Elbow Depth [ft. btoc]	5/8" Tube Depth [ft. btoc]
1	147349	100	218'	222554	228'	214'	199'
2	147219	100	219'	222555	228'	215'	200'
3	147347	100	220'	222556	228'	216'	201'

Other Info:	
Transducer Type:	Level Troll 500
Kellum Design:	2" & 1" webbing wrap
Kellum Locations:	1st kellum @ 18' btoc: others every 40 there afte
Tether:	1/4"
Marking on Tubing:	Port #'s and color code
Marking on Cables:	Port #'S
Bundle Sheating:	Black Diagonal / Taped every 20' intervals
Marks on Bundle:	E.P. markings @ every 40'
Pump Tube:	268'
Reel / Packaging:	SF FLUTe
Casing Adapter Info:	ABQ FLUTe
Wellhead Info:	ABQ FLUTe
Vent Tube:	n/a
Clamps:	ABQ FLUTe
Shipped Via:	ABQ FLUTe
Other Notes:	

Attachment A1-4
California Department of Water Resources Well Completion Reports

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Page 1 of 4

Owner's Well Number MW-23-060

Date Work Began 04/30/2009 Date Work Ended 5/2/2009

Local Permit Agency * No permit required by CERCLA exemption

Permit Number * Permit Date

State of California

Well Completion Report

Refer to Instruction Pamphlet

No. xxxxxxx

DWR Use Only – Do Not Fill In

State Well Number/Site Number

N Latitude W Longitude

APN/TRS/Other

Geologic Log

Orientation ● Vertical ○ Horizontal ○ Angle Specify

Drilling Method Rotosonic Drilling Fluid

Depth from Surface Feet	to Feet	Description (Describe material, grain size, color, etc)
0	1	Sandy gravel (GP)
1	60	(BR) Miocene conglomerate, red

Total Depth of Boring 60 Feet

Total Depth of Completed Well 60 Feet

Well Owner

Name Pacific Gas & Electric

Mailing Address PO BOX 337

City Needles State CA Zip 92363

Well Location

Address

City Topock County San Bernardino

Latitude Deg Min. Sec. N Longitude Deg. Min. Sec. W

Datum NAD83 Decimal Lat. 2101286.15 Decimal Long. 7616448.6

APN Book Page Parcel

Township Range Section

Location Sketch

(Sketch must be drawn by hand after form is printed.)

North

West

East

South

Illustrate or describe distance of well from roads, buildings, fences, rivers, etc. and attach a map. Use additional paper if necessary. Please be accurate and complete.

Activity

● New Well

○ Modification/Repair

○ Deepen

○ Other

○ Destroy

Describe procedures and materials under "GEOLOGIC LOG"

Planned Uses

○ Water Supply

☐ Domestic ☐ Public

☐ Irrigation ☐ Industrial

○ Cathodic Protection

○ Dewatering

○ Heat Exchange

○ Injection

● Monitoring

○ Remediation

○ Sparging

○ Test Well

○ Vapor Extraction

○ Other

Water Level and Yield of Completed Well

Depth to first water (Feet below surface)

Depth to Static Water Level 51 (Feet) Date Measured

Estimated Yield * (GPM) Test Type

Test Length (Hours) Total Drawdown (Feet)

*May not be representative of a well's long term yield.

Casings

Depth from Surface Feet	to Feet	Borehole Diameter (Inches)	Type	Material	Wall Thickness (Inches)	Outside Diameter (Inches)	Screen Type	Slot Size if Any (Inches)
0	50	10	Blank	PVC Sch. 40	0.154	2.375	N/A	
50	60	10	Screen	PVC Sch. 40	0.154	2.375	Slotted	0.020

Annular Material

Depth from Surface Feet	to Feet	Fill	Description
0	43	Cement	Portland grout
43	48	Bentonite	
48	60	Filter Pack	#3 Monterey sand

Attachments

☑ Geologic Log

☑ Well Construction Diagram

☐ Geophysical Log(s)

☐ Soil/Water Chemical Analyses

☐ Other

Attach additional information, if it exists.

Certification Statement

I, the undersigned, certify that this report is complete and accurate to the best of my knowledge and belief

Name CH2M HILL

Person, Firm or Corporation

155 Grand Ave Suite 1000 Oakland CA 94612

Address City State Zip

Signed

C-57 Licensed Water Well Contractor

Date Signed 10/19/09

C-57 License Number 694686

DWR 188 REV. 1/2006

IF ADDITIONAL SPACE IS NEEDED, USE NEXT CONSECUTIVELY NUMBERED FORM

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State of California

Well Completion Report

Refer to Instruction Pamphlet

No. xxxxxxx

Page 1 of 4

Owner's Well Number MW-23-080

Date Work Began 04/30/2009 Date Work Ended 5/2/2009

Local Permit Agency * No permit required by CERCLA exemption

Permit Number * Permit Date

DWR Use Only – Do Not Fill In

State Well Number/Site Number

Latitude N Longitude W

APN/TRS/Other

Geologic Log

Orientation ● Vertical ○ Horizontal ○ Angle Specify

Drilling Method Rotosonic Drilling Fluid

Depth from Surface Feet	to Feet	Description (Describe material, grain size, color, etc)
0	1	Sandy grave (GP), grey
1	80	(BR) Miocene Conglomerate, red

Total Depth of Boring 80 Feet

Total Depth of Completed Well 80 Feet

Well Owner

Name Pacific Gas & Electric

Mailing Address PO BOX 337

City Needles State CA Zip 92363

Well Location

Address

City Topock County San Bernardino

Latitude Deg. Min. Sec. N Longitude Deg Min Sec W

Datum NAD83 Decimal Lat. 2101286.15 Decimal Long. 7616448.6

APN Book Page Parcel

Township Range Section

Location Sketch

(Sketch must be drawn by hand after form is printed.)

North

West

East

South

Illustrate or describe distance of well from roads, buildings, fences, rivers, etc. and attach a map. Use additional paper if necessary. Please be accurate and complete.

Activity

● New Well

○ Modification/Repair

○ Deepen

○ Other

○ Destroy

Describe procedures and materials under "GEOLOGIC LOG"

Planned Uses

○ Water Supply

☐ Domestic ☐ Public

☐ Irrigation ☐ Industrial

○ Cathodic Protection

○ Dewatering

○ Heat Exchange

○ Injection

● Monitoring

○ Remediation

○ Sparging

○ Test Well

○ Vapor Extraction

○ Other

Water Level and Yield of Completed Well

Depth to first water (Feet below surface)

Depth to Static Water Level 51 (Feet) Date Measured

Estimated Yield * (GPM) Test Type

Test Length (Hours) Total Drawdown (Feet)

*May not be representative of a well's long term yield.

Casings

Depth from Surface Feet	to Feet	Borehole Diameter (Inches)	Type	Material	Wall Thickness (Inches)	Outside Diameter (Inches)	Screen Type	Slot Size if Any (Inches)
0	75	10	Blank	PVC Sch. 40	0.154	2.375	N/A	
75	80	10	Screen	PVC Sch. 40	0.154	2.375	Slotted	0.020

Annular Material

Depth from Surface Feet	to Feet	Fill	Description
0	43	Cement	Portland grout
43	48	Bentonite	
48	63	Filter Pack	#3 Monterey sand
63	73	Bentonite	
73	80	Filter Pack	#3 Monterey sand

Attachments

☑ Geologic Log

☑ Well Construction Diagram

☐ Geophysical Log(s)

☐ Soil/Water Chemical Analyses

☐ Other

Attach additional information, if it exists.

Certification Statement

I, the undersigned, certify that this report is complete and accurate to the best of my knowledge and belief

Name CH2M HILL
Person, Firm or Corporation

155 Grand Ave Suite 1000 Oakland CA 94612
Address City State Zip

Signed 10/19/09 694686
C-57 Licensed Water Well Contractor Date Signed C-57 License Number

DWR 188 REV. 1/2006

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State of California

Well Completion Report

Refer to Instruction Pamphlet

No. xxxxxxx

Page 1 of 5

Owner's Well Number MW-57-050

Date Work Began 01/14/2009 Date Work Ended 1/21/2009

Local Permit Agency * No permit required by CERCLA exemption

Permit Number * Permit Date

DWR Use Only – Do Not Fill In

State Well Number/Site Number

Latitude N Longitude W

APN/TRS/Other

Geologic Log

Orientation ● Vertical ○ Horizontal ○ Angle Specify

Drilling Method Rotosonic Drilling Fluid

Depth from Surface Feet	to Feet	Description (Describe material, grain size, color, etc)
0	3	Sandy silt with gravel (ML), dark brown
3	46	Silty gravel (GM), dark brown
46	52	(BR) Conglomerate, yellowish red

Total Depth of Boring 52.3 Feet

Total Depth of Completed Well 52.0 Feet

Well Owner

Name Pacific Gas & Electric

Mailing Address PO BOX 337

City Needles State CA Zip 92363

Well Location

Address

City Topock County San Bernardino

Latitude Deg Min Sec N Longitude Deg Min Sec W

Datum NAD83 Decimal Lat. 2100906.35 Decimal Long. 7616384.[illegible]

APN Book Page Parcel

Township Range Section

Location Sketch

(Sketch must be drawn by hand after form is printed.)

North

West

East

South

Illustrate or describe distance of well from roads, buildings, fences, rivers, etc. and attach a map. Use additional paper if necessary. Please be accurate and complete.

Activity

● New Well

○ Modification/Repair

○ Deepen

○ Other

○ Destroy

Describe procedures and materials under "GEOLOGIC LOG"

Planned Uses

○ Water Supply

☐ Domestic ☐ Public

☐ Irrigation ☐ Industrial

○ Cathodic Protection

○ Dewatering

○ Heat Exchange

○ Injection

● Monitoring

○ Remediation

○ Sparging

○ Test Well

○ Vapor Extraction

○ Other

Water Level and Yield of Completed Well

Depth to first water (Feet below surface)

Depth to Static Water Level (Feet) Date Measured

Estimated Yield * (GPM) Test Type

Test Length (Hours) Total Drawdown (Feet)

*May not be representative of a well's long term yield.

Casings

Depth from Surface Feet	to Feet	Borehole Diameter (Inches)	Type	Material	Wall Thickness (Inches)	Outside Diameter (Inches)	Screen Type	Slot Size if Any (Inches)
0	40	6	Blank	PVC Sch. 40	0.154	2.375	N/A	
40	50	6	Screen	PVC Sch. 40	0.154	2.375	Slotted	0.010
50	52	6	Blank	PVC Sch. 40	0.154	2.375	N/A	

Annular Material

Depth from Surface Feet	to Feet	Fill	Description
0	33	Cement	Portland grout
33	38	Bentonite	
38	52	Filter Pack	#3 Monterey sand

Attachments

☑ Geologic Log

☑ Well Construction Diagram

☐ Geophysical Log(s)

☐ Soil/Water Chemical Analyses

☐ Other

Attach additional information, if it exists.

Certification Statement

I, the undersigned, certify that this report is complete and accurate to the best of my knowledge and belief

Name CH2M HILL
Person, Firm or Corporation

155 Grand Ave Suite 1000 Oakland CA 94612
Address City State Zip

Signed C-57 Licensed Water Well Contractor 10/19/09 694686
Date Signed C-57 License Number

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Well Completion Report

Refer to Instruction Pamphlet

No. xxxxxxx

Page 1 of 6
Owner's Well Number MW-57-070
Date Work Began 01/14/2009 Date Work Ended 1/28/2009
Local Permit Agency * No permit required by CERCLA exemption
Permit Number * Permit Date

DWR Use Only – Do Not Fill In
State Well Number/Site Number
Latitude N Longitude W
APN/TRS/Other

Geologic Log

Orientation ● Vertical ○ Horizontal ○ Angle Specify
Drilling Method Rotosonic Drilling Fluid

Depth from Surface Feet	to Feet	Description (Describe material, grain size, color, etc)
0	3	Sandy silt with gravel (ML), dark brown
3	46	Silty Gravel (GM), dark brown
46	70	(BR) conglomerate, yellowish red

Total Depth of Boring 70 Feet
Total Depth of Completed Well 70 Feet

Well Owner

Name Pacific Gas & Electric
Mailing Address PO BOX 337
City Needles State CA Zip 92363

Well Location

Address
City Topock County San Bernardino
Latitude (Deg. Min. Sec.) N Longitude (Deg. Min. Sec.) W
Datum NAD83 Decimal Lat. 2100893.58 Decimal Long. 7616394.[illegible]
APN Book Page Parcel
Township Range Section

Location Sketch

(Sketch must be drawn by hand after form is printed.)

North

West

East

South

Illustrate or describe distance of well from roads, buildings, fences, rivers, etc. and attach a map. Use additional paper if necessary. **Please be accurate and complete.**

Activity

● New Well
○ Modification/Repair
  ○ Deepen
  ○ Other
○ Destroy
Describe procedures and materials under "GEOLOGIC LOG"

Planned Uses

○ Water Supply
  ☐ Domestic ☐ Public
  ☐ Irrigation ☐ Industrial
○ Cathodic Protection
○ Dewatering
○ Heat Exchange
○ Injection
● Monitoring
○ Remediation
○ Sparging
○ Test Well
○ Vapor Extraction
○ Other

Water Level and Yield of Completed Well

Depth to first water (Feet below surface)
Depth to Static Water Level 53 (Feet) Date Measured 03/31/2009
Estimated Yield * (GPM) Test Type
Test Length (Hours) Total Drawdown (Feet)
*May not be representative of a well's long term yield.

Casings

Depth from Surface Feet	to Feet	Borehole Diameter (Inches)	Type	Material	Wall Thickness (Inches)	Outside Diameter (Inches)	Screen Type	Slot Size if Any (Inches)
0	55	6	Blank	PVC Sch. 40	0.154	2.375	N/A	
55	70	6	Screen	PVC Sch. 40	0.154	2.375	Slotted	0.010

Annular Material

Depth from Surface Feet	to Feet	Fill	Description
0	48	Cement	Portland grout
48	53	Bentonite	
53	70	Filter Pack	#3 Monterey sand

Attachments

☑ Geologic Log
☑ Well Construction Diagram
☐ Geophysical Log(s)
☐ Soil/Water Chemical Analyses
☐ Other
Attach additional information, if it exists.

Certification Statement

I, the undersigned, certify that this report is complete and accurate to the best of my knowledge and belief
Name CH2M HILL
Person, Firm or Corporation
155 Grand Ave Suite 1000 (Address) Oakland (City) CA (State) 94612 (Zip)
Signed (C-57 Licensed Water Well Contractor) 10/19/09 (Date Signed) 694686 (C-57 License Number)

DWR 188 REV. 1/2006

IF ADDITIONAL SPACE IS NEEDED, USE NEXT CONSECUTIVELY NUMBERED FORM

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State of California

Well Completion Report

Refer to Instruction Pamphlet

No. xxxxxxx

Page 1 of 8

Owner's Well Number MW-57-185

Date Work Began 01/14/2009 Date Work Ended 2/16/2009

Local Permit Agency * No permit required by CERCLA exemption

Permit Number * Permit Date

DWR Use Only – Do Not Fill In

State Well Number/Site Number

N Latitude W Longitude

APN/TRS/Other

Geologic Log

Orientation ● Vertical ○ Horizontal ○ Angle Specify

Drilling Method Rotosonic+diamon-bit rotary Drilling Fluid

Depth from Surface Feet	to Feet	Description (Describe material, grain size, color, etc)
0	3	Silty sand with gravel (ML), dark brown
3	46	Silty gravel (GM), dark brown
46	146	(BR) Miocene conglomerate, yellowish red
146	153	(BR) Miocene conglomerate, reddish orange, wea
153	155	(BR) Metaconglomerate, dark yellowish orange
155	156	(BR) Altered Metadiorite, yellowish brown
156	192	(BR) Metadiorite, yellowish green

Total Depth of Boring 192 Feet

Total Depth of Completed Well 192 Feet

Well Owner

Name Paficic Gas & Electric

Mailing Address PO Box 337

City Needles State CA Zip 92363

Well Location

Address

City Topock County San Bernardino

Latitude Deg Min Sec N Longitude Deg Min Sec W

Datum NAD83 Decimal Lat. 2100899.56 Decimal Long. 7616389

APN Book Page Parcel

Township Range Section

Location Sketch

(Sketch must be drawn by hand after form is printed.)

North

West

East

South

Illustrate or describe distance of well from roads, buildings, fences, rivers, etc. and attach a map. Use additional paper if necessary. Please be accurate and complete.

Activity

- ● New Well
- ○ Modification/Repair
  - ○ Deepen
  - ○ Other
- ○ Destroy
  Describe procedures and materials under "GEOLOGIC LOG"

Planned Uses

- ○ Water Supply
  - ☐ Domestic ☐ Public
  - ☐ Irrigation ☐ Industrial
- ○ Cathodic Protection
- ○ Dewatering
- ○ Heat Exchange
- ○ Injection
- ● Monitoring
- ○ Remediation
- ○ Sparging
- ○ Test Well
- ○ Vapor Extraction
- ○ Other

Water Level and Yield of Completed Well

Depth to first water (Feet below surface)

Depth to Static Water Level 52 (Feet) Date Measured 03/31/2009

Estimated Yield * (GPM) Test Type

Test Length (Hours) Total Drawdown (Feet)

*May not be representative of a well's long term yield.

Casings

Depth from Surface Feet	to Feet	Borehole Diameter (Inches)	Type	Material	Wall Thickness (Inches)	Outside Diameter (Inches)	Screen Type	Slot Size if Any (Inches)
0	70	6	Blank	PVC Sch. 40	0.280	6.625	N/A	
70	184	3.8	Screen	PVC Sch. 40	0.216	3.5	Slotted	0.030
184	192	3.8	Blank	PVC Sch. 40	0.216	3.5	N/A	

Annular Material

Depth from Surface Feet	to Feet	Fill	Description
0	70	Cement	Portland grout
70	192	None	Open hole

Attachments

- ☑ Geologic Log
- ☑ Well Construction Diagram
- ☐ Geophysical Log(s)
- ☐ Soil/Water Chemical Analyses
- ☐ Other

Attach additional information, if it exists.

Certification Statement

I, the undersigned, certify that this report is complete and accurate to the best of my knowledge and belief

Name CH2M HILL
Person, Firm or Corporation

155 Grand Ave Suite 1000 Oakland CA 94612
Address City State Zip

Signed 10/17/09 694686
C-57 Licensed Water Well Contractor Date Signed C-57 License Number

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Well Completion Report

Refer to Instruction Pamphlet

No. xxxxxxx

Page 1 of 6

Owner's Well Number MW-58-065

Date Work Began 01/29/2009 Date Work Ended 2/12/2009

Local Permit Agency * No permit required by CERCLA exemption

Permit Number * Permit Date

DWR Use Only – Do Not Fill In

State Well Number/Site Number

Latitude N Longitude W

APN/TRS/Other

Geologic Log

Orientation ● Vertical ○ Horizontal ○ Angle Specify

Drilling Method Rotosonic Drilling Fluid

Depth from Surface Feet	to Feet	Description (Describe material, grain size, color, etc)
0	2	Sandy silt (ML), brown
2	17	Gravel, sand, silt (GM), brown
51	53	Silt (ML), dark brown
53	60	Gravelly sand (SP), yellowish brown
60	65	(BR) Metadiorite, highly weathered

Total Depth of Boring 66.5 Feet

Total Depth of Completed Well 66.0 Feet

Well Owner

Name Pacific Gas & Electric

Mailing Address PO Box 337

City Needles State CA Zip 92363

Well Location

Address

City Topock County San Bernardino

Latitude Deg Min Sec N Longitude Deg Min Sec W

Datum NAD83 Decimal Lat. 2100607.15 Decimal Long. 7616136.8

APN Book Page Parcel

Township Range Section

Location Sketch

(Sketch must be drawn by hand after form is printed.)

North

West

East

South

Illustrate or describe distance of well from roads, buildings, fences, rivers, etc. and attach a map. Use additional paper if necessary. Please be accurate and complete.

Activity

● New Well

○ Modification/Repair

○ Deepen

○ Other

○ Destroy

Describe procedures and materials under "GEOLOGIC LOG"

Planned Uses

○ Water Supply

☐ Domestic ☐ Public

☐ Irrigation ☐ Industrial

○ Cathodic Protection

○ Dewatering

○ Heat Exchange

○ Injection

● Monitoring

○ Remediation

○ Sparging

○ Test Well

○ Vapor Extraction

○ Other

Water Level and Yield of Completed Well

Depth to first water (Feet below surface)

Depth to Static Water Level 67 (Feet) Date Measured 04/01/2009

Estimated Yield * (GPM) Test Type

Test Length (Hours) Total Drawdown (Feet)

*May not be representative of a well's long term yield.

Casings

Depth from Surface Feet	to Feet	Borehole Diameter (Inches)	Type	Material	Wall Thickness (Inches)	Outside Diameter (Inches)	Screen Type	Slot Size if Any (Inches)
0	54	6	Blank	PVC Sch. 40	0.154	2.375	N/A	
54	64	6	Screen	PVC Sch. 40	0.154	2.375	Slotted	0.010
64	66	6	Blank	PVC Sch. 40	0.154	2.375	N/A	

Annular Material

Depth from Surface Feet	to Feet	Fill	Description
0	46	Cement	Portland grout
46	51	Bentonite	
51	66	Filter Pack	#3 Monterey sand

Attachments

☑ Geologic Log

☑ Well Construction Diagram

☐ Geophysical Log(s)

☐ Soil/Water Chemical Analyses

☐ Other

Attach additional information, if it exists.

Certification Statement

I, the undersigned, certify that this report is complete and accurate to the best of my knowledge and belief

Name CH2M HILL
Person, Firm or Corporation

155 Grand Ave Suite 1000 Oakland CA 94612
Address City State Zip

Signed
C-57 Licensed Water Well Contractor

10/19/09 694686
Date Signed C-57 License Number

DWR 188 REV. 1/2006

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State of California

Well Completion Report

Refer to Instruction Pamphlet

No. xxxxxxx

Page 1 of 7

Owner's Well Number MW-58-115

Date Work Began 01/29/2009 Date Work Ended 3/27/2009

Local Permit Agency * No permit required by CERCLA exemption

Permit Number * Permit Date

DWR Use Only – Do Not Fill In

State Well Number/Site Number

N W

Latitude Longitude

APN/TRS/Other

Geologic Log

Orientation ● Vertical ○ Horizontal ○ Angle Specify

Drilling Method Rotosonic+ Diamond-bit rotary Drilling Fluid

Depth from Surface Feet	to Feet	Description Describe material, grain size, color, etc
0	2	Sandy silt (ML), brown
2	17	Gravel, sand, silt (GM), brown
17	51	Silty sand with gravel (SM), brown
51	53	Silt (ML), dark brown
53	60	Gravelly sand (SP) yellowish brown
60	66	(BR) Weathered metadiorite
66	115	(BR) Metadiorite, yellowish green

Total Depth of Boring 206 Feet

Total Depth of Completed Well 115 Feet

Well Owner

Name Pacific Gas & Electric

Mailing Address PO Box 337

City Needles State CA Zip 92363

Well Location

Address

City Topock County San Bernardino

Latitude __ Deg __ Min __ Sec N Longitude __ Deg __ Min __ Sec W

Datum NAD83 Decimal Lat. 2100607.15 Decimal Long. 7616136.8

APN Book Page Parcel

Township Range Section

Location Sketch

(Sketch must be drawn by hand after form is printed.)

North

West

East

South

Illustrate or describe distance of well from roads, buildings, fences, rivers, etc. and attach a map. Use additional paper if necessary. Please be accurate and complete.

Activity

● New Well

○ Modification/Repair

○ Deepen

○ Other

○ Destroy

Describe procedures and materials under "GEOLOGIC LOG"

Planned Uses

○ Water Supply

☐ Domestic ☐ Public

☐ Irrigation ☐ Industrial

○ Cathodic Protection

○ Dewatering

○ Heat Exchange

○ Injection

● Monitoring

○ Remediation

○ Sparging

○ Test Well

○ Vapor Extraction

○ Other

Water Level and Yield of Completed Well

Depth to first water (Feet below surface)

Depth to Static Water Level 68 (Feet) Date Measured 04/01/2009

Estimated Yield * (GPM) Test Type

Test Length (Hours) Total Drawdown (Feet)

*May not be representative of a well's long term yield.

Casings

Depth from Surface Feet	to Feet	Borehole Diameter (Inches)	Type	Material	Wall Thickness (Inches)	Outside Diameter (Inches)	Screen Type	Slot Size if Any (Inches)
0	66	6	Conductor	PVC Sch. 40	0.280	6.625	N/A	
66	206	3.8	Open hole				N/A	

Annular Material

Depth from Surface Feet	to Feet	Fill	Description
0	66	Cement	Portland Grout
0	206	Openhole	FLUTe multi-level

Attachments

☑ Geologic Log

☑ Well Construction Diagram

☐ Geophysical Log(s)

☐ Soil/Water Chemical Analyses

☐ Other

Attach additional information, if it exists.

Certification Statement

I, the undersigned, certify that this report is complete and accurate to the best of my knowledge and belief

Name CH2M HILL

Person, Firm or Corporation

155 Grand Ave Suite 1000 Oakland CA 94612

Address City State Zip

Signed C-57 Licensed Water Well Contractor 11/19/09 694686

Date Signed C-57 License Number

DWR 188 REV. 1/2006

IF ADDITIONAL SPACE IS NEEDED, USE NEXT CONSECUTIVELY NUMBERED FORM

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State of California

Well Completion Report

Refer to Instruction Pamphlet

No. xxxxxxx

Page 1 of 7

Owner's Well Number MW-58-205

Date Work Began 01/29/2009 Date Work Ended 3/27/2009

Local Permit Agency * No permit required by CERCLA exemption

Permit Number * Permit Date

DWR Use Only – Do Not Fill In

State Well Number/Site Number

N W

Latitude Longitude

APN/TRS/Other

Geologic Log

Orientation ● Vertical ○ Horizontal ○ Angle Specify

Drilling Method Rotosonic+ Diamond-bit rotary Drilling Fluid

Depth from Surface Feet	to Feet	Description Describe material, grain size, color, etc
0	2	Sandy silt (ML), brown
2	17	Gravel, sand, silt (GM), brown
17	51	Silty sand with gravel (SM), brown
51	53	Silt (ML), dark brown
53	60	Gravelly sand (SP) yellowish brown
60	66	(BR) Weathered metadiorite
66	206	(BR) Metadiorite, yellowish green

Total Depth of Boring 206 Feet

Total Depth of Completed Well 206 Feet

Well Owner

Name Pacific Gas & Electric

Mailing Address PO Box 337

City Needles State CA Zip 92363

Well Location

Address

City Topock County San Bernardino

Latitude Deg Min Sec N Longitude Deg Min Sec W

Datum NAD83 Decimal Lat. 2100607.15 Decimal Long. 7616136.8

APN Book Page Parcel

Township Range Section

Location Sketch

(Sketch must be drawn by hand after form is printed.)

North

West

East

South

Illustrate or describe distance of well from roads, buildings, fences, rivers, etc. and attach a map. Use additional paper if necessary. **Please be accurate and complete.**

Activity

● New Well

○ Modification/Repair

○ Deepen

○ Other

○ Destroy

Describe procedures and materials under "GEOLOGIC LOG"

Planned Uses

○ Water Supply

☐ Domestic ☐ Public

☐ Irrigation ☐ Industrial

○ Cathodic Protection

○ Dewatering

○ Heat Exchange

○ Injection

● Monitoring

○ Remediation

○ Sparging

○ Test Well

○ Vapor Extraction

○ Other

Water Level and Yield of Completed Well

Depth to first water (Feet below surface)

Depth to Static Water Level 68 (Feet) Date Measured 04/01/2009

Estimated Yield * (GPM) Test Type

Test Length (Hours) Total Drawdown (Feet)

*May not be representative of a well's long term yield.

Casings

Depth from Surface Feet	to Feet	Borehole Diameter (Inches)	Type	Material	Wall Thickness (Inches)	Outside Diameter (Inches)	Screen Type	Slot Size if Any (Inches)
0	66	6	Conductor	PVC Sch. 40	0.280	6.625	N/A	
66	206	3.8	Open hole	N/A	N/A	N/A		

Annular Material

Depth from Surface Feet	to Feet	Fill	Description
0	66	Cement	Portland Grout
0	206	None	FLUTe Multi-level

Attachments

☑ Geologic Log

☑ Well Construction Diagram

☐ Geophysical Log(s)

☐ Soil/Water Chemical Analyses

☐ Other

Attach additional information, if it exists.

Certification Statement

I, the undersigned, certify that this report is complete and accurate to the best of my knowledge and belief

Name CH2M HILL

Person, Firm or Corporation

155 Grand Ave Suite 1000 Oakland CA 94612

Address City State Zip

Signed 10/19/09 C-57 License Number 694686

C-57 Licensed Water Well Contractor Date Signed C-57 License Number

DWR 188 REV. 1/2006

IF ADDITIONAL SPACE IS NEEDED, USE NEXT CONSECUTIVELY NUMBERED FORM

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State of California

Well Completion Report

Refer to Instruction Pamphlet

No. xxxxxxx

Page 1 of 5

Owner's Well Number MW-59-100

Date Work Began 02/25/2009 Date Work Ended 2/26/2009

Local Permit Agency * No permit required by CERCLA exemption

Permit Number * Permit Date

DWR Use Only – Do Not Fill In

State Well Number/Site Number

N Latitude W Longitude

APN/TRS/Other

Geologic Log

Orientation ● Vertical ○ Horizontal ○ Angle Specify

Drilling Method Rotosonic Drilling Fluid

Depth from Surface Feet	to Feet	Description Describe material, grain size, color, etc
0	82	Silty Sand (SM), brown
82	101	Gravelly sand (SP), dark brown

Total Depth of Boring 101 Feet

Total Depth of Completed Well 101 Feet

Well Owner

Name Pacific Gas & Electric

Mailing Address PO Box 337

City Needles State CA Zip 92363

Well Location

Address

City Topock County San Bernardino

Latitude __ Deg __ Min __ Sec N Longitude __ Deg __ Min __ Sec W

Datum NAD83 Decimal Lat. 2100851.96 Decimal Long. 76160818

APN Book Page Parcel

Township Range Section

Location Sketch

(Sketch must be drawn by hand after form is printed.)

North

West

East

South

Illustrate or describe distance of well from roads, buildings, fences, rivers, etc. and attach a map. Use additional paper if necessary. Please be accurate and complete.

Activity

● New Well

○ Modification/Repair

○ Deepen

○ Other

○ Destroy

Describe procedures and materials under "GEOLOGIC LOG"

Planned Uses

○ Water Supply

☐ Domestic ☐ Public

☐ Irrigation ☐ Industrial

○ Cathodic Protection

○ Dewatering

○ Heat Exchange

○ Injection

● Monitoring

○ Remediation

○ Sparging

○ Test Well

○ Vapor Extraction

○ Other

Water Level and Yield of Completed Well

Depth to first water (Feet below surface)

Depth to Static Water Level 85 (Feet) Date Measured

Estimated Yield * (GPM) Test Type

Test Length (Hours) Total Drawdown (Feet)

*May not be representative of a well's long term yield.

Casings

Depth from Surface Feet	to Feet	Borehole Diameter (Inches)	Type	Material	Wall Thickness (Inches)	Outside Diameter (Inches)	Screen Type	Slot Size if Any (Inches)
0	86	6	Blank	PVC Sch. 40	0.154	2.375	N/A	
86	101	6	Screen	PVC Sch. 40	0.154	2.375	Slotted	0.020

Annular Material

Depth from Surface Feet	to Feet	Fill	Description
0	79	Cement	Portland grout
79	84	Bentonite	
84	101	Filter Pack	#3 Monterey sand

Attachments

☑ Geologic Log

☑ Well Construction Diagram

☐ Geophysical Log(s)

☐ Soil/Water Chemical Analyses

☐ Other

Attach additional information, if it exists.

Certification Statement

I, the undersigned, certify that this report is complete and accurate to the best of my knowledge and belief

Name CH2M HILL

Person, Firm or Corporation

155 Grand Ave Suite 1000 Oakland CA 94612

Address City State Zip

Signed 10/9/09 694696

C-57 Licensed Water Well Contractor Date Signed C-57 License Number

DWR 188 REV. 1/2006

IF ADDITIONAL SPACE IS NEEDED, USE NEXT CONSECUTIVELY NUMBERED FORM

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Page 1 of 6

Owner's Well Number MW-60-125

Date Work Began 02/27/2009 Date Work Ended 3/3/2009

Local Permit Agency * No permit required by CERCLA exemption

Permit Number * Permit Date

State of California

Well Completion Report

Refer to Instruction Pamphlet

No. xxxxxxx

DWR Use Only – Do Not Fill In

State Well Number/Site Number

N W

Latitude Longitude

APN/TRS/Other

Geologic Log

Orientation ● Vertical ○ Horizontal ○ Angle Specify

Drilling Method Rotosonic+Diamond-bit rotary Drilling Fluid

Depth from Surface Feet	to Feet	Description Describe material, grain size, color, etc
0	9	Silty Sand (SM), yellowish brown
9	123	(BR) Metadiorite, dusky green

Total Depth of Boring 123 Feet

Total Depth of Completed Well 123 Feet

Well Owner

Name Pacific Gas & Electric

Mailing Address PO Box 337

City Needles State CA Zip 92363

Well Location

Address

City Topock County San Bernardino

Latitude Deg. Min. Sec. N Longitude Deg. Min. Sec. W

Datum NAD83 Decimal Lat. 2100491.63 Decimal Long. 7616434 [illegible]

APN Book Page Parcel

Township Range Section

Location Sketch

(Sketch must be drawn by hand after form is printed.)

North

West

East

South

Illustrate or describe distance of well from roads, buildings, fences, rivers, etc. and attach a map. Use additional paper if necessary. **Please be accurate and complete.**

Activity

● New Well
○ Modification/Repair
  ○ Deepen
  ○ Other
○ Destroy
Describe procedures and materials under "GEOLOGIC LOG"

Planned Uses

○ Water Supply
  ☐ Domestic ☐ Public
  ☐ Irrigation ☐ Industrial
○ Cathodic Protection
○ Dewatering
○ Heat Exchange
○ Injection
● Monitoring
○ Remediation
○ Sparging
○ Test Well
○ Vapor Extraction
○ Other

Water Level and Yield of Completed Well

Depth to first water (Feet below surface)

Depth to Static Water Level 98 (Feet) Date Measured

Estimated Yield * (GPM) Test Type

Test Length (Hours) Total Drawdown (Feet)

*May not be representative of a well's long term yield.

Casings

Depth from Surface Feet	to Feet	Borehole Diameter (Inches)	Type	Material	Wall Thickness (Inches)	Outside Diameter (Inches)	Screen Type	Slot Size if Any (Inches)
0	103	6	Blank	PVC Sch. 40	0.154	2.375	N/A	
103	123	6	Screen	PVC Sch. 40	0.154	2.375	Slotted	0.010

Annular Material

Depth from Surface Feet	to Feet	Fill	Description
0	91	Cement	Portland grout
91	101	Bentonite	
101	123	Filter Pack	#3 Monterey sand

Attachments

☑ Geologic Log
☑ Well Construction Diagram
☐ Geophysical Log(s)
☐ Soil/Water Chemical Analyses
☐ Other

Attach additional information, if it exists.

Certification Statement

I, the undersigned, certify that this report is complete and accurate to the best of my knowledge and belief

Name CH2M HILL
Person, Firm or Corporation

155 Grand Ave Suite 1000 Oakland CA 94612
Address City State Zip

Signed
C-57 Licensed Water Well Contractor

Date Signed 10/19/09

C-57 License Number 694686

DWR 188 REV. 1/2006

IF ADDITIONAL SPACE IS NEEDED, USE NEXT CONSECUTIVELY NUMBERED FORM

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State of California

Well Completion Report

Refer to Instruction Pamphlet

No. xxxxxxx

Page 1 of 6

Owner's Well Number MW-61-110

Date Work Began 03/04/2009 Date Work Ended 3/13/2009

Local Permit Agency * No permit required by CERCLA exemption

Permit Number * Permit Date

DWR Use Only – Do Not Fill In

State Well Number/Site Number

N Latitude W Longitude

APN/TRS/Other

Geologic Log

Orientation ● Vertical ○ Horizontal ○ Angle Specify

Drilling Method Rotosonic+Diamond-bit rotary Drilling Fluid

Depth from Surface Feet	to Feet	Description (Describe material, grain size, color, etc)
0	14	Gravel, sand, silt (GM), dark brown
14	63	Poorly graded sand with silt and gravel (SP-SM),
63	112	(BR) Metadiorite, dusky yellowish green

Total Depth of Boring 112 Feet

Total Depth of Completed Well 112.4 Feet

Well Owner

Name Pacific Gas & Electric

Mailing Address PO Box 337

City Needles State CA Zip 92363

Well Location

Address

City Topock County San Bernardino

Latitude Deg Min Sec N Longitude Deg Min Sec W

Datum NAD83 Decimal Lat. 2100713.02 Decimal Long. 7616591.

APN Book Page Parcel

Township Range Section

Location Sketch

(Sketch must be drawn by hand after form is printed.)

North

West

East

South

Illustrate or describe distance of well from roads, buildings, fences, rivers, etc. and attach a map. Use additional paper if necessary. Please be accurate and complete.

Activity

● New Well
○ Modification/Repair
○ Deepen
○ Other
○ Destroy
Describe procedures and materials under "GEOLOGIC LOG"

Planned Uses

○ Water Supply
☐ Domestic ☐ Public
☐ Irrigation ☐ Industrial
○ Cathodic Protection
○ Dewatering
○ Heat Exchange
○ Injection
● Monitoring
○ Remediation
○ Sparging
○ Test Well
○ Vapor Extraction
○ Other

Water Level and Yield of Completed Well

Depth to first water (Feet below surface)

Depth to Static Water Level 87 (Feet) Date Measured

Estimated Yield * (GPM) Test Type

Test Length (Hours) Total Drawdown (Feet)

*May not be representative of a well's long term yield.

Casings

Depth from Surface Feet	to Feet	Borehole Diameter (Inches)	Type	Material	Wall Thickness (Inches)	Outside Diameter (Inches)	Screen Type	Slot Size if Any (Inches)
0	92	6	Blank	PVC Sch. 40	0.154	2.375	N/A	
92	112	6	Screen	PVC Sch. 40	0.154	2.375	Slotted	0.010

Annular Material

Depth from Surface Feet	to Feet	Fill	Description
0	84	Cement	Portland grout
84	89	Bentonite	
89	112	Filter Pack	#3 Monterey sand

Attachments

☑ Geologic Log
☑ Well Construction Diagram
☐ Geophysical Log(s)
☐ Soil/Water Chemical Analyses
☐ Other

Attach additional information, if it exists.

Certification Statement

I, the undersigned, certify that this report is complete and accurate to the best of my knowledge and belief

Name CH2M HILL
Person, Firm or Corporation

155 Grand Ave Suite 1000 Oakland CA 94612
Address City State Zip

Signed C-57 Licensed Water Well Contractor

10/19/09 Date Signed

694686 C-57 License Number

DWR 188 REV. 1/2006

IF ADDITIONAL SPACE IS NEEDED, USE NEXT CONSECUTIVELY NUMBERED FORM

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State of California

Well Completion Report

Refer to Instruction Pamphlet

No. xxxxxxx

Page 1 of 7

Owner's Well Number MW-62-065

Date Work Began 03/14/2009 Date Work Ended 3/18/2009

Local Permit Agency * No permit required by CERCLA exemption

Permit Number * Permit Date

DWR Use Only – Do Not Fill In

State Well Number/Site Number

N Latitude W Longitude

APN/TRS/Other

Geologic Log

Orientation ● Vertical ○ Horizontal ○ Angle Specify

Drilling Method Rotosonic Drilling Fluid

Depth from Surface Feet	to Feet	Description (Describe material, grain size, color, etc)
0	5	Silty sand (SM), yellowish brown
5	65	(BR) Miocene conglomerate, reddish brown
65	110	(BR) Miocene conglomerate, brown

Total Depth of Boring 112 Feet

Total Depth of Completed Well 112.4 Feet

Well Owner

Name Pacific Gas & Electric

Mailing Address PO Box 337

City Needles State CA Zip 92363

Well Location

Address

City Topock County San Bernardino

Latitude Deg Min Sec N Longitude Deg Min Sec W

Datum NAD83 Decimal Lat. 2101064.51 Decimal Long. 7616560.8

APN Book Page Parcel

Township Range Section

Location Sketch

(Sketch must be drawn by hand after form is printed.)

North

West

East

South

Illustrate or describe distance of well from roads, buildings, fences, rivers, etc. and attach a map. Use additional paper if necessary. Please be accurate and complete.

Activity

● New Well
○ Modification/Repair
○ Deepen
○ Other
○ Destroy

Describe procedures and materials under "GEOLOGIC LOG"

Planned Uses

○ Water Supply
☐ Domestic ☐ Public
☐ Irrigation ☐ Industrial
○ Cathodic Protection
○ Dewatering
○ Heat Exchange
○ Injection
● Monitoring
○ Remediation
○ Sparging
○ Test Well
○ Vapor Extraction
○ Other

Water Level and Yield of Completed Well

Depth to first water (Feet below surface)

Depth to Static Water Level 48 (Feet) Date Measured

Estimated Yield * (GPM) Test Type

Test Length (Hours) Total Drawdown (Feet)

*May not be representative of a well's long term yield.

Casings

Depth from Surface Feet	to Feet	Borehole Diameter (Inches)	Type	Material	Wall Thickness (Inches)	Outside Diameter (Inches)	Screen Type	Slot Size if Any (Inches)
0	45	6	Blank	PVC Sch. 40	0.154	2.375	N/A	
45	65	6	Screen	PVC Sch. 40	0.154	2.375	Slotted	0.010

Annular Material

Depth from Surface Feet	to Feet	Fill	Description
0	37	Cement	Portland grout
37	42	Bentonite	
42	65	Filter Pack	#3 Monterey sand

Attachments

☑ Geologic Log
☑ Well Construction Diagram
☐ Geophysical Log(s)
☐ Soil/Water Chemical Analyses
☐ Other

Attach additional information, if it exists.

Certification Statement

I, the undersigned, certify that this report is complete and accurate to the best of my knowledge and belief

Name CH2M HILL
Person, Firm or Corporation

155 Grand Ave Suite 1000 Oakland CA 94612
Address City State Zip

Signed 10/19/09 694686
C-57 Licensed Water Well Contractor Date Signed C-57 License Number

DWR 188 REV. 1/2006

IF ADDITIONAL SPACE IS NEEDED, USE NEXT CONSECUTIVELY NUMBERED FORM

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State of California

Well Completion Report

Refer to Instruction Pamphlet

No. xxxxxxx

Page 1 of 8

Owner's Well Number MW-62-110

Date Work Began 03/14/2009 Date Work Ended 3/18/2009

Local Permit Agency * No permit required by CERCLA exemption

Permit Number * Permit Date

DWR Use Only – Do Not Fill In

State Well Number/Site Number

N Latitude W Longitude

APN/TRS/Other

Geologic Log

Orientation ● Vertical ○ Horizontal ○ Angle Specify

Drilling Method Rotosonic+Diamond-bit rotary Drilling Fluid

Depth from Surface Feet	to Feet	Description Describe material, grain size, color, etc
0	5	Silty sand (SM), yellowish brown
5	65	(BR) Miocene conglomerate, reddish brown
65	110	(BR) Miocene conglomerate, brown

Total Depth of Boring 191.5 Feet

Total Depth of Completed Well 110 Feet

Well Owner

Name Pacific Gas & Electric

Mailing Address PO Box 337

City Needles State CA Zip 92363

Well Location

Address

City Topock County San Bernardino

Latitude Deg Min Sec N Longitude Deg Min Sec W

Datum NAD83 Decimal Lat. 2101064.5 Decimal Long. 7616561.0

APN Book Page Parcel

Township Range Section

Location Sketch

(Sketch must be drawn by hand after form is printed.)

North

West

East

South

Illustrate or describe distance of well from roads, buildings, fences, rivers, etc. and attach a map. Use additional paper if necessary. Please be accurate and complete.

Activity

● New Well

○ Modification/Repair

  ○ Deepen

  ○ Other

○ Destroy

Describe procedures and materials under "GEOLOGIC LOG"

Planned Uses

○ Water Supply

  ☐ Domestic ☐ Public

  ☐ Irrigation ☐ Industrial

○ Cathodic Protection

○ Dewatering

○ Heat Exchange

○ Injection

● Monitoring

○ Remediation

○ Sparging

○ Test Well

○ Vapor Extraction

○ Other

Water Level and Yield of Completed Well

Depth to first water (Feet below surface)

Depth to Static Water Level 48 (Feet) Date Measured

Estimated Yield * (GPM) Test Type

Test Length (Hours) Total Drawdown (Feet)

*May not be representative of a well's long term yield.

Casings

Depth from Surface Feet	to Feet	Borehole Diameter (Inches)	Type	Material	Wall Thickness (Inches)	Outside Diameter (Inches)	Screen Type	Slot Size if Any (Inches)
0	75	6	Conductor	PVC Sch. 40	0.280	6.625	N/A	
75	192	3.8	Open hole	N/A	N/A	N/A	N/A	

Annular Material

Depth from Surface Feet	to Feet	Fill	Description
0	75	Cement	Portland grout
0	192	None	FLUTe multilevel

Attachments

☑ Geologic Log

☑ Well Construction Diagram

☐ Geophysical Log(s)

☐ Soil/Water Chemical Analyses

☐ Other

Attach additional information, if it exists.

Certification Statement

I, the undersigned, certify that this report is complete and accurate to the best of my knowledge and belief

Name CH2M HILL
Person, Firm or Corporation

155 Grand Ave Suite 1000 Oakland CA 94612
Address City State Zip

Signed 10/19/09 694686
C-57 Licensed Water Well Contractor Date Signed C-57 License Number

DWR 188 REV. 1/2006

IF ADDITIONAL SPACE IS NEEDED, USE NEXT CONSECUTIVELY NUMBERED FORM

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State of California

Well Completion Report

Refer to Instruction Pamphlet

No. xxxxxxx

Page 1 of 8

Owner's Well Number MW-62-190

Date Work Began 03/14/2009 Date Work Ended 3/18/2009

Local Permit Agency * No permit required by CERCLA exemption

Permit Number * Permit Date

DWR Use Only – Do Not Fill In

State Well Number/Site Number

N Latitude W Longitude

APN/TRS/Other

Geologic Log

Orientation ● Vertical ○ Horizontal ○ Angle Specify

Drilling Method Rotosonic+Diamond-bit rotary Drilling Fluid

Depth from Surface Feet	to Feet	Description (Describe material, grain size, color, etc.)
0	5	Silty sand (SM), yellowish brown
5	65	(BR) Miocene conglomerate, reddish brown
65	192	(BR) Miocene conglomerate, brown

Total Depth of Boring 191.5 Feet

Total Depth of Completed Well 191.5 Feet

Well Owner

Name Pacific Gas & Electric

Mailing Address PO Box 337

City Needles State CA Zip 92363

Well Location

Address

City Topock County San Bernardino

Latitude Deg. Min. Sec. N Longitude Deg. Min. Sec. W

Datum NAD83 Decimal Lat. 2101064.5 Decimal Long. 7616561.0

APN Book Page Parcel

Township Range Section

Location Sketch

(Sketch must be drawn by hand after form is printed.)

North

West

East

South

Illustrate or describe distance of well from roads, buildings, fences, rivers, etc. and attach a map. Use additional paper if necessary. Please be accurate and complete.

Activity

● New Well

○ Modification/Repair

○ Deepen

○ Other

○ Destroy

Describe procedures and materials under "GEOLOGIC LOG".

Planned Uses

○ Water Supply

☐ Domestic ☐ Public

☐ Irrigation ☐ Industrial

○ Cathodic Protection

○ Dewatering

○ Heat Exchange

○ Injection

● Monitoring

○ Remediation

○ Sparging

○ Test Well

○ Vapor Extraction

○ Other

Water Level and Yield of Completed Well

Depth to first water (Feet below surface)

Depth to Static Water Level 48 (Feet) Date Measured

Estimated Yield * (GPM) Test Type

Test Length (Hours) Total Drawdown (Feet)

*May not be representative of a well's long term yield.

Casings

Depth from Surface Feet	to Feet	Borehole Diameter (Inches)	Type	Material	Wall Thickness (Inches)	Outside Diameter (Inches)	Screen Type	Slot Size if Any (Inches)
0	75	6	Blank	PVC Sch. 40	0.280	6.625	N/A	
75	192	3.8	Open hole					

Annular Material

Depth from Surface Feet	to Feet	Fill	Description
0	75	Cement	Portland grout
0	192		FLUTe multilevel

Attachments

☑ Geologic Log

☑ Well Construction Diagram

☐ Geophysical Log(s)

☐ Soil/Water Chemical Analyses

☐ Other

Attach additional information, if it exists.

Certification Statement

I, the undersigned, certify that this report is complete and accurate to the best of my knowledge and belief

Name CH2M HILL (Person, Firm or Corporation)

155 Grand Ave Suite 1000 (Address) Oakland (City) CA (State) 94612 (Zip)

Signed (C-57 Licensed Water Well Contractor) 10/19/09 (Date Signed) 694686 (C-57 License Number)

DWR 188 REV. 1/2006

IF ADDITIONAL SPACE IS NEEDED, USE NEXT CONSECUTIVELY NUMBERED FORM

*The free Adobe Reader may be used to view and complete this form. However, software must be purchased to complete, save, and reuse a saved form.

File Original with DWR

State of California

Well Completion Report

Refer to Instruction Pamphlet

No. xxxxxxx

Page 1 of 5

Owner's Well Number MW-63-065

Date Work Began 04/06/2009 Date Work Ended 4/8/2009

Local Permit Agency * No permit required by CERCLA exemption

Permit Number * Permit Date

DWR Use Only – Do Not Fill In

State Well Number/Site Number

Latitude N Longitude W

APN/TRS/Other

Geologic Log

Orientation ● Vertical ○ Horizontal ○ Angle Specify

Drilling Method Diamond-bit rotary Drilling Fluid

Depth from Surface Feet	to Feet	Description Describe material, grain size, color, etc
0	30	(BR) Miocene conglomerate, brown
30	66	(BR) Miocene conglomerate, moderate brown

Total Depth of Boring 66 Feet

Total Depth of Completed Well 66 Feet

Well Owner

Name Pacific Gas & Electric

Mailing Address PO Box 337

City Needles State CA Zip 92363

Well Location

Address

City Topock County San Bernardino

Latitude Deg. Min. Sec. N Longitude Deg. Min. Sec. W

Datum NAD83 Decimal Lat. 2100944.6 Decimal Long. 7616913.3

APN Book Page Parcel

Township Range Section

Location Sketch

(Sketch must be drawn by hand after form is printed.)

North

West

East

South

Illustrate or describe distance of well from roads, buildings, fences, rivers, etc. and attach a map. Use additional paper if necessary. Please be accurate and complete.

Activity

● New Well

○ Modification/Repair

○ Deepen

○ Other

○ Destroy

Describe procedures and materials under "GEOLOGIC LOG"

Planned Uses

○ Water Supply

☐ Domestic ☐ Public

☐ Irrigation ☐ Industrial

○ Cathodic Protection

○ Dewatering

○ Heat Exchange

○ Injection

● Monitoring

○ Remediation

○ Sparging

○ Test Well

○ Vapor Extraction

○ Other

Water Level and Yield of Completed Well

Depth to first water (Feet below surface)

Depth to Static Water Level 48 (Feet) Date Measured

Estimated Yield * (GPM) Test Type

Test Length (Hours) Total Drawdown (Feet)

*May not be representative of a well's long term yield.

Casings

Depth from Surface Feet	to Feet	Borehole Diameter (Inches)	Type	Material	Wall Thickness (Inches)	Outside Diameter (Inches)	Screen Type	Slot Size if Any (Inches)
0	46		Blank	PVC Sch. 40	0.154	2.375	N/A	
46	66		Screen	PVC Sch. 40	0.154	2.375	Slotted	0.020

Annular Material

Depth from Surface Feet	to Feet	Fill	Description
0	38	Cement	Portland grout
38	43	Bentonite	
43	66	Filter Pack	#3 Monterey sand

Attachments

☑ Geologic Log

☑ Well Construction Diagram

☐ Geophysical Log(s)

☐ Soil/Water Chemical Analyses

☐ Other

Attach additional information, if it exists.

Certification Statement

I, the undersigned, certify that this report is complete and accurate to the best of my knowledge and belief

Name CH2M HILL
Person, Firm or Corporation

155 Grand Ave Suite 1000 Oakland CA 94612
Address City State Zip

Signed
C-57 Licensed Water Well Contractor

10/19/09 Date Signed

694686 C-57 License Number

DWR 188 REV. 1/2006

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File Original with DWR

State of California

Well Completion Report

Refer to Instruction Pamphlet

No. xxxxxxx

Page 1 of 9

Owner's Well Number MW-64-150

Date Work Began 05/03/2009 Date Work Ended 5/15/2009

Local Permit Agency * No permit required by CERCLA exemption

Permit Number * Permit Date

DWR Use Only – Do Not Fill In

State Well Number/Site Number

N Latitude W Longitude

APN/TRS/Other

Geologic Log

Orientation ● Vertical ○ Horizontal ○ Angle Specify

Drilling Method Rotosonic+Diamond-bit rotary Drilling Fluid

Depth from Surface Feet	to Feet	Description Describe material, grain size, color, etc
0	20	(BR) Metadiorite, dark greenish grey
20	27	(BR) Metadiorite, dusky yellowish green
27	150	(BR) Metadiorite, grayish olive

Total Depth of Boring 260 Feet

Total Depth of Completed Well 150 Feet

Well Owner

Name Pacific Gas & Electric

Mailing Address PO Box 337

City Needles State CA Zip 92363

Well Location

Address

City Topock County San Bernardino

Latitude Deg. Min. Sec. N Longitude Deg. Min. Sec. W

Datum NAD83 Decimal Lat. 2100509.0 Decimal Long. 7616908.5

APN Book Page Parcel

Township Range Section

Location Sketch

(Sketch must be drawn by hand after form is printed.)

North

West

East

South

Illustrate or describe distance of well from roads, buildings, fences, rivers, etc. and attach a map. Use additional paper if necessary. Please be accurate and complete.

Activity

● New Well

○ Modification/Repair

  ○ Deepen

  ○ Other

○ Destroy

Describe procedures and materials under "GEOLOGIC LOG"

Planned Uses

○ Water Supply

  ☐ Domestic ☐ Public

  ☐ Irrigation ☐ Industrial

○ Cathodic Protection

○ Dewatering

○ Heat Exchange

○ Injection

● Monitoring

○ Remediation

○ Sparging

○ Test Well

○ Vapor Extraction

○ Other

Water Level and Yield of Completed Well

Depth to first water (Feet below surface)

Depth to Static Water Level 120 (Feet) Date Measured

Estimated Yield * (GPM) Test Type

Test Length (Hours) Total Drawdown (Feet)

*May not be representative of a well's long term yield.

Casings

Depth from Surface Feet	to Feet	Borehole Diameter (Inches)	Type	Material	Wall Thickness (Inches)	Outside Diameter (Inches)	Screen Type	Slot Size if Any (Inches)
0	20	6	Conductor	PVC Sch. 40	0.280	6.625	N/A	
20	260	3.8	Open hole					

Annular Material

Depth from Surface Feet	to Feet	Fill	Description
0	20	Cement	Portland grout
0	260		FLUTe multilevel

Attachments

☑ Geologic Log

☑ Well Construction Diagram

☐ Geophysical Log(s)

☐ Soil/Water Chemical Analyses

☐ Other

Attach additional information, if it exists.

Certification Statement

I, the undersigned, certify that this report is complete and accurate to the best of my knowledge and belief

Name CH2M HILL

Person, Firm or Corporation

155 Grand Ave Suite 1000 Oakland CA 94612

Address City State Zip

Signed

C-57 Licensed Water Well Contractor

10/19/09 Date Signed

694686 C-57 License Number

DWR 188 REV. 1/2006

IF ADDITIONAL SPACE IS NEEDED, USE NEXT CONSECUTIVELY NUMBERED FORM

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File Original with DWR

State of California

Well Completion Report

Refer to Instruction Pamphlet

No. xxxxxxx

Page 1 of 14

Owner's Well Number MW-64-205

Date Work Began 05/03/2009 Date Work Ended 5/15/2009

Local Permit Agency * No permit required by CERCLA exemption

Permit Number * Permit Date

DWR Use Only – Do Not Fill In

State Well Number/Site Number

Latitude N Longitude W

APN/TRS/Other

Geologic Log

Orientation ● Vertical ○ Horizontal ○ Angle Specify

Drilling Method Rotosonic+Diamond-bit rotary Drilling Fluid

Depth from Surface Feet	to Feet	Description Describe material, grain size, color, etc
0	65	(BR) Metadiorite, weathered
20	27	(BR) Metadiorite, dusky yellowish green
27	205	(BR) Metadiorite, grayish olive

Total Depth of Boring 260 Feet

Total Depth of Completed Well 205 Feet

Well Owner

Name Pacific Gas & Electric

Mailing Address PO Box 337

City Needles State CA Zip 92363

Well Location

Address

City Topock County San Bernardino

Latitude Deg Min Sec N Longitude Deg Min Sec W

Datum NAD83 Decimal Lat. 2100509.0 Decimal Long. 7616908.5

APN Book Page Parcel

Township Range Section

Location Sketch

(Sketch must be drawn by hand after form is printed.)

North

West

East

South

Illustrate or describe distance of well from roads, buildings, fences, rivers, etc. and attach a map. Use additional paper if necessary. Please be accurate and complete.

Activity

● New Well

○ Modification/Repair

○ Deepen

○ Other

○ Destroy

Describe procedures and materials under "GEOLOGIC LOG"

Planned Uses

○ Water Supply

☐ Domestic ☐ Public

☐ Irrigation ☐ Industrial

○ Cathodic Protection

○ Dewatering

○ Heat Exchange

○ Injection

● Monitoring

○ Remediation

○ Sparging

○ Test Well

○ Vapor Extraction

○ Other

Water Level and Yield of Completed Well

Depth to first water (Feet below surface)

Depth to Static Water Level 120 (Feet) Date Measured

Estimated Yield * (GPM) Test Type

Test Length (Hours) Total Drawdown (Feet)

*May not be representative of a well's long term yield.

Casings

Depth from Surface Feet	to Feet	Borehole Diameter (Inches)	Type	Material	Wall Thickness (Inches)	Outside Diameter (Inches)	Screen Type	Slot Size if Any (Inches)
0	20	6	Blank	PVC Sch. 40	0.280	6.625	N/A	
20	260	3.8	Open hole					

Annular Material

Depth from Surface Feet	to Feet	Fill	Description
0	20	Cement	Portland grout
0	260		FLUTe Multilevel

Attachments

☑ Geologic Log

☑ Well Construction Diagram

☐ Geophysical Log(s)

☐ Soil/Water Chemical Analyses

☐ Other

Attach additional information, if it exists.

Certification Statement

I, the undersigned, certify that this report is complete and accurate to the best of my knowledge and belief

Name CH2M HILL
Person, Firm or Corporation

155 Grand Ave Suite 1000 Oakland CA 94612
Address City State Zip

Signed
C-57 Licensed Water Well Contractor

10/19/09 694686
Date Signed C-57 License Number

DWR 188 REV. 1/2006

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File Original with DWR

State of California

Well Completion Report

Refer to Instruction Pamphlet

No. xxxxxxx

Page 1 of 8
Owner's Well Number MW-64-260
Date Work Began 05/03/2009 Date Work Ended 5/15/2009
Local Permit Agency * No permit required by CERCLA exemption
Permit Number * Permit Date

DWR Use Only – Do Not Fill In
State Well Number/Site Number
N W
Latitude Longitude
APN/TRS/Other

Geologic Log

Orientation ● Vertical ○ Horizontal ○ Angle Specify
Drilling Method Rotosonic+Diamond-bit rotary Drilling Fluid

Depth from Surface Feet	to Feet	Description Describe material, grain size, color, etc
0	20	(BR) Metadiorite, dark greenish grey
20	27	(BR) Metadiorite, dusky yellowish green
27	260	(BR) Metadiorite, grayish olive

Total Depth of Boring 260 Feet
Total Depth of Completed Well 260 Feet

Well Owner

Name Pacific Gas & Electric
Mailing Address PO Box 337
City Needles State CA Zip 92363

Well Location

Address
City Topock County San Bernardino
Latitude Deg Min. Sec. N Longitude Deg Min Sec W
Datum NAD83 Decimal Lat. 2100509.0 Decimal Long. 7616908.5
APN Book Page Parcel
Township Range Section

Location Sketch

(Sketch must be drawn by hand after form is printed.)

North
West
East
South

Illustrate or describe distance of well from roads, buildings, fences, rivers, etc. and attach a map. Use additional paper if necessary. Please be accurate and complete.

Activity

● New Well
○ Modification/Repair
  - ○ Deepen
  - ○ Other
○ Destroy
Describe procedures and materials under "GEOLOGIC LOG"

Planned Uses

○ Water Supply
  - ☐ Domestic ☐ Public
  - ☐ Irrigation ☐ Industrial
○ Cathodic Protection
○ Dewatering
○ Heat Exchange
○ Injection
● Monitoring
○ Remediation
○ Sparging
○ Test Well
○ Vapor Extraction
○ Other

Water Level and Yield of Completed Well

Depth to first water (Feet below surface)
Depth to Static Water Level 120 (Feet) Date Measured
Estimated Yield * (GPM) Test Type
Test Length (Hours) Total Drawdown (Feet)
*May not be representative of a well's long term yield.

Casings

Depth from Surface Feet	to Feet	Borehole Diameter (Inches)	Type	Material	Wall Thickness (Inches)	Outside Diameter (Inches)	Screen Type	Slot Size if Any (Inches)
0	20	6	Blank	PVC Sch. 40	0.280	6.625	N/A	
20	260	3.8	Open hole					

Annular Material

Depth from Surface Feet	to Feet	Fill	Description
0	20	Cement	Portland grout
0	260		FLUTe multilevel

Attachments

☑ Geologic Log
☑ Well Construction Diagram
☐ Geophysical Log(s)
☐ Soil/Water Chemical Analyses
☐ Other
Attach additional information, if it exists.

Certification Statement

I, the undersigned, certify that this report is complete and accurate to the best of my knowledge and belief
Name CH2M HILL
Person, Firm or Corporation
155 Grand Ave Suite 1000 Oakland CA 94612
Address City State Zip
Signed 10/19/09 694686
C-57 Licensed Water Well Contractor Date Signed C-57 License Number

DWR 188 REV. 1/2006

IF ADDITIONAL SPACE IS NEEDED, USE NEXT CONSECUTIVELY NUMBERED FORM

Attachment A2
Field Screening Data
(This attachment is provided on CD-ROM)

Attachment A2-1
Borehole Geophysical Logs

PACIFIC SURVEYS

CALIPER
BOREHOLE VOLUME

Job No.
14457

Company	CH2M HILL
Well	MW-57-BR
Field	TOPOCK
County	SAN BERNARDINO State CA

Location:

N34*42.897' W114*29.387'
Pacific Gas & Electric Facility

Sec. Twp. Rge.

Other Services:

Dual Induction
ATV
OPTV

Permanent Datum	G.L.		Elevation above perm. datum	Elevation
Log Measured From	G.L.	0'		K.B.
Drilling Measured From	G.L.			D.F.
				G.L.

Date	2/16/2009		
Run Number	TWO		
Depth Driller	185'		
Depth Logger	185'		
Bottom Logged Interval	184'		
Top Log Interval	0'		
Pump Set @	N/A		
Time Pumping Prior to Survey	N/A		
Density / Viscosity	N/A		
Max. Recorded Temp.	N/A		
Pump Rate (GPM)	N/A		
Time Well Ready	4:00 PM		
Time Logger on Bottom	4:30 PM		
Equipment Number	PS-1		
Location	L.A.		
Recorded By	ABREAU		
Witnessed By	A. BREWSTER		

Borehole Record				Tubing Record			
Run Number	Bit	From	To	Size	Weight	From	To

Casing Record	Size	Wgt/Ft	Top	Bottom
Surface String	5"	Sch 80 pvc	0'	70'
Prot. String				
Production String	3"	Sch 40 pvc	0'	184'
Liner				

<<< Fold Here >>>

All interpretations are opinions based on inferences from electrical or other measurements and Pacific Surveys cannot and do not guarantee the accuracy or correctness of any interpretation, and we shall not, except in the case of gross or wilful negligence on our part, be liable or responsible for any loss, costs, damages, or expenses incurred or sustained by anyone resulting from any interpretation made by any of our officers, agents or employees. These interpretations are also subject to Pacific Surveys' general terms and conditions set out in our current Price Schedule.

Comments

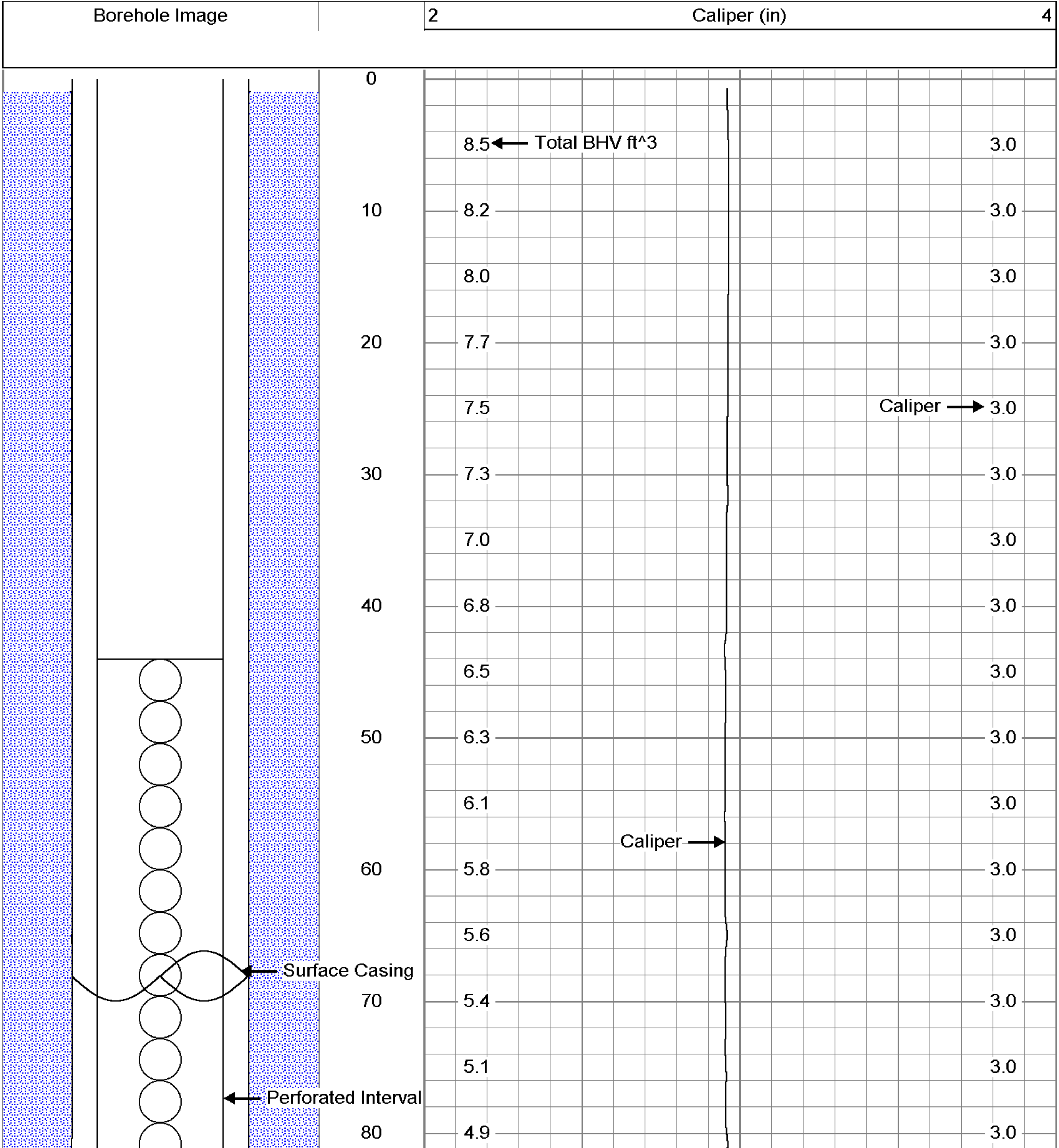
XY Caliper Calibration Report

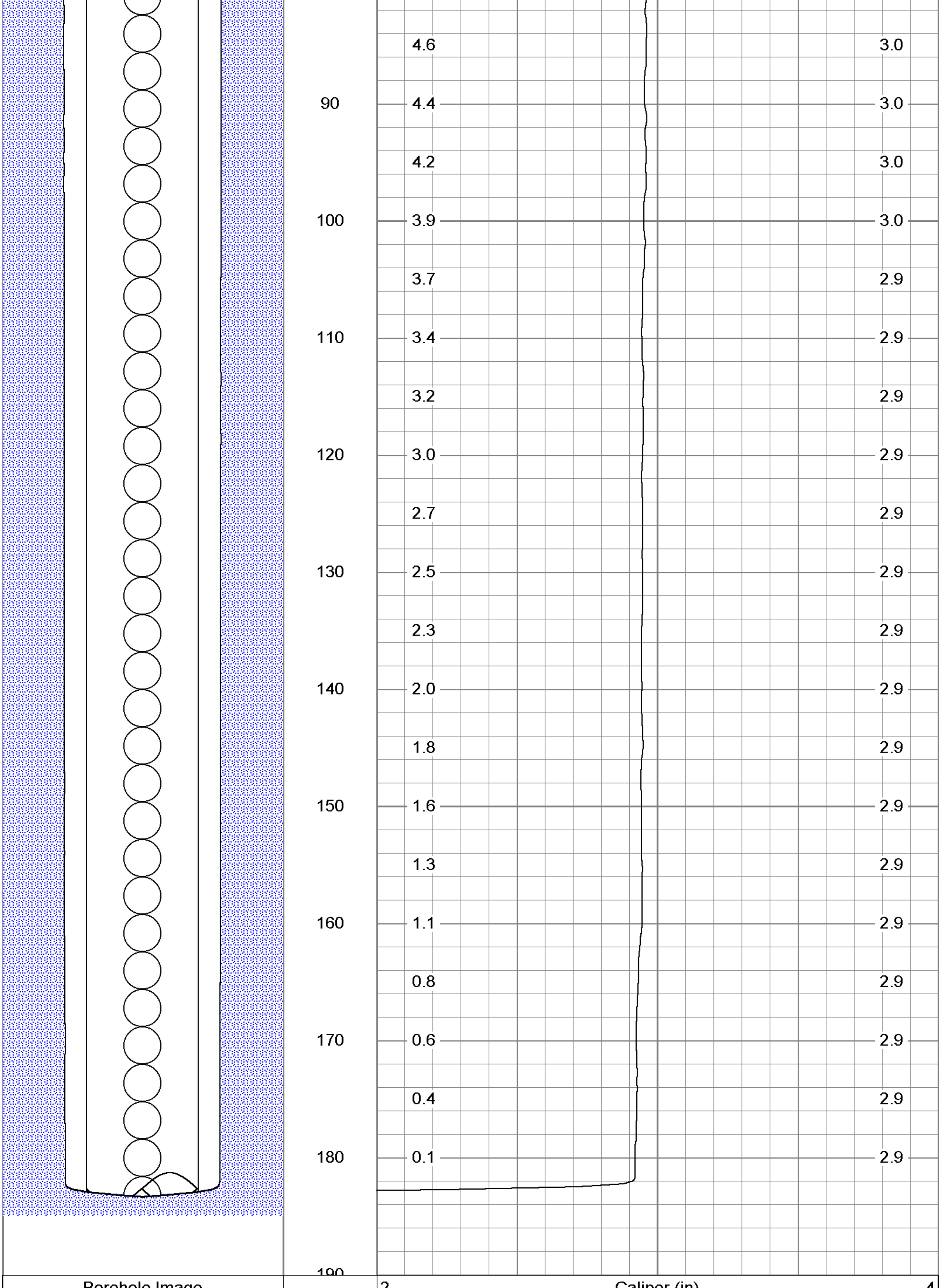
Serial Number:	Short
Tool Model:	Comprobe
Performed:	Tue Dec 02 23:07:28 2008

Small Ring:	6	in
Large Ring:	16	in

	X Caliper	Y Caliper	
Reading with Small Ring:	762.874	762.874	cps
Reading with Large Ring:	1710.1	1710.1	cps
Gain:	0.0105572	0.0105572	
Offset:	-1.35379	-1.35379	

Database File:	14457.db
Dataset Pathname:	pge/well/run1/cal_run2.
Presentation Format:	XYC_GPH
Dataset Creation:	Mon Feb 16 16:35:14 2009 by Calc Warrior Version 6.6
Charted by:	Depth in Feet scaled 1:120




4.6
3.0
90
4.4
3.0
4.2
3.0
100
3.9
3.0
3.7
2.9
110
3.4
2.9
3.2
2.9
120
3.0
2.9
2.7
2.9
130
2.5
2.9
2.3
2.9
140
2.0
2.9
1.8
2.9
150
1.6
2.9
1.3
2.9
160
1.1
2.9
0.8
2.9
170
0.6
2.9
0.4
2.9
180
0.1
2.9
190
Borehole Image
2
Caliper (in)
4

PACIFIC SURVEYS

DUAL INDUCTION
GAMMA-RAY

Job No.
14457

Company	CH2M HILL
Well	MW-57-BR
Field	TOPOCK
County	SAN BERNARDINO State CA

Location:

N34*42.897' W114*29.387'
Pacific Gas & Electric Facility

Sec. Twp. Rge.

Other Services:

Caliper
ATV
OPTV

Permanent Datum	G.L.		Elevation	Elevation
Log Measured From	G.L.	0'	above perm. datum	K.B. D.F. G.L.
Drilling Measured From	G.L.			

Date	2/16/2009		
Run Number	TWO		
Depth Driller	185'		
Depth Logger	185'		
Bottom Logged Interval	184'		
Top Log Interval	0'		
Pump Set @	N/A		
Time Pumping Prior to Survey	N/A		
Density / Viscosity	N/A		
Max. Recorded Temp.	N/A		
Pump Rate (GPM)	N/A		
Time Well Ready	4:00 PM		
Time Logger on Bottom	4:30 PM		
Equipment Number	PS-1		
Location	L.A.		
Recorded By	ABREAU		
Witnessed By	A. BREWSTER		

Borehole Record				Tubing Record			
Run Number	Bit	From	To	Size	Weight	From	To

Casing Record	Size	Wgt/Ft	Top	Bottom
Surface String	5"	Sch 80 pvc	0'	70'
Prot. String				
Production String	3"	Sch 40 pvc	0'	184'
Liner				

<<< Fold Here >>>

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Comments

Dual Induction Calibration Report

Serial-Model: 0001-ALT
Surface Cal Performed: Wed Jul 16 12:29:06 2008

Readings

References

Results

Loop:	Air	Loop		Air	Loop		m	b
Deep	1417.370	3879.020	cps	0.000	612.000	mmho-m	0.249	-352.377
Medium	1932.610	14228.100	cps	0.000	1960.000	mmho-m	0.159	-308.072

Gamma Ray Calibration Report

Serial Number:	PS_1	
Tool Model:	01	
Performed:	Wed Jul 16 12:42:11 2008	
Calibrator Value:	162	GAPI
Background Reading:	41.1721	cps
Calibrator Reading:	160.188	cps
Sensitivity:	1.36116	GAPI/cps

Database File:	14457.db
Dataset Pathname:	pge/well/run1/dil_run2.
Presentation Format:	DIL
Dataset Creation:	Mon Feb 16 16:05:55 2009 by Calc Warrior Version 6.6
Charted by:	Depth in Feet scaled 1:120

50 Gamma Ray (GAPI) 150

0 RILM (Ohm-m) 100

0 RILD (Ohm-m) 100

100 RILM backup (Ohm-m)1000

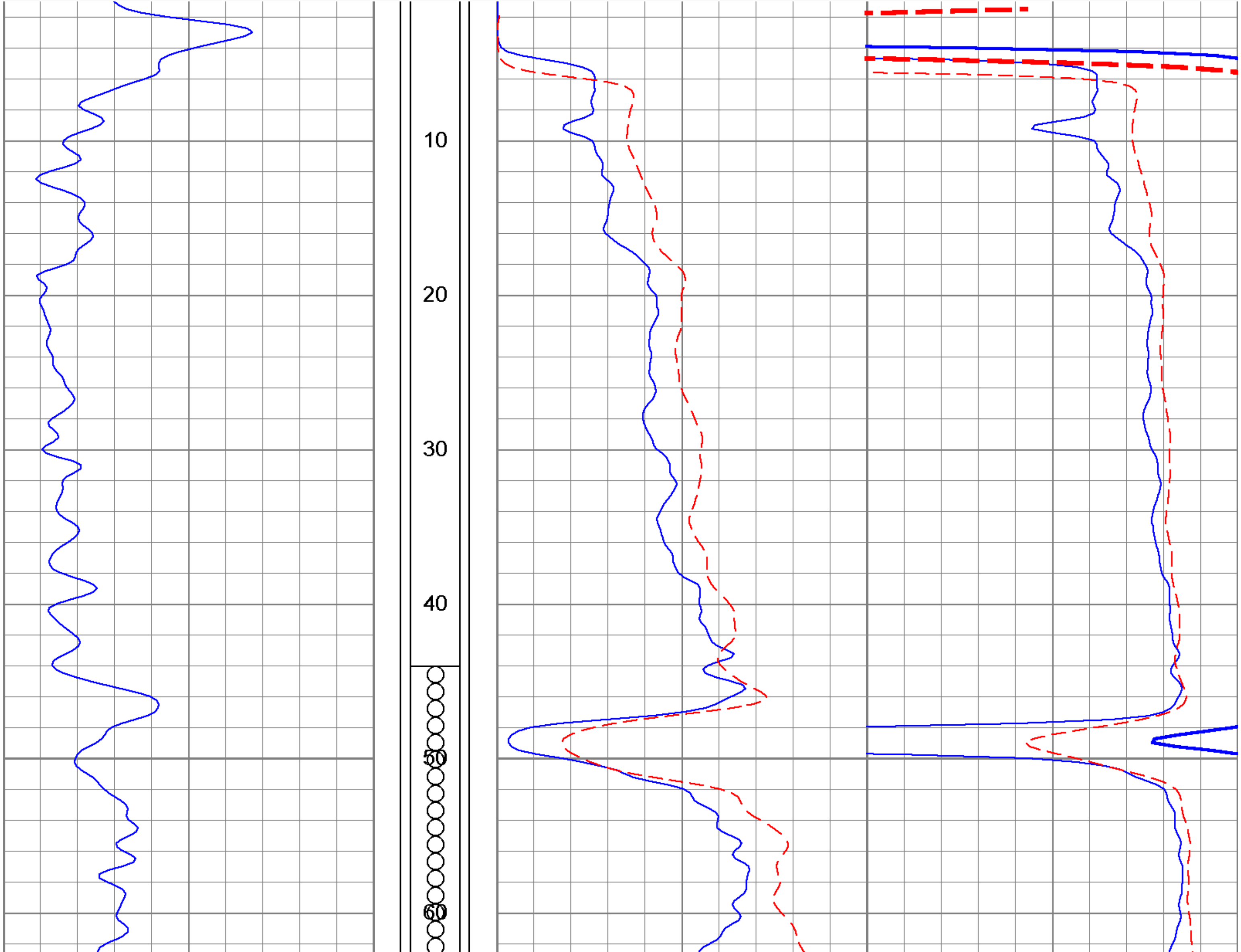
100 RILD backup (Ohm-m)1000

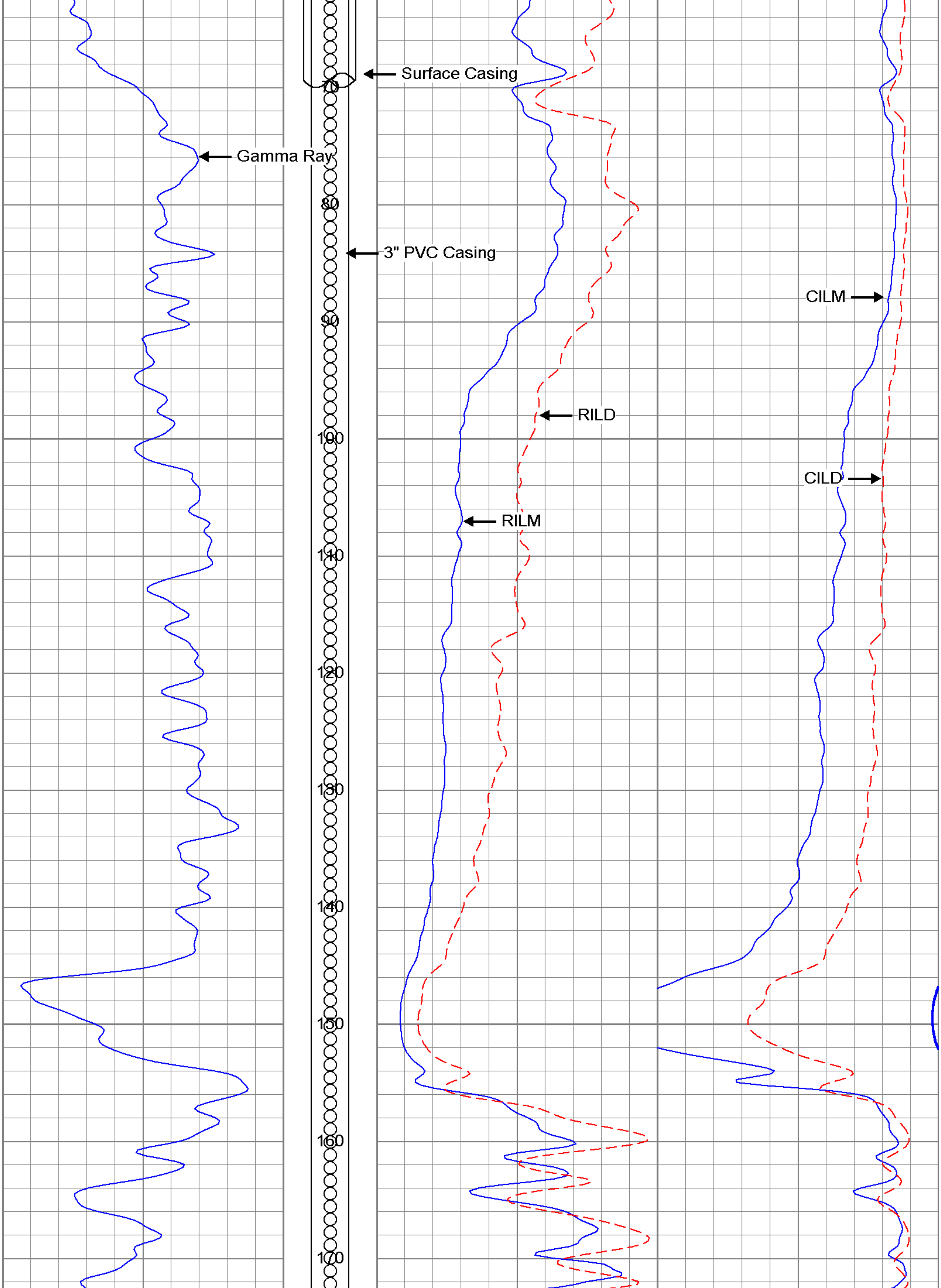
100 CILM (mmho-m) 0

100 CILD (mmho-m) 0

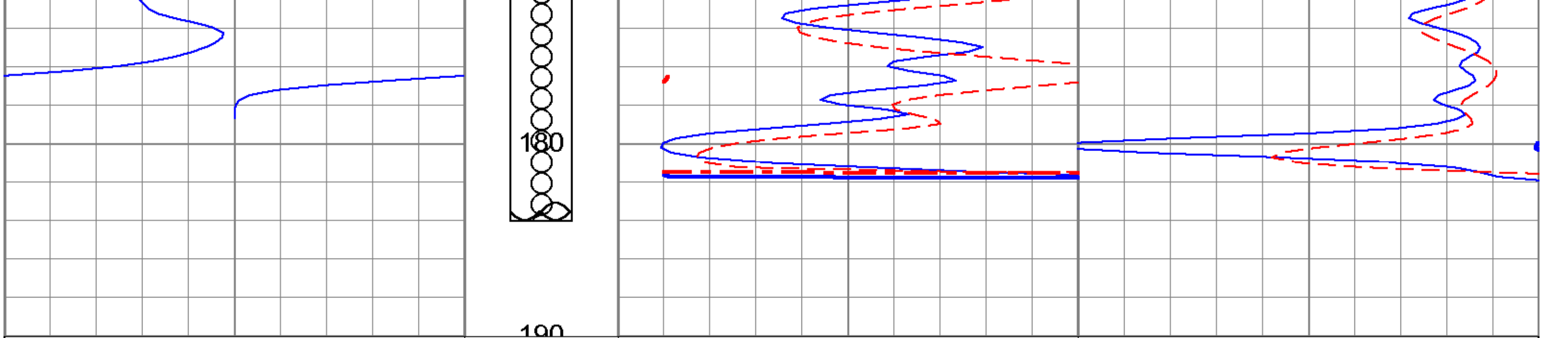
1000 CILM backup (mmho-m) 100

1000 CILD backup (mmho-m) 100





Surface Casing
Gamma Ray
3" PVC Casing
CILM
RILD
CILD
RILM
70
80
90
100
110
120
130
140
150
160
170



50 Gamma Ray (GAPI) 150	0 RILM (Ohm-m) 100	100 CILM (mmho-m) 0
	0 RILD (Ohm-m) 100	100 CILD (mmho-m) 0
	100 RILM backup (Ohm-m)1000	1000 CILM backup (mmho-m) 100
	100 RILD backup (Ohm-m)1000	1000 CILD backup (mmho-m) 100

PACIFIC SURVEYS

CALIPER
CASING VOLUME

Job No.
14458

Company	CH2M HILL
Well	MW-58-BR
Field	TOPOCK
County	SAN BERNARDINO State CA

Location:

N34*42.839' W114*29.429'
Pacific Gas & Electric Facility

Sec. Twp. Rge.

Other Services:

DUAL INDUCTION
GAMMA RAY

Permanent Datum	G.L.		Elevation	Elevation
Log Measured From	G.L.	0'	above perm. datum	K.B.
Drilling Measured From	G.L.			D.F.
				G.L.

Date	2/13/2009		
Run Number	ONE		
Depth Driller	115'		
Depth Logger	114.4'		
Bottom Logged Interval	114'		
Top Log Interval	0'		
Pump Set @	N/A		
Time Pumping Prior to Survey	N/A		
Density / Viscosity	N/A		
Max. Recorded Temp.	N/A		
Pump Rate (GPM)	N/A		
Time Well Ready	8:30 AM		
Time Logger on Bottom	8:45 AM		
Equipment Number	PS-1		
Location	L.A.		
Recorded By	ABREAU		
Witnessed By	A. BREWSTER		

Borehole Record				Tubing Record			
Run Number	Bit	From	To	Size	Weight	From	To

Casing Record	Size	Wgt/Ft	Top	Bottom
Surface String	6"	Sch 80 pvc	0'	66'
Prot. String				
Production String	3"	Sch 80 pvc	0'	115'
Liner				

<<< Fold Here >>>

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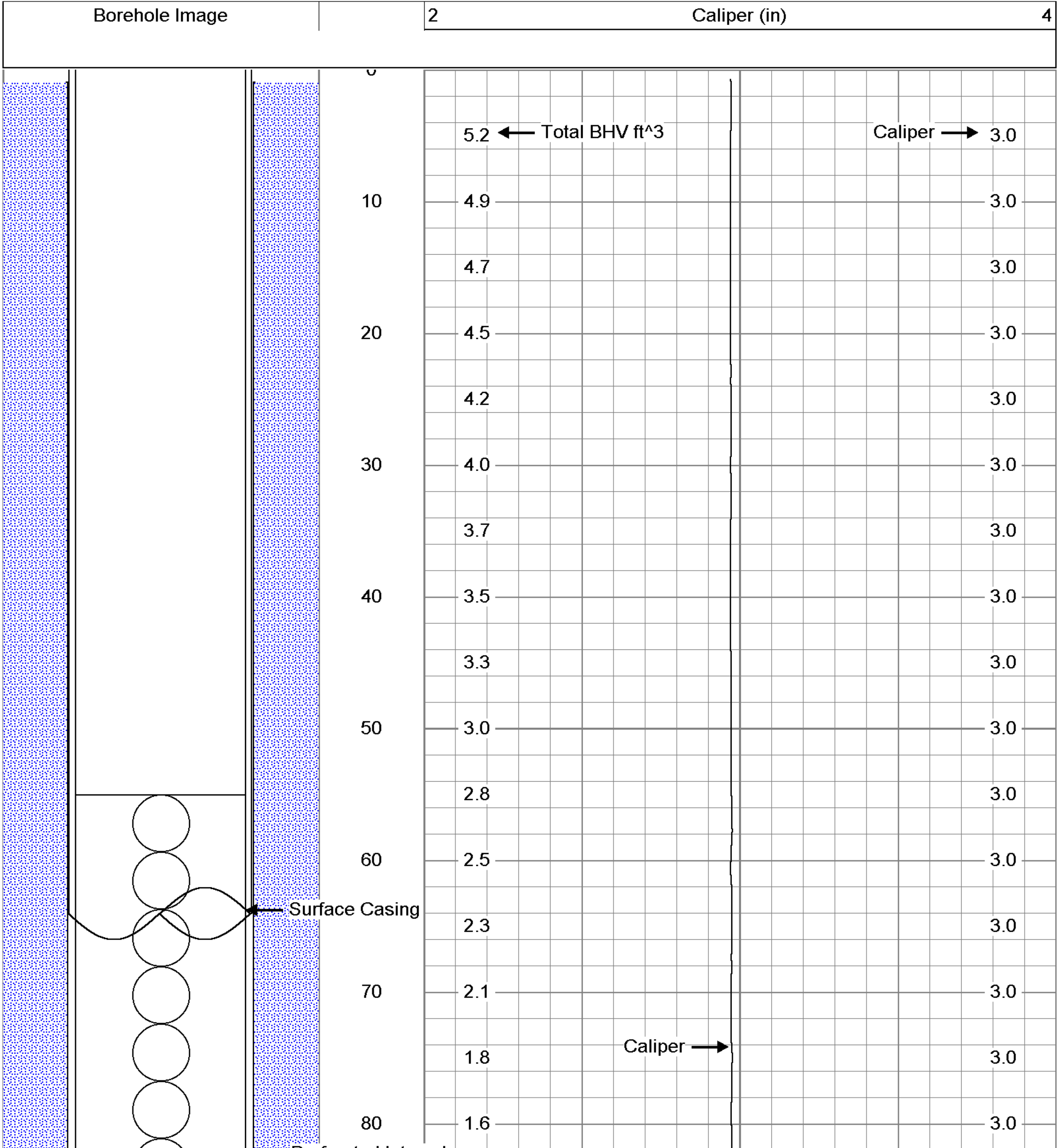
Comments

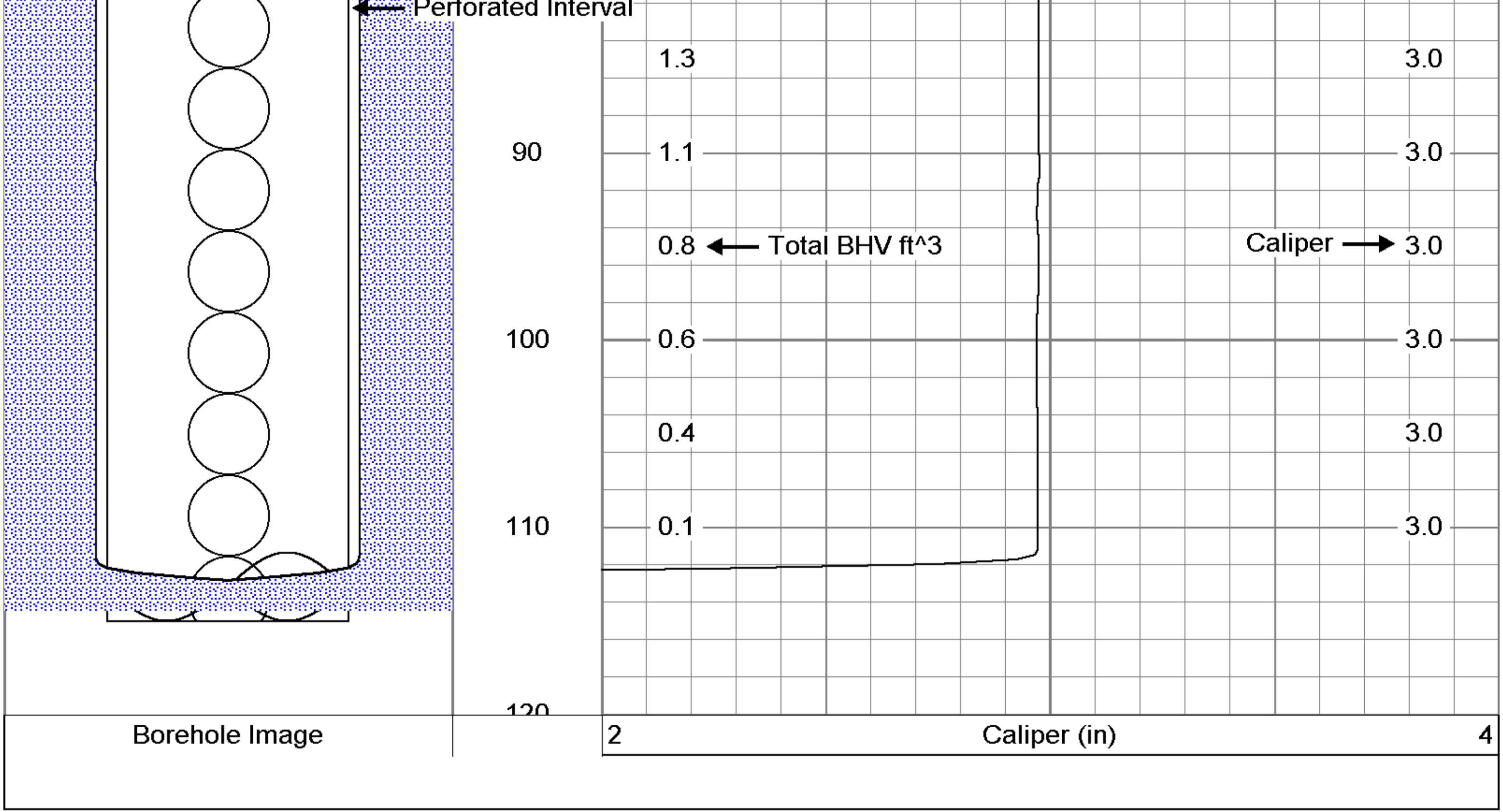
XY Caliper Calibration Report

Serial Number:	Short
Tool Model:	Comprobe
Performed:	Tue Dec 02 23:07:28 2008
Small Ring:	6 in
Large Ring:	16 in

	X Caliper	Y Caliper	
Reading with Small Ring:	762.874	762.874	cps
Reading with Large Ring:	1710.1	1710.1	cps
Gain:	0.0105572	0.0105572	
Offset:	-1.45379	-1.45379	

Database File:	14458.db
Dataset Pathname:	PGE/well/run1/CAL
Presentation Format:	XYC_GPH
Dataset Creation:	Fri Feb 13 12:00:44 2009 by Log Warrior Version 6.6
Charted by:	Depth in Feet scaled 1:120




Perforated Interval
90
100
110
120
1.3
1.1
0.8
Total BHV ft^3
0.6
0.4
0.1
Caliper
3.0
3.0
3.0
3.0
3.0
3.0
Borehole Image
2
Caliper (in)
4

PACIFIC SURVEYS

DUAL INDUCTION GAMMA-RAY

Job No.
14458

Company	CH2M HILL
Well	MW-58-BR
Field	TOPOCK
County	SAN BERNARDINO State CA

Location:

N34*42.839' W114*29.428'
Pacific Gas & Electric Facility

Sec. Twp. Rge.

Other Services:

CALIPER

Permanent Datum	G.L.		
Log Measured From	G.L.	0'	
Drilling Measured From	G.L.		

Elevation above perm. datum

Elevation
K.B.
D.F.
G.L.

Date	2/13/2009		
Run Number	ONE		
Depth Driller	115'		
Depth Logger	114.4'		
Bottom Logged Interval	114'		
Top Log Interval	0'		
Pump Set @	N/A		
Time Pumping Prior to Survey	N/A		
Density / Viscosity	N/A		
Max. Recorded Temp.	N/A		
Pump Rate (GPM)	N/A		
Time Well Ready	8:30 AM		
Time Logger on Bottom	8:45 AM		
Equipment Number	PS-1		
Location	L.A.		
Recorded By	ABREAU		
Witnessed By	A. BREWSTER		

Borehole Record				Tubing Record			
Run Number	Bit	From	To	Size	Weight	From	To

Casing Record	Size	Wgt/Ft	Top	Bottom
Surface String	6"	Sch 80 pvc	0'	66'
Prot. String				
Production String	3"	Sch 80 pvc	0'	115'
Liner				

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All interpretations are opinions based on inferences from electrical or other measurements and Pacific Surveys cannot and do not guarantee the accuracy or correctness of any interpretation, and we shall not, except in the case of gross or wilful negligence on our part, be liable or responsible for any loss, costs, damages, or expenses incurred or sustained by anyone resulting from any interpretation made by any of our officers, agents or employees. These interpretations are also subject to Pacific Surveys' general terms and conditions set out in our current Price Schedule.

Comments

Dual Induction Calibration Report

Serial-Model: 0001-ALT
Surface Cal Performed: Wed Jul 16 12:29:06 2008

Readings References Results

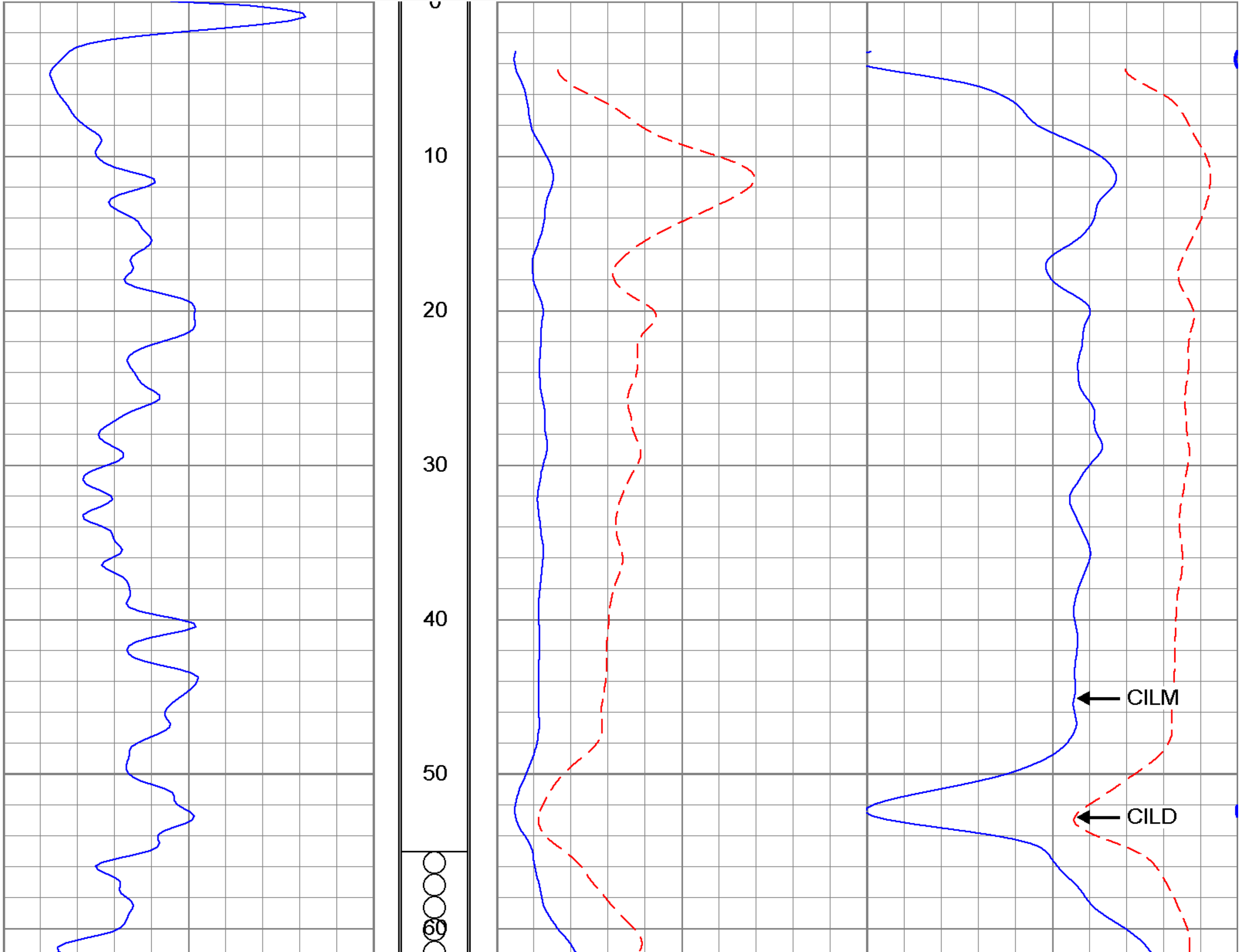
Loop:	Air	Loop		Air	Loop		m	b
Deep	1417.370	3879.020	cps	0.000	612.000	mmho-m	0.249	-352.377
Medium	1932.610	14228.100	cps	0.000	1960.000	mmho-m	0.159	-308.072

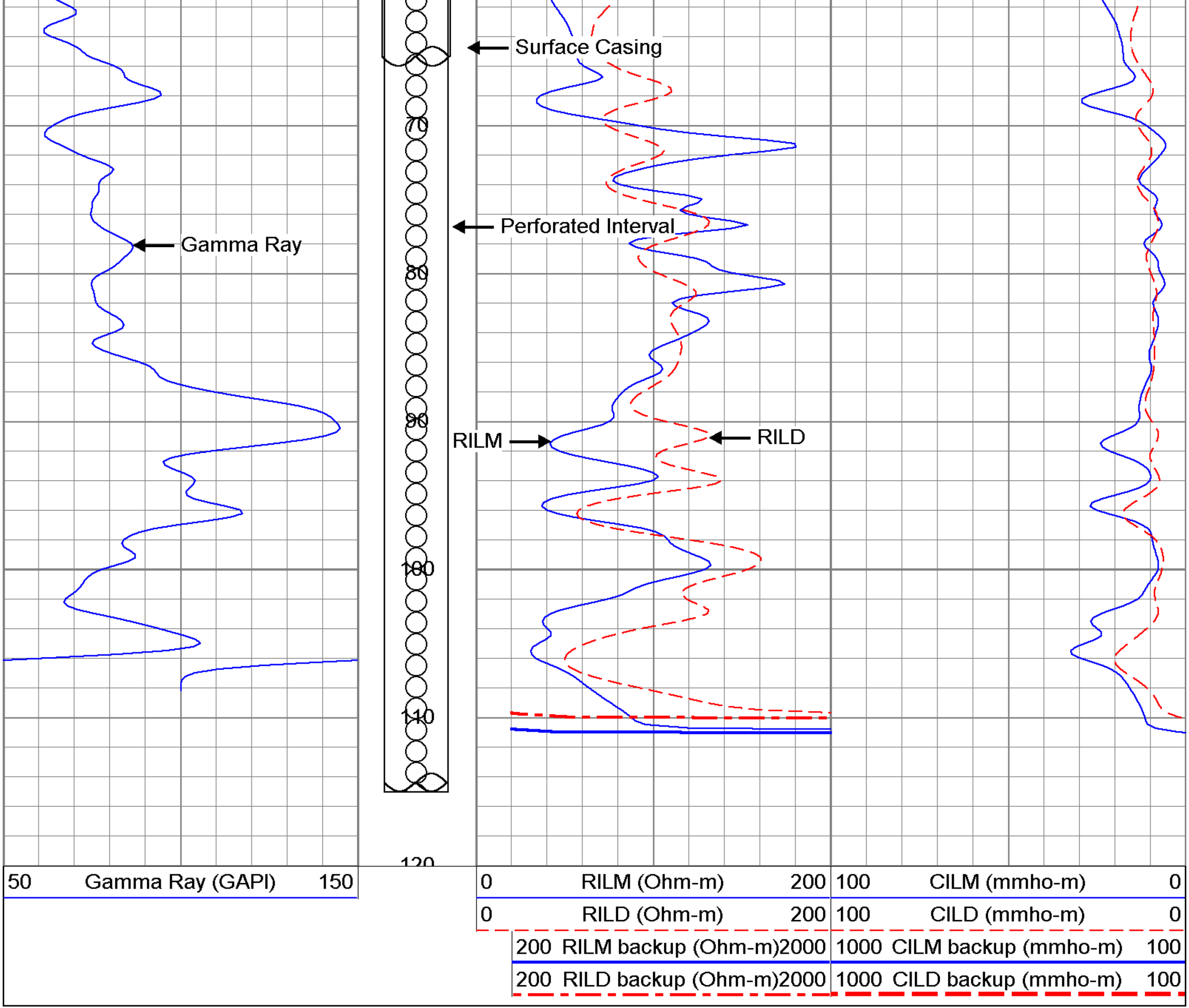
Gamma Ray Calibration Report

Serial Number:	PS_1	
Tool Model:	01	
Performed:	Wed Jul 16 12:42:11 2008	
Calibrator Value:	162	GAPI
Background Reading:	41.1721	cps
Calibrator Reading:	160.188	cps
Sensitivity:	1.36116	GAPI/cps

Database File: 14458.db
Dataset Pathname: PGE/well/run1/DIL.2
Presentation Format: DIL
Dataset Creation: Fri Feb 13 08:58:55 2009 by Calc Warrior Version 6.6
Charted by: Depth in Feet scaled 1:120

50 Gamma Ray (GAPI) 150	0 RILM (Ohm-m) 200	100 CILM (mmho-m) 0
	0 RILD (Ohm-m) 200	100 CILD (mmho-m) 0
	200 RILM backup (Ohm-m) 2000	1000 CILM backup (mmho-m) 100
	200 RILD backup (Ohm-m) 2000	1000 CILD backup (mmho-m) 100




Surface Casing
Perforated Interval
Gamma Ray
RILM
RILD
70
80
90
100
110
120
50 Gamma Ray (GAPI) 150
0 RILM (Ohm-m) 200
0 RILD (Ohm-m) 200
200 RILM backup (Ohm-m) 2000
200 RILD backup (Ohm-m) 2000
100 CILM (mmho-m) 0
100 CILD (mmho-m) 0
1000 CILM backup (mmho-m) 100
1000 CILD backup (mmho-m) 100

Attachment A2-2
Hydrophysical Data

RAS
Integrated Subsurface Evaluation

September 22, 2009

Mr. Rob Tweidt
Northstar Environmental Remediation
26225 Enterprise Court
Lake Forest, California 96230

RE: **Hydrophysical Logging and Discrete Point Sampling Investigation, PG&E Topock Compressor Station, Needles, California**

Dear Mr. Tweidt:

Attached please find RAS's Final Report presenting results from our Hydrophysical Logging and Discrete Point Sampling Investigation at the PG&E Topock Compressor Station, Needles, California. The wells tested included MW-57BR, MW-58BR (after deepening), MW-62BR and MW-64BR,

We appreciate the opportunity to work with you on this project.

Please call with any questions.

Best Regards,
RAS, Inc.

William H. Pedler
President

Executive Summary

During the period from February 25 through May 8, 2004, RAS conducted borehole hydrophysics in four wellbores at the PG&E Topock Compressor Station in Needles, California. This work was performed for Northstar Environmental Remediation of Lake Forest, CA (Northstar) under contract to CH2MHill of San Francisco, CA, in support of their contaminant migration investigation. The objective of this work was to employ borehole hydrophysical and discrete point sampling methods to provide additional data for evaluation of the groundwater contaminant plume and to evaluate preferential groundwater migration pathways at the subject site.

RAS applied hydrophysical logging (HPL), and discrete point sampling methods to evaluate four newly drilled wellbores. These wells were MW-57BR, MW-58BR, MW-62BR and MW-64BR. Well MW-58BR was tested twice, the second time after additional drilling was conducted to deepen the interval of investigation. Details of testing procedures can be founded in Appendix A of this report. Detailed field notes describing field activities are included in Appendix B, data logs and results of analysis are included in Appendix C and integrated data montages for each well can be found in Appendix D. A CD-ROM data disk with all these data and a copy of this report is also attached.

Ambient flow characterization (native flow during ambient or background pressures conditions) was conducted in each well. In all wells, ambient flow was observed to be occurring at extremely low flow rates during the period of our testing. Interval specific ambient flow ranged from less than 0.001 to 0.005 gallons per minute (gpm). The lowest ambient flow was observed in well MW-64BR, where flow over the entire saturated interval (apparently via primary porosity or extensive annealed micro-fracturing) occurred at less than 0.001 gallons per minute (gpm). The highest ambient flow rate was observed in Well MW-57BR at 0.005 gpm at the interval from 168 to 174 feet[1] (ftbtopvcc).

Flow evaluation was also conducted during stressed conditions where flow was induced into the wellbore by either pumping or slug testing methods. Aquifer conditions permitted constant rate pumping to be conducted in three of the four wells (MW-57BR, MW-58BR and MW-62BR). Aquifer conditions at MW-64BR were such that low rate pumping (<0.5 gpm) could not be sustained and as such, slug test procedures were required. The results of this testing suggested that, in general, the water bearing intervals were moderate to extremely low flowing units with interval specific flow rates ranging from 0.008 to 2.20 gpm. The lowest interval specific flow rate occurred over the entire saturated portion of well MW-

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[1] All depths are referenced to feet below top of PVC casing (ftbtopvcc) or feet below ground surface (ftbgs). The data montages presented in Appendix D include a column of depth referenced to MSL.

64BR (0.008 gpm) and the greatest interval specific flow rate occurred in Well MW-57BR at a depth of 168 to 174 ftbtopvcc at 2.10 gpm. It should be noted that the interval of highest flow during pumping also corresponded to the interval displaying the greatest ambient flow (MW-57BR).

Discrete point sampling was conducted in each well to evaluate the interval specific concentration and vertical distribution of hexavalent chromium in each well. For each well, the depth location for the discrete point sampling was based on the hydrophysical logging results. This type of sampling was employed because borehole conditions required installation of a temporary slotted screen casing. The condition of the geologic material encountered at each of the subjects wells was deemed sufficiently unstable that there was a real threat of borehole collapse. The installation of the slotted screen prevented unstable geologic materials from entering the well and provided a safe downhole environment for testing.

The results of the discrete point sampling were incorporated with the interval specific flow results in order to estimate the interval specific concentrations. These calculations are based on the mass balance equation. The observed concentrations (those concentrations reported from the laboratory) and the calculated interval specific concentration are presented on each well montage in Appendix D. Observed concentrations varied from ND or <1ppb (collected at 203 ftbtopvcc in well MW-58BR during ambient flow conditions) to 1200ppb (two samples collected at 94.5 and 108 ftbtopvcc both in well MW-62BR). The calculated interval specific concentrations ranged from ND or <1ppb.

Based on pressure histories and corresponding interval specific flow rates observed during ambient and pumping conditions, interval specific hydraulic conductivities were estimated for each well. These estimates were intended to be preliminary in nature and were not based on any site specific algorithms that may have been developed by others. For simplicity, the estimates were based on Thiem (1906) and presented in the summary table for each well. These results were also plotted on data montages in Appendix D. In summary, the resulting interval specific hydraulic conductivity estimates ranged from 6.4E-2 to 8.09E0 feet per day.

Based on geologic logs, collected by others and presented in the data montages, the subject wells encountered a layer of unconsolidated sediment overlaying either conglomerate or metadiorite bedrock water. However, in the case of MW-57BR, both types of bedrock were encountered with the conglomerate overlying the metadiorite. The highest interval of hydraulic conductivity was found in metadiorite in MW-57BR. In general, both geologic units contained water bearing intervals and neither was significantly more hydraulically conductive than the other.

A figure of interval specific hydraulic conductivity and corresponding chromium concentrations is presented in Figure 1. Due to the apparent lack of linear correlation between contaminant concentrations and hydraulic conductivities, fractures may still be the dominant mechanism for contaminant transport.

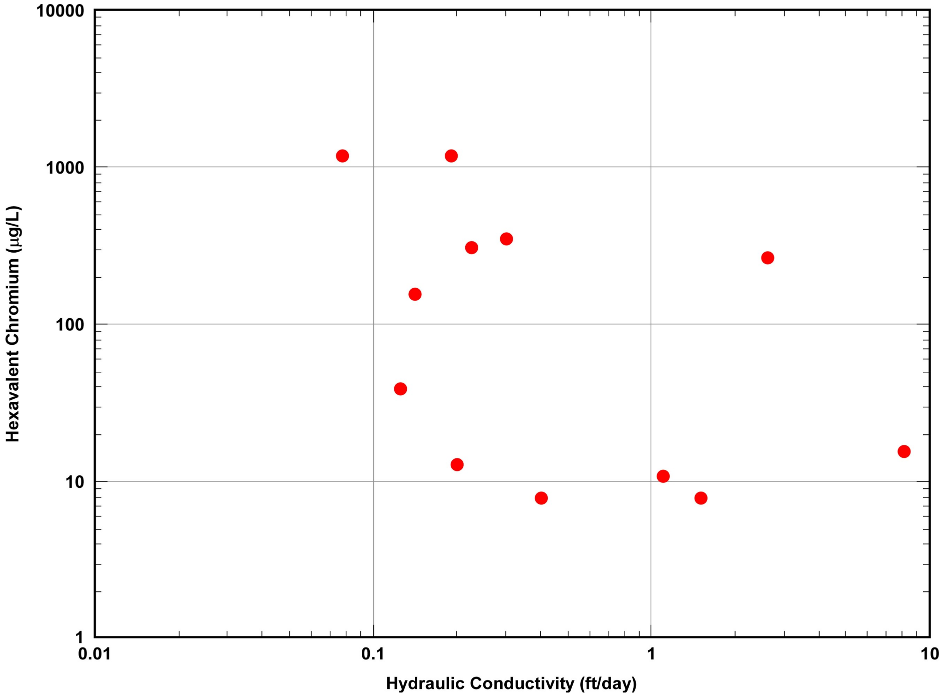

Figure 1. Interval Specific Hydraulic Conductivity versus Hexavalent Chromium.

Individual Well Discussion

On a well-specific basis, the RAS investigation suggested the following:

Well MW-57BR

During the period from February 26, 2009 to March 1, 2009, RAS conducted hydrophysical logging in well MW-57BR. The well had been recently drilled, properly developed and allowed sufficient time to stabilize prior to our arrival on site (greater than seven days). After conducting a health and safety meeting and being thoroughly briefed on site specific operational requirements, RAS personnel, under the direction and with assistance of Northstar, initiated equipment set up and check out. These procedures included initial decontamination of all downhole equipment, equipment move-in and configuration at the subject well. Test procedures, detailed notes of field activities and results of analyses can be found in Appendices A, B and C, respectively. The data montage for well MW-57BR with summarized results can be found in Appendix D. In addition, the final well construction and geology are included in this montage. This montage is the cornerstone of the following discussion of our results and is intended to be read together with this report.

The ambient FEC and temperature log is presented in panel nine of the MW-57BR data montage. The FEC log displays two distinct step change increases in FEC with depth. These step changes occurred from 117 to 130 and 145.5 to 156 ftbtopvcc. The temperature log displays a typical geothermal gradient with no discerning features of note. The temperature increased from about 25 to 28 degrees Centigrade (C) over the saturated interval of 56.5 to 177 feet. This equates to a thermal gradient of about 2.5 C per 100 feet.

Ambient flow characterization (AFC) was conducted on February 27, 2009. Please refer to Appendix A for detailed procedures of the test. At the time of testing, the depth to water was 53.09 ftbtopvcc. Flow characterization was conducted during the period from 12:50 to 17:40 hours, during which period, fourteen logging runs were conducted. Water level returned to within 0.1 feet of the background value after about 30 minutes. A final log was collected the following morning prior to commencing additional testing. Analysis of these logs using the centroid and integral methods suggest the presence of two water bearing intervals from 146 to 151 and 168 to 174 feet[2]. Ambient flow for these intervals was extremely low at 0.003 and 0.005 gpm, respectively.

On February 28, 2009, evaluation of these intervals by pumping during injection testing was conducted with a formation production rate of about 2.1 gpm. Analysis of the data collected during this testing suggested that the upper interval,

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[2] All depths referenced to top of PVC casing.

from 146 to 151 ft was inflowing at 0.03 gpm and the lower interval from 168 to 174 was flowing at 2.1 gpm. These interval specific flow rates, with an associated drawdown of about 10.3 feet, resulted in interval specific hydraulic conductivity for the intervals at 146 to 151 and 168 to 174 ft of 1.25E-1 and 8.1E+0 ft/day, respectively. The HPL results also suggested that the upper and deeper flow intervals had interval specific FEC of about 2500 µS/cm and 20,000 µS/cm, respectively. Please refer to Appendix B for HPL data analysis details and a summary table of these results.

Based on the results of the HPL, discrete point sampling was conducted during ambient and pumping conditions. These groundwater samples were collected to evaluate the interval specific concentrations of hexavalent chromium concentrations. Sampling was conducted at 92.6, 102.0, 114.0, 154.0 and 174.9 feet. The results of the discrete point sampling were incorporated with the interval specific flow results in order to estimate the interval specific concentrations. These calculations are based on the mass balance equation. The observed concentrations (those concentrations reported from the laboratory) and the calculated interval specific concentration are the montage in Appendix D. In summary, the calculated interval specific contaminant concentrations for the intervals from 146 to 151 and 168 to 174 ft were 39 and 16 ppb, respectively.

Review of the natural gamma and induction/resistivity data and comparison to the HPL results does not suggest an obvious relationship between the flow intervals and a geophysical response. The details from the geologic log do not correspond or account for the geophysical responses. The cross-over signatures of the medium and deep induction/resistivity logs near the flow interval at 168 to 174 feet suggest a thin bed response and perhaps have some relationship to the flow interval. However, without high resolution optical or acoustic data over this interval, the physical nature of the flow intervals is challenging to discern.

Well MW-58BR

During the period from March 3 to March 5, 2009, RAS conducted hydrophysical logging in well MW-58BR. The well had been recently drilled, properly developed and allowed sufficient time to stabilize prior to our arrival on site (greater than seven days). Prior to installation, all downhole equipment was decontaminated. Following decontamination procedures, equipment move-in and configuration at the subject well were conducted. After equipment set-up, check out and calibration, RAS initiated hydrophysical testing and downhole sampling at well MW-58BR. Test procedures, detailed notes of field activities and results of analyses can be found in Appendices A, B and C, respectively. Based on these results, the well was subsequently drilled deeper and re-tested. As the subsequent testing included the originally drilled interval, only the later testing will be discussed and present in this report.

On April 30, 2009, RAS returned to the subject well and tested MW-58BR after additional drilling to deepen the subject well was completed. The total depth of the original wellbore was about 110 feet and with an ambient depth to water of 67.74 feet. The total depth after re-drilling was approximately 206 feet with the ambient depth to water at 67.44. Again, the well was allowed sufficient time to stabilize prior to testing. Hydrophysical logging and discrete point sampling were conducted during the period from April 30 to May 3, 2009. The results are summarized in the data montage for MW-57BR found in Appendix D. In addition, the final well construction and geology are included in this montage. This montage is the cornerstone of the following discussion of our results and should be read together with this report.

The ambient FEC and temperature log is presented in panel six of the MW-58BR data montage. The FEC log displays two distinct step change increases in FEC with depth. These step changes occurred from 86 to 93 ft with a more gradual increase with depth from 160 to 186 ftbtopvcc. The temperature log displays a typical geothermal gradient with no discerning features of note. The temperature increased from about 28 to 29.3 degrees Centigrade (C) over the saturated interval of 98 to 207 feet. This equates to a thermal gradient of about 1.2 C per 100 feet.

Ambient flow characterization (AFC) was conducted May 1 through May 2, 2009. Two days were required for AFC given the extremely low flow that was observed. Please refer to Appendix A for detailed procedures of the test. During the period of testing, the depth to water was relatively stable and only varied from 67.06 to 67.11 ftbtopvcc. A detailed pressure history is provided in the attached Processing Notes. Flow characterization was concluded on the morning of May 3, when the final AFC log was collected prior to initiating pumping. During this period, twenty logging runs were conducted. Analysis of these logs using the centroid and integral methods suggest the presence of very low-rate upflow occurring from the bottommost water bearing interval from 190 to 207 ftbtopvcc. Analysis of these data suggests that the inflow rate for this interval was extremely low at 0.004 gpm. The outflow location(s) could not be determined from these data due to the extremely low inflow rate and the extended period of additional testing time required (approximately five additional days).

On May 3, 2009, additional aquifer evaluation by slug test (rising head) after DI water emplacement testing was conducted with a water level head displacement of about 7 feet. The average formation production rate during logging was about 0.5 gpm. Analysis of the data collected during this testing suggested that seven (7) conductive, or water bearing, intervals were present. These intervals were at the depths of 95.9 to 103.7, 106.6 to 111.3, 114.7 to 120.1, 128.0 to 130.5, 132.4 to 136.3, 148 to 190 and 190.0 to 207 ftbtopvcc. The interval specific flow rates ranged from 0.003 to 0.27 gpm. The minimum and maximum inflow rates occurred at 128.0 to 130.5 and 148 to 190 ftbtopvcc, respectively. These interval specific flow rates, with an associated drawdown of about 6.8 feet, resulted in interval specific hydraulic conductivity estimates ranging from 0.2 to 2.6 feet per day. The HPL results also suggested that the flow intervals had reasonably similar interval specific FEC of about 10,000 µS/cm. Please refer to Appendix B for HPL data analysis details and a summary table of these results.

On May 8, 2009, discrete point sampling was conducted during ambient and pumping conditions. These groundwater samples were collected to evaluate the interval specific concentrations of hexavalent chromium. Sampling during pumping at approximately 0.5 gpm was conducted at 125, 140 180 and 206 ftbtopvcc. Prior to initiating pumping, a sample was collected from 203 ftbtopvcc under ambient, upflowing, conditions. The results from the lab of the discrete point samples collected during pumping were incorporated with the interval specific flow results to estimate the actual interval specific concentrations, as based on the mass balance equation. The observed concentrations (those concentrations reported from the laboratory) and the calculated interval specific concentrations are presented on the montage for MW-57BR in Appendix D. In summary, the calculated interval specific contaminant concentration increased dramatically with depth, from 8 ppb for the conductive intervals at 95.9 to 103.7, 106.6 to 111.3, and 114.7 to 120.1 ft to 256ppb for the bottommost interval at 190.0 to 207 ft. However, the sample collected during ambient conditions was reported at <1ppb. This observation suggests that while this interval was uncontaminated during ambient pressure and flow conditions, after several hours of pumping, contaminated groundwater was drawn either vertically and or horizontally to the deepest interval in the subject well.

Limited geophysical data were available for comparison with the hydrophysical results. The interval over which the natural gamma and induction/resistivity data is available for comparison was 0 to 110 ftbtopvcc. This depth corresponds to the original depth of well MW-58BR prior to re-drilling. The uppermost water bearing interval occurs within this interval, from 95.9 to 103.7 ft. This water bearing interval encapsulates an increase in deep and medium resistivity. A decrease in natural gamma is also noted over this interval.

The details from the geologic log do not correspond or account for the geophysical responses. The cross-over signatures of the medium and deep induction/resistivity logs near the flow interval at 69 to 95 feet occurs in the meta-diorite and suggest either a variation in petrology, fracturing, fracture fill material, a combination of these factors or something else. Without high resolution optical or acoustic data over this interval, the physical nature of the flow intervals is very challenging to discern.

Please refer to Appendix B for HPL data analysis details and a summary table of these results.

MW-62BR

During the period from May 5 to May 8, 2009, RAS conducted hydrophysical logging in well MW-62BR. The well had been recently drilled, properly developed and allowed sufficient time to stabilize prior to our arrival on site (greater than seven days). Prior to installation, all downhole equipment was decontaminated. Following decontamination procedures, equipment move-in and configuration at the subject well were conducted. After equipment set-up, check out and calibration, RAS initiated hydrophysical testing and downhole sampling. Test procedures, detailed notes of field activities and results of analyses can be found in Appendices A, B and C, respectively.

On May 5, 2009, after tool calibration and an ambient FEC and temperature log hydrophysical logging for ambient flow characterization (AFC) was initiated. Ambient flow characterization was initiated on May 5 and conducted for two days due to extremely low inflow rates observed. Following AFC, flow characterization during stressed (pumping) and discrete point sampling were conducted from May 7 to May 8, 2009. The results are summarized in the data montage for MW-62BRfound in Appendix D. In addition, the final well construction and geology are included in this montage. This montage is the cornerstone of the following discussion of our results and should be read by the reader during his review of this report.

The ambient FEC and temperature log is presented in panel four of the MW-62BR data montage. The FEC log displays two distinct step change increases in FEC with depth. These step changes occurred from 88 to 99 ft with another at depth from 147 to 153 ftbtopvcc. The temperature log displays an atypical geothermal gradient with a distinct “swoosh” type signature. The temperature log was constant with depth at about 28.3 C to about 76.4 feet, and then the temperature gradually decreases to about 27.9 C at 139 feet, before resuming a traditional geothermal gradient to total depth (191 ftptopvcc).

Ambient flow characterization was initiated on May 5 and concluded the morning of May 7, 2009. This extended period of time was required given the extremely low flow that was observed. Please refer to Appendix A for detailed procedures of the test. After an initial stabilization period of about two hours following emplacement, the depth to water was relatively stable and varied only about 0.2 feet during the period of testing. A detailed pressure history is provided in the Processing Notes in Appendix B. Ambient flow characterization was concluded on the morning of May 7 when the final AFC log was collected prior to initiating pumping. During this period twenty logging runs were conducted. Analysis of these logs using the centroid and integral methods suggest the presence of a very low rate upflow occurring from the bottommost water bearing interval at 185 to 190 ftbtopvcc. Analysis of these data suggests that the inflow rate for this interval was extremely low at 0.01 gpm. The outflow location could not be unequivocally determined from these data, but this analysis does suggests that the outflow zone was the uppermost water bearing interval from 85 to 95 feet.

On May 7, 2009, additional aquifer evaluation by pumping during deionized water injection was conducted. The average formation production rate during logging was 1.3 gpm with a reasonably stable drawdown of about 23.10 feet. Analysis of the data collected during this testing suggested that six (6) conductive, or water bearing, intervals were identified. These intervals were at depths 85.8 to 95.0, 95 to 107, 142 to 151.2, 156 to 171.2, 173.9 to 182.1 and 185 to total depth (~190) ftbtopvcc. The interval specific flow rates ranged from 0.04 to 0.56 gpm. The minimum and maximum inflow rates occurred at 142 to 151.2 and 185 to 190 ftbtopvcc, respectively. These interval specific flow rates, with an associated drawdown of about 23.1 feet, resulted in interval specific hydraulic conductivity estimates ranging from 4.45E-02 to 3.00E-01 feet per day. The HPL results also suggested that the flow intervals had increasing interval specific FEC with depth, specifically increasing from 6,000 at the uppermost interval to 12,200 µS/cm for the deepest water bearing interval. Please refer to Appendix B for HPL data analysis details and a summary table of these results.

On May 8, 2009, discrete point sampling was conducted during ambient and pumping conditions. These groundwater samples were collected to evaluate the interval specific concentrations of hexavalent chromium. Samples during pumping at approximately 1.2 gpm were collected from 94.5, 108, 149, 170, 184.5 feet and from the pump discharge. Prior to pumping, a sample was collected at 187 ftbtopvcc under ambient, upflowing, conditions. The results from the laboratory of the discrete point samples collected during pumping were incorporated with the interval specific flow results to estimate the actual interval specific concentrations, as based on the mass balance equation. The observed concentrations (those concentrations reported from the laboratory) and the calculated interval specific concentrations are presented on the well MW-62BR montage in Appendix D. In summary, the calculated interval specific contaminant concentrations notably decreased with depth, from 1200 ppb for the conductive intervals at 95.9 to 103.7, 106.6 to 111.3, 114.7 to 120.1 to 256ppb for the bottommost interval at 190.0 to 207 ft. However, the sample collected during ambient conditions was reported at <1ppb. This observation suggests that while this interval was uncontaminated during ambient pressure and flow conditions, after several hours of pumping, contaminated groundwater was drawn either vertically and/or horizontally to the subject well’s deepest interval.

No geophysical data was available for comparison with the hydrophysical results.

Please refer to Appendix B for HPL data analysis details and a summary table of these results.

MW-64BR

During the period from May 27 to June 1, 2009, RAS conducted hydrophysical logging in well MW-64BR. The well had been recently drilled, properly developed and allowed sufficient time to stabilize prior to our arrival on site (greater than seven days). After conducting a health and safety meeting and being thoroughly briefed on site specific operational requirements, RAS personnel initiated equipment set up and check out. These procedures included initial decontamination of all downhole equipment, equipment move-in and configuration at the subject well. Downhole sampling was not conducted at well MW-64BR due to extremely low overall well yield and lack of any significant preferential flow intervals. Test procedures, detailed notes of field activities and results of analyses can be found in Appendices A, B and C, respectively. The results summarized the data montage for MW-64BR can be found in Appendix D. In addition, the final well construction and geology are included in this montage. This montage should be reviewed by the reader during his reading of this report.

The ambient FEC and temperature log is presented in panel four of MW-64BR data montage. The FEC log displays an increase in FEC with depth over the upper 40 feet of the fluid column. The temperature log displays a “swoosh” type signature, first decreasing to a depth 174 feet, then increasing to total depth. During the initial ambient FEC and temperature log, some residual drilling material was encountered at about 228 feet. This material fouled the FEC sensors causing the decrease in FEC at this depth and the remaining errant readings to TD. As such, the FEC data is not representative of the fluid column from 228 to 258 feet. This residual material was removed from the wellbore and all subsequent logs were successfully collected.

Ambient flow characterization was initiated on May 29, 2009. Please refer to Appendix A for detailed procedures of the test. At the time of testing, the depth to water was 119.48 ftbtopvcc. Ambient flow characterization was initiated May 29 at 12:05 and concluded on May 31 at 09:05 hours. During this period, fifteen (15) logging runs were conducted. At the completion of emplacement procedures, the water level was elevated approximately 6.5 feet above the ambient elevation. Hand bailing was conducted immediately after emplacement, and prior to logging, to carefully return the water level elevation back to the ambient elevation. Analysis of these logs using the centroid and integral methods suggest extremely low inflow over the entire saturated interval. No distinct or preferred flow intervals were apparent. As such, the observable and recorded increase in FEC suggests primary flow. Analysis suggests an inflow rate of less than 0.001 gpm for the entire saturated interval.

On May 31, 2009, flow evaluation of the saturated interval was conducted using the HPL slug test after emplacement (SAE) method. Analysis of the data collected during SAE testing supports the ambient flow characterization and confirms the lack of any preferential flow paths. Analysis of the data suggests that the total flow over the entire saturated interval was 0.008 gpm. This overall flow rate is also supported by the water level recovery curve. Based on the rising head data, an overall hydraulic conductivity based on Hvorslev (1951) of 6.4E-2 feet per day was calculated.

The HPL results also suggested an interval specific formation water concentration of 11,000 µS/cm for the saturated interval. Please refer to Appendix B for HPL data analysis details and summary table of these results.

Based on the results of the HPL, discrete point sampling was not conducted as the well could not produce sufficient volumes of formation water without dewatering the interval(s) of interest.

Similar to MW-62BR, no geophysical logs were collected in this well.

Please refer to Appendix B for HPL data analysis details and a summary table of these results.

Limitations

Water levels have been measured in the well bores at the times and under the conditions stated in the report. These data have been reviewed and interpretations have been made in the text of this report. However, it must be noted that fluctuations in the level of the groundwater may occur due to variations in rainfall and other factors different from those prevailing at the time measurements were made.

Except as noted within the text of the report, no quantitative laboratory testing was performed to verify the calibration of the logging tool. Where such analyses have been conducted by an outside laboratory, RAS, Inc. has relied upon the data provided, and has not conducted an independent evaluation of the reliability of these data.

Conclusions and recommendations contained in this report may be based in part upon various types of chemical data and are contingent upon their validity. These data have been reviewed and interpretations made in the report. As indicated within the report, these data are developed based on the field calibration of the logging tool. Where more specific information is necessary, the tool measurements should be verified based on quantitative lab analyses of grab samples obtained directly from the wellbore. Moreover, it should be noted that the variations in the types and concentrations of groundwater constituents and variations in their flow paths may occur due to seasonal water table fluctuations, past site practices, the passage of time, and other factors. Should additional chemical data become available in the future, these data should be reviewed by RAS, and the conclusions and recommendations presented herein modified accordingly.

The values for bedrock hydraulic conductivity given in this report should be viewed as "equivalent hydraulic conductivities", which are computed based on an assumed, or equivalent, interval length and a uniformly pervious porous media behavior. This industry standard approach has several limitations, which are well documented in the current literature. In addition, the accuracy of the equivalent hydraulic conductivities when presented herein is subject to the applicability of the boundary condition assumptions inherent in the permeameter/slug test/pumping test analysis method used.

RAS's logging was performed in accordance with generally accepted industry practices involving similar studies at the same time and in the same general area. RAS has observed that degree of care and skill generally exercised by others under similar circumstances and conditions. Interpretation of logs from the newly developed techniques, Scanning Colloidal Borescope Flowmeter, Hydrophysical Logging ("NxHpL™") and Wireline Straddle Packer Testing ("WSP™") (whether made directly from visual observations or by data processing or otherwise), or interpretation of test or other data, and any recommendation or hydrogeologic description based upon such interpretations, are opinions based upon inferences from measurements, empirical relationships and assumptions. These inferences and assumptions require engineering judgment, and therefore are not scientific certainties. As such, other professional engineers or analysts may differ as to their interpretation. Accordingly, RAS cannot and does not warrant the accuracy, correctness or completeness of any such interpretation, recommendation or hydrogeologic description.

All technical data, evaluations, analysis, reports, and other work products are instruments of RAS's professional services intended for one time use on this project. Any reuse of work product by Client for other than the purpose for which they were originally intended will be at Client's sole risk and without liability to RAS. RAS makes no warranties, either express or implied. Under no circumstances shall RAS or its employees be liable for consequential damages.

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APPENDIX A

TECHNICAL PROCEDURES

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Hydrophysical Logging for Aquifer Characterization

TP-19

Prepared by: ______________________________ Date: 7-15-2008

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Reviewed by: ______________________________ Date: __________

Approved by: ______________________________ Date: __________

TP-19

Revision History

Revision Level	Issue Date	Change Summary
6	07/15/08	Revisions to Sampling protocol and format TOC
5	03/16/07	Edits for Intera Bruce Site Test Plan
4	2/14/07	Draft version editing for Intera Bruce Site Test Plan
3	06/05/06	New contact information.
2	11/03/03	Includes procedures for Depth Specific Sampling
1	07/8/02	Technical Editing
0	08/15/98	RAS Issue date

Table of Contents

1.0 SCOPE

1.1 Purpose

The purpose of this procedure is to assure the accuracy, validity, and applicability of the methods used to record hydrophysical logs in a previously drilled borehole. This procedure provides a guide for the Client's contractor to perform the described activity. From this procedure the Client can evaluate these activities for meeting the requirements of the Project.

This procedure describes the components of Hydrophysical logging, the principles of the methods used and their limits. It also describes the detailed methods to be used for calibration, operation and performance verification of the equipment. In addition, requirements for data acceptance, documentation, and control are defined, and means of data traceability are provided.

1.2 Applicability

This procedure applies to all personnel contractor personnel who may perform work or use data obtained from this procedure if it is deemed to potentially affect public health and safety related the Project

2.0 REFERENCES

2.1 Tsang, C.F., F.V. Hale, and P. Hufschmied, "Determination of. Fracture Inflow Parameters with a Borehole Fluid Conductivity Logging Method," Water Resources Research, Vol. 26, No., 4, 561-578, April 1990.

2.2 Pedler, W.H., Head, C.L. and Williams, L.L., "HydrophysicalLogging: A New Wellbore Technology for Hydrogeologic and Contaminant Characterization of Aquifers," Proceedings of the Sixth National Outdoor Action Conference, National Groundwater Association, May 11-13, 1992.

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2.4 Work instructions as called out herein.

2.5 Technical procedure TP-13.

3.0 DEFINITIONS

3.1 Hydrophysical Logging: Technology for evaluating hydrologic conditions surrounding a borehole.

Specifically, The Hydrophysical (HPL) logging method uses repeat logs of FEC and temperature to analyze and determine the location of hydraulically conductive intervals within a wellbore. The results can be used in conjunction with drawdown data obtained during active pumping to determine interval specific hydraulic conductivity or transmissivity. The technique can also be used to characterize ambient (non-pumping) flow conditions.

3.2 FEC: Fluid electrical conductivity.

3.3 Standard Reference Solution: A solution of known electrochemical properties, calibrated to a known FEC, to be used for calibration of HpL Sonde.

3.4 HPL Sonde: Wireline logging tool which measures FEC and temperature for use during Hydrophysical Logging.

3.6 Emplacement - The process of replacing ambient fluids in a borehole with deionized water.

3.7 Injection line - Either flexible tubing or rigid pipe used for emplacement.

3.8 Affected Interval: That interval in a borehole into which fluids flow during inflow or out of which fluids flow during outflow.

During ambient testing, the affected interval is defined as the zone between the deepest productive interval in a given well and the water surface.

During active pumping or DI emplacement, the affected interval is defined as the zone between the deepest hydraulically active interval in a given well and the inlet of the extraction pump.

3.9 Low yield well: Any well having a specific capacity less than 0.1 gallon per minute per foot of drawdown.

3.10 Moderate yield well: Any well having a specific capacity between 0.1 gallon per minute and 4.0 gallons/minute per foot of drawdown.

3.11 High yield well: Any well having a specific capacity greater than 4.0 gallons per minute per foot of drawdown.

3.12 Specific capacity is defined as the rate of fluid influx of a borehole, in units of flow rate per unit drawdown.

3.13 Slug test: Method for testing flow in a well which involves rapid extraction of a finite fluid volume to produce a one-time, sudden, finite decrease in fluid level in the well, and monitoring subsequent fluid recovery.

3.14 Pumping test: Method for testing flow in a well which involves continuous extraction of fluid at a constant rate to maintain a fixed decrease in fluid level in the well, while monitoring fluid extraction rate and water level. In HpL testing, a pumping test may also include simultaneous fluid injection at a fixed rate.

7.1 Deionized (DI) water: Water with a very low concentration of dissolved species and having typically between 5 and 25 µS/cm conductivity.

7.2 Discrete Point Fluid Sampler: Down hole logging tool that is used to collect a depth specific fluid sample lowered to a depth pre-selected by hydrophysical logging results.

3.17 Personnel

3.17.1 Principal Investigator (PI): Responsible for assuring full compliance with this procedure. PI shall require that all personnel assigned to work under this procedure have the necessary technical training, experience, and personnel skills to adequately perform this procedure.

The PI is also responsible for overall operations and data quality.

The PI shall determine whether the data and procedures meet the acceptance criteria.

3.17.2 If necessary due to field conditions, the PI may perform the duties of the Logging Engineer and/or the Technician.

3.17.3 If necessary due to field conditions, the Logging Engineer may perform the duties of the Technician.

4.0 REQUIREMENTS

4.1 Prerequisites

4.1.1 Borehole of appropriate size and completion methodology.

In open bedrock boreholes, casing shall be installed through the overburden and grouted at the rock/alluvium interface to inhibit water leakage into the borehole from the saturated alluvium. For cased boreholes, the well shall be fully cased and gravel packed with single or multiple screened intervals.

The diameter of the borehole shall be 4 inches or greater. For boreholes which require higher pumping rates (> 4 gpm) a 4 inch diameter pump may be required. For use with a 4 inch diameter pump, the diameter of the borehole shall be 6 inches or greater.

For newly drilled wells, cuttings and drill fluids shall be removed from the affected fractures by standard well development procedures.

4.1.2 Source of DI water. If DI water is prepared at the site, the pre-treated water shall be potable and less than 1000 µS/cm FEC.

4.1.3 Surface injection and submersible extraction pump(s) for HPL testing.

4.2 Tools, Material, and Equipment

Typical field equipment includes for shallow (less than 300 feet total depth):

- Fluid management system
  - Back Pressure Regulator or orifices
  - Rubber hose (0.75-inch i.d.) for injection
  - Submersible Pump
  - Evacuation Line
  - Storage tanks (as required) with inlet/outlet valves
  - Surface Pump
  - Fluid management manifold/Monitoring Panel
  - Mechanical hose spoolers (pump, injection)
  - Data Acquisition System (for recording volumes, flow rates, time)
  - Wireline System
  - Cable
  - Power supply
    - Wireline winch unit
    - Boom and drawworks
  - Depth encoder
  - Water level indicator
  - Computer System
  - NxHpl™ Logging tool
  - Downhole Fluid Sampler

- Deionized water (prepared with wellbore fluids or transported on-site)
- Appropriate water sample containers (typically provided by client)
- Steam Cleaner (for logging/sampling tools)
- Deionizing Units

4.2.2 For wells greater than 300 feet total depth, an independent pumping system and standard wireline logging truck is required. This includes:

Wireline System, Cable, Power supply, Wireline winch unit, Boom and drawworks, Depth encoder, Water level indicator, Computer System, Hydrophysical Logging tool, and Downhole Fluid Sampler.

4.2.3 RAS independent pumping system includes:

Fluid management system, Back Pressure Regulator or orifices, 1” galvanized pipe for injection lines, 2” galvanized pipe for evacuation lines, Submersible Pump, Storage tanks (as required) with inlet/outlet valves, Surface Pump, Fluid management manifold/Monitoring Panel, and Data Acquisition System (for recording volumes, flow rates, time).

4.2.4 Deionized water (prepared with wellbore fluids or transported onto the site).

4.2.3 Standard reference solutions: A minimum of 4 prepared solutions for calibration check of FEC measurements by the HpL sonde.

4.2.4 Surface flow meters may be provided by the client.

4.2.5 Steam cleaning equipment, if required.

4.3 Precautions and Limits

7.1.1 The operational temperatures and pressures for the RAS’s advanced, multi FEC/T arrayed hydrophysical tool are:

- Maximum operating pressure is approximately 1,000 PSI.
- Maximum practical operational temperature is 80°C.

4.3.2 Hydrophysical tests require that the borehole fluid be emplaced with deionized water. Improper emplacement of the DI water or its subsequent contamination can drastically affect the quality of the test.

4.3.3 The minimum borehole size is 4”. Larger boreholes (6” or greater) may be required to utilize 4” diameter pumps if it is necessary to achieve flow rates higher than approximately 4 gpm. This may occur when testing of a high yield well.

4.3.4 The Hydrophysical technique requires a fluid filled borehole.

7.1.1 Bridges, constrictions in the borehole diameter, will make it impossible to lower the tool into the borehole and difficult to retrieve the tool.

4.4 Acceptance Criteria

7.1.1 Forms shall be filled out as called for in this Technical Procedure.

7.1.2 Field calibration checks shall meet the criteria outlined in TP-13.

7.1.3 Evaluation of the test procedure and data for acceptability shall be the sole responsibility of the PI.

5.0 DETAILED PROCEDURE

When logging for hydrologic purposes only, as in this procedure, FEC and temperature measurements are sufficient to characterize the well.

5.1 Before Arrival On Site

5.1.1 Examine any previously obtained wireline logs, noting in particular conditions which may cause tool sticking or variations in data quality.

5.1.2 Note depths of water table, surface casing, hole size changes, and hole bottom for use in calibrating depth measurements during logging.

5.1.3 The PI shall discuss hole conditions with the drillers, or review drilling reports for information which may affect the design of the HpL tests.

5.1.4 The PI shall review recent field activities carried out in the borehole of interest which may impact hydrology or fluid chemistry within the interval affected by the HpL tests. This includes but is not limited to any pump tests, interference tests, or load tests.

5.1.5 The PI shall also review all pre-existing hydrogeological data from the site and develop a preliminary testing plan, based on all information which can allow determination of whether the well will be low, moderate, or high yield.

5.1.6 Evaluate water quality and determine if it is necessary to provide an external water source for DI water.

5.1.7 Prepare a list of materials requirements, including pump(s) if necessary, tubing, measurement equipment, and the necessity to provide a source of DI water.

5.1.8 Each measurement device which affects quality shall be calibrated prior to use.

5.2 Upon Arrival On-Site

In addition to the requirements of TP-13:

5.2.1 The well site shall be clear of all equipment within a 25 foot radius of the well head.

5.2.2 Calibration documents for all quality affecting measurement devices shall be made available to the site manager upon request.

5.3 Verify on site conditions

5.3.1 Review well construction details and record available site conditions, well conditions and flow yield information, verify the previously designed testing program.

5.3.2 Review and record additional wellbore construction/site details recorde the following information:

Ambient depth-to-water, depth of casing, depth of well, lithology (if available), estimated well yield and any available drawdown data, and type and concentration of contamination (if any).

5.3.3 Prepare deionized (DI) water. Consult with DI water tank firm for assistance if necessary. If DI water has not been transported to the site, surface or groundwater may be used if it is of suitable quality. Generally, source water containing less than 1000 micro Siemens per centimeter (µS/cm) and less then 20 ppb VOCs will not significantly affect the deionizing units, but this should be confirmed with the DI water firm. If the groundwater from the well under test cannot be used for DI water generation, then DI water must be transported to the site and containerized at the wellhead.

Depending on the amount of Hydrophysical testing to be performed (ambient and/or active) the typical volume of DI water required for each borehole is approximately three times the volume of the standing column of formation water in the wellbore per type of Hydrophysical characterization.

If preparation takes place on site, pump the source water through a pre-filter, to deionizing units, and into the storage tanks.

Monitor the FEC of the DI water in-line to verify homogeneity; the target value is 5 to 25 µS/cm. Record the results.

5.3.4 A pre-survey calibration check of the HPL sonde shall be performed.

5.4 Conduct ambient FEC/Temperature log

5.4.1 Set datum on the depth encoder with the FEC sensor on the tool as 0 depth at the top of casing. If no space is available at the wellhead, measure 10 feet from the FEC sensor up the cable (using measuring tape) and reference with a wrap of electrical tape. Lower the tool down the hole to the point where the tape equals the elevation at the top of the casing and reference that as 10 feet depth on the depth encoder.

5.4.2 Place the top of the tool approximately 3 feet below the free-water surface to allow it to achieve thermal equilibrium. Monitor the temperature output until thermal stabilization is observed at approximately ± 0.2 °C. The rate of change of temperature shall be less than 1 °C/minute.

5.4.3 After thermal stabilization of the logging tool is observed, log the ambient conditions of the wellbore (temperature and FEC). During the logging run, the data shall be plotted in real time in log format on the computer screen and the data string shall be simultaneously recorded on the hard drive.

Log the ambient fluid conditions in both directions (i.e. record down and up). The ideal logging speed is 5 feet per minute (fpm).

5.4.4 At the completion of the ambient FEC/Temperature test, the recorded data shall be backed up *immediately* to floppy disk (high density disk) or CD-R.

At completion of the ambient log, place the tool approximately 10 feet below the free water surface. The tool may remain there during equipment set up as long as borehole conditions permit. The Logging Engineer under PI direction may choose to remove the logging tool from the well during installation of the pumping equipment.

5.4.5 Measure and record ambient depth.

5.5 Conduct ambient flow characterization

Ambient flow characterization consists of a time series of FEC logs recorded after DI water emplacement. Continuous logging of the interval of interest is required. In addition to the logging results, pressure and flow data shall be recorded throughout the test in digital form and periodically in field notes.

5.5.1 DI Emplacement Procedure.

DI water is injected at the bottom of the well. Water is extracted from the top to maintain a constant water level in the well, to minimize disturbance to the local hydrologic system. The HpL sonde is used during emplacement to monitor the position of the DI water front as it moves up the well. A pressure transducer placed immediately below the extraction pump is used to monitor the water level in the well.

5.5.1.1 Attach back pressure regulator or orifice, if used, and weighted boot, to end of emplacement line and secure. Insure that the injection line is of adequate length to reach the bottom of the wellbore.

5.5.1.2 Lower the flexible emplacement line to the bottom of the well allowing one foot of clearance from the well bottom to the outlet of the injection line.

5.5.1.3 Lower tool about 10 feet below the water surface. The tool will be stationed beneath the submersible pump during non-logging times.

5.5.1.4 Lower submersible pump in the well to a depth just above the logging tool. Record approximate depth of the pump location.

5.5.1.5 Lower a pressure transducer a minimum of 5 feet below the bottom of the pump.

(The sequence of 5.5.1.3 through 5.5.1.5 may be changed as required at the discretion of the PI or Logging Engineer.)

5.5.1.6 Record all initial readings of gauges at elapsed time 0.0 minutes.

5.5.1.7 Mark hoses with a round of electrical tape for reference. In addition, establish datum for tool depth to the nearest foot and mark on wire with wrap of tape. Reset datum on optical encoder for this depth.

5.5.1.8 Pump DI water to the bottom of the wellbore using the surface pump and the injection riser. Simultaneously use the submersible pump to maintain a stable, elevated total head by extracting groundwater from near the free water surface. The injection and extraction rates should be approximately the same. When groundwater from the subject well is used for DI water generation, generate DI water from the extracted formation water and recirculate to the well bottom via the solid riser.

5.5.1.9 Throughout this procedure, the water level and flow data shall be recorded digitally. In addition, a hand-held water level meter shall be used to periodically record the elevated total head. All flow data shall be periodically recorded to field notes.

5.5.1.10 Evaluate the rate at which the DI water advances up the well. In the event that it is necessary to modify the rate of injection/extraction, the PI shall oversee the change.

If borehole conditions permit (i.e. the absence of constricted borehole intervals), the logging tool is used to monitor the advancement of the fluid up the borehole as it displaces the standing formation water. Draw the logging tool up the wellbore in successive increments as the DI water is emplaced. The logged FEC value changes from that of the ambient fluid to that of DI water at the depth of the DI water interface. Continuous profiling may also be performed to monitor the progress of DI water emplacement.

5.5.1.11 Monitor and record the electrical conductivity of the fluid expelled from the extraction pump during emplacement procedures. Record these values and the times at which they were measured.

5.5.1.12 Emplacement is complete when DI water, or sufficiently diluted formation water, is observed from the evacuation pump or when logging tool stationed near the pump indicates DI water or sufficiently diluted formation water.

5.5.1.13 Upon completion, turn off the evacuation pump. Then turn off the injection line.

5.5.1.14 If a pumping rig is used, check valves shall be installed in the extraction line to ensure that fluid is not drawn back into the well when the pump is turned off. In this case, leave the emplacement line, the extraction pump, the pressure transducer, and the HpL sonde in the well.

5.5.1.15 If appropriate, the extraction line shall be removed from the well immediately after emplacement is complete.

5.5.1.16 Record volumes of extracted and injected fluids. Calculate the volume of DI water lost to the formation: $V_{injected} - V_{extracted} = V_{lost}$. This value will be negative if there is a net flow into the well.

5.5.2 After DI emplacement is complete, perform continuous FEC/Temperature logging until 80% saturation is observed in the affected interval, or until 5 hours of logging has been performed.

5.6 Characterize the well for additional testing

The RAS PI shall determine at this time (based on all information available, including the data obtained in 5.5) whether the well is characterized by a low, intermediate, or high yield. If the PI feels that enough information is available to define the well type, testing shall proceed with item 5.8. If the PI determines that additional testing is needed, it shall proceed so as to minimize disturbance to the aquifer(s) under test.

5.6.1 Conduct a slug test.

5.6.1.1 Rapidly extract 1-2 ft of fluid from the well.

5.6.1.2 Monitor and record the fluid level as it recovers.

5.6.1.3 If the fluid recovers more slowly than 1 foot/minute the well is of a low yield type. Skip the remainder of 5.6.1 and initiate 5.7.

5.6.2 Conduct a second slug test at a higher drawdown.

5.6.3 If necessary , conduct a controlled, short term well production test (pump test) to further characterize the overall hydraulics of the wellbore.

5.6.3.1 Select the pumping rate as follows: The rate(s) of pumping are determined by drawdown information previously obtained or at rate(s) appropriate for the wellbore diameter and saturated interval thickness. The appropriate extraction rate is a function of length of saturated interval, borehole diameter, and previous well yield knowledge. The appropriate pumping procedures to be employed are also dictated by the length of the exposed rock interval. In general, the extraction flow rate should be sufficient to induce adequate inflow from the producing intervals. The concern is that the extraction flow rate does not cause extreme drawdown within the well i.e. lowering the free water surface to the depth of the shallowest conductive interval.

5.6.3.2 Treat extracted water as follows: On-site pre-treatment of groundwater using activated carbon, can be conducted prior to DI water generation, if there is a contaminated groundwater source. In addition, on-site treatment can also be considered to handle extracted fluids that would require containerization and treatment prior to disposal.

5.6.3.3 While extraction proceeds, manually record elapsed time of pumping, depth to water determined using a hand-held water level indicator, total gallons extracted, and extraction flow rate. This provides a manual back-up of the data recorded digitally during the test.

5.6.3.4 Continue pumping until at least three wellbore volumes have been extracted from the wellbore, or a stabilized water level elevation is obtained. Record wellbore volume.

5.7 Review data obtained during the pumping test to determine pumping and logging procedures.

Extraction procedures for detection and characterization of hydraulically conductive intervals are determined based on the pumping test information. The emplacement, testing and pumping procedures will differ depending upon well yield and determined lengths of intervals of interest. In wellbore situations where intervals of interest are small (less than 30 feet) and hydraulic characteristics observed during drilling and preliminary hydraulic testing indicate hydraulically conductive intervals with extremely low flow rates (i.e. <0.10 gpm/foot of drawdown), a slug testing procedure may be employed. In wellbore cases where the preliminary hydraulic testing indicates low to moderate total yield (i.e. 0.10 < Q < 4 gpm/foot of drawdown), constant low flow rate pumping after DI water emplacement procedures may be employed. In wellbore situations where intervals of interest are large, and high total yield (i.e. > 4 gpm/foot of drawdown) is observed, constant pumping during DI water injection procedures shall be employed.

5.8 DI water emplacement

After the PI has determined the test protocol, the fluid in the well shall be replaced again with DI water, following the procedure outlined in 5.5.1 above.

5.9 Conduct active flow testing

5.9.1 Low yield active test procedure:

If the well is of low yield type, proceed as follows:

5.9.1.1 Perform a slug test in accordance with procedures developed by Hvorslev (1951). Rapidly extract a small volume of water from near the free water surface using the extraction riser and pump. A drop in piezometric head of 2-10 feet should be adequate for the initial test. Record the rise in the free water surface with time using the pressure transducer, and develop a conventional time-lag plot. Log the well continuously with the HpL sonde to monitor changes in the fluid column.

5.9.1.2 The completion of the slug test shall be defined as follows: Either (a) 80% of the head disturbance has decayed, or (b) a 20-hour time period has elapsed, whichever occurs first.

5.9.1.3 Repeat the DI emplacement procedure 5.8 and the low yield active test procedure 5.9.1 with successive increases in the drop of piezometric head (or volume extracted) associated with each slug test. Let the wellbore recover and record the rise in the free water surface. Repeat logging of the wellbore fluid after the free water surface has recovered to a satisfactory elevation.

5.9.1.4 The number of repetitions shall be determined by the PI in the field after review of previous results.

5.9.1.5 Record digitally the data from the pressure transducer throughout the test. Periodically manually record the borehole fluid level.

5.9.2 Moderate yield active test procedure:

Time Series Hydrophysical Logging During Continuous Pumping After DI water Emplacement

5.9.2.1 The PI shall select a pumping rate such that drawdown of the free water surface produced during pumping shall not overlap any identified water producing interval.

5.9.2.2 Maintain a constant flow rate from the evacuation pump and record the total volume of groundwater evacuated from the wellbore. Employ a continuous reading pressure transducer (or equivalent device) to monitor and record digitally the depressed total head during pumping, along with the associated pumping rate. Manually record depth to water and the flow data.

5.9.2.3 Conduct HydroPhysical logging continuously. The number of logging runs and the length of time required to conduct all logging is a function of the particular hydraulic conditions.

5.9.2.4 Logging and pumping shall continue until the FEC of the fluid in the affected interval is more than 80% the FEC of the formation water.

5.9.2.5 This process may be repeated, at the PI's discretion, starting with DI emplacement procedure 5.6 and the moderate yield active test procedure 5.7.2, increasing the pumping rate.

5.9.2.6 The number of repetitions is determined in the field after review of previous results.

5.9.2.7 Record digitally the data from the pressure transducer and from the extraction line flow meter throughout the test.

5.9.3 High yield active test procedure.

Time Series Wellbore Fluid Logging During Continuous Pumping and Simultaneous DI Water Injection

5.9.3.1 The RAS PI shall select a pumping rate such that drawdown of the free water surface produced during pumping does not overlap any identified water producing interval.

5.9.3.2 Maintain a constant flow rate from the evacuation pump and record this rate and the associated drawdown. During this period, conduct HydroPhysical logging until reasonably similar Hydrophysicallogs are observed and a reasonably stable drawdown is achieved.

5.9.3.3 After reasonably similar downhole fluid conditions are observed and simultaneous with extraction pumping, inject DI water at the bottom of the well at a constant rate of 10 to 30% of that employed for extraction. Increase the total rate of extraction to maintain total formation production reasonably similar to that prior to DI water injection (i.e. increase the total extraction by amount equal to the DI water injection rate).

5.9.3.4 Continuous logging shall be conducted until stabilized and consistent diluted FEC logs are observed. A minimum of 6 downward logs shall be recorded in the stable, diluted condition prior to terminating the test.

5.9.3.5 After stabilized and consistent FEC logs are observed, terminate DI water injection. Reduce the total extraction flow rate to the net formation rate and conduct continuous logging. Conduct logging until stable and consistent FEC values are observed.

5.9.3.6 Record digitally the data from the pressure transducer and from the extraction and injection line flow meters throughout the test.

5.9.3 If inflow characterization at a second pumping rate is desired, the following procedure shall be followed:

5.9.3.1 Terminate DI injection.

5.9.3.2 Increase the extraction rate to the new value.

5.9.3.3 Follow the procedures detailed in 5.9.3.1 to 5.9.3.6.

5.9.4 Although pumping and testing procedures vary depending upon wellbore hydraulics and construction detail, there are several requirements which are common to all of the active tests described above.

5.9.4.1 Periodically record the total volume and flow rate of well fluids extracted and the total volume and flow rate of DI water injected. Use a continuous reading pressure transducer or similar device to monitor the depressed total head during pumping. Manually record the depressed total head (piezometric surface) periodically, with the associated pumping and injection data.

5.10 Depth Specific Sampling

At the conclusion of hydrophysical testing, downhole, depth specific sampling can be conducted. The contamination concentration values derived from the collected samples, in conjunction with the hydrophysical logging results, can be used to estimate the interval specific contaminant concentration for the sampled hydraulically conductive intervals.

5.10.1 Pumping at the same formation production rate as employed during hydrophysical testing is initiated, or maintained.

5.10.2 Periodic FEC/Temperature logs are conducted during pumping until stable logs are observed and any residual DI water has been pumped out of the well.

5.10.3 Based on review of the hydrophysical logging results, the location of the water bearing intervals are identified and sampling depths are selected. Typically, the sampling depth is located 1-5 feet above an identified water bearing interval.

5.10.4 Prior to each sampling run, the inside of the sampler barrel and petcock are thoroughly cleaned with deionized water and Alconox soap, rinsed with DI water and dried off.

5.10.5 The sampler ports are closed at the surface. The operator will physically confirm that the ports are closed prior to placing in the wellbore.

5.10.6 Depth datum for the location of inlet port is referenced to same datum as hydrophysical logging.

5.10.7 The sampler is lowered to the selected depth, opened for at least 5 minutes to insure complete filling, closed and withdrawn to the surface. At the surface, the ASDE is recorded and the sampler is decanted into laboratory containers and reassembled.

5.10.8 Prior to each sampling run, the inside of the sampler barrel and petcock are thoroughly cleaned with deionized water and Alconox soap, rinsed with DI water and dried off.

5.10.9 Procedures 5.10.6 through 5.10.8 repeated until all selected intervals sampled.

5.11 Post-log calibration

Carry out post-log calibration, following procedures in TP-FEC.

5.12 Departure from site

5.12.1 Turn all pumps off. Clean evacuation line and outside of pump as required by site-specific procedures.

5.12.2 Remove the tool from the well. Clean the wireline and the tool as required by site-specific procedures.

5.12.3 Remove the injection line from the well. Clean the injection line as required by site-specific procedures.

5.12.4 Store the pumps and logging tools properly for transport.

5.12.5 Place cover on well and lock (if available).

6.0 RECORDS

Records of the data obtained from each measurement shall be produced as follows:

6.1 Paper copies of HpL logs shall be provided as shown in Appendix 7.9.

6.2 Digitally acquired flow, pressure, and head data shall be recorded along with on-site calibration data.

6.3 Forms shall be completed as detailed in this procedure and in TP-13.

6.3.1 As provided by contractor.

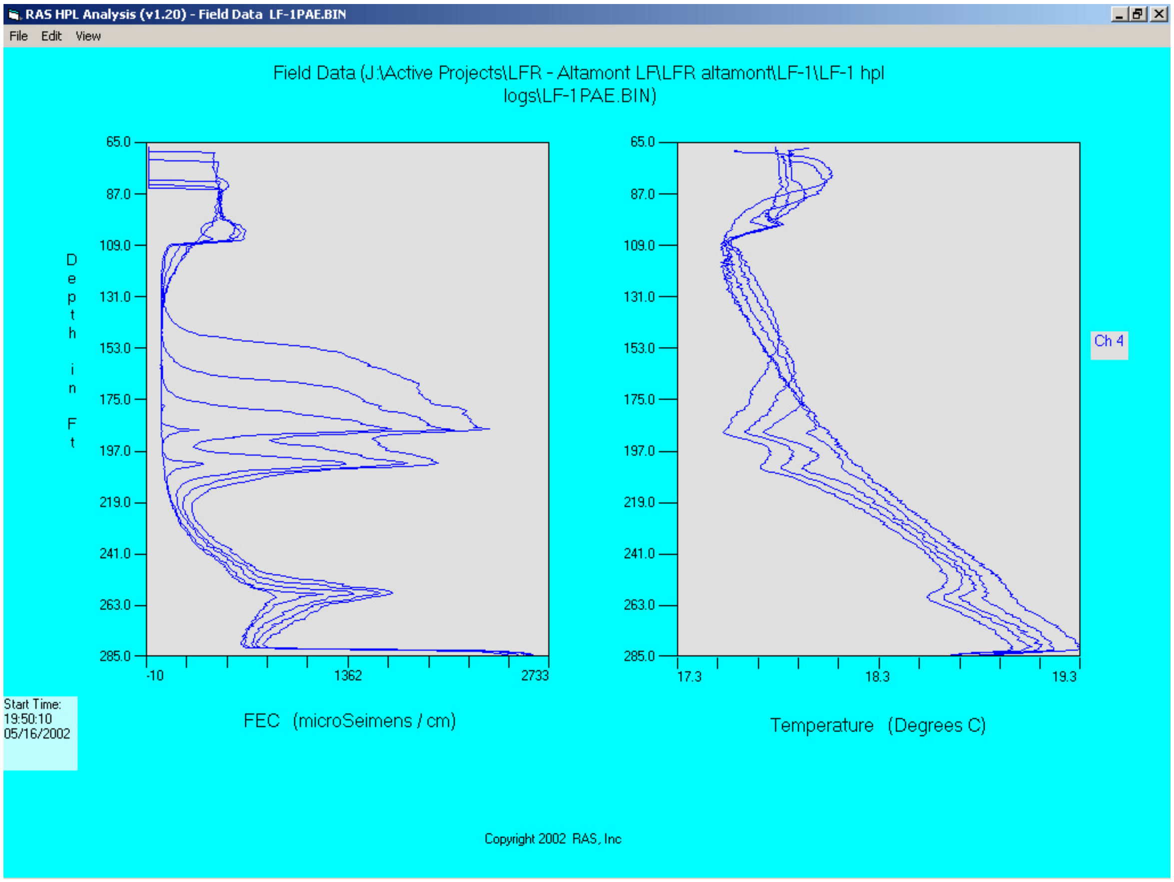
6.4 Exceptions shall be handled as detailed in TP-13.

6.5 Field Modifications shall be handled as detailed in TP-13.

7.0 APPENDICES

7.1 Typical HPL log data.

7.2 Forms as provided by Contractor



Integrated Subsurface Evaluation

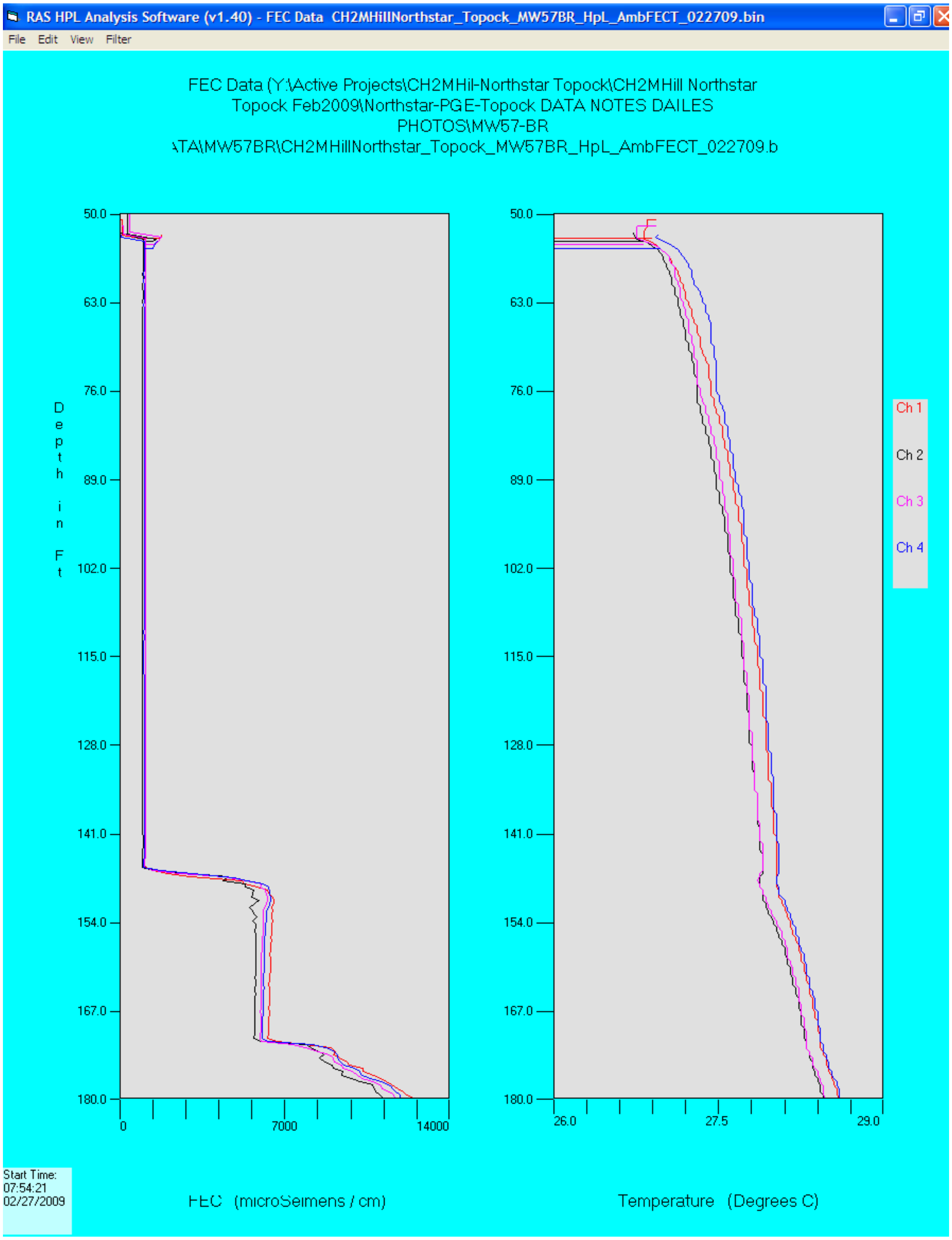
APPENDIX B

FIELD NOTES AND DAILIES REPORTS

APPENDIX C

DATA AND ANALYSIS

CH2MHill – NorthStar
PG&E Topock Compressor Station
Monitoring Well MW-57BR
HPL PROCESSING NOTES
ALL DEPTHS REFERENCED TO TOP OF PVC CASING



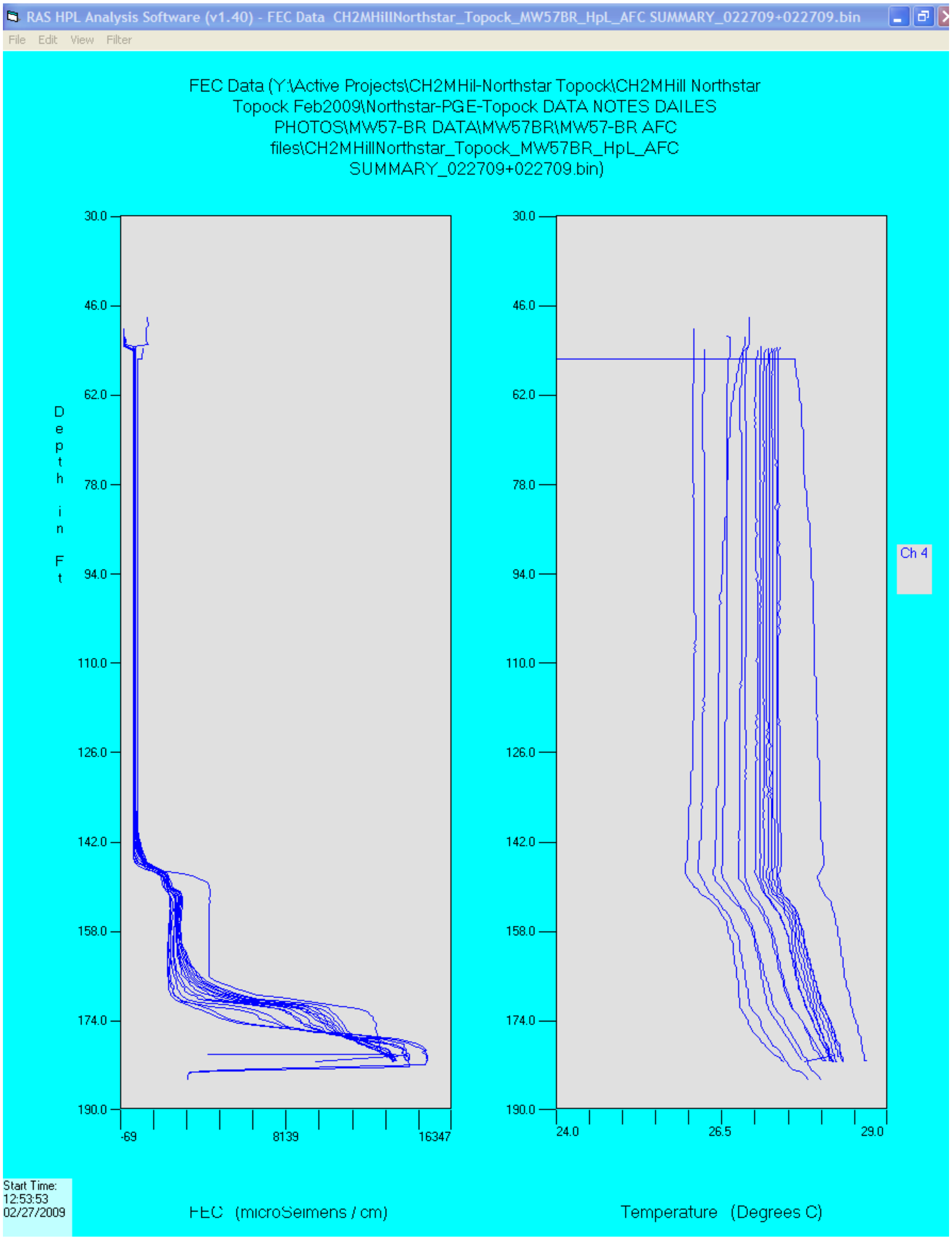
RAS HPL Analysis Software (v1.40) - FEC Data CH2MHillNorthstar_Topock_MW57BR_HpL_AmbFECT_022709.bin

FEC Data (Y:\Active Projects\CH2MHil-Northstar Topock\CH2MHill Northstar Topock Feb2009\Northstar-PGE-Topock DATA NOTES DAILES PHOTOS\MW57-BR \TA\MW57BR\CH2MHillNorthstar_Topock_MW57BR_HpL_AmbFECT_022709.b

Start Time: 07:54:21 02/27/2009

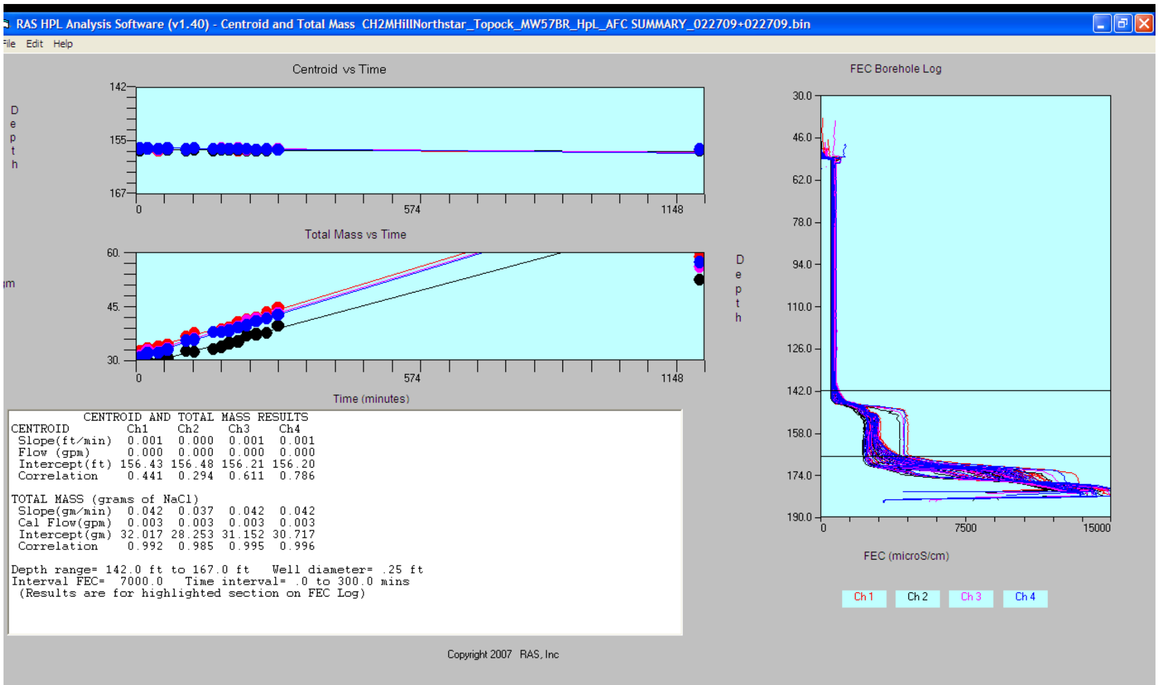
Figure 1. MW-57BR Ambient FEC and Temperature Log.

CH2MHill – NorthStar
PG&E Topock Compressor Station
Monitoring Well MW-57BR
HPL PROCESSING NOTES
ALL DEPTHS REFERENCED TO TOP OF PVC CASING



FEC Data (Y:\Active Projects\CH2MHil-Northstar Topock\CH2MHill Northstar Topock Feb2009\Northstar-PGE-Topock DATA NOTES DAILES PHOTOS\MW57-BR DATA\MW57BR\MW57-BR AFC files\CH2MHillNorthstar_Topock_MW57BR_HpL_AFC SUMMARY_022709+022709.bin)

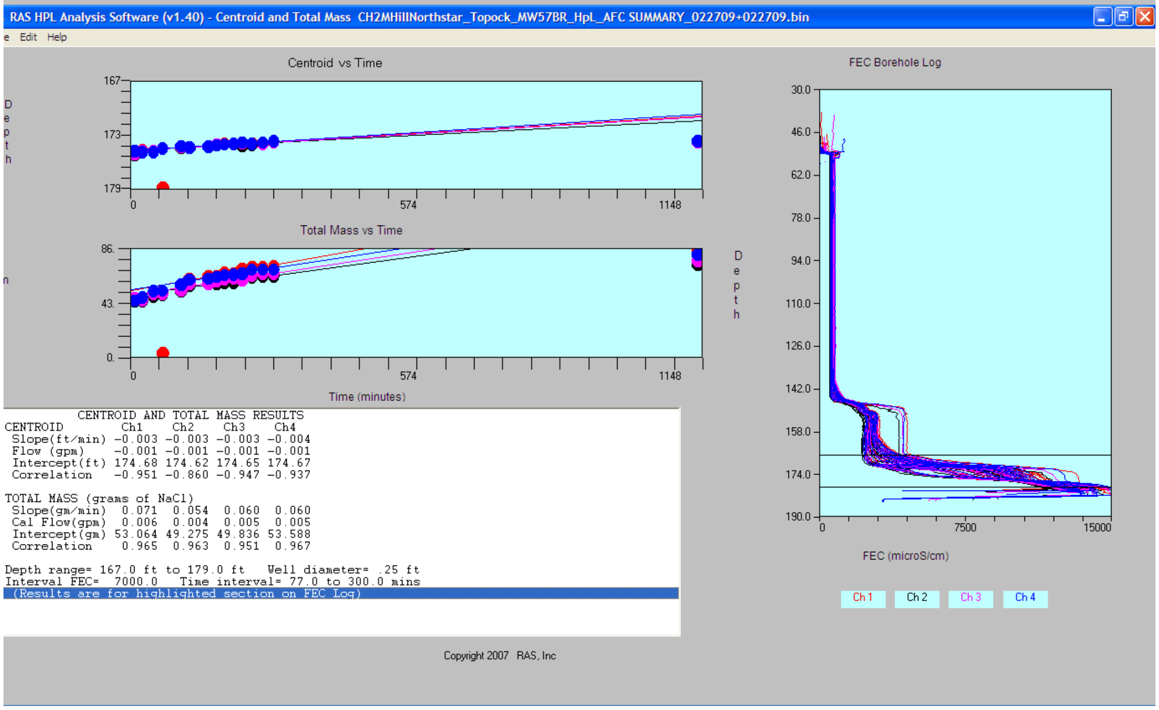
Figure 2. MW-57BR Summary of FEC Logs for Ambient Flow Characterization.



```
          CENTROID AND TOTAL MASS RESULTS
CENTROID        Ch1    Ch2    Ch3    Ch4
 Slope(ft/min)  0.001  0.000  0.001  0.001
 Flow (gpm)     0.000  0.000  0.000  0.000
 Intercept(ft) 156.43 156.48 156.21 156.20
 Correlation    0.441  0.294  0.611  0.786

TOTAL MASS (grams of NaCl)
 Slope(gm/min)  0.042  0.037  0.042  0.042
 Cal Flow(gpm)  0.003  0.003  0.003  0.003
 Intercept(gm) 32.017 28.253 31.152 30.717
 Correlation    0.992  0.985  0.995  0.996

Depth range= 142.0 ft to 167.0 ft   Well diameter= .25 ft
Interval FEC=  7000.0   Time interval= .0 to 300.0 mins
 (Results are for highlighted section on FEC Log)
```

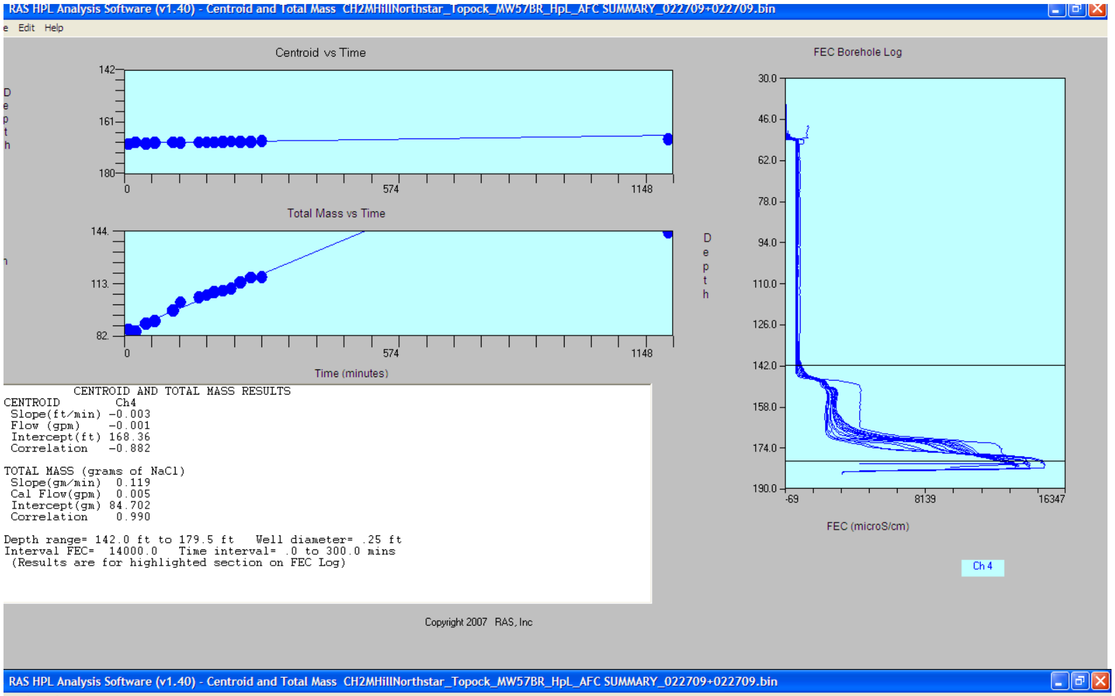


```
          CENTROID AND TOTAL MASS RESULTS
CENTROID        Ch1    Ch2    Ch3    Ch4
 Slope(ft/min) -0.003 -0.003 -0.003 -0.004
 Flow (gpm)    -0.001 -0.001 -0.001 -0.001
 Intercept(ft) 174.68 174.62 174.65 174.67
 Correlation   -0.951 -0.860 -0.947 -0.937

TOTAL MASS (grams of NaCl)
 Slope(gm/min)  0.071  0.054  0.060  0.060
 Cal Flow(gpm)  0.006  0.004  0.005  0.005
 Intercept(gm) 53.064 49.275 49.836 53.588
 Correlation    0.965  0.963  0.951  0.967

Depth range= 167.0 ft to 179.0 ft   Well diameter= .25 ft
Interval FEC=  7000.0   Time interval= 77.0 to 300.0 mins
 (Results are for highlighted section on FEC Log)
```

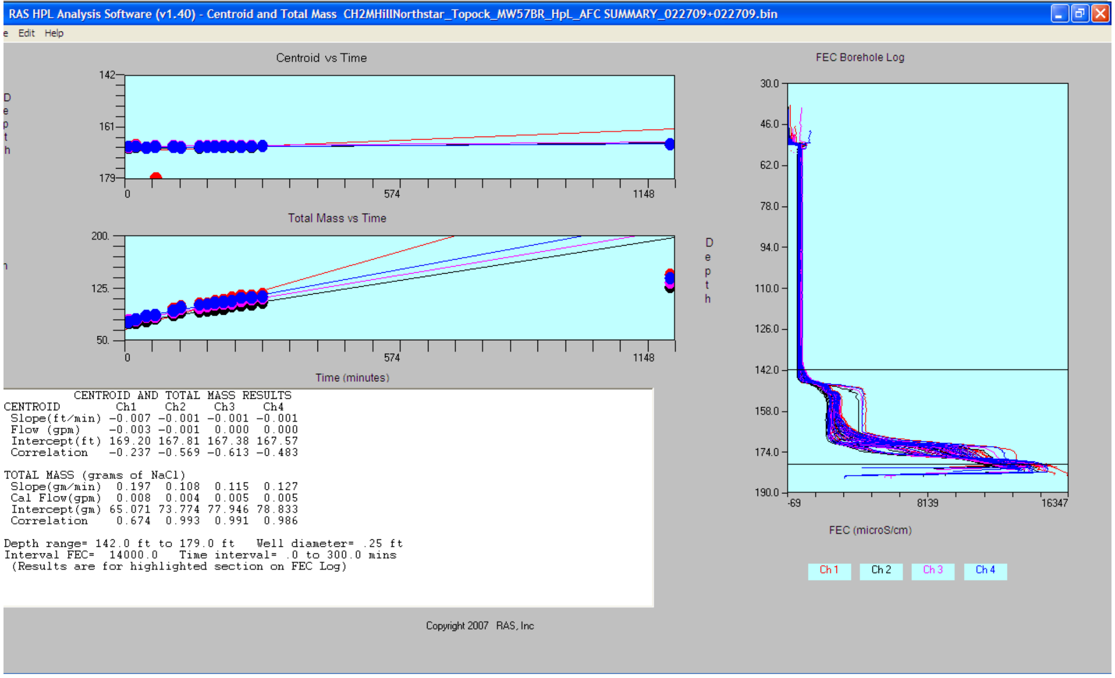
Figure 3. MW-57BR Centroid and Integral Analysis Logs for Ambient Flow Characterization.



```
        CENTROID AND TOTAL MASS RESULTS
CENTROID         Ch4
 Slope(ft/min) -0.003
 Flow (gpm)    -0.001
 Intercept(ft) 168.36
 Correlation   -0.882

TOTAL MASS (grams of NaCl)
 Slope(gm/min)  0.119
 Cal Flow(gpm)  0.005
 Intercept(gm) 84.702
 Correlation    0.990

Depth range= 142.0 ft to 179.5 ft   Well diameter= .25 ft
Interval FEC=  14000.0   Time interval= .0 to 300.0 mins
 (Results are for highlighted section on FEC Log)
```

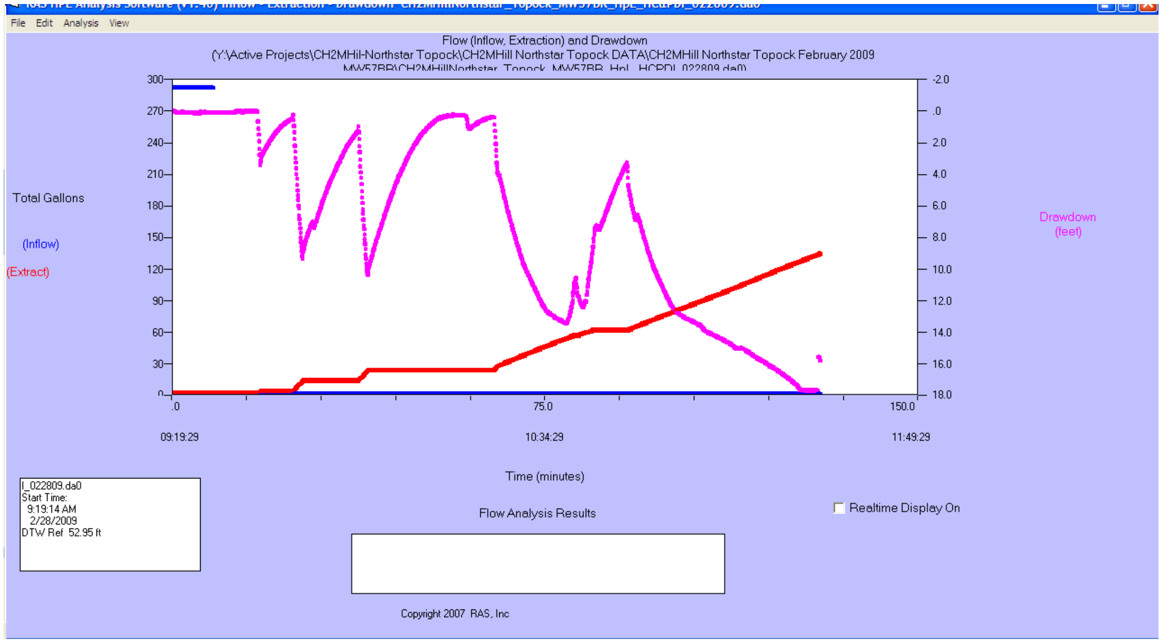


```
        CENTROID AND TOTAL MASS RESULTS
CENTROID         Ch1    Ch2    Ch3    Ch4
 Slope(ft/min) -0.007 -0.001 -0.001 -0.001
 Flow (gpm)    -0.003 -0.001  0.000  0.000
 Intercept(ft) 169.20 167.81 167.38 167.57
 Correlation   -0.237 -0.569 -0.613 -0.483

TOTAL MASS (grams of NaCl)
 Slope(gm/min)  0.197  0.108  0.115  0.127
 Cal Flow(gpm)  0.008  0.004  0.005  0.005
 Intercept(gm) 65.071 73.774 77.946 78.833
 Correlation    0.674  0.993  0.991  0.986

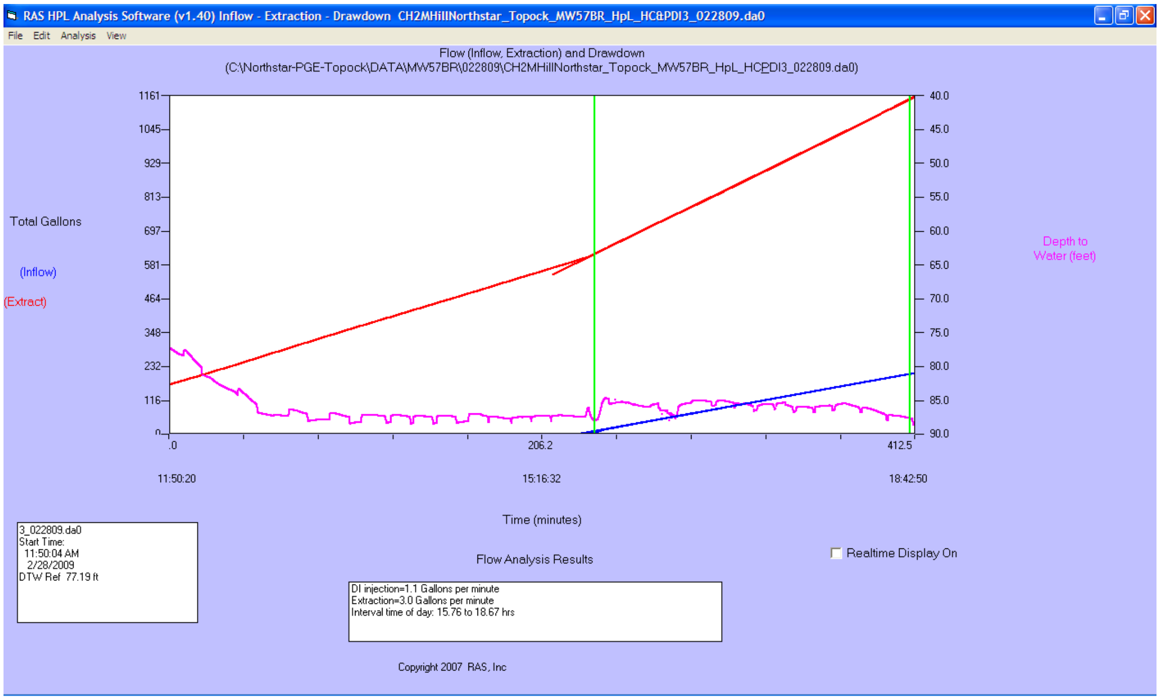
Depth range= 142.0 ft to 179.0 ft   Well diameter= .25 ft
Interval FEC=  14000.0   Time interval= .0 to 300.0 mins
 (Results are for highlighted section on FEC Log)
```

Figure 4. MW-57BR Centroid and Integral Analysis Logs for Ambient Flow Characterization.



I_022809.da0
Start Time:
9:19:14 AM
2/28/2009
DTW Ref 52.95 ft

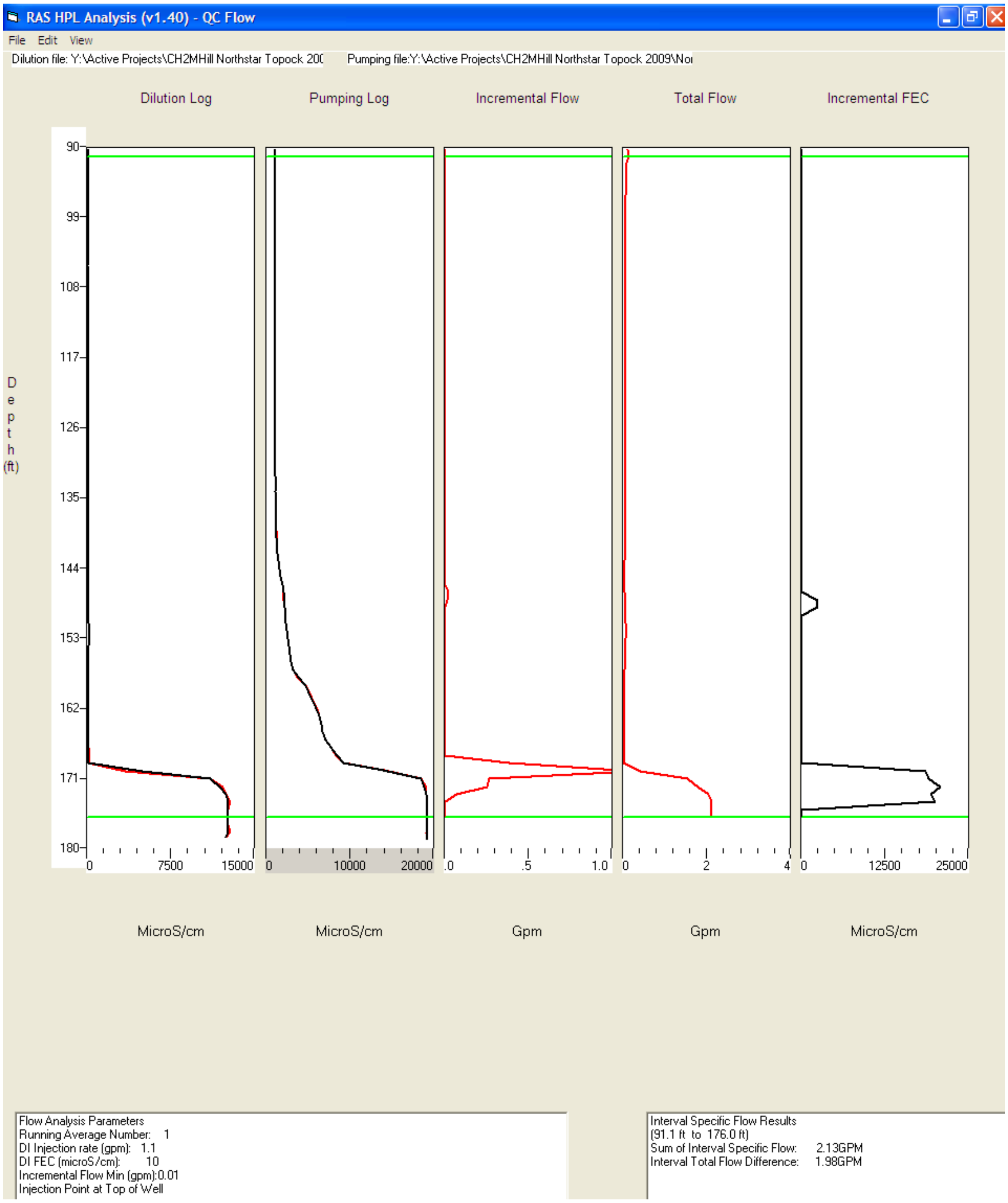
Figure 5. MW-57BR Pressure and Flow data during Overall Hydraulic Characterization.



3_022809.da0
Start Time:
11:50:04 AM
2/28/2009
DTW Ref 77.19 ft

DI injection=1.1 Gallons per minute
Extraction=3.0 Gallons per minute
Interval time of day: 15.76 to 18.67 hrs

Figure 6. MW-57BR Pressure and Flow data during Pumping During Injection Testing.

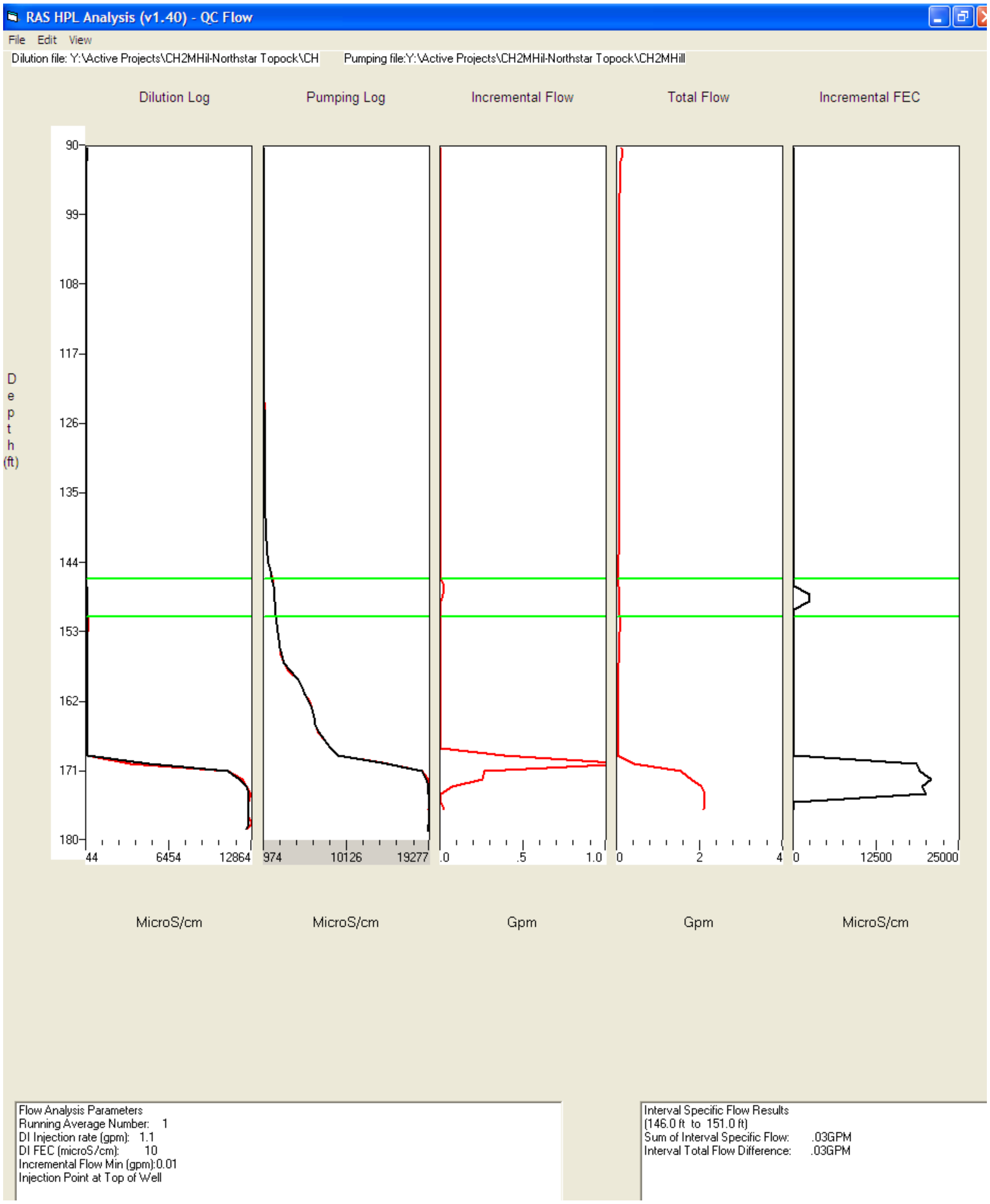


Dilution file: Y:\Active Projects\CH2MHill Northstar Topock 200
Pumping file:Y:\Active Projects\CH2MHill Northstar Topock 2009\Noi

Flow Analysis Parameters
Running Average Number: 1
DI Injection rate (gpm): 1.1
DI FEC (microS/cm): 10
Incremental Flow Min (gpm):0.01
Injection Point at Top of Well

Interval Specific Flow Results
(91.1 ft to 176.0 ft)
Sum of Interval Specific Flow: 2.13GPM
Interval Total Flow Difference: 1.98GPM

Figure 7. MW-57BR Results of Hydrophysical Testing, Pumping During Injection, complete interval.



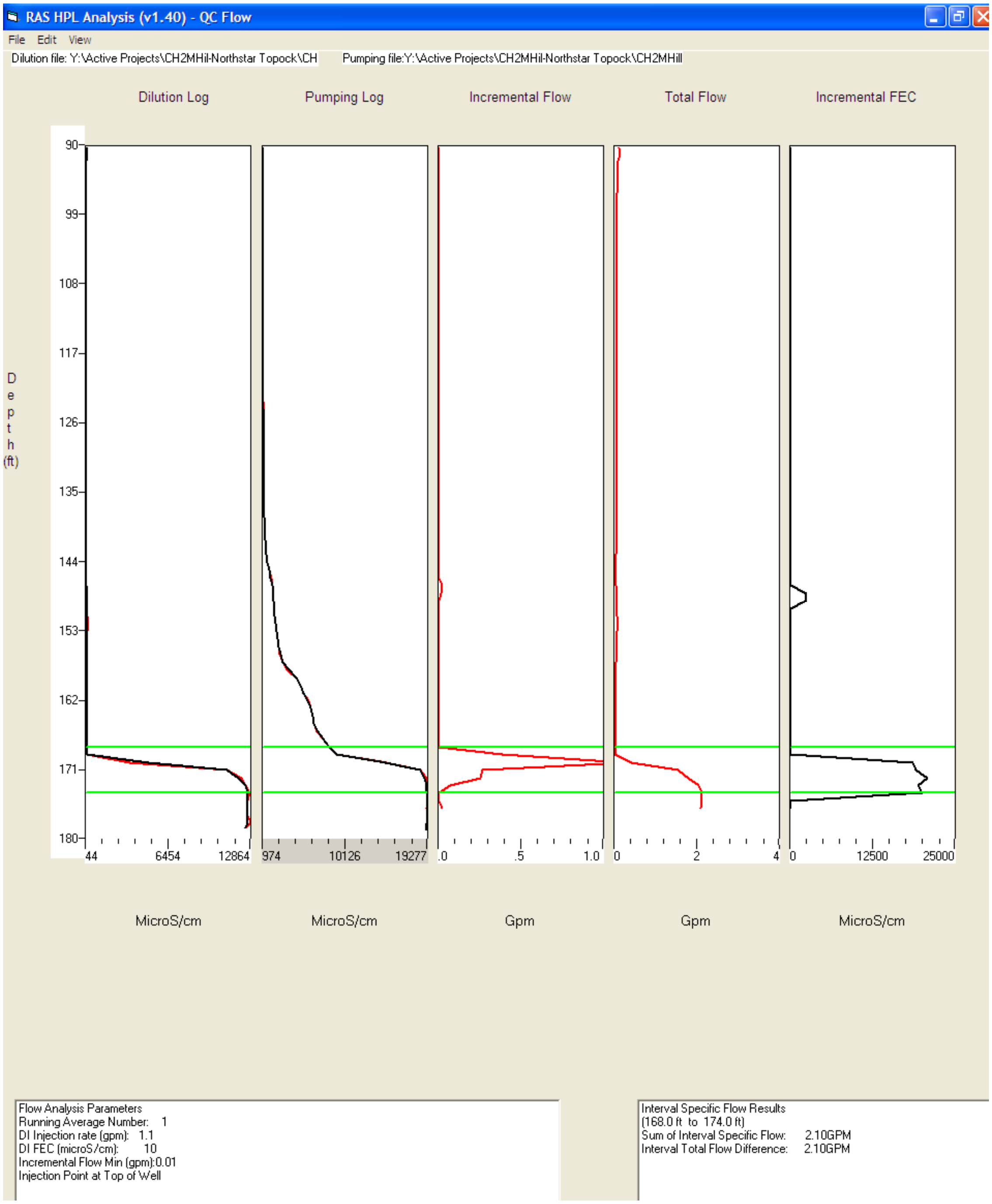
Dilution file: Y:\Active Projects\CH2MHil-Northstar Topock\CH

Pumping file:Y:\Active Projects\CH2MHil-Northstar Topock\CH2MHill

Flow Analysis Parameters
Running Average Number: 1
DI Injection rate (gpm): 1.1
DI FEC (microS/cm): 10
Incremental Flow Min (gpm):0.01
Injection Point at Top of Well

Interval Specific Flow Results
(146.0 ft to 151.0 ft)
Sum of Interval Specific Flow: .03GPM
Interval Total Flow Difference: .03GPM

Figure 8. MW-57BR Results of Hydrophysical Testing, Pumping During Injection, interval of analysis from 146 to 151 feet.



Dilution file: Y:\Active Projects\CH2MHil-Northstar Topock\CH

Pumping file:Y:\Active Projects\CH2MHil-Northstar Topock\CH2MHill

Flow Analysis Parameters
Running Average Number: 1
DI Injection rate (gpm): 1.1
DI FEC (microS/cm): 10
Incremental Flow Min (gpm):0.01
Injection Point at Top of Well

Interval Specific Flow Results
(168.0 ft to 174.0 ft)
Sum of Interval Specific Flow: 2.10GPM
Interval Total Flow Difference: 2.10GPM

Figure 9. MW-57BR Results of Hydrophysical Testing, Pumping During Injection, interval of analysis from 146 to 151 feet.

CH2MHill – NorthStar
PG&E Topock Compressor Station
Monitoring Well MW-58BR
HPL PROCESSING NOTES
ALL DEPTHS REFERENCED TO TOP OF PVC CASING

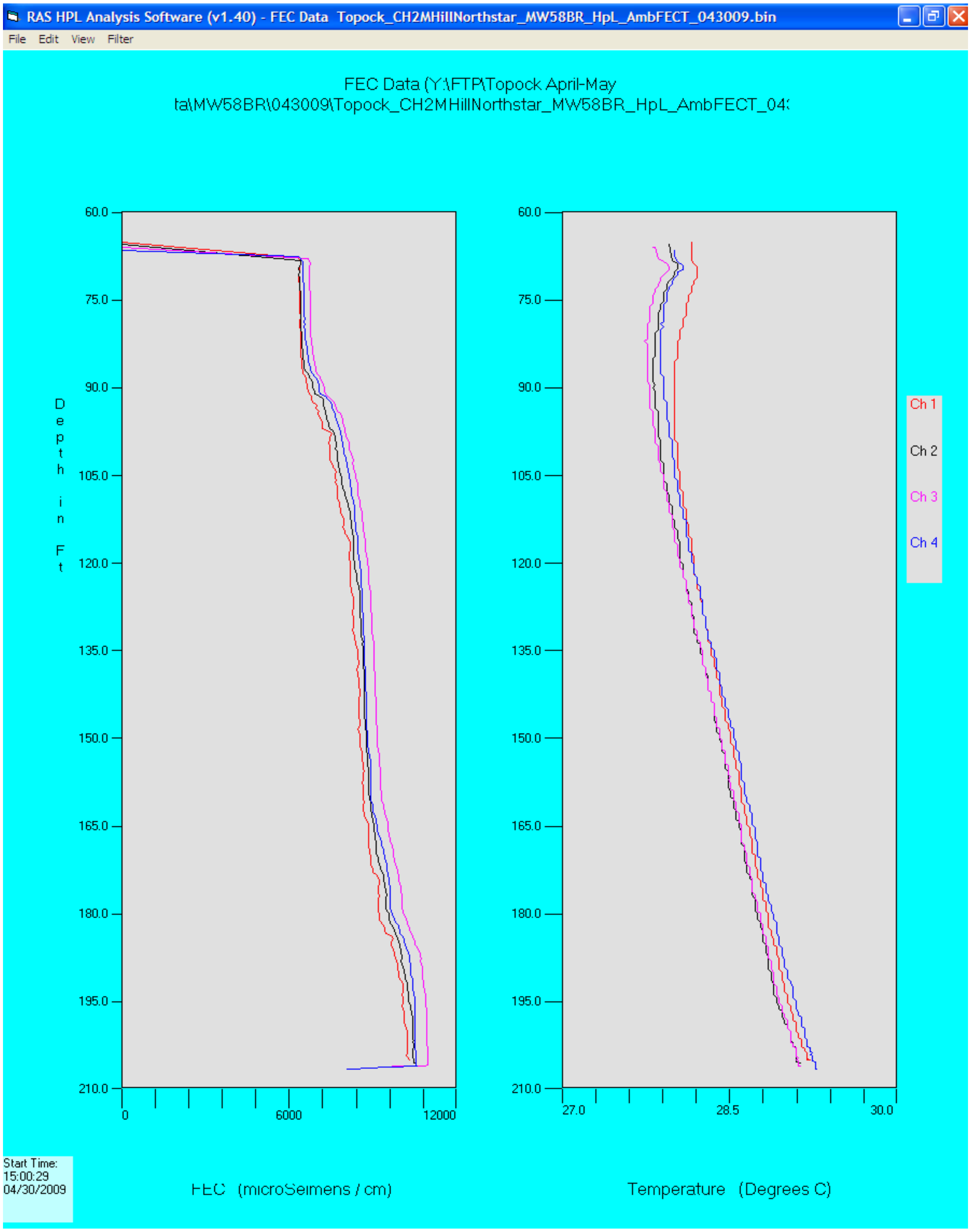
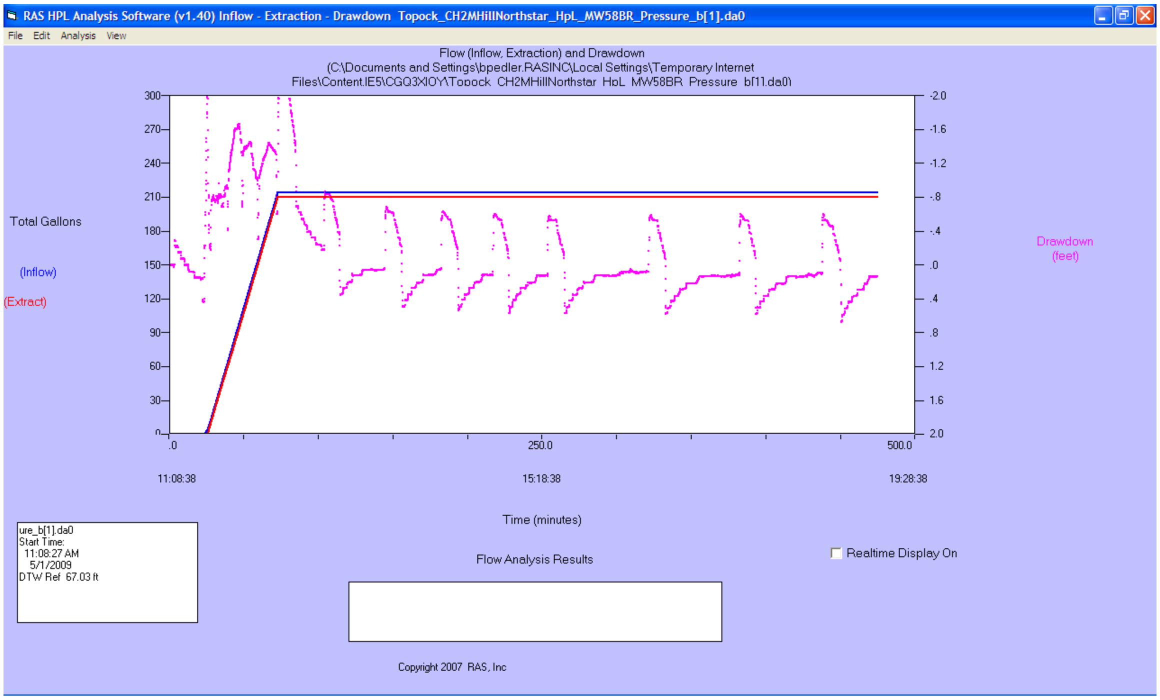


Figure 1. MW-58BR Ambient FEC and Temperature Log.

CH2MHill – NorthStar
PG&E Topock Compressor Station
Monitoring Well MW-58BR
HPL PROCESSING NOTES
ALL DEPTHS REFERENCED TO TOP OF PVC CASING


RAS HPL Analysis Software (v1.40) Inflow - Extraction - Drawdown Topock_CH2MHillNorthstar_HpL_MW58BR_Pressure_b[1].da0

Flow (Inflow, Extraction) and Drawdown
(C:\Documents and Settings\bpedler.RASINC\Local Settings\Temporary Internet Files\Content.IE5\CGQ3XIOY\Topock CH2MHillNorthstar HpL MW58BR Pressure b[1].da0)

ure_b[1].da0
Start Time:
11:08:27 AM
5/1/2009
DTW Ref 67.03 ft

Flow Analysis Results

☐ Realtime Display On

Copyright 2007 RAS, Inc

Figure 2. MW-58BR. Pressure History During Ambient Flow Characterization.

CH2MHill – NorthStar
PG&E Topock Compressor Station
Monitoring Well MW-58BR
HPL PROCESSING NOTES
ALL DEPTHS REFERENCED TO TOP OF PVC CASING

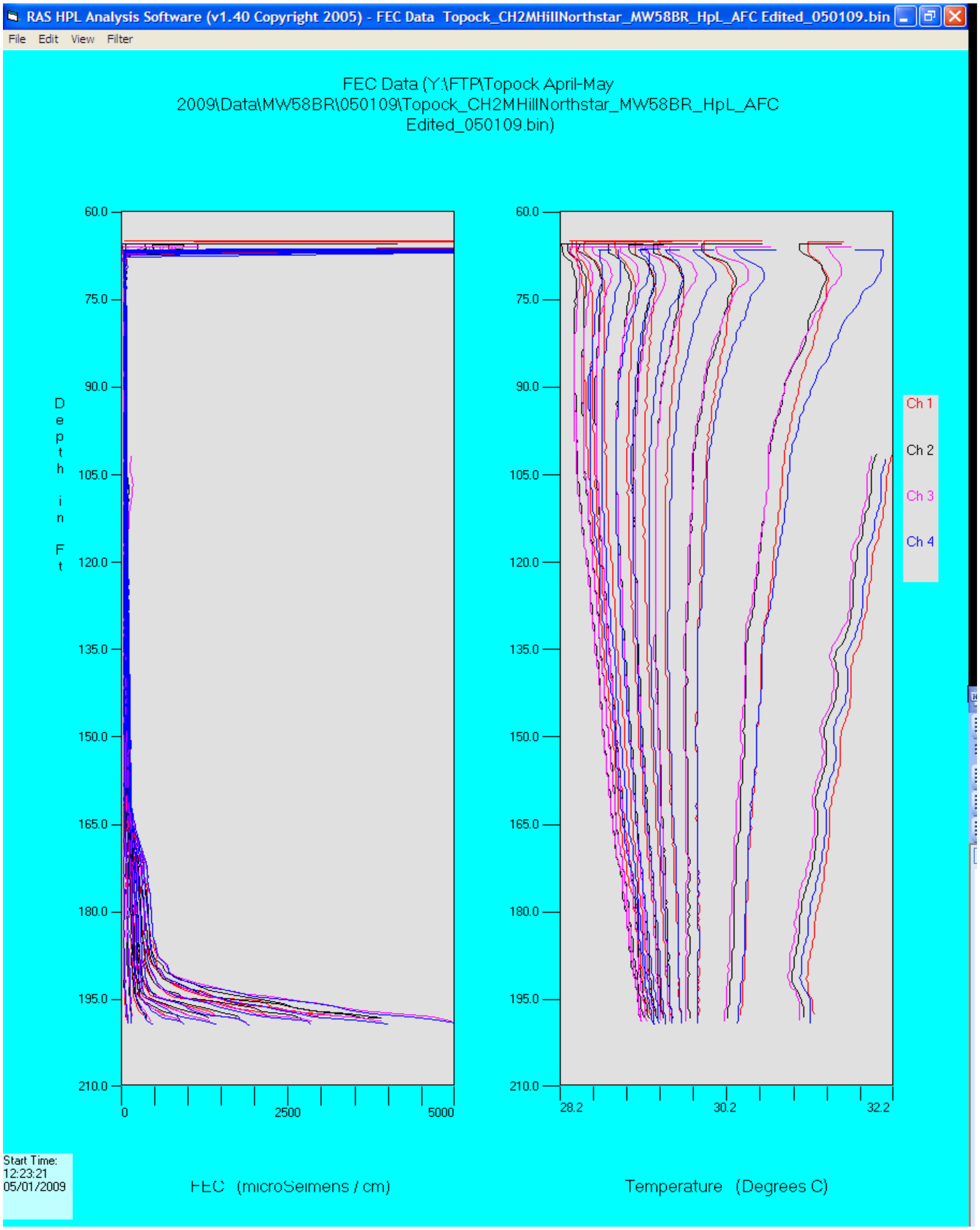
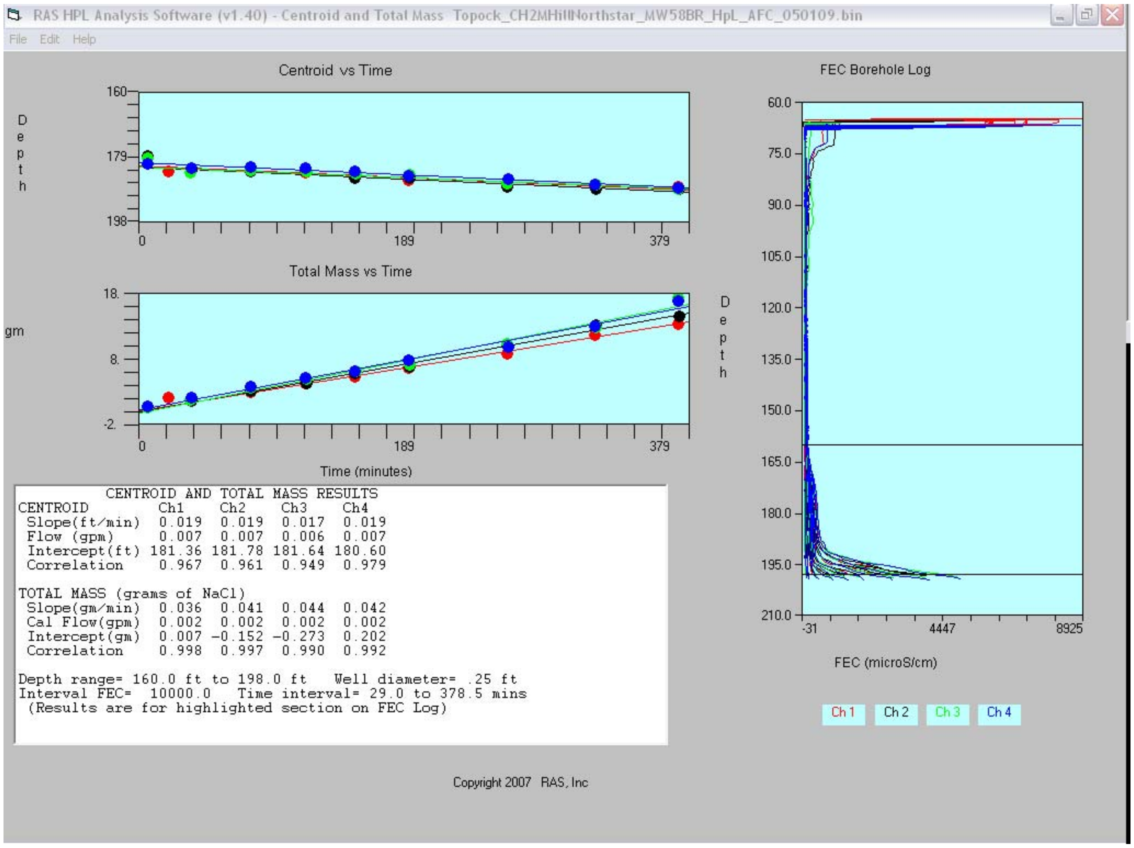


Figure 3. MW-58BR. Summary of logs collected during Day 1 of AFC Testing.

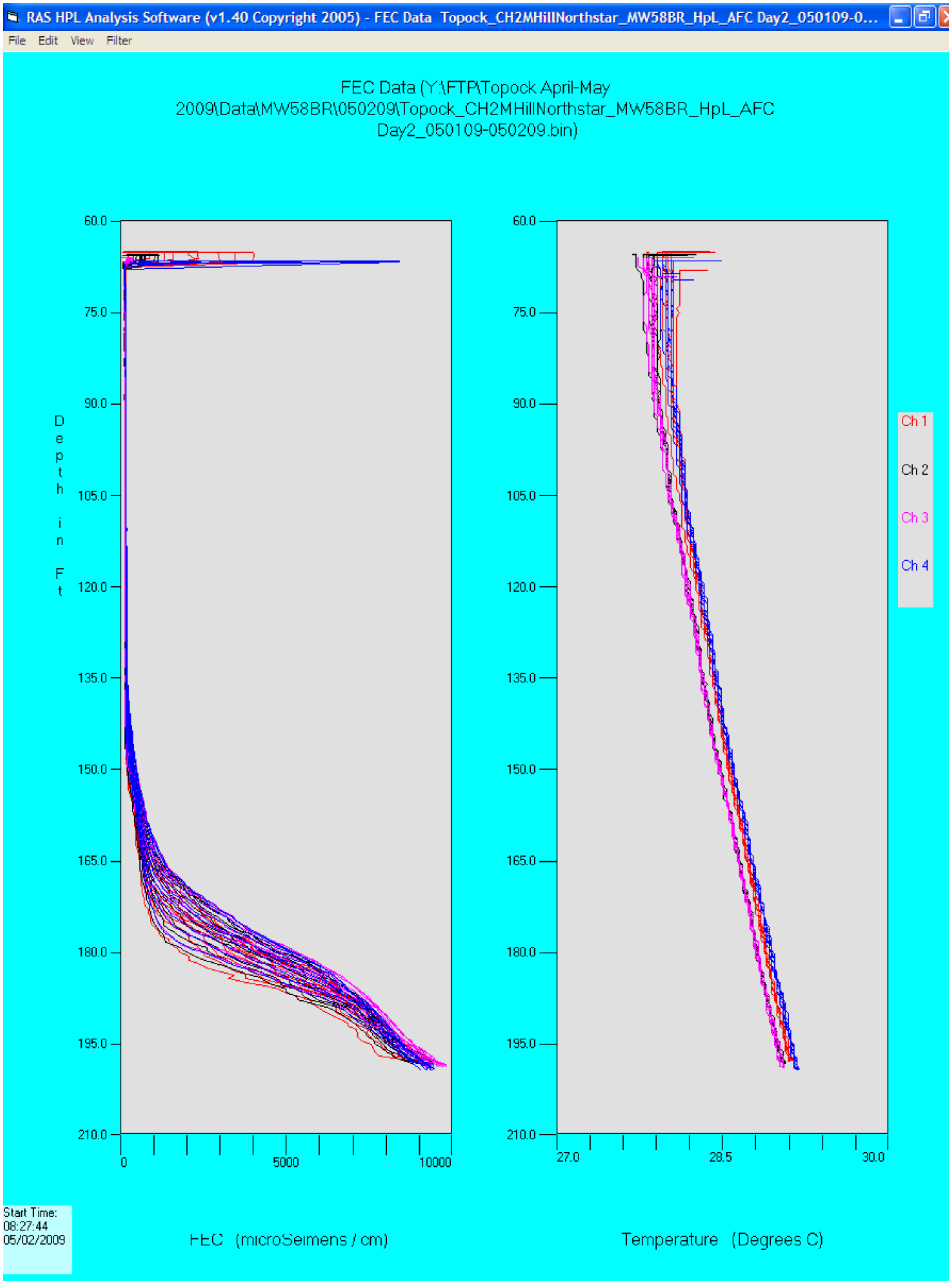


```
          CENTROID AND TOTAL MASS RESULTS
CENTROID          Ch1     Ch2     Ch3     Ch4
 Slope(ft/min)   0.019   0.019   0.017   0.019
 Flow (gpm)      0.007   0.007   0.006   0.007
 Intercept(ft) 181.36  181.78  181.64  180.60
 Correlation     0.967   0.961   0.949   0.979

TOTAL MASS (grams of NaCl)
 Slope(gm/min)   0.036   0.041   0.044   0.042
 Cal Flow(gpm)   0.002   0.002   0.002   0.002
 Intercept(gm)   0.007  -0.152  -0.273   0.202
 Correlation     0.998   0.997   0.990   0.992

Depth range= 160.0 ft to 198.0 ft   Well diameter= .25 ft
Interval FEC=  10000.0   Time interval= 29.0 to 378.5 mins
 (Results are for highlighted section on FEC Log)
```

Figure 4. MW-58BR. Integral and Centroid analysis of Day 1 data.

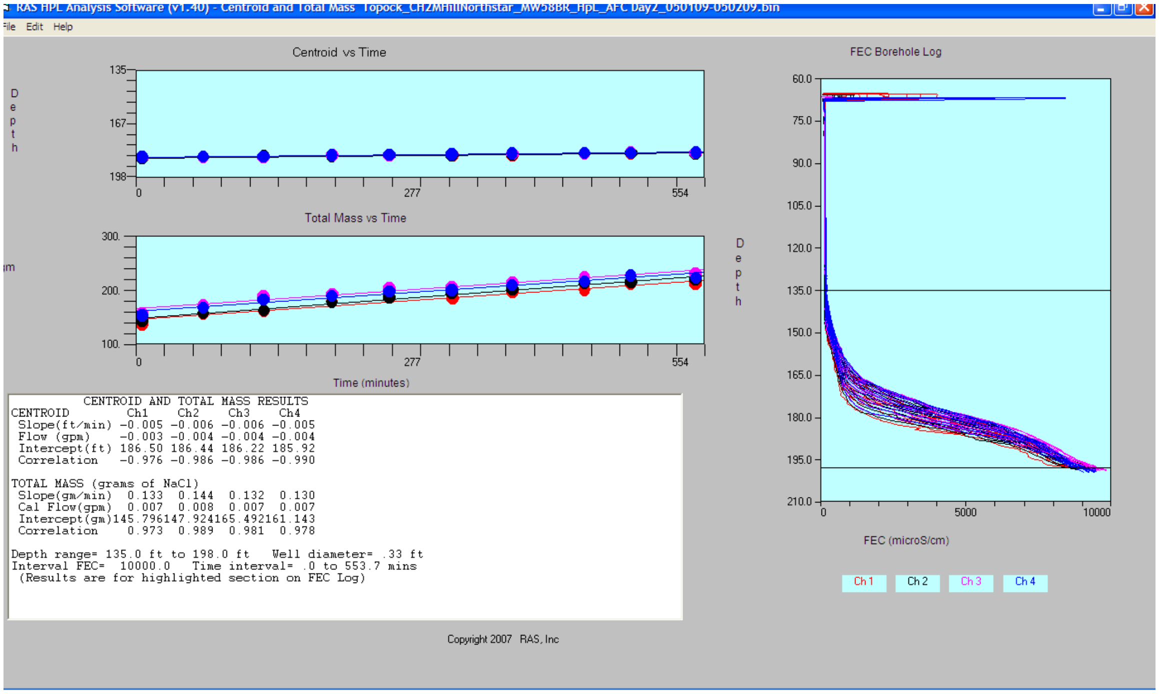


RAS HPL Analysis Software (v1.40 Copyright 2005) - FEC Data Topock_CH2MHillNorthstar_MW58BR_HpL_AFC Day2_050109-0...

FEC Data (Y:\FTP\Topock April-May 2009\Data\MW58BR\050209\Topock_CH2MHillNorthstar_MW58BR_HpL_AFC Day2_050109-050209.bin)

Start Time:
08:27:44
05/02/2009

Figure 5. MW-58BR. Summary of Logs for AFC Day 2.



```
          CENTROID AND TOTAL MASS RESULTS
CENTROID         Ch1    Ch2    Ch3    Ch4
 Slope(ft/min) -0.005 -0.006 -0.006 -0.005
 Flow (gpm)    -0.003 -0.004 -0.004 -0.004
 Intercept(ft) 186.50 186.44 186.22 185.92
 Correlation   -0.976 -0.986 -0.986 -0.990

TOTAL MASS (grams of NaCl)
 Slope(gm/min)  0.133  0.144  0.132  0.130
 Cal Flow(gpm)  0.007  0.008  0.007  0.007
 Intercept(gm)145.796147.924165.492161.143
 Correlation    0.973  0.989  0.981  0.978

Depth range= 135.0 ft to 198.0 ft   Well diameter= .33 ft
Interval FEC=  10000.0   Time interval= .0 to 553.7 mins
 (Results are for highlighted section on FEC Log)
```

Figure 6. MW-58BR. Centroid/Integration Analysis Day 2 AFC data only

CH2MHill – NorthStar
PG&E Topock Compressor Station
Monitoring Well MW-58BR
HPL PROCESSING NOTES
ALL DEPTHS REFERENCED TO TOP OF PVC CASING

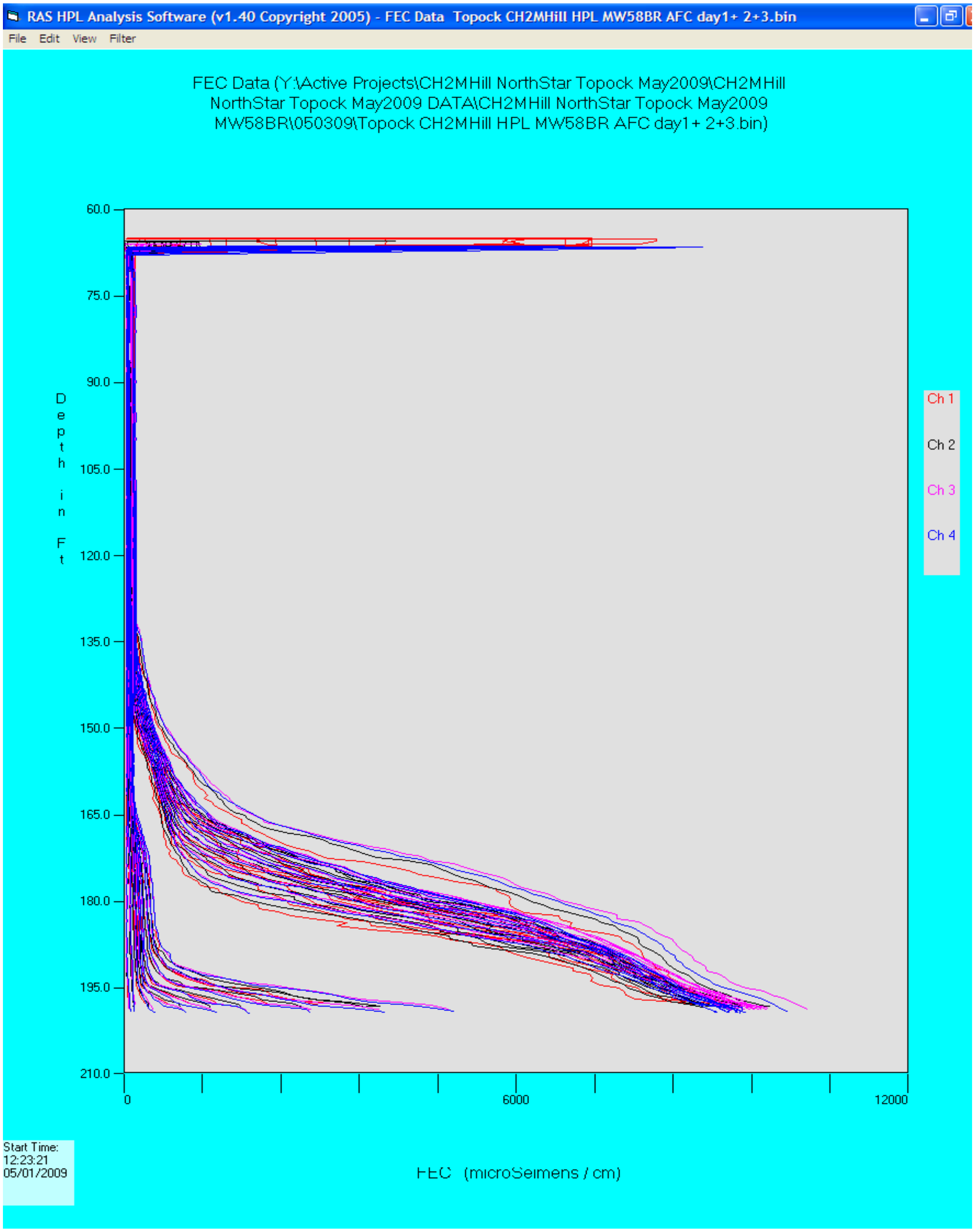
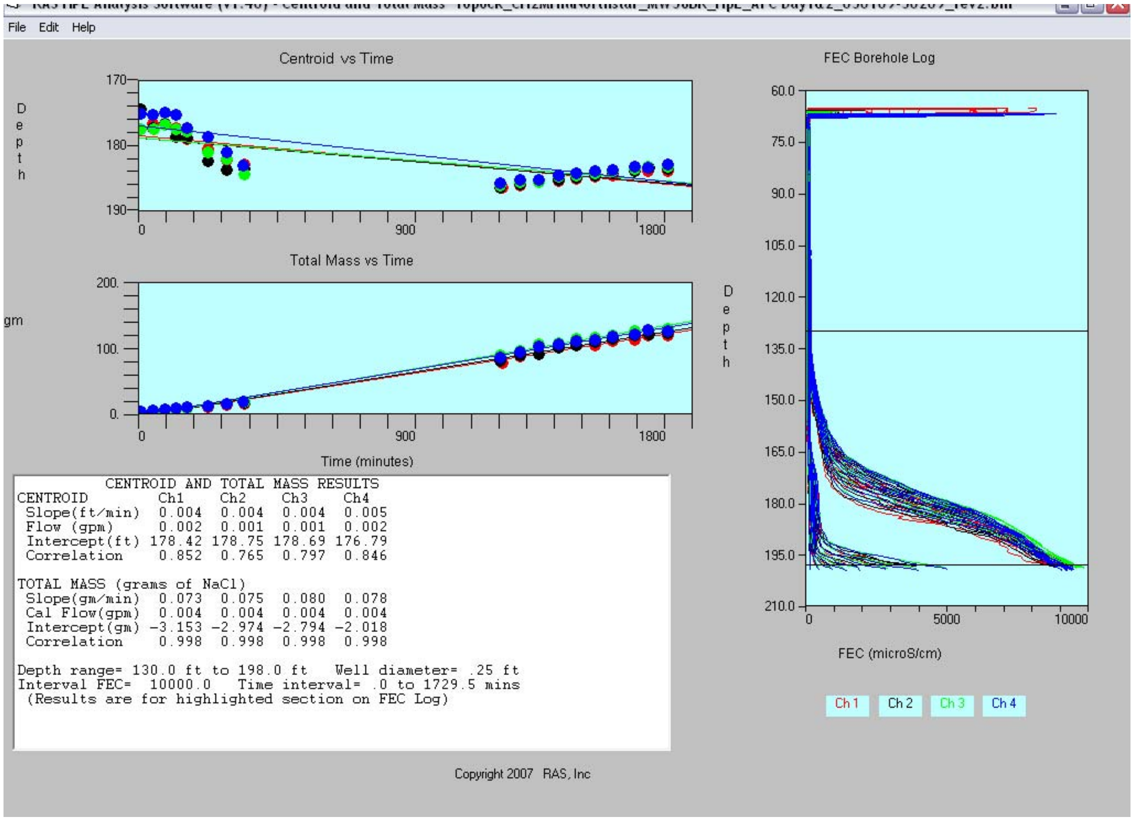


Figure 7. MW-58BR. Summary of Logs Collected on Day 1 & Day 2.

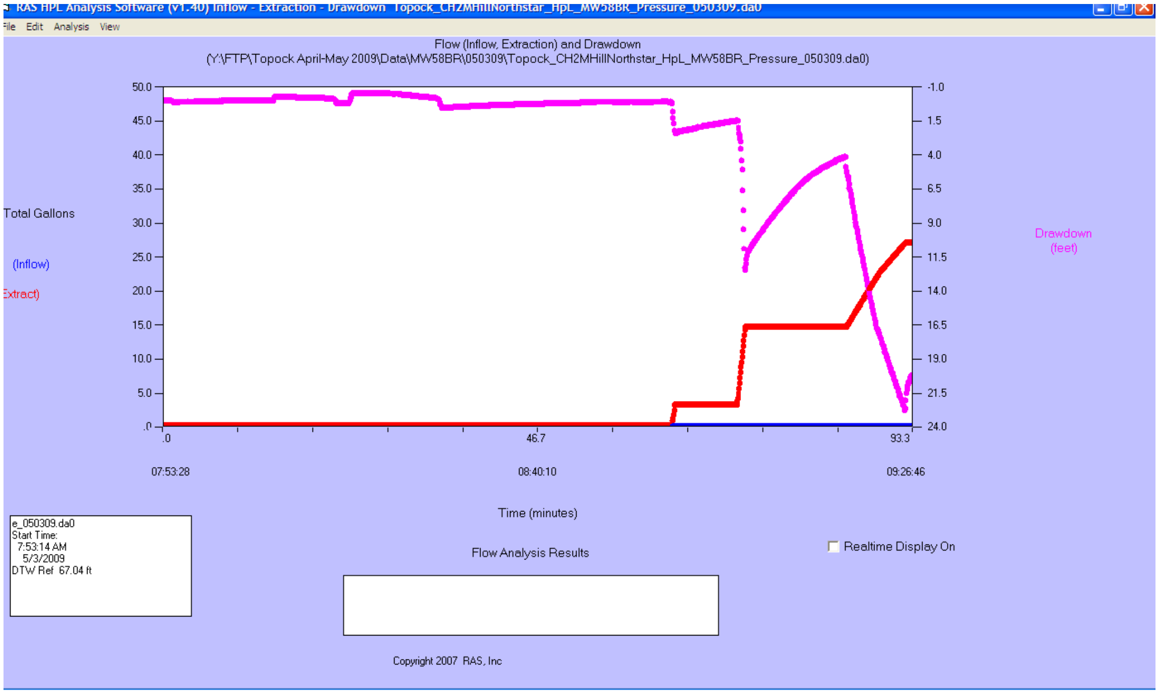


```
          CENTROID AND TOTAL MASS RESULTS
CENTROID         Ch1     Ch2     Ch3     Ch4
 Slope(ft/min)  0.004   0.004   0.004   0.005
 Flow (gpm)     0.002   0.001   0.001   0.002
 Intercept(ft) 178.42  178.75  178.69  176.79
 Correlation    0.852   0.765   0.797   0.846

TOTAL MASS (grams of NaCl)
 Slope(gm/min)  0.073   0.075   0.080   0.078
 Cal Flow(gpm)  0.004   0.004   0.004   0.004
 Intercept(gm) -3.153  -2.974  -2.794  -2.018
 Correlation    0.998   0.998   0.998   0.998

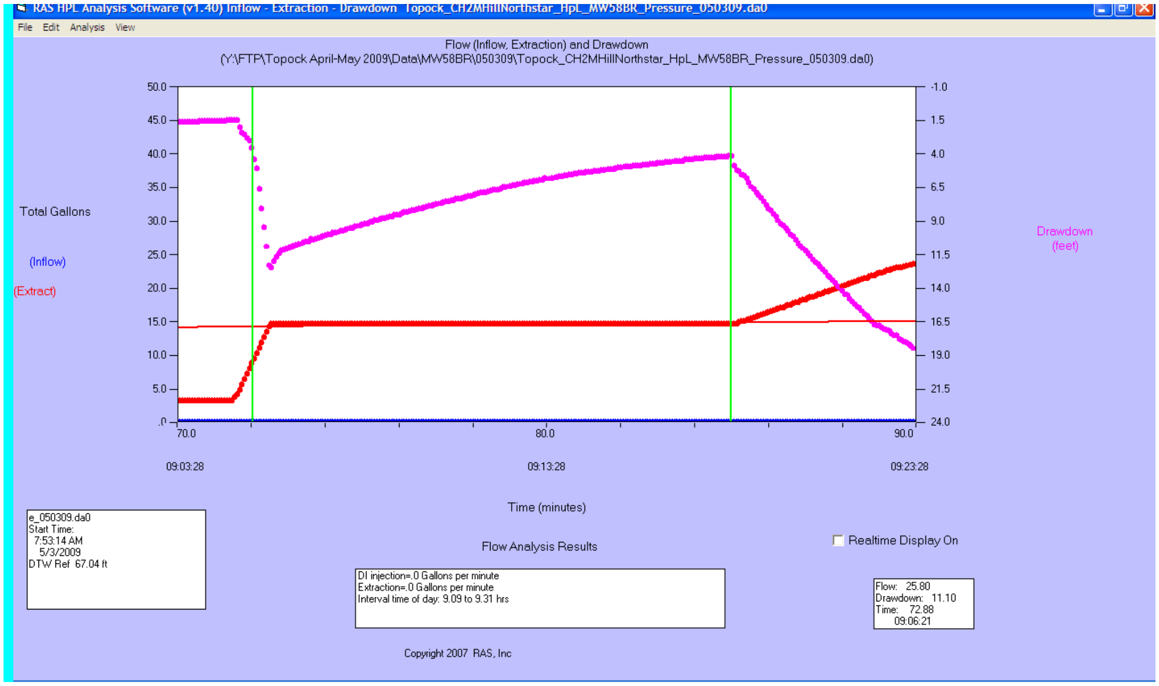
Depth range= 130.0 ft to 198.0 ft   Well diameter= .25 ft
Interval FEC=  10000.0   Time interval= .0 to 1729.5 mins
 (Results are for highlighted section on FEC Log)
```

Figure 8. MW-58BR. Centroid and Integration Analysis Day 1& 2 AFC data.



e_050309.da0
Start Time:
7:53:14 AM
5/3/2009
DTW Ref 67.04 ft

Figure 9. MW-58BR. Overall Well Hydraulic Characterization before Emplacement for for Slug Test After Emplacement (SAE).



e_050309.da0
Start Time:
7:53:14 AM
5/3/2009
DTW Ref 67.04 ft

DI injection=.0 Gallons per minute
Extraction=.0 Gallons per minute
Interval time of day: 9.09 to 9.31 hrs

Flow: 25.80
Drawdown: 11.10
Time: 72.88
09:06:21

Figure 10. MW-58BR. Summary of Rising Head Data during SAE. Average Volumetric Flow Rates.

DD = 11.1 ft @ 72.9 mins

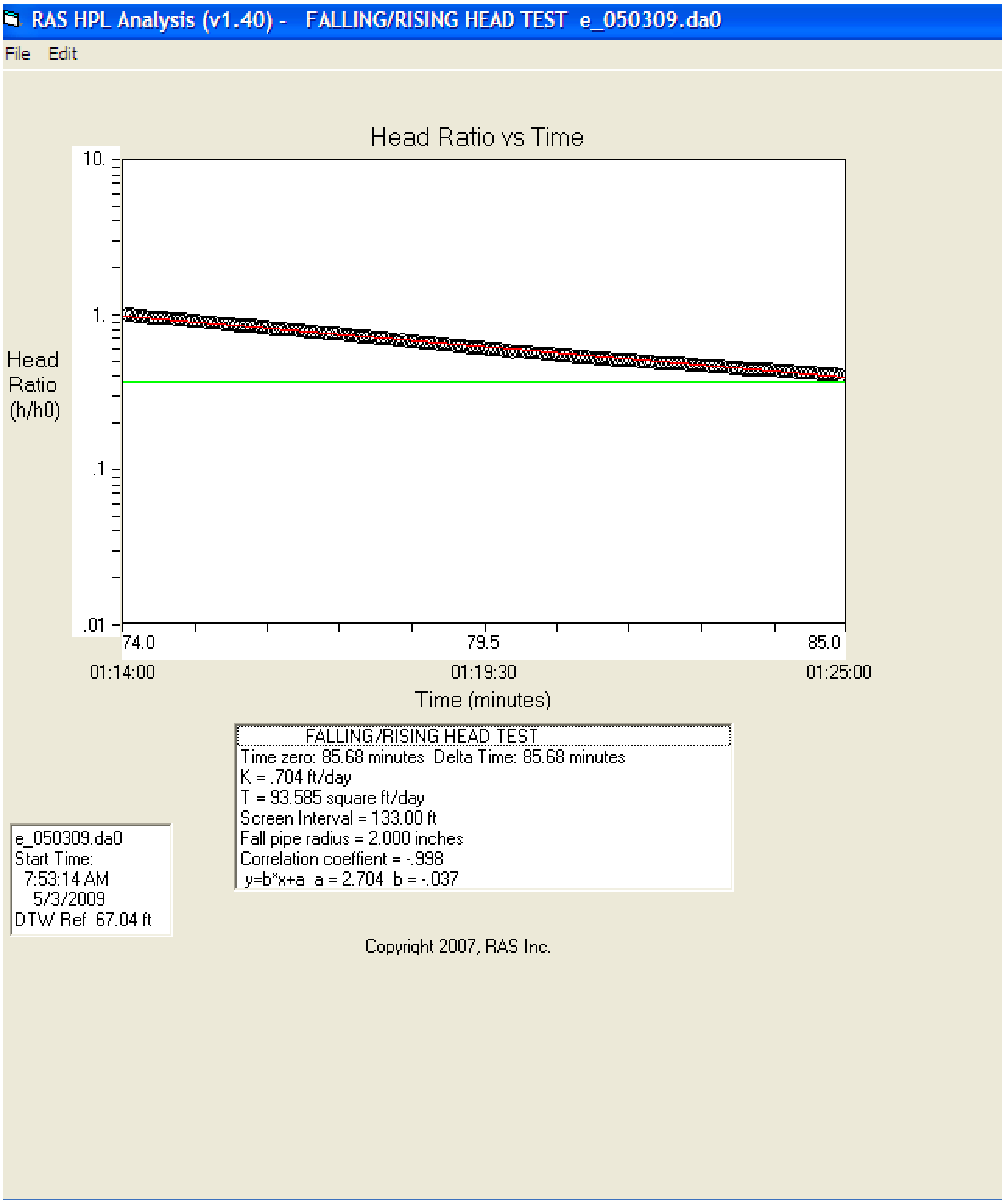
DD = 5.67 @ 80.05 mins

Average flowrate
11.1-5.67 = 5.43 feet
In 7.15 mins

4 inch well = 0.66 gallons per foot

0.66*5.43 = 3.58 gallons in 7.15 mins or

0.5 gpm average rate

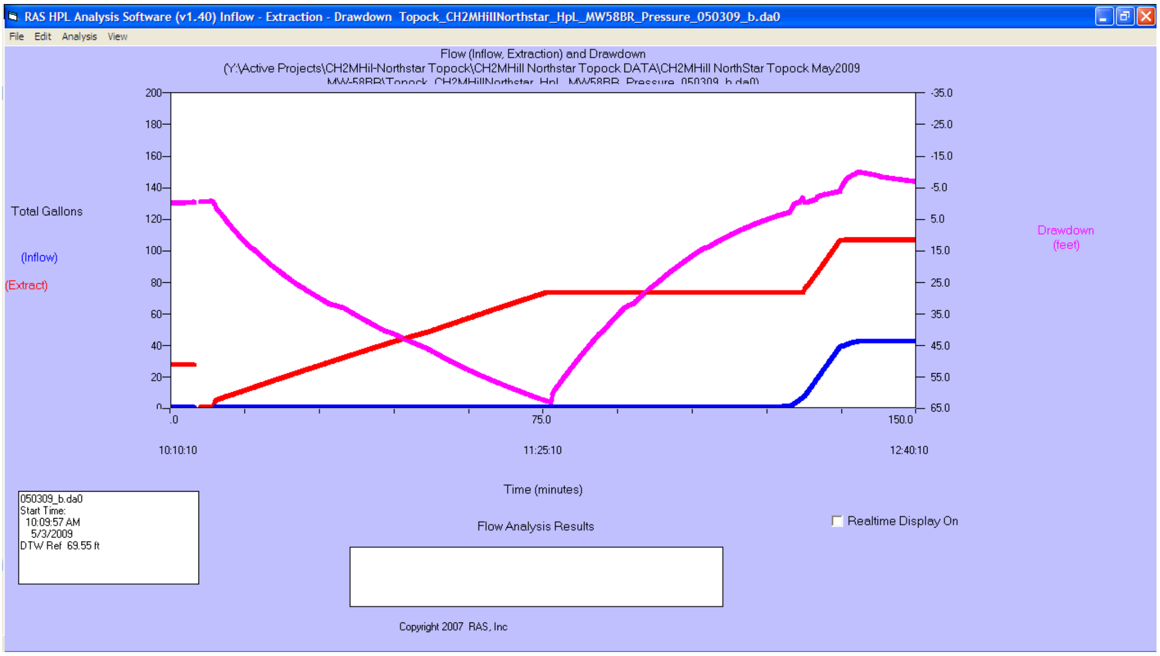


FALLING/RISING HEAD TEST
Time zero: 85.68 minutes Delta Time: 85.68 minutes
K = .704 ft/day
T = 93.585 square ft/day
Screen Interval = 133.00 ft
Fall pipe radius = 2.000 inches
Correlation coeffient = -.998
y=b*x+a a = 2.704 b = -.037

e_050309.da0
Start Time:
7:53:14 AM
5/3/2009
DTW Ref 67.04 ft

Copyright 2007, RAS Inc.

Figure 11. MW-58BR. Results of 10 ft dP slug test



RAS HPL Analysis Software (v1.40) Inflow - Extraction - Drawdown Topock_CH2MHillNorthstar_HpL_MW58BR_Pressure_050309_b.da0

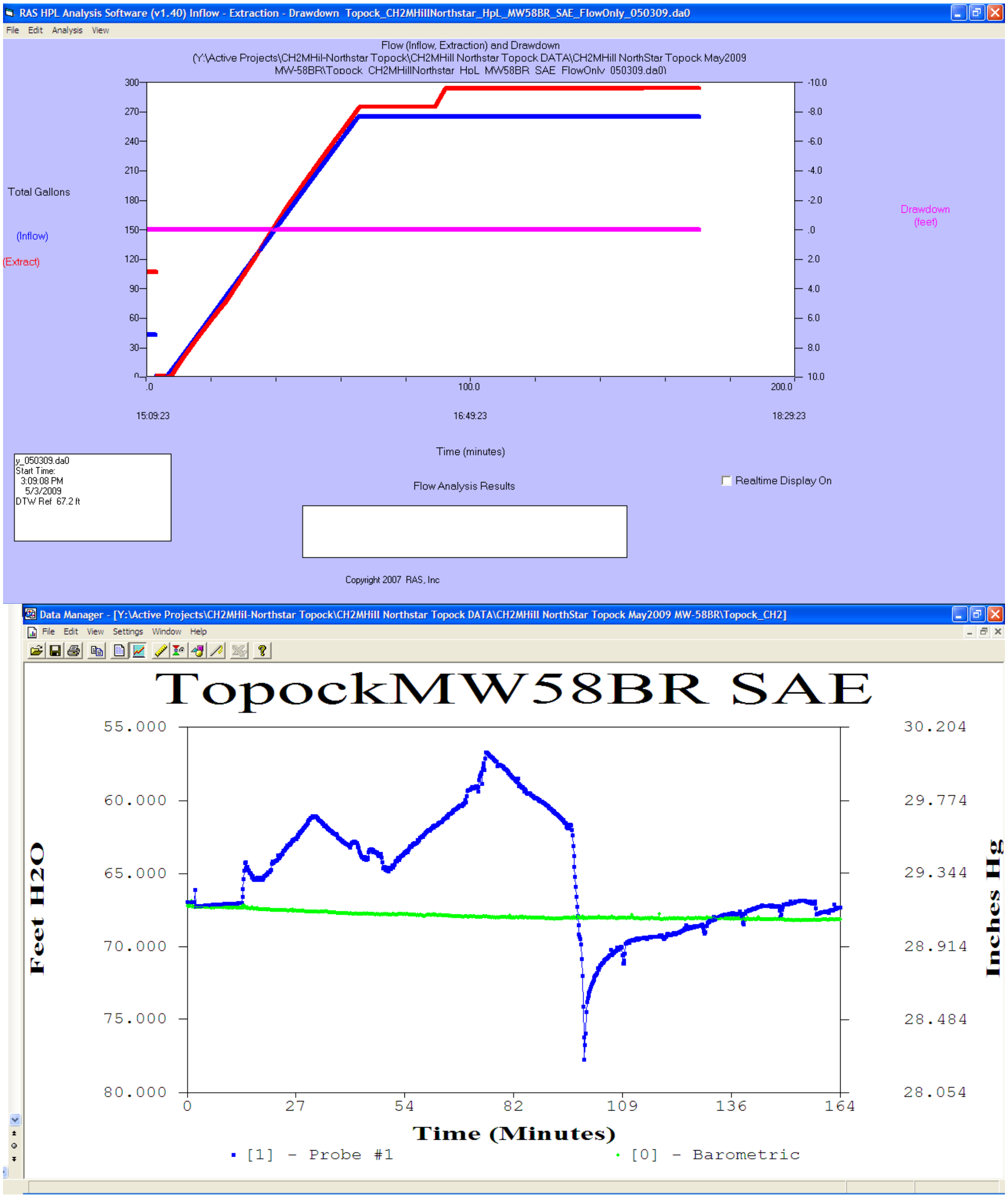
Flow (Inflow, Extraction) and Drawdown
(Y:\Active Projects\CH2MHil-Northstar Topock\CH2MHill Northstar Topock DATA\CH2MHill NorthStar Topock May2009
MW-58BR\Topock_CH2MHillNorthstar_HpL_MW58BR_Pressure_050309_b.da0)

050309_b.da0
Start Time:
10:09:57 AM
5/3/2009
DTW Ref 69.55 ft

☐ Realtime Display On

Copyright 2007 RAS, Inc

Figure 12. MW-58BR. Pressure and Flow Results of Short Term Pump Test.



RAS HPL Analysis Software (v1.40) Inflow - Extraction - Drawdown Topock_CH2MHillNorthstar_HpL_MW58BR_SAE_FlowOnly_050309.da0

Flow (Inflow, Extraction) and Drawdown
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MW-58BR\Topock_CH2MHillNorthstar_HpL_MW58BR_SAE_FlowOnly_050309.da0)

y_050309.da0
Start Time:
3:09:08 PM
5/3/2009
DTW Ref 67.2 ft

Flow Analysis Results

☐ Realtime Display On

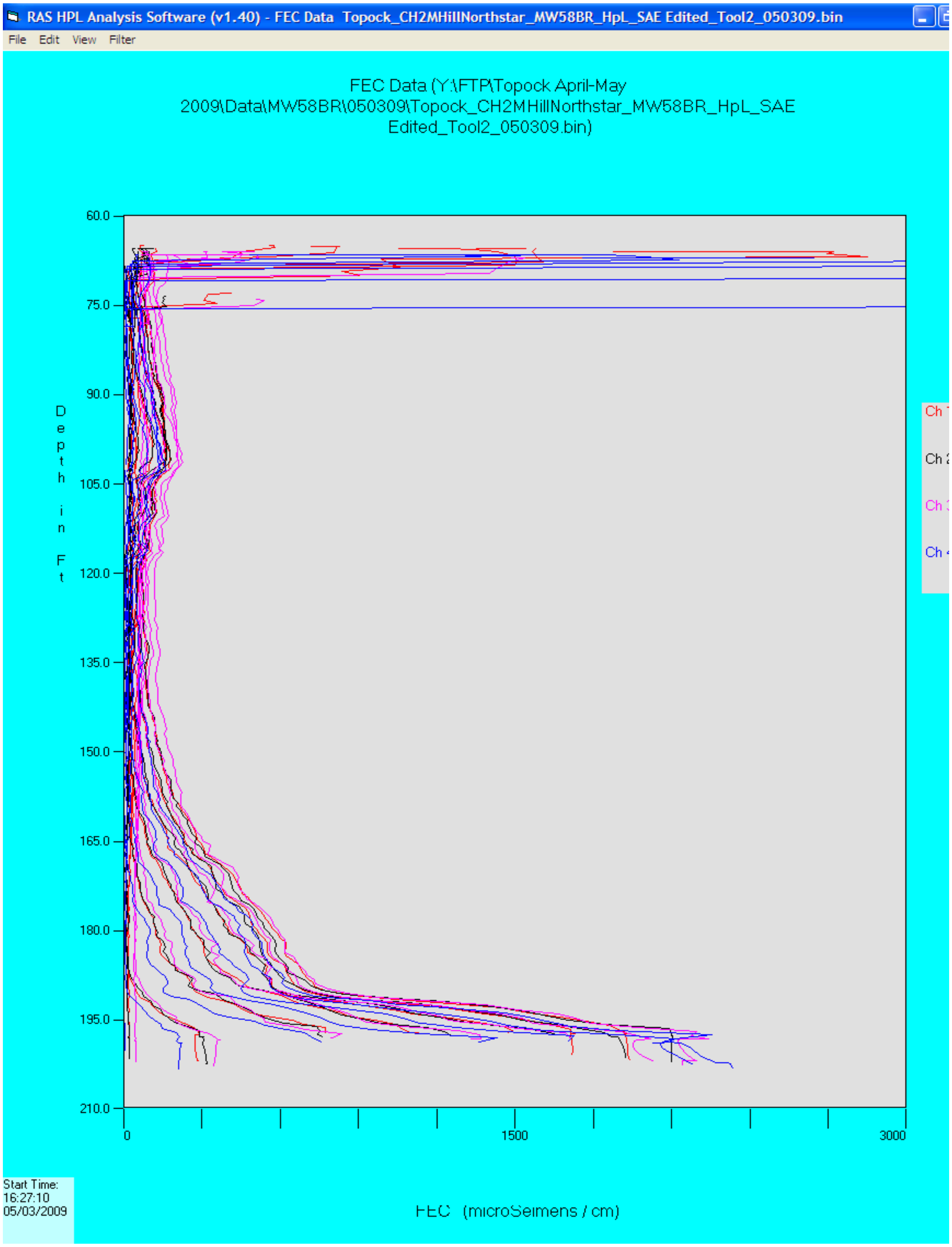
Copyright 2007 RAS, Inc

Data Manager - [Y:\Active Projects\CH2MHil-Northstar Topock\CH2MHill Northstar Topock DATA\CH2MHill NorthStar Topock May2009 MW-58BR\Topock_CH2]

TopockMW58BR SAE

Figure 13. MW-58BR pumping history during SAE test. Pressure measured by Hermit PT in lower figure. T = 0 mins at 15:02:30 hours. Slug withdrawal occurred at 16:38 for SAE testing, 73.88 DTW maximum displacement. Ambient DTW was 67.10 or 6.78 delta.

CH2MHill – NorthStar
PG&E Topock Compressor Station
Monitoring Well MW-58BR
HPL PROCESSING NOTES
ALL DEPTHS REFERENCED TO TOP OF PVC CASING



Figrue 14. MW-58BR. Summary of Logs Collected during SAE testing.

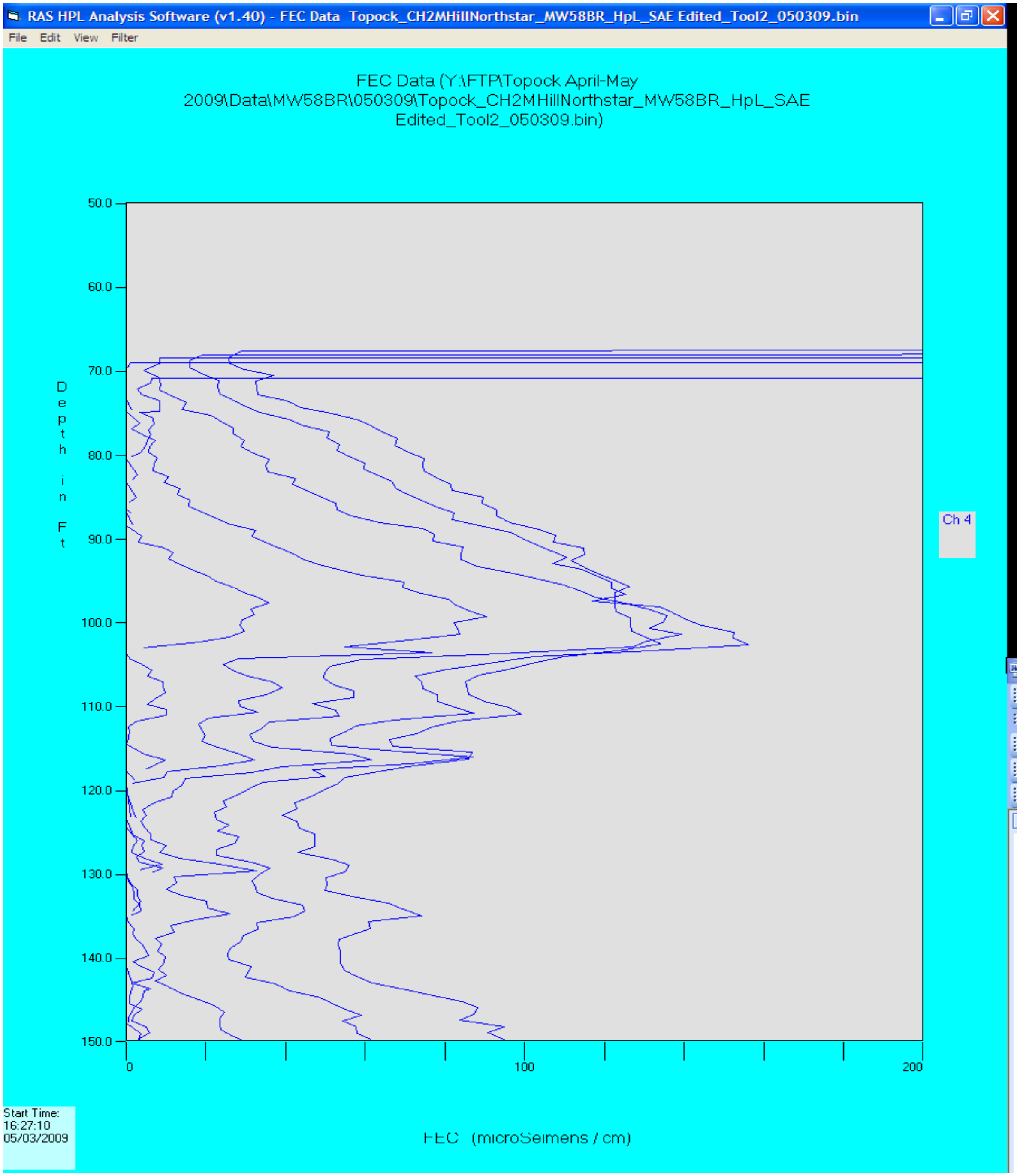
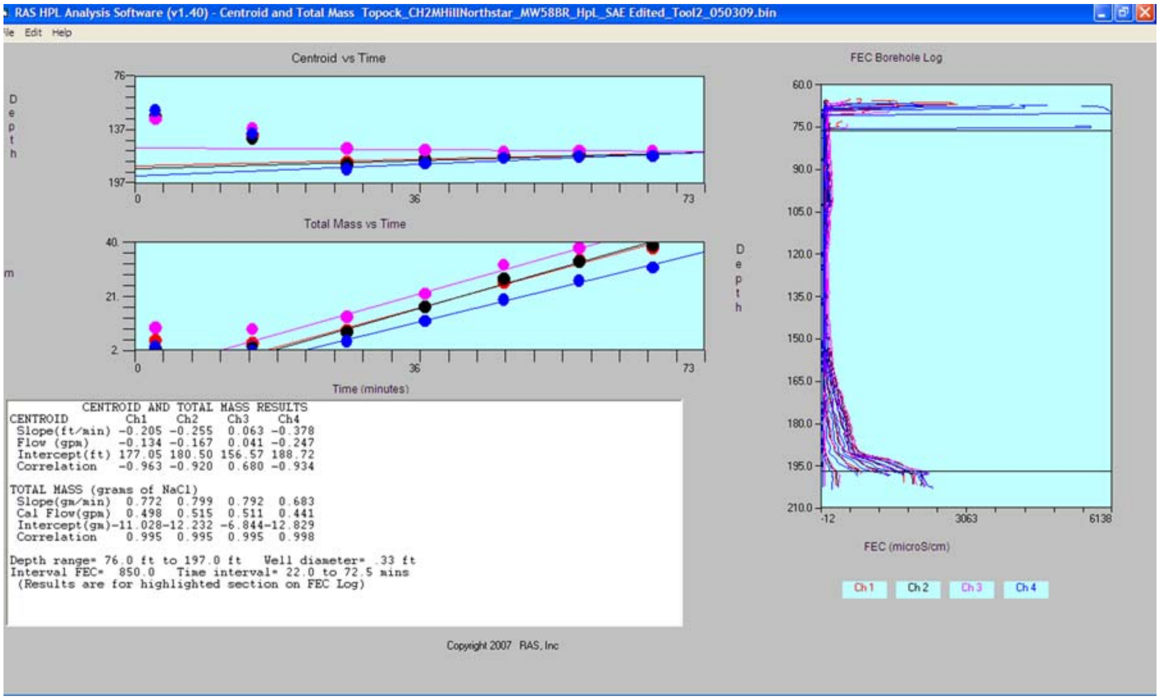


Figure 15. MW-58BR Summary of Hydrophysical logs collected during SAE Testing. Channel 4 only, enhanced scales for inflow indentification.

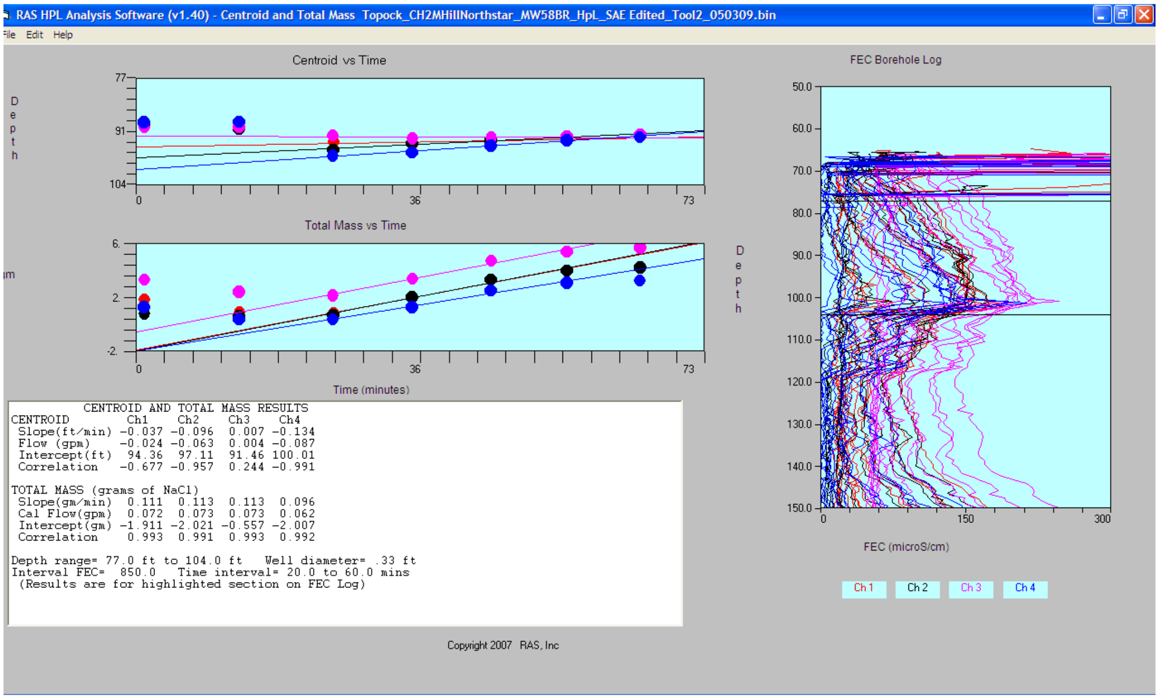


```
          CENTROID AND TOTAL MASS RESULTS
CENTROID          Ch1     Ch2     Ch3     Ch4
 Slope(ft/min) -0.205 -0.255  0.063 -0.378
 Flow (gpm)    -0.134 -0.167  0.041 -0.247
 Intercept(ft) 177.05 180.50 156.57 188.72
 Correlation   -0.963 -0.920  0.680 -0.934

TOTAL MASS (grams of NaCl)
 Slope(gm/min)  0.772  0.799  0.792  0.683
 Cal Flow(gpm)  0.498  0.515  0.511  0.441
 Intercept(gm)-11.028-12.232 -6.844-12.829
 Correlation    0.995  0.995  0.995  0.998

Depth range= 76.0 ft to 197.0 ft   Well diameter= .33 ft
Interval FEC=  850.0   Time interval= 22.0 to 72.5 mins
 (Results are for highlighted section on FEC Log)
```

Figure 16. MW-58BR Normalized interval FEC to match volumetric flow rate calculated above (0.5gpm)

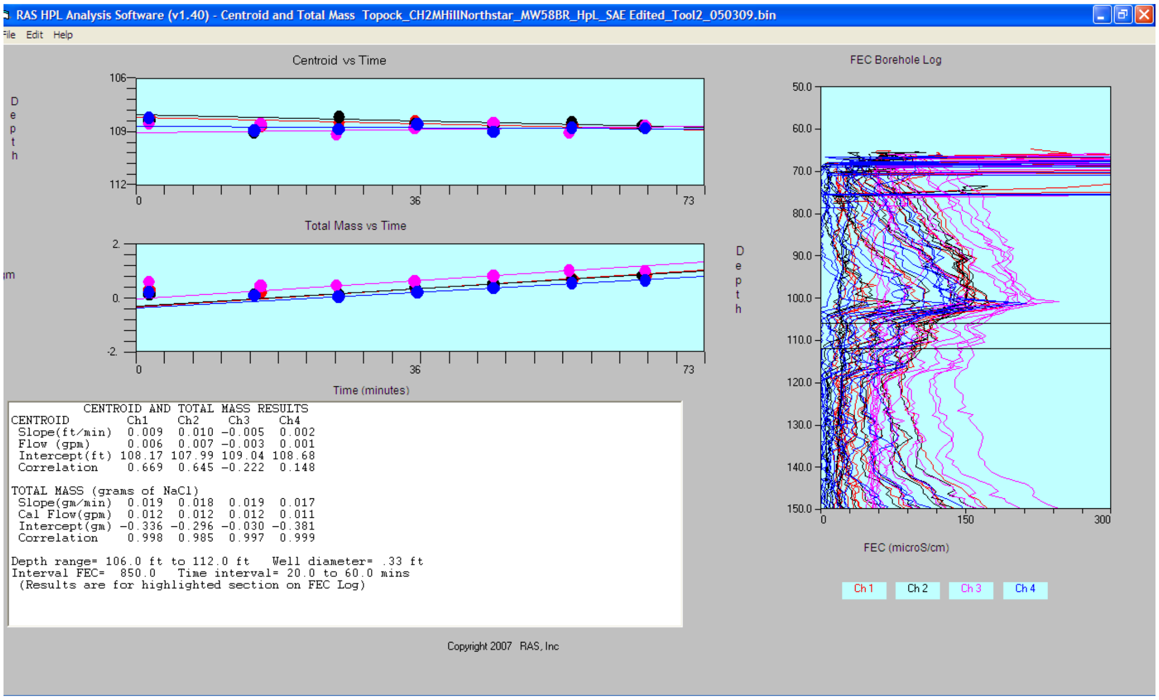


```
          CENTROID AND TOTAL MASS RESULTS
CENTROID          Ch1     Ch2     Ch3     Ch4
 Slope(ft/min) -0.037 -0.096  0.007 -0.134
 Flow (gpm)    -0.024 -0.063  0.004 -0.087
 Intercept(ft)  94.36  97.11  91.46 100.01
 Correlation   -0.677 -0.957  0.244 -0.991

TOTAL MASS (grams of NaCl)
 Slope(gm/min)  0.111  0.113  0.113  0.096
 Cal Flow(gpm)  0.072  0.073  0.073  0.062
 Intercept(gm) -1.911 -2.021 -0.557 -2.007
 Correlation    0.993  0.991  0.993  0.992

Depth range= 77.0 ft to 104.0 ft   Well diameter= .33 ft
Interval FEC=  850.0   Time interval= 20.0 to 60.0 mins
 (Results are for highlighted section on FEC Log)
```

Figure 17. MW-58BR Results of Integral and Centroid Analysis, interval of analysis for inflow at 95.9 to 103.7 feet.

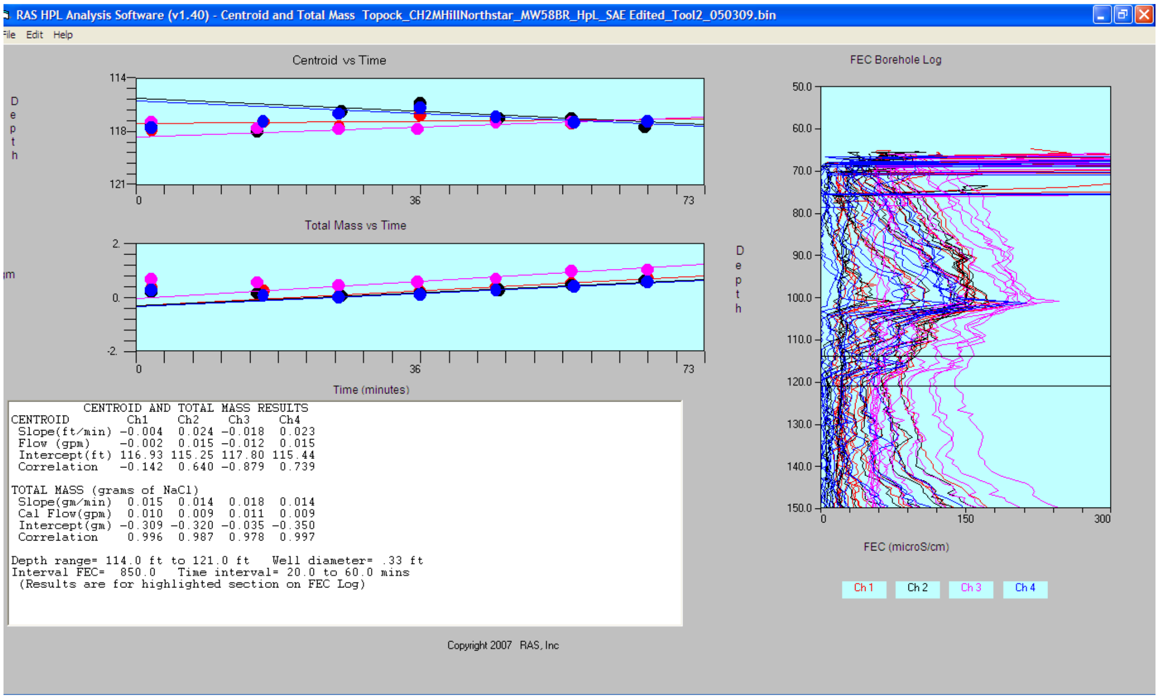


```
          CENTROID AND TOTAL MASS RESULTS
CENTROID          Ch1     Ch2     Ch3     Ch4
 Slope(ft/min)  0.009   0.010  -0.005   0.002
 Flow (gpm)     0.006   0.007  -0.003   0.001
 Intercept(ft) 108.17  107.99  109.04  108.68
 Correlation    0.669   0.645  -0.222   0.148

TOTAL MASS (grams of NaCl)
 Slope(gm/min)  0.019   0.018   0.019   0.017
 Cal Flow(gpm)  0.012   0.012   0.012   0.011
 Intercept(gm) -0.336  -0.296  -0.030  -0.381
 Correlation    0.998   0.985   0.997   0.999

Depth range= 106.0 ft to 112.0 ft   Well diameter= .33 ft
Interval FEC=  850.0   Time interval= 20.0 to 60.0 mins
 (Results are for highlighted section on FEC Log)
```

Figure 18. MW-58BR Results of Integral and Centroid Analysis, interval of analysis for inflow at 106.6 to 111.3 feet.

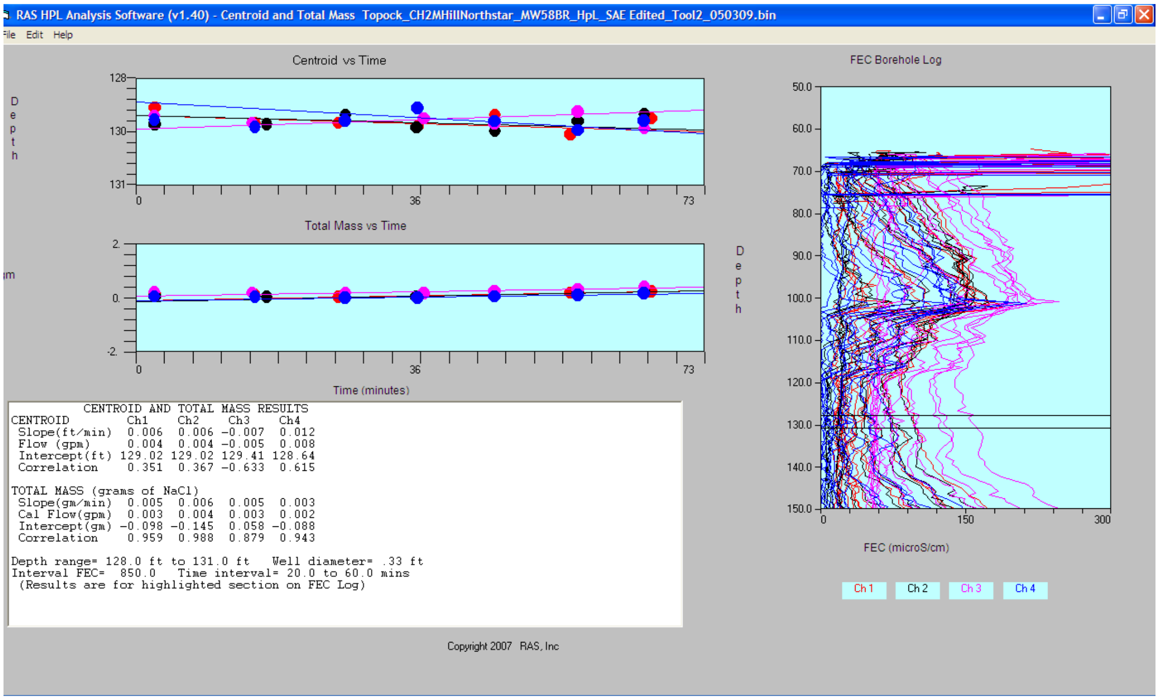


```
          CENTROID AND TOTAL MASS RESULTS
CENTROID          Ch1     Ch2     Ch3     Ch4
 Slope(ft/min) -0.004   0.024  -0.018   0.023
 Flow (gpm)    -0.002   0.015  -0.012   0.015
 Intercept(ft) 116.93  115.25  117.80  115.44
 Correlation   -0.142   0.640  -0.879   0.739

TOTAL MASS (grams of NaCl)
 Slope(gm/min)  0.015   0.014   0.018   0.014
 Cal Flow(gpm)  0.010   0.009   0.011   0.009
 Intercept(gm) -0.309  -0.320  -0.035  -0.350
 Correlation    0.996   0.987   0.978   0.997

Depth range= 114.0 ft to 121.0 ft   Well diameter= .33 ft
Interval FEC=  850.0   Time interval= 20.0 to 60.0 mins
 (Results are for highlighted section on FEC Log)
```

Figure 19. MW-58BR Results of Integral and Centroid Analysis, interval of analysis for inflow at 114.7 to 120.1 feet.

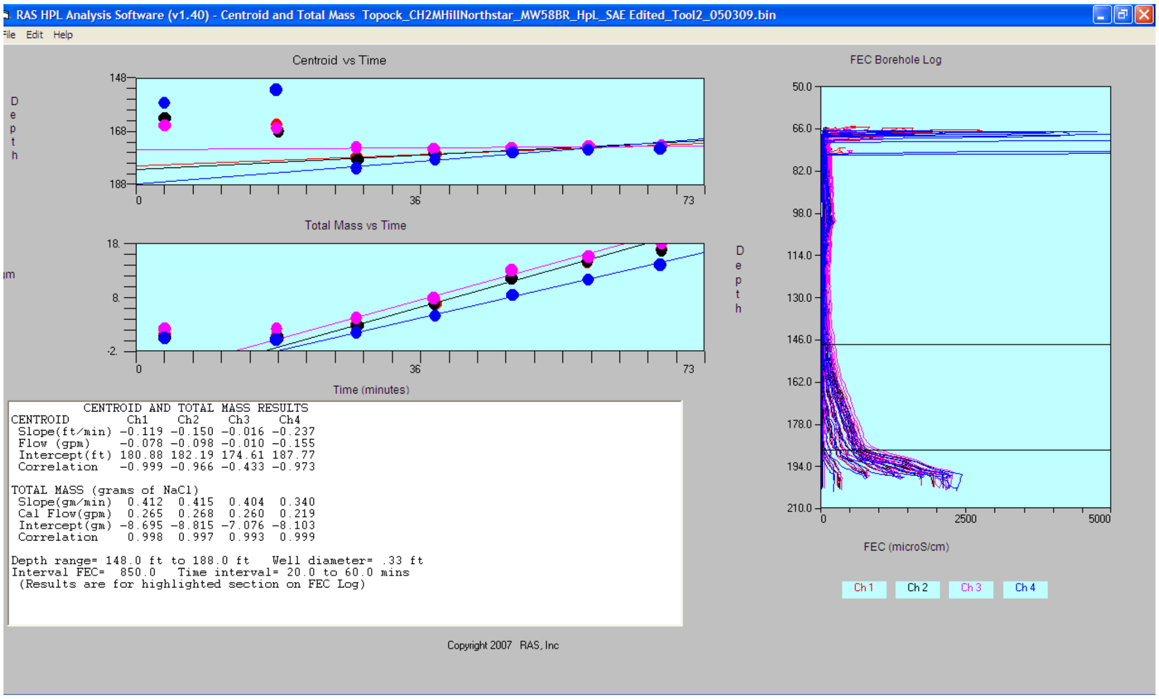


```
          CENTROID AND TOTAL MASS RESULTS
CENTROID         Ch1    Ch2    Ch3    Ch4
 Slope(ft/min)  0.006  0.006 -0.007  0.012
 Flow (gpm)     0.004  0.004 -0.005  0.008
 Intercept(ft) 129.02 129.02 129.41 128.64
 Correlation    0.351  0.367 -0.633  0.615

TOTAL MASS (grams of NaCl)
 Slope(gm/min)  0.005  0.006  0.005  0.003
 Cal Flow(gpm)  0.003  0.004  0.003  0.002
 Intercept(gm) -0.098 -0.145  0.058 -0.088
 Correlation    0.959  0.988  0.879  0.943

Depth range= 128.0 ft to 131.0 ft   Well diameter= .33 ft
Interval FEC=  850.0   Time interval= 20.0 to 60.0 mins
 (Results are for highlighted section on FEC Log)
```

Figure 20. MW-58BR Results of Integral and Centroid Analysis, interval of analysis for inflow at 128.0 to 130.5 feet.

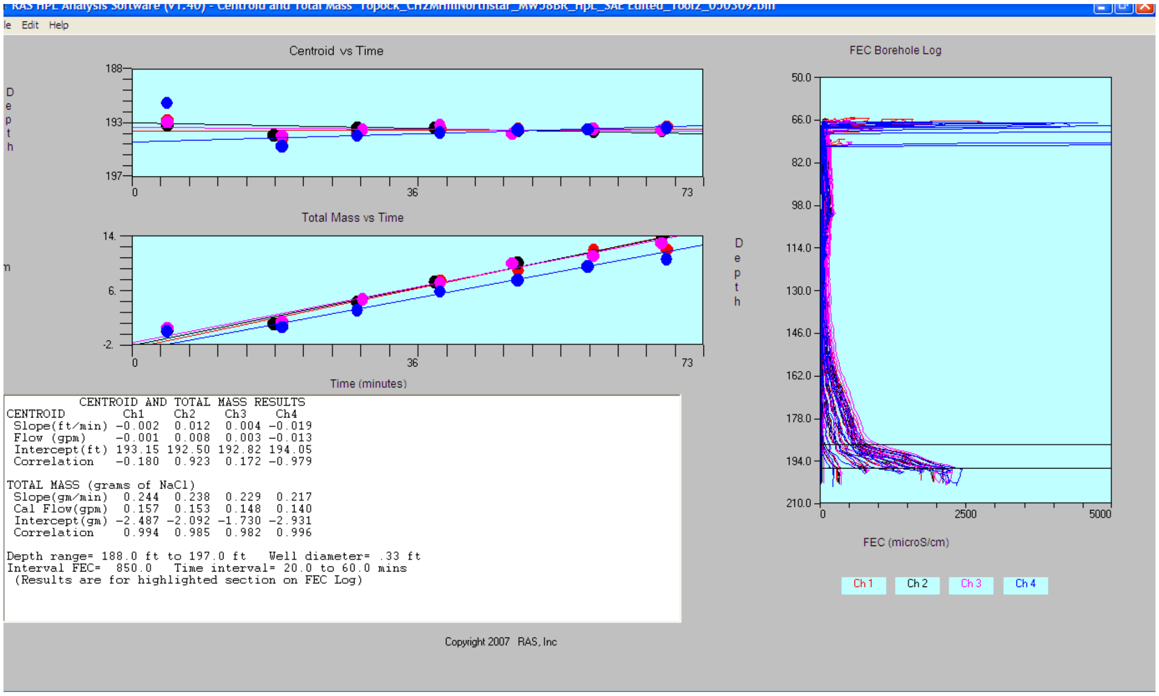


```
          CENTROID AND TOTAL MASS RESULTS
CENTROID         Ch1    Ch2    Ch3    Ch4
 Slope(ft/min) -0.119 -0.150 -0.016 -0.237
 Flow (gpm)    -0.078 -0.098 -0.010 -0.155
 Intercept(ft) 180.88 182.19 174.61 187.77
 Correlation   -0.999 -0.966 -0.433 -0.973

TOTAL MASS (grams of NaCl)
 Slope(gm/min)  0.412  0.415  0.404  0.340
 Cal Flow(gpm)  0.265  0.268  0.260  0.219
 Intercept(gm) -8.695 -8.815 -7.076 -8.103
 Correlation    0.998  0.997  0.993  0.999

Depth range= 148.0 ft to 188.0 ft   Well diameter= .33 ft
Interval FEC=  850.0   Time interval= 20.0 to 60.0 mins
 (Results are for highlighted section on FEC Log)
```

Figure 21. MW-58BR Results of Integral and Centroid Analysis, interval of analysis for inflow at 132.4 to 136.3 feet.

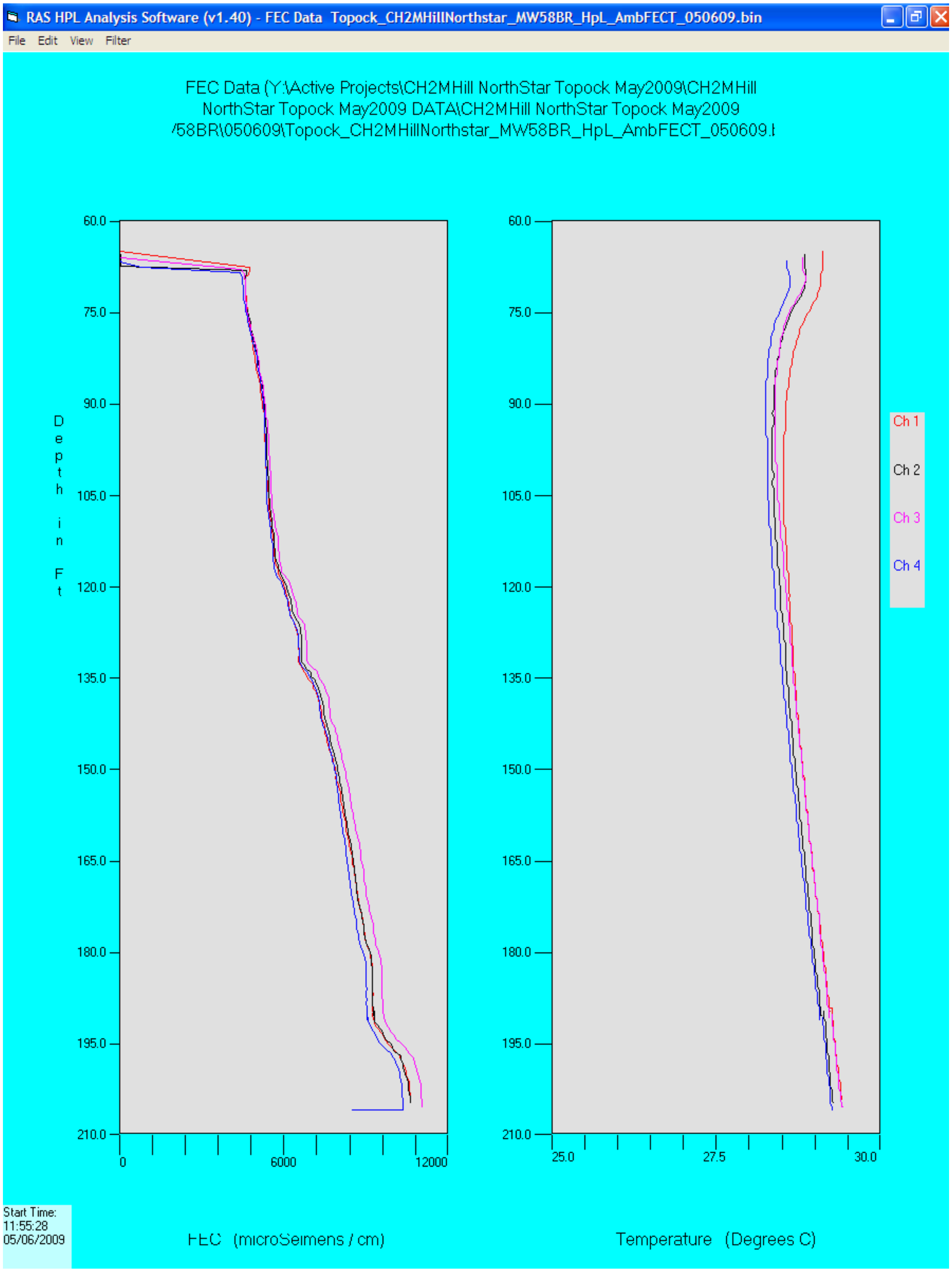


```
          CENTROID AND TOTAL MASS RESULTS
CENTROID        Ch1    Ch2    Ch3    Ch4
 Slope(ft/min) -0.002  0.012  0.004 -0.019
 Flow (gpm)    -0.001  0.008  0.003 -0.013
 Intercept(ft) 193.15 192.50 192.82 194.05
 Correlation   -0.180  0.923  0.172 -0.979

TOTAL MASS (grams of NaCl)
 Slope(gm/min)  0.244  0.238  0.229  0.217
 Cal Flow(gpm)  0.157  0.153  0.148  0.140
 Intercept(gm) -2.487 -2.092 -1.730 -2.931
 Correlation    0.994  0.985  0.982  0.996

Depth range= 188.0 ft to 197.0 ft   Well diameter= .33 ft
Interval FEC=  850.0   Time interval= 20.0 to 60.0 mins
 (Results are for highlighted section on FEC Log)
```

Figure 22. MW-58BR Results of Integral and Centroid Analysis, interval of analysis for inflow at 190.0 to 207.0 feet.



FEC Data (Y:\Active Projects\CH2MHill NorthStar Topock May2009\CH2MHill NorthStar Topock May2009 DATA\CH2MHill NorthStar Topock May2009 /58BR\050609\Topock_CH2MHillNorthstar_MW58BR_HpL_AmbFECT_050609.

Start Time:
11:55:28
05/06/2009

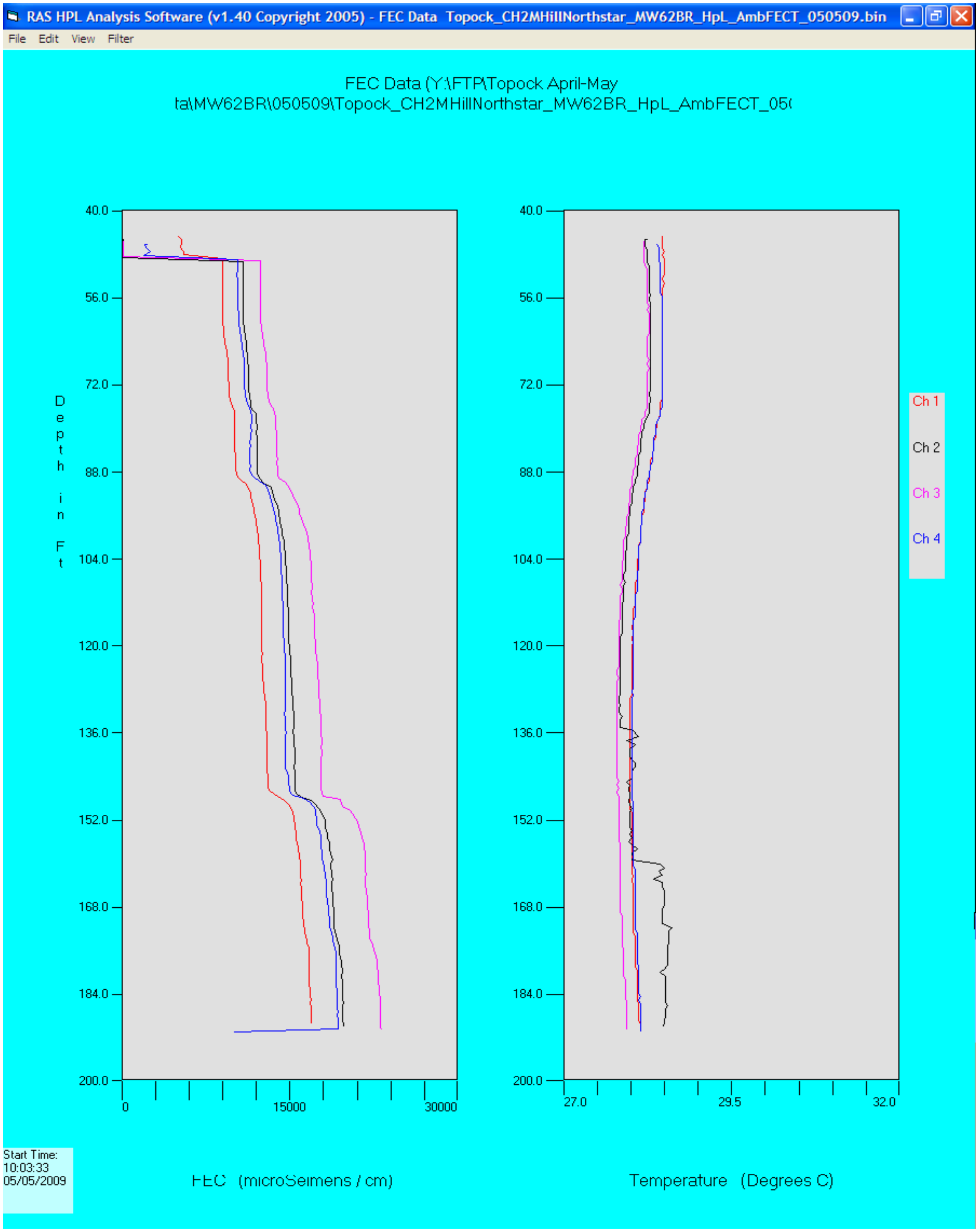
Figure 23. MW-58BR Ambient FEC and Temperature Log Collected before Ambient Discrete Fluid Sample at 203 feet.

CH2MHill – NorthStar
PG&E Topock Compressor Station
Monitoring Well MW-58BR
HPL PROCESSING NOTES
ALL DEPTHS REFERENCED TO TOP OF PVC CASING

Summary of Preliminary HPL Results Conductive Feature (CF) Depths						
			Ambient Conditions Interval Specific Flow Rate	**Pumping Conditions Interval Specific Flow Rate**	**Interval Specific Concen-tration**	**Interval Specific Hydraulic Conductivity**
	Depth (ft)		gpm (US)	gpm (US)	µS/cm	ft/day
CF	top	Bottom				
1	95.9	103.7	0	0.07	~10,000	1.5
2	106.6	111.3	0	0.01	~10,000	0.4
3	114.7	120.1	0	0.01	~10,000	0.3
4	128.0	130.5	0	0.003	~10,000	0.2
5	132.4	136.3	0	0.01	~10,000	0.4
6	148	190	0	0.27	~10,000	1.1
7	190.0	207	.004	0.15	~10,000	2.6
	Sum of Interval Specific Flowrates			0.523		
	Total observed at from rising head			0.5		
	ALL DEPTHS REFERENCED TO TOP OF CASING (TOC); CASING STICKUP = 27.25”					

Table 1. CH2MHill Topock Well MW-58BR, Summary of Results, Ambient Flow Characterization and Slug After Emplacement Tests.

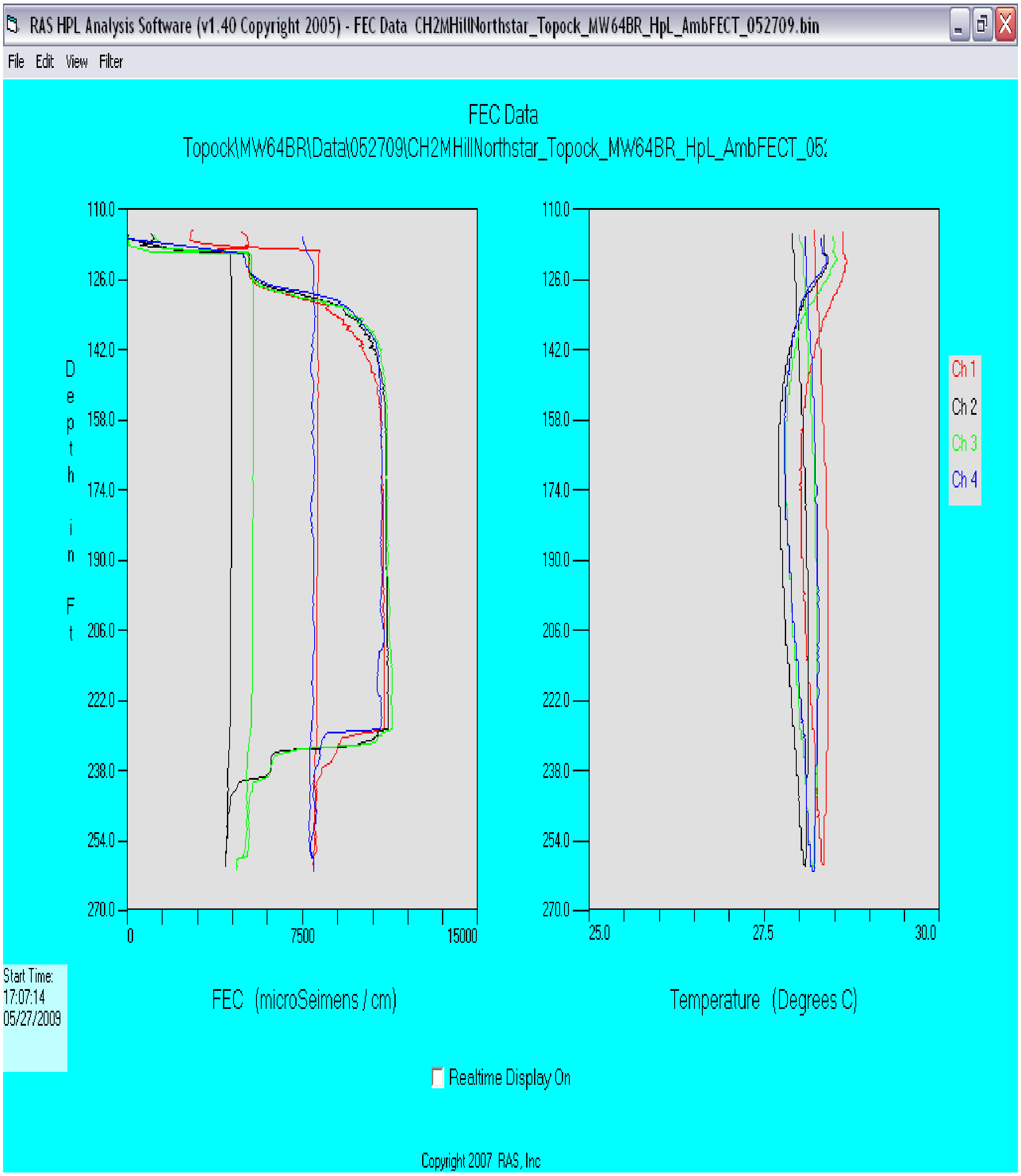
CH2MHill – NorthStar
PG&E Topock Compressor Station
Monitoring Well MW-62BR
HPL PROCESSING NOTES
ALL DEPTHS REFERENCED TO TOP OF PVC CASING



Start Time:
10:03:33
05/05/2009

Figure 1. MW-62BR Ambient Fluid Electrical Conductivity and Temperature.

CH2MHill – NorthStar
PG&E Topock Compressor Station
Monitoring Well MW-64BR
HPL PROCESSING NOTES
ALL DEPTHS REFERENCED TO TOP OF PVC CASING

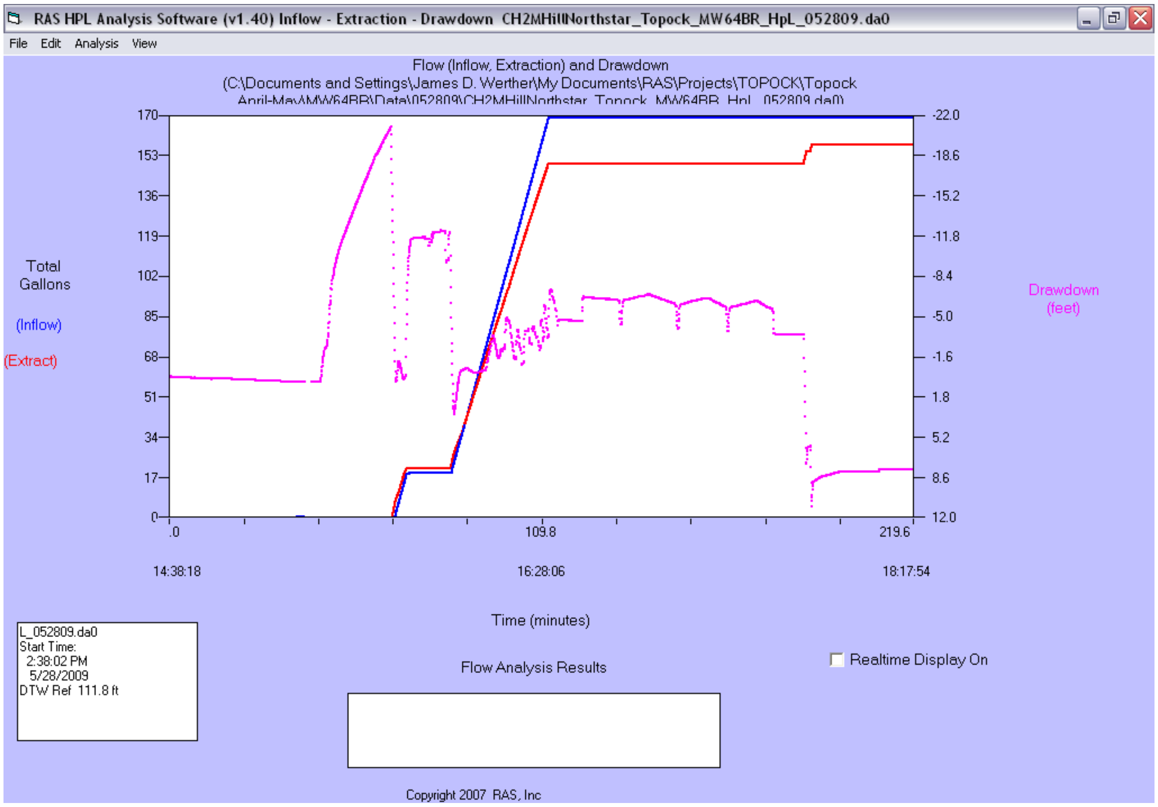


Start Time:
17:07:14
05/27/2009

☐ Realtime Display On

Figure 1. MW-64BR Ambient FEC and Temperature Log, **Note:** Bentonite plug @ 230' fouling all 4 sensors. Well screen was pressure washed with DI water and bentonite material removed from well.

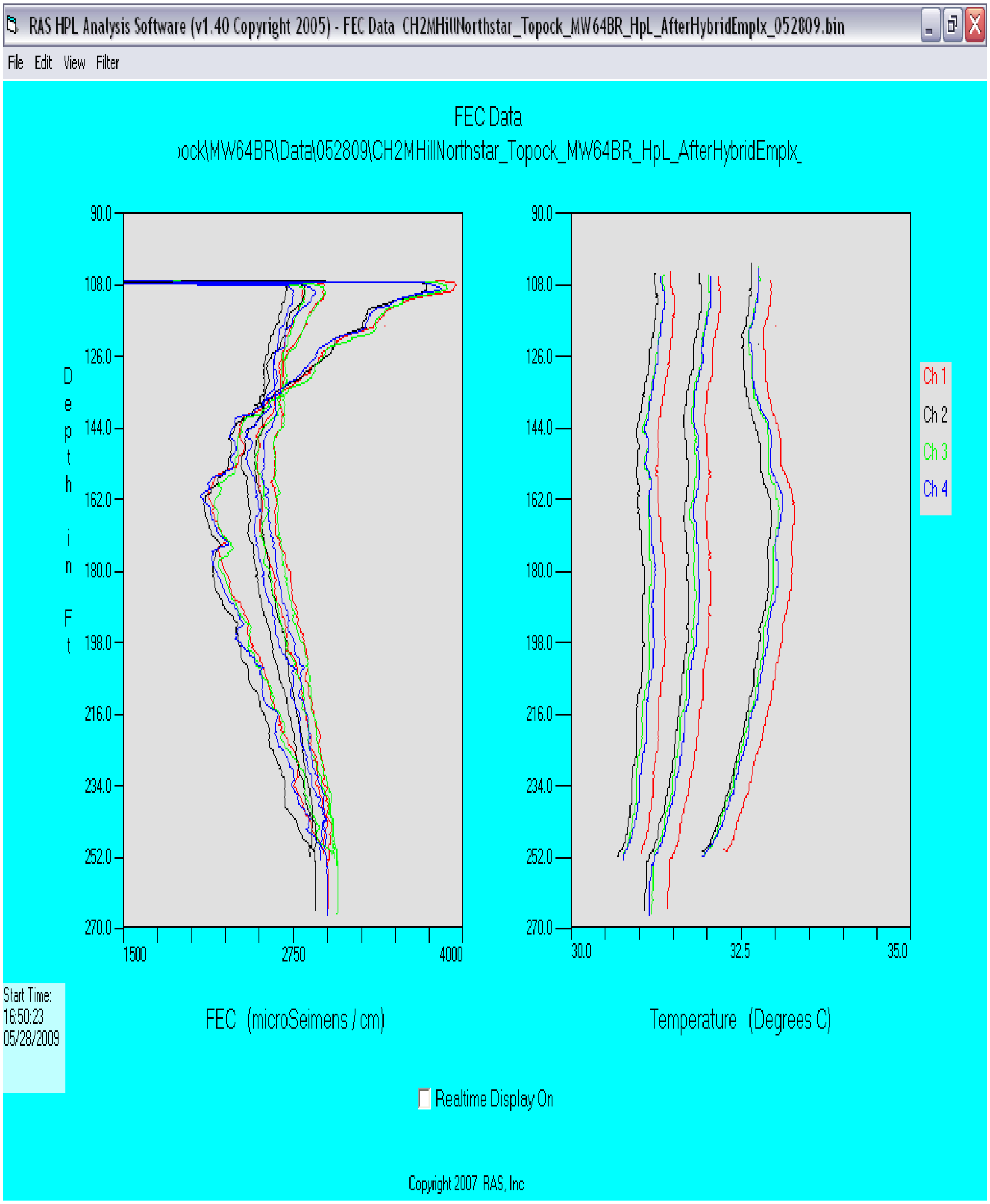
CH2MHill – NorthStar
PG&E Topock Compressor Station
Monitoring Well MW-64BR
HPL PROCESSING NOTES
ALL DEPTHS REFERENCED TO TOP OF PVC CASING



L_052809.da0
Start Time:
2:38:02 PM
5/28/2009
DTW Ref 111.8 ft

Figure 2. MW-64BR Pressure data – during pressure washing and pumping of well to clean out screen of bentonite material.

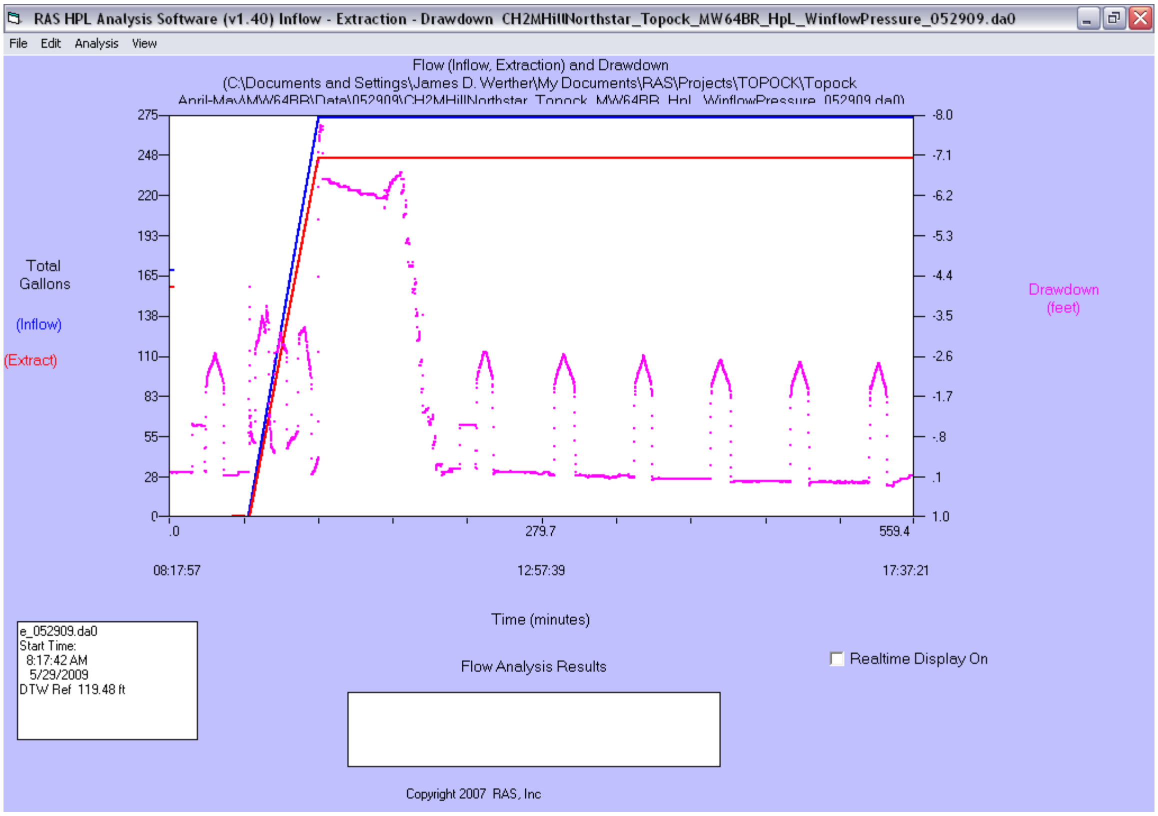
CH2MHill – NorthStar
PG&E Topock Compressor Station
Monitoring Well MW-64BR
HPL PROCESSING NOTES
ALL DEPTHS REFERENCED TO TOP OF PVC CASING



Start Time:
16:50:23
05/28/2009

☐ Realtime Display On

Figure 3. MW-64BR Post pressure washing of screen logs. Material previously fouling HPL tool sensors removed. Tool performed properly as demonstrated by these logs.



e_052909.da0
Start Time:
8:17:42 AM
5/29/2009
DTW Ref 119.48 ft

Figure 4. MW-64BR Flow and Pressure Data During Emplacement and Ambient Flow Characterization. Day 1 data.

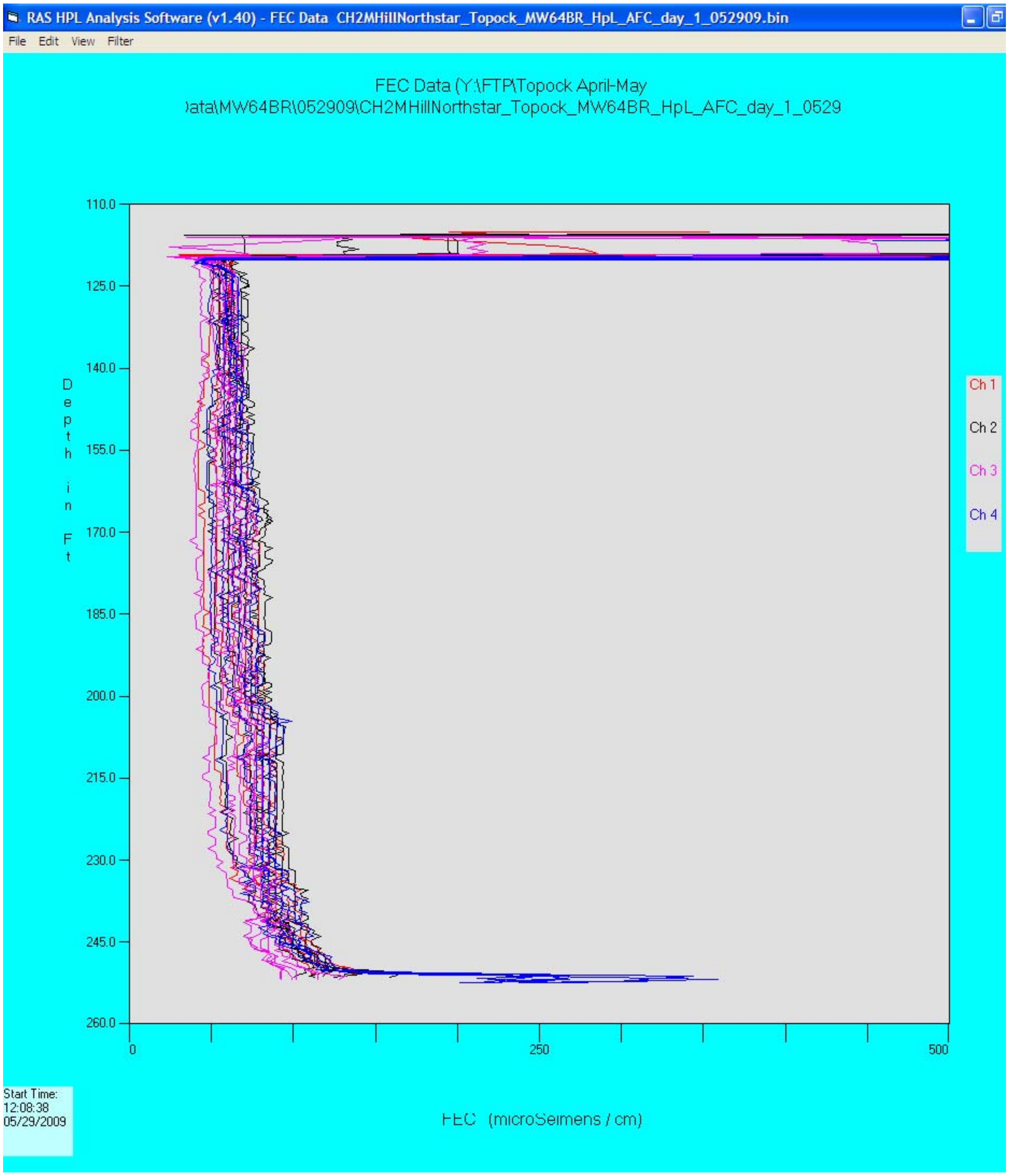
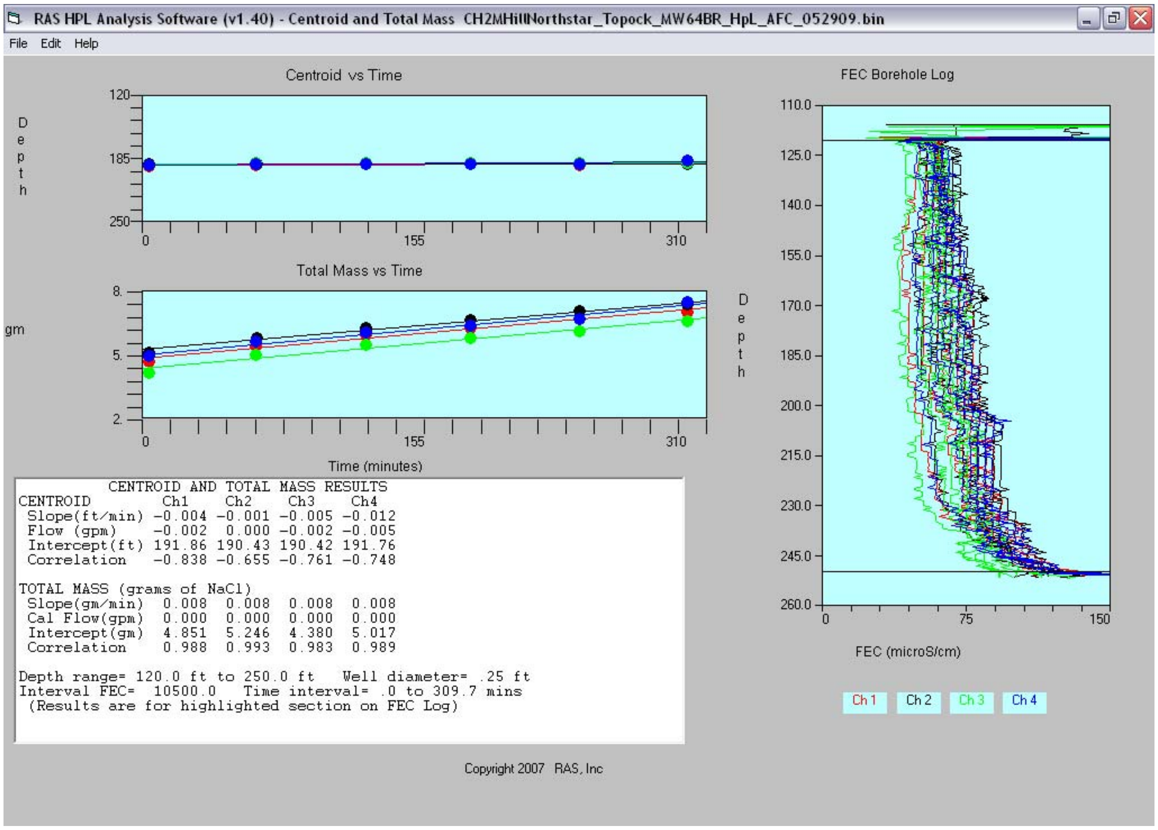


Figure 5. MW-64BR, Summary of Logs collected during Day 1 of Ambient Flow Characterization.



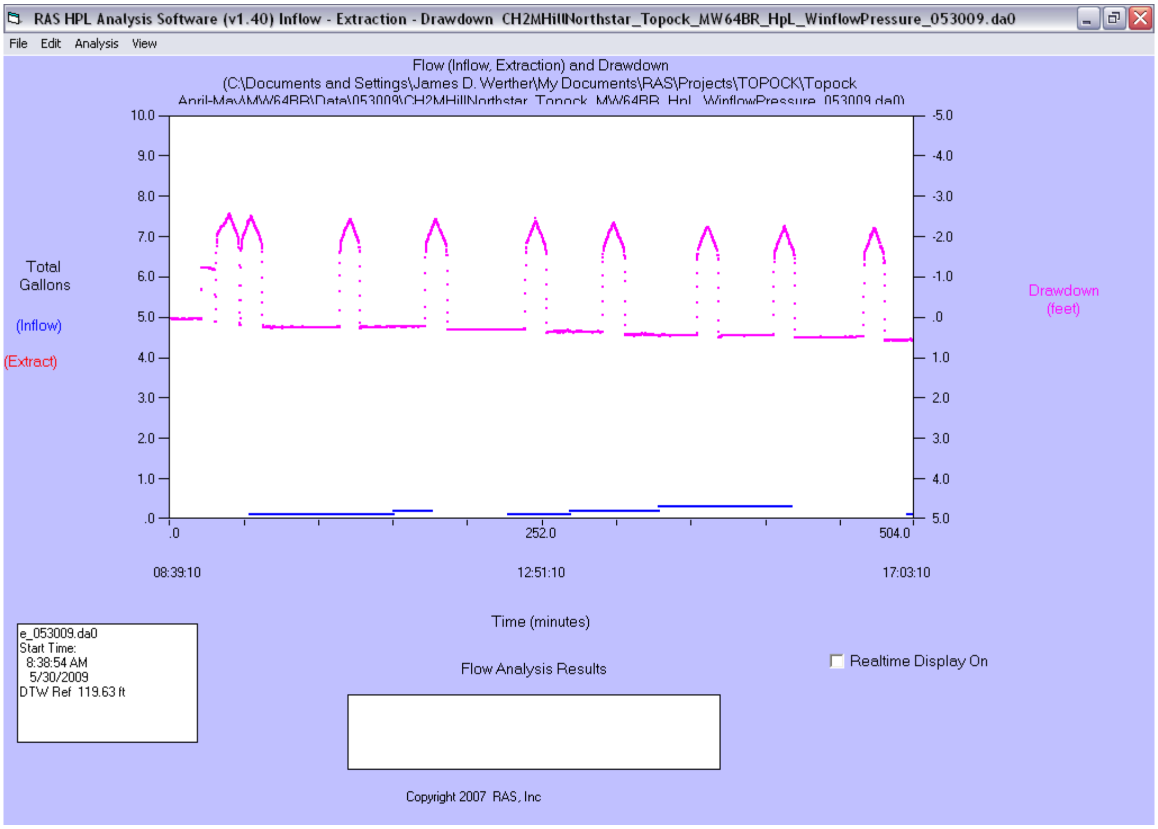
```
          CENTROID AND TOTAL MASS RESULTS
CENTROID         Ch1    Ch2    Ch3    Ch4
 Slope(ft/min) -0.004 -0.001 -0.005 -0.012
 Flow (gpm)    -0.002  0.000 -0.002 -0.005
 Intercept(ft) 191.86 190.43 190.42 191.76
 Correlation   -0.838 -0.655 -0.761 -0.748

TOTAL MASS (grams of NaCl)
 Slope(gm/min)  0.008  0.008  0.008  0.008
 Cal Flow(gpm)  0.000  0.000  0.000  0.000
 Intercept(gm)  4.851  5.246  4.380  5.017
 Correlation    0.988  0.993  0.983  0.989

Depth range= 120.0 ft to 250.0 ft   Well diameter= .25 ft
Interval FEC=  10500.0   Time interval= .0 to 309.7 mins
 (Results are for highlighted section on FEC Log)
```

Figure 6. MW-64BR Centroid & Total Mass Analysis – AFC Day 1- Data suggest flow was less than 0.001 gpm.

053009 – Ambient Flow Characterization Day 2


RAS HPL Analysis Software (v1.40) Inflow - Extraction - Drawdown CH2MHillNorthstar_Topock_MW64BR_HpL_WinflowPressure_053009.da0

Flow (Inflow, Extraction) and Drawdown
(C:\Documents and Settings\James D. Werther\My Documents\RAS\Projects\TOPOCK\Topock April-May\MW64BR\Data\053009\CH2MHillNorthstar_Topock_MW64BR_HpL_WinflowPressure_053009.da0)

e_053009.da0
Start Time:
8:38:54 AM
5/30/2009
DTW Ref 119.63 ft

Figure 7. MW-64BR Pressure history during Day 2 of Ambient Flow Characterization.

CH2MHill – NorthStar
PG&E Topock Compressor Station
Monitoring Well MW-64BR
HPL PROCESSING NOTES
ALL DEPTHS REFERENCED TO TOP OF PVC CASING

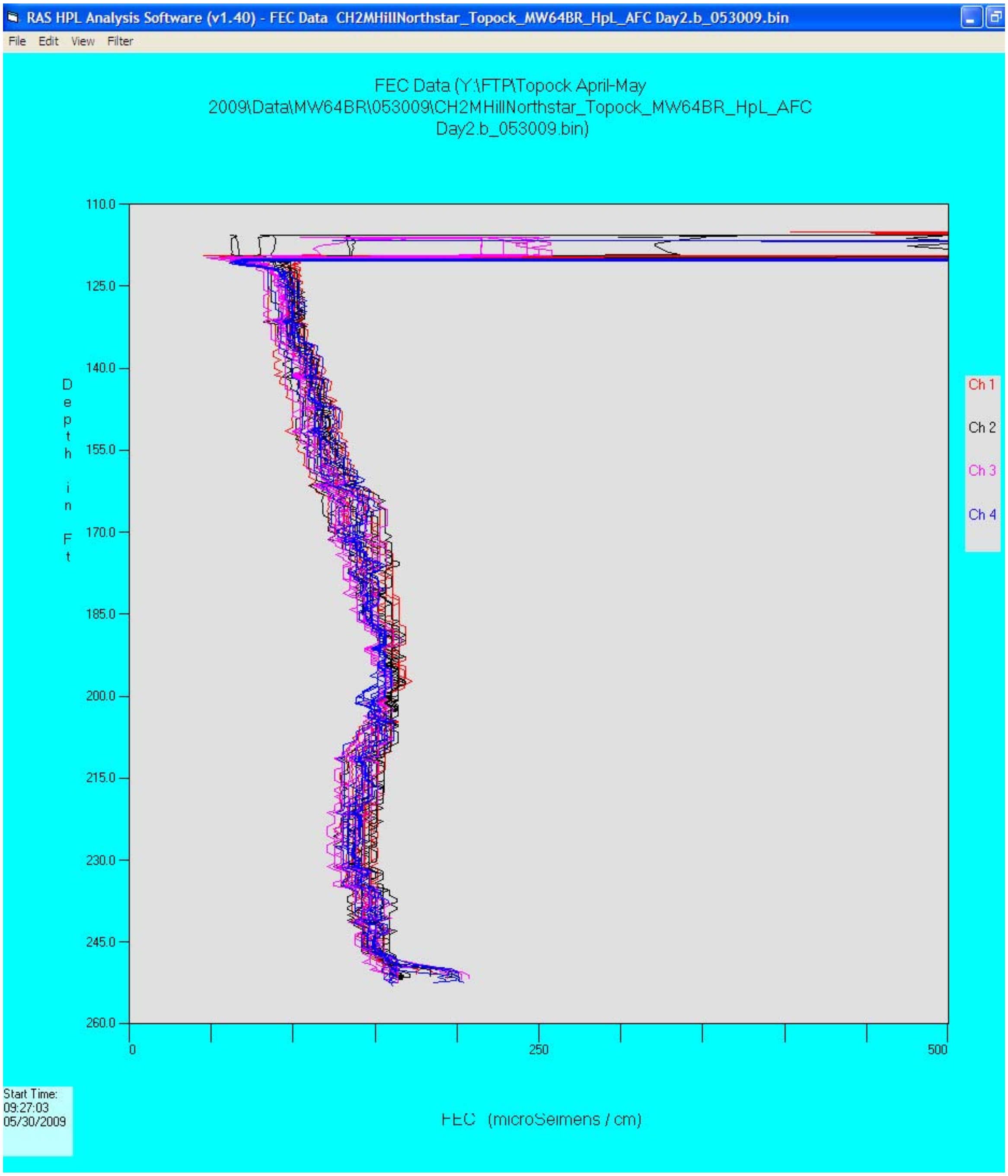


Figure 8. MW-64BR, Summary of Logs collected during Day 2 of AFC.

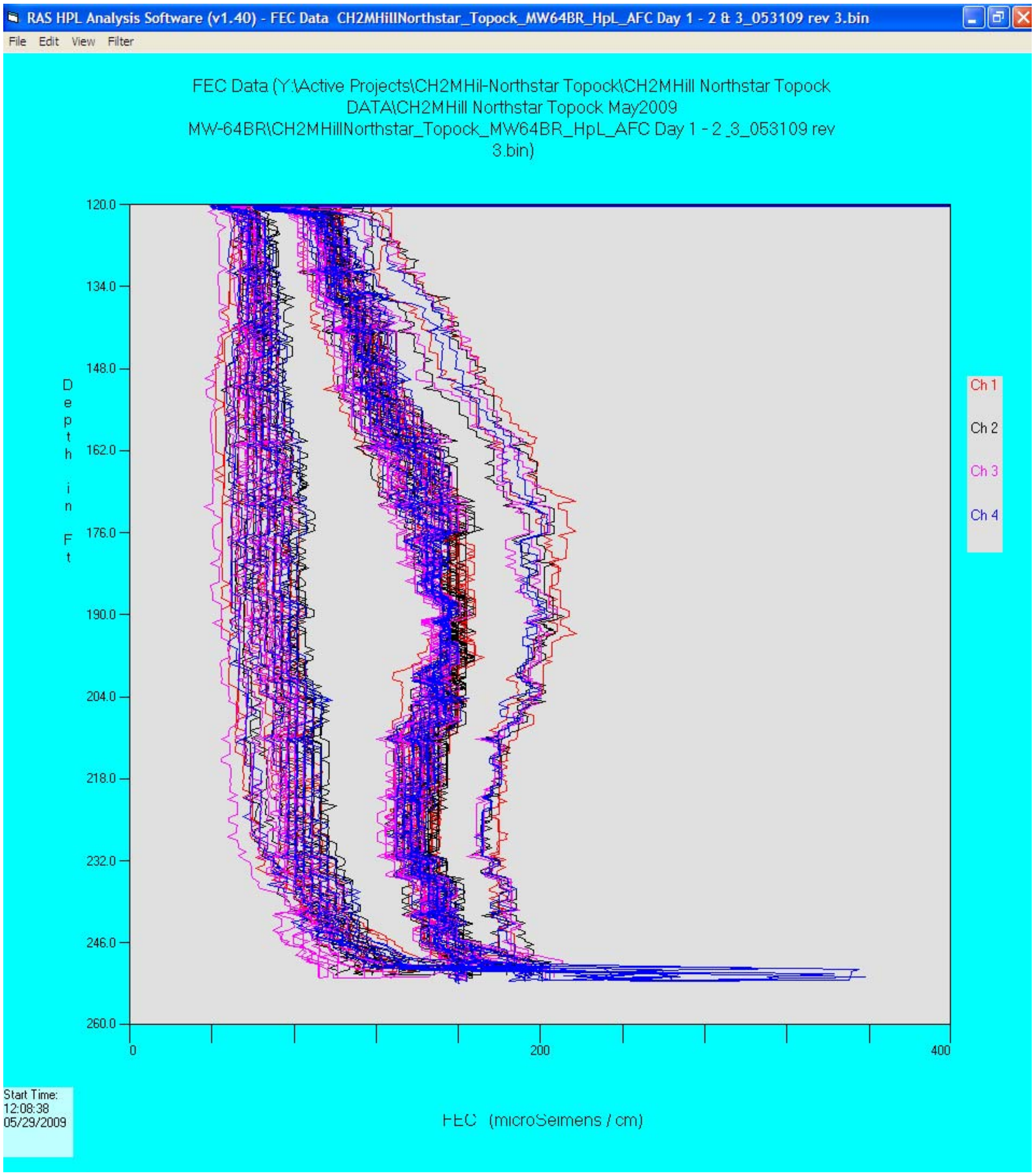
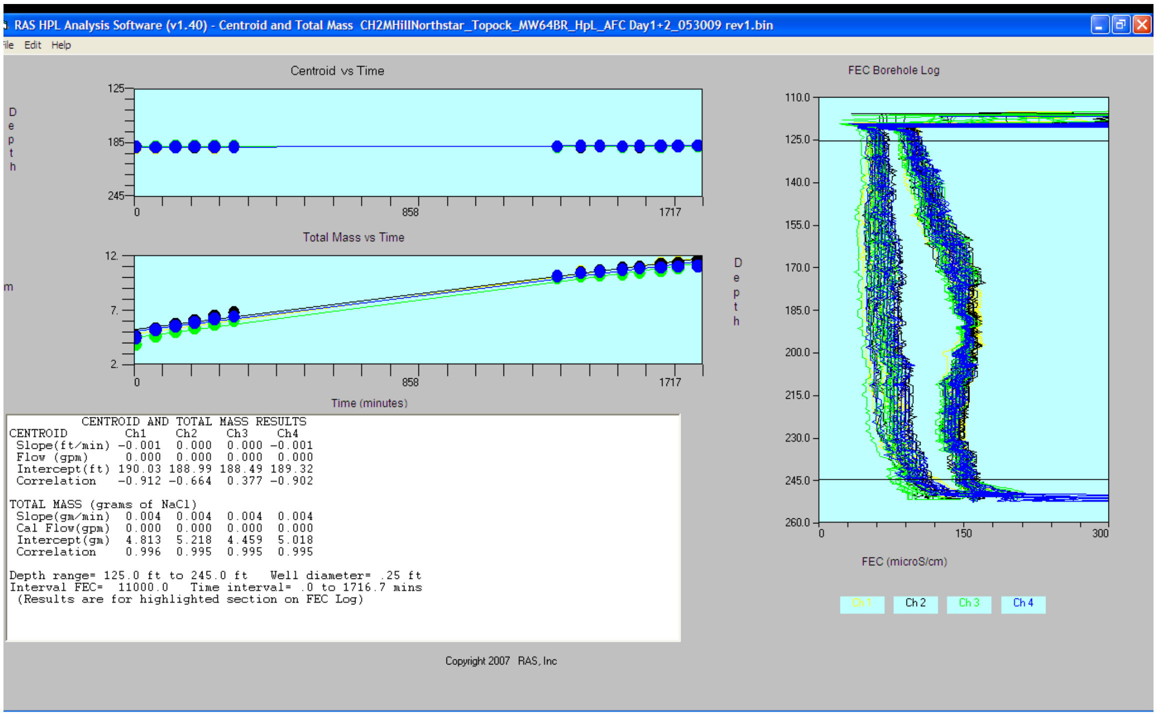


Figure 9. MW-64BR, AFC Days 1, 2 and 3 compiled for analysis.

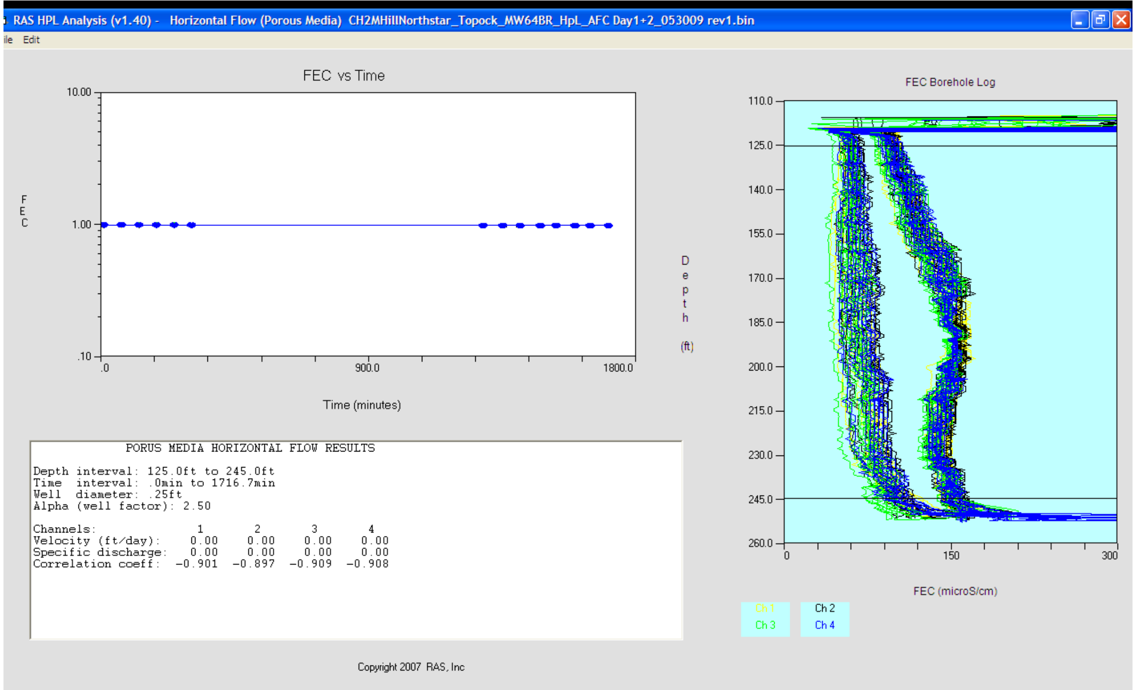


```
          CENTROID AND TOTAL MASS RESULTS
CENTROID        Ch1    Ch2    Ch3    Ch4
 Slope(ft/min) -0.001  0.000  0.000 -0.001
 Flow (gpm)     0.000  0.000  0.000  0.000
 Intercept(ft) 190.03 188.99 188.49 189.32
 Correlation   -0.912 -0.664  0.377 -0.902

TOTAL MASS (grams of NaCl)
 Slope(gm/min)  0.004  0.004  0.004  0.004
 Cal Flow(gpm)  0.000  0.000  0.000  0.000
 Intercept(gm)  4.813  5.218  4.459  5.018
 Correlation    0.996  0.995  0.995  0.995

Depth range= 125.0 ft to 245.0 ft   Well diameter= .25 ft
Interval FEC=  11000.0   Time interval= .0 to 1716.7 mins
 (Results are for highlighted section on FEC Log)
```

Figure 10. MW-64BR Integral and Centroid Analysis of HPL Data Collected on Day 1 and Day 2. Still below 0.001 gpm

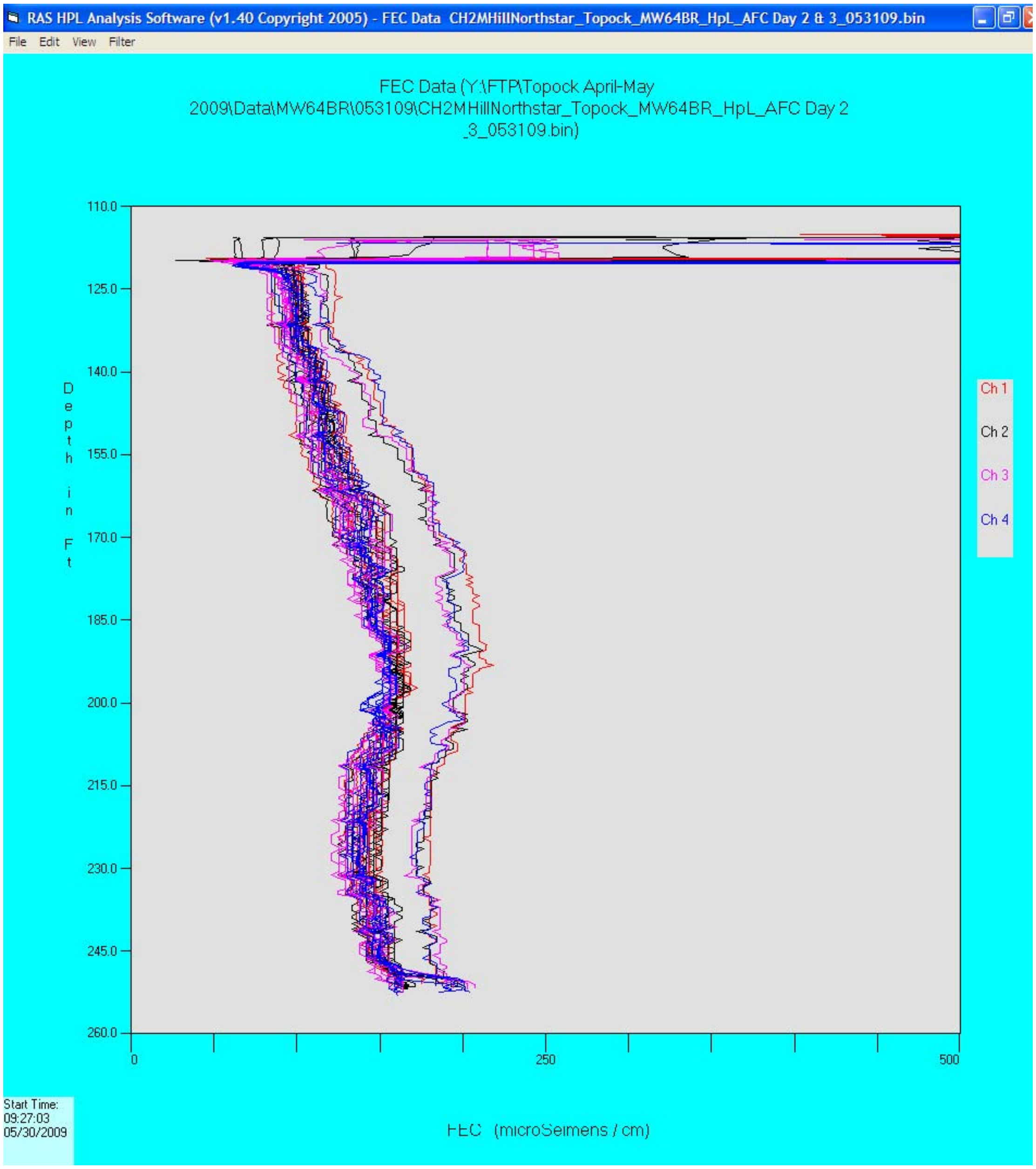


```
             PORUS MEDIA HORIZONTAL FLOW RESULTS

Depth interval: 125.0ft to 245.0ft
Time  interval: .0min to 1716.7min
Well  diameter: .25ft
Alpha (well factor): 2.50

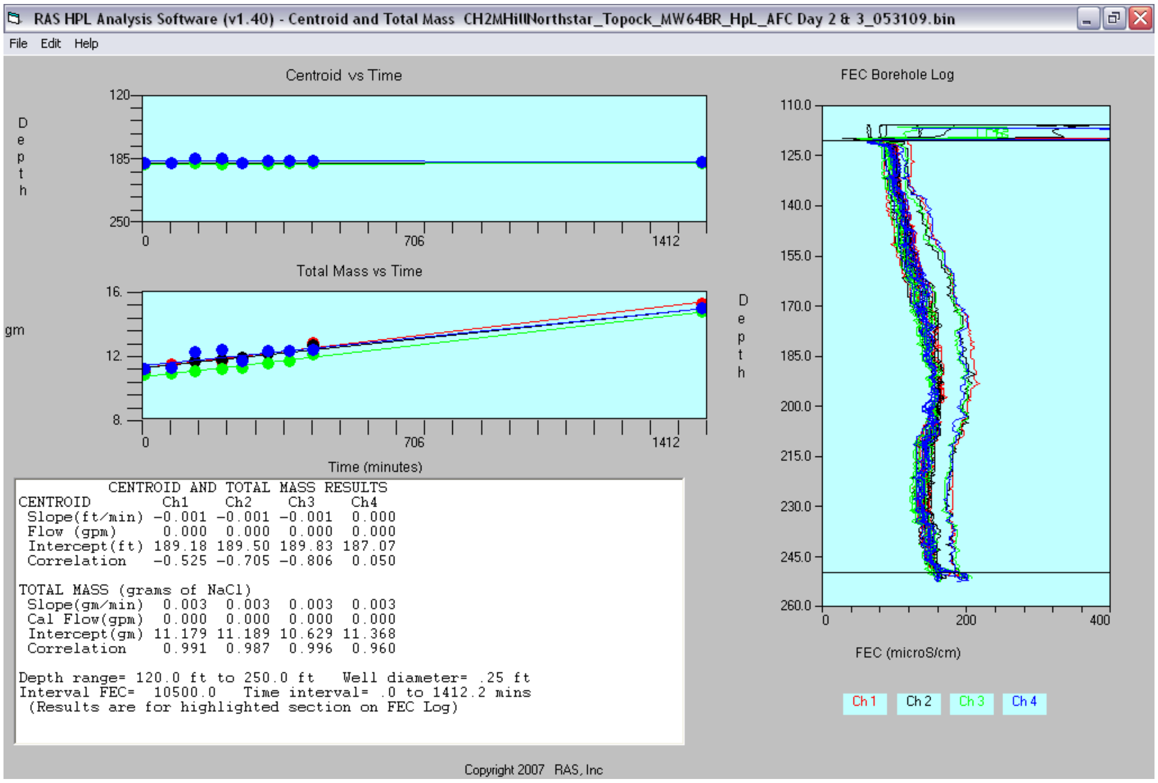
Channels:              1       2       3       4
Velocity (ft/day):    0.00    0.00    0.00    0.00
Specific discharge:   0.00    0.00    0.00    0.00
Correlation coeff:  -0.901  -0.897  -0.909  -0.908
```

Figure 11. MW-64BR, Traditional Dilution Analysis of HPL Data Collected on Day 1 and Day 2. Flow velocity less than 0.01 feet per day.



Start Time:
09:27:03
05/30/2009

Figure 12. MW-64BR, Summary of Logs from Day 2 and single log collected in AM of Day 3.

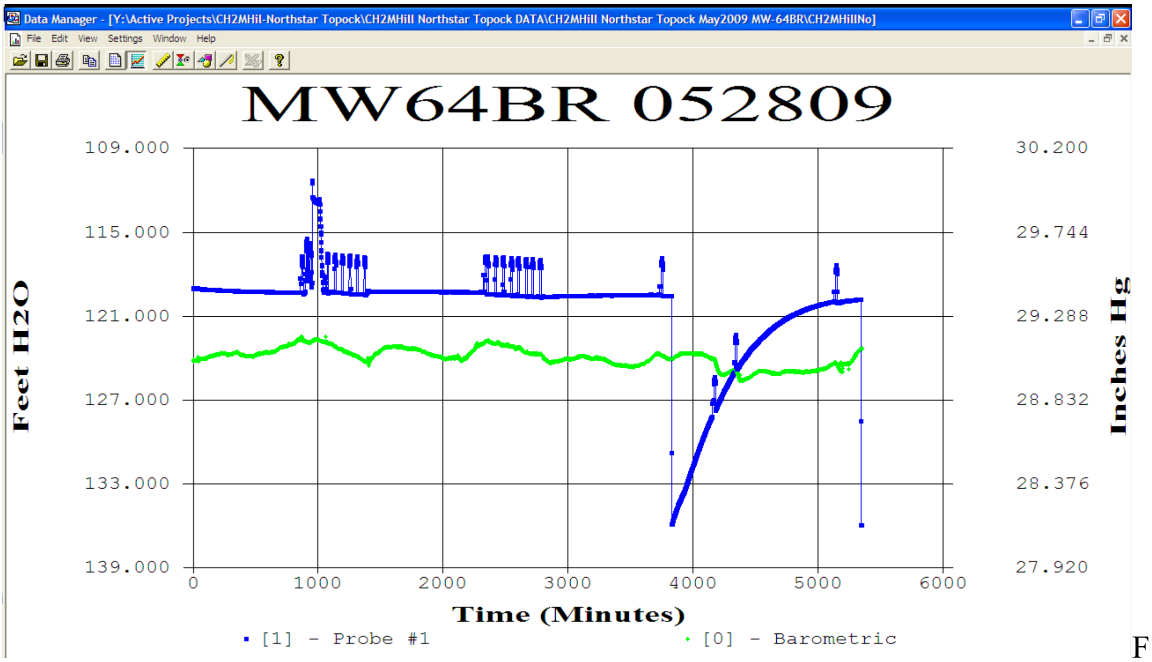


```
          CENTROID AND TOTAL MASS RESULTS
CENTROID        Ch1    Ch2    Ch3    Ch4
 Slope(ft/min) -0.001 -0.001 -0.001  0.000
 Flow (gpm)     0.000  0.000  0.000  0.000
 Intercept(ft) 189.18 189.50 189.83 187.07
 Correlation   -0.525 -0.705 -0.806  0.050

TOTAL MASS (grams of NaCl)
 Slope(gm/min)  0.003  0.003  0.003  0.003
 Cal Flow(gpm)  0.000  0.000  0.000  0.000
 Intercept(gm) 11.179 11.189 10.629 11.368
 Correlation    0.991  0.987  0.996  0.960

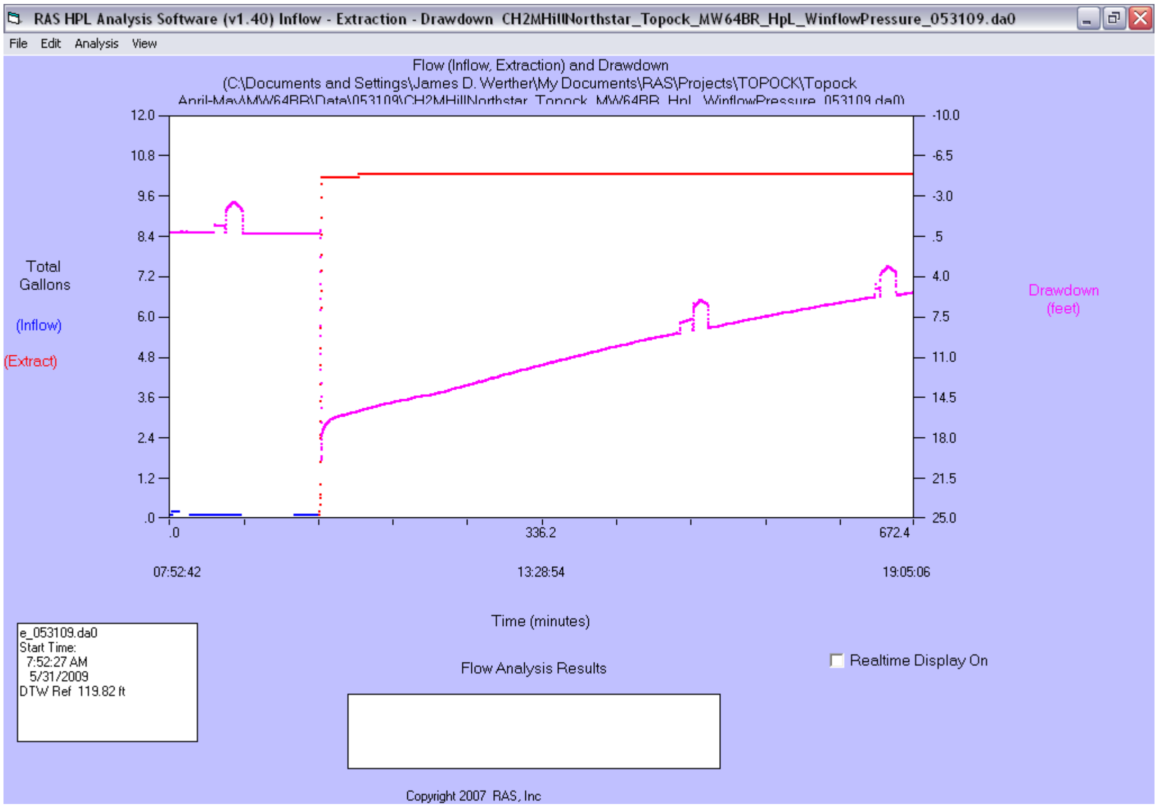
Depth range= 120.0 ft to 250.0 ft   Well diameter= .25 ft
Interval FEC=  10500.0   Time interval= .0 to 1412.2 mins
 (Results are for highlighted section on FEC Log)
```

Figure 13. MW-64BR Centroid & Total Mass Analysis - AFC Day 2 & 3 - Data suggest flow was less than 0.001 gpm.



F

Figure 14. MW-64BR Complete Pressure History During HPL Testing, T = 0 @ 5/28/09 20:18 hours. Pressure monitoring completed at 6/1/09 13:34 hours. AFC logging noted by series of pressure spikes. Slug test and recover at ~ 3800 minutes.



e_053109.da0
Start Time:
7:52:27 AM
5/31/2009
DTW Ref 119.82 ft

Figure 15. MW-64BR. Pressure history during Slug Test After Emplacement Procedures (SAE)

Volumetric Average Flowrate Calculations (average inflow rate from rising head data and casing diameter)

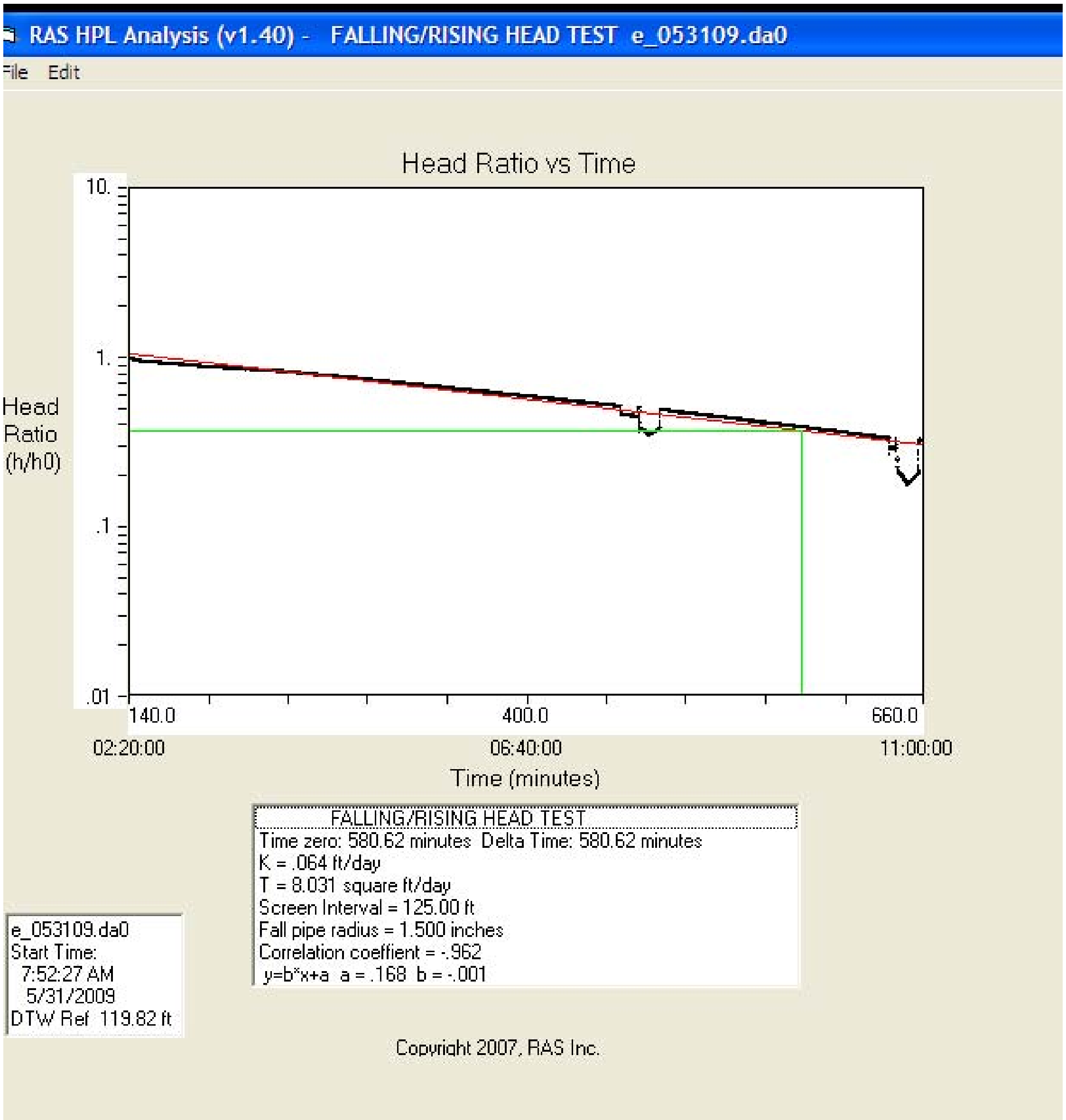
T1 = 153 min @ 16.1 feet

T2 = 639 min @ 5.6 feet

dT = 486 minutes
dDD = 10.5 feet

In 3 inch well, 1 foot = 0.367 gallons

Therefore,
(10.5*0.367)/486 mins = 0.008 gpm



FALLING/RISING HEAD TEST
Time zero: 580.62 minutes Delta Time: 580.62 minutes
K = .064 ft/day
T = 8.031 square ft/day
Screen Interval = 125.00 ft
Fall pipe radius = 1.500 inches
Correlation coeffient = -.962
y=b*x+a a = .168 b = -.001

e_053109.da0
Start Time:
7:52:27 AM
5/31/2009
DTW Ref 119.82 ft

Copyright 2007, RAS Inc.

Figure 16. MW-64BR. Rising Head Test Analysis

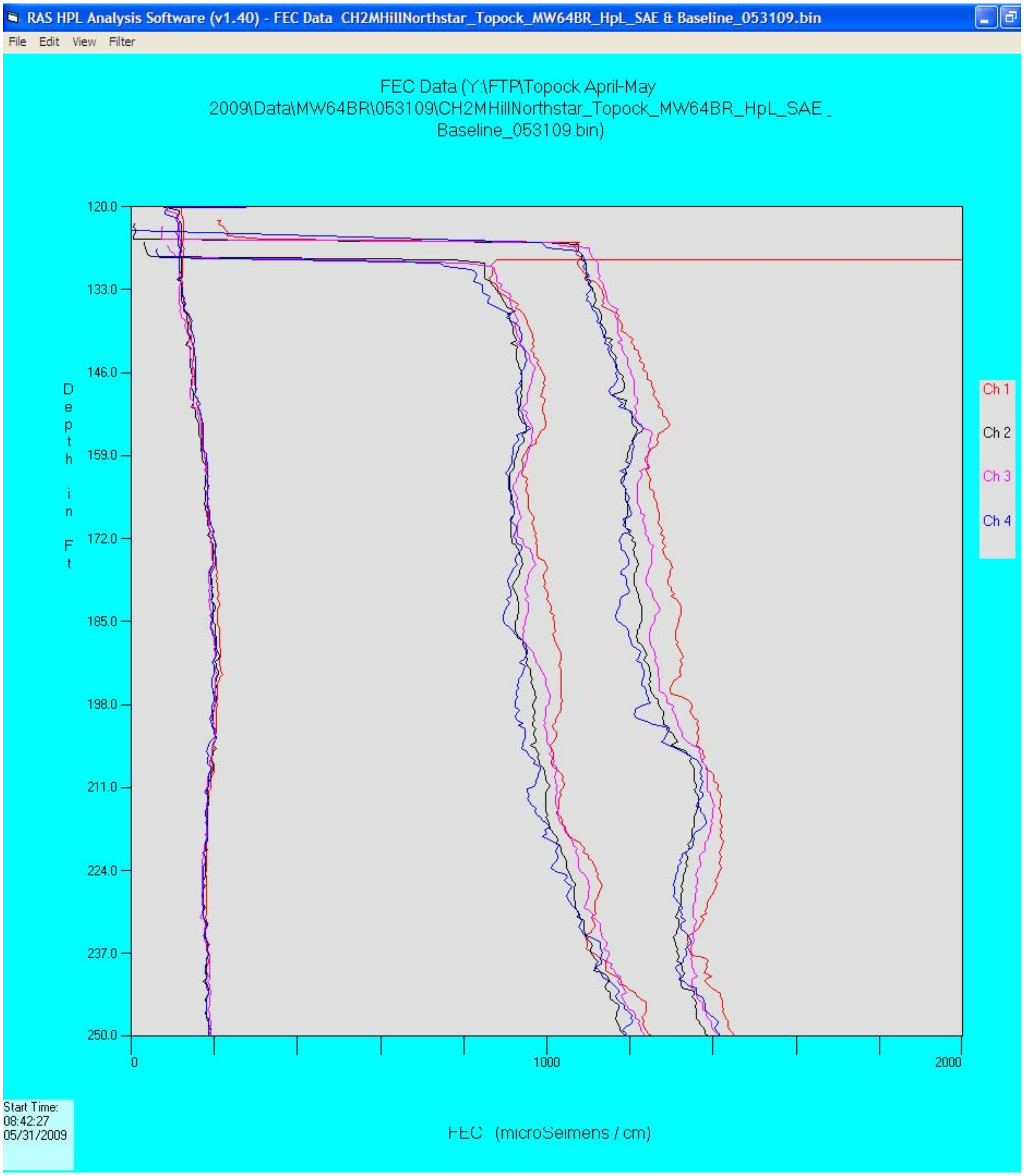
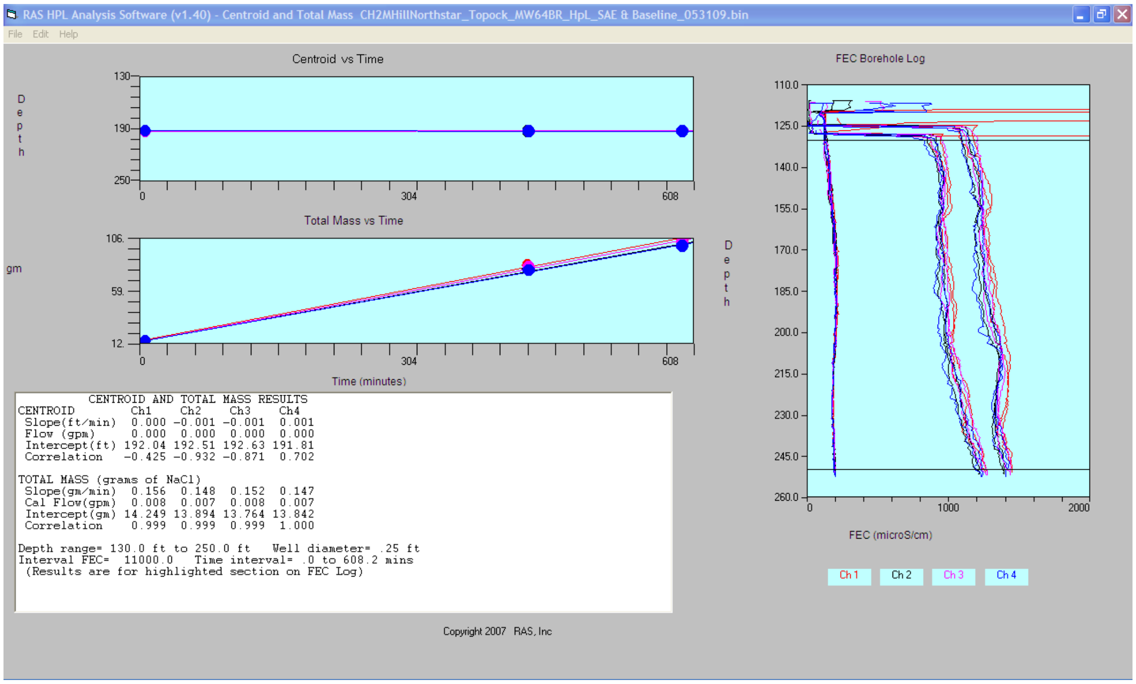


Figure 17. MW-64BR. Summary of Logs collected during SAE test. 16 foot slug removed.



```
          CENTROID AND TOTAL MASS RESULTS
CENTROID          Ch1    Ch2    Ch3    Ch4
 Slope(ft/min)   0.000 -0.001 -0.001  0.001
 Flow (gpm)      0.000  0.000  0.000  0.000
 Intercept(ft) 192.04 192.51 192.63 191.81
 Correlation    -0.425 -0.932 -0.871  0.702

TOTAL MASS (grams of NaCl)
 Slope(gm/min)   0.156  0.148  0.152  0.147
 Cal Flow(gpm)   0.008  0.007  0.008  0.007
 Intercept(gm) 14.249 13.894 13.764 13.842
 Correlation     0.999  0.999  0.999  1.000

Depth range= 130.0 ft to 250.0 ft   Well diameter= .25 ft
Interval FEC=  11000.0   Time interval= .0 to 608.2 mins
 (Results are for highlighted section on FEC Log)
```

Figure 18. MW-64BR Centroid Total Mass Analysis – Total Formation Production 0.008 gpm and compares very favorably with average formation flow calculated volumetrically from rising head data (above).

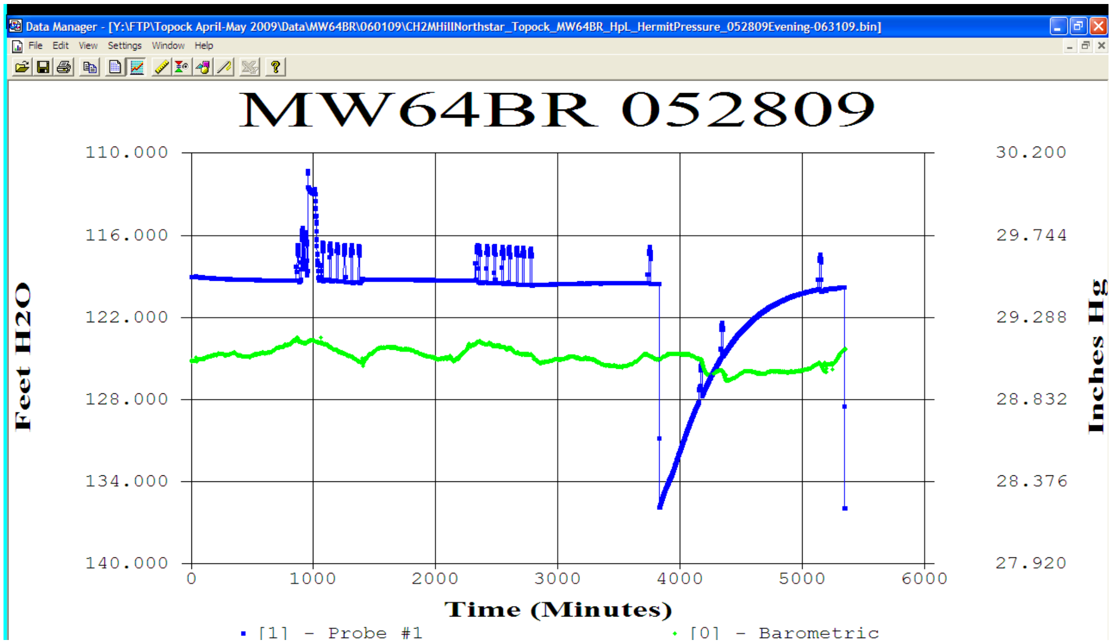
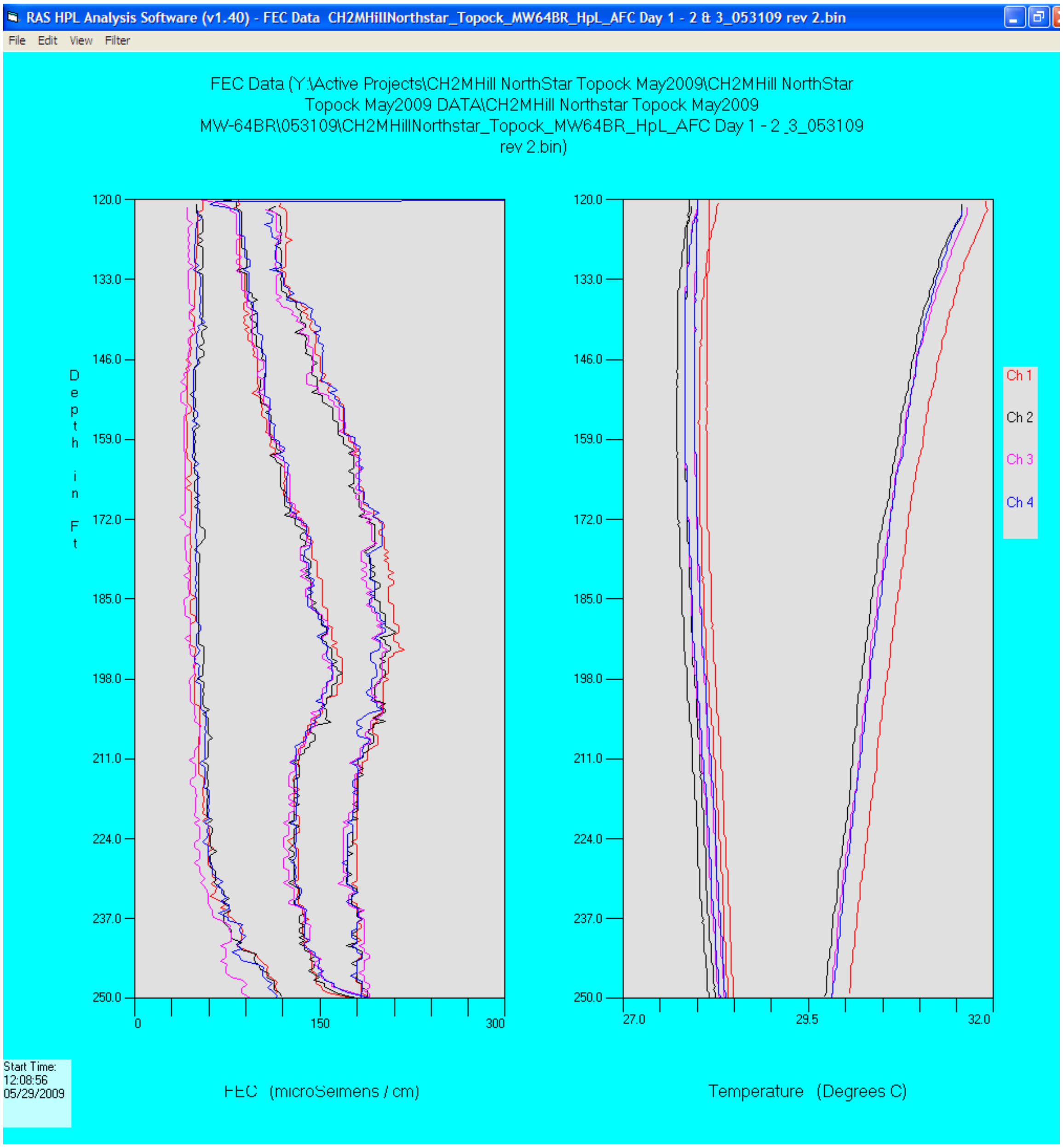


Figure 19. MW-64BR Topock MW-64BR complete pressure history. Start 5-28-09 @20:18 hours, end 6-01-09 13:34 hours.

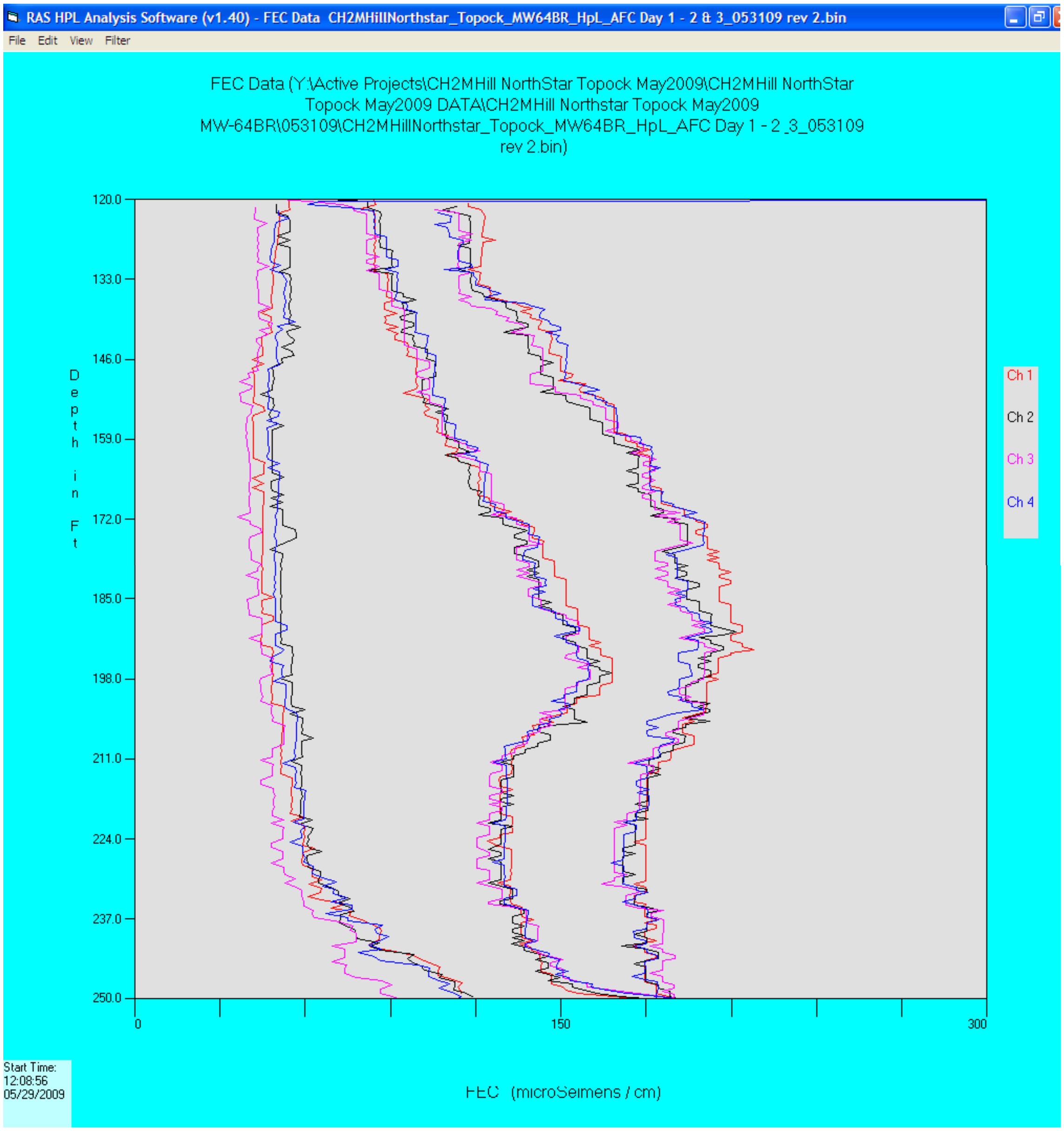


RAS HPL Analysis Software (v1.40) - FEC Data CH2MHillNorthstar_Topock_MW64BR_HpL_AFC Day 1 - 2 & 3_053109 rev 2.bin

FEC Data (Y:\Active Projects\CH2MHill NorthStar Topock May2009\CH2MHill NorthStar Topock May2009 DATA\CH2MHill Northstar Topock May2009 MW-64BR\053109\CH2MHillNorthstar_Topock_MW64BR_HpL_AFC Day 1 - 2 3_053109 rev 2.bin)

Start Time:
12:08:56
05/29/2009

Figure 20.MW-64BR Summary of Single Daily AFC Logs. Single log collect at beginning of each day. Day 1 left, Day 2 center and Day 3 on right. 4 channel FEC and Temperature data presented.

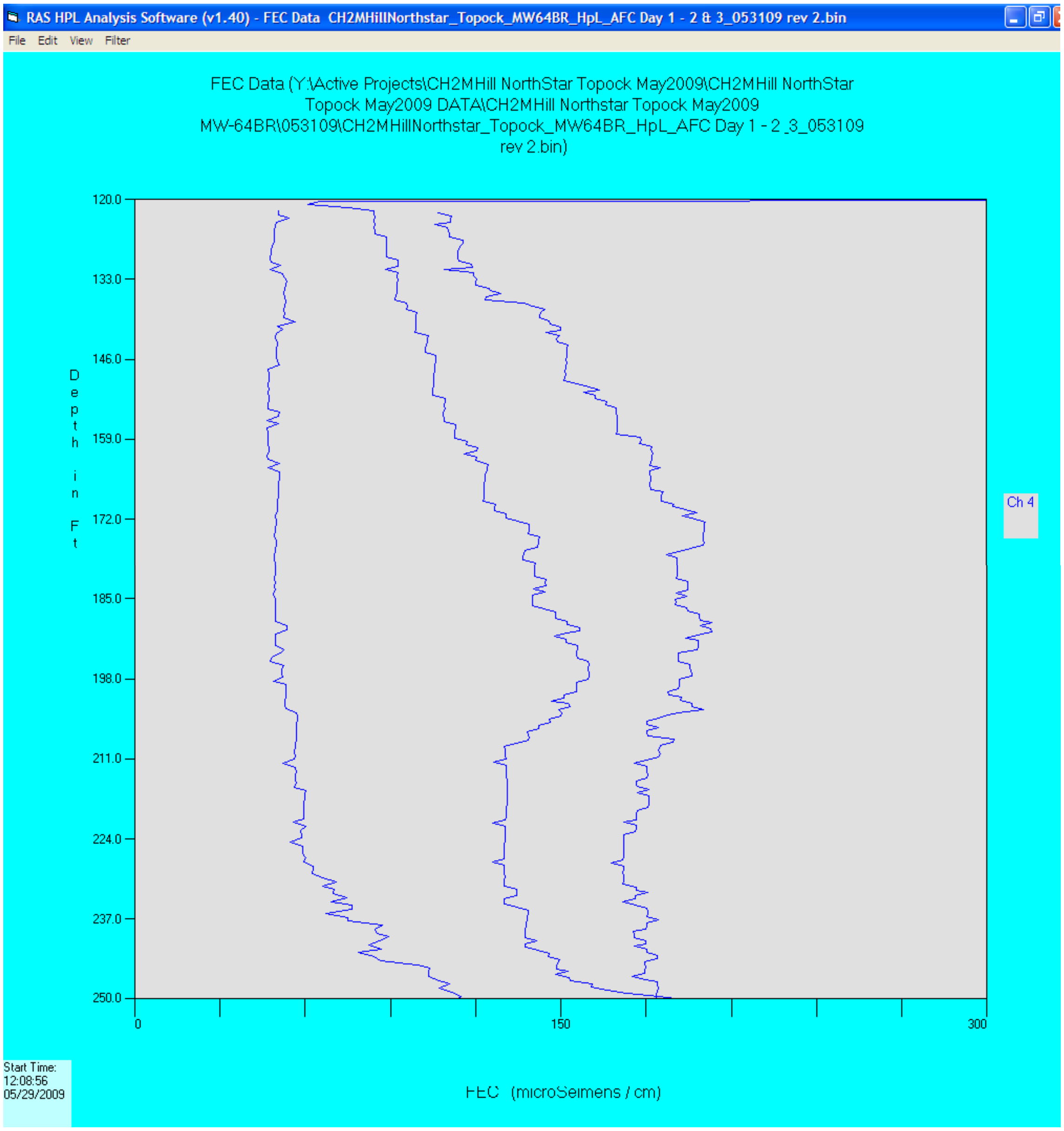


RAS HPL Analysis Software (v1.40) - FEC Data CH2MHillNorthstar_Topock_MW64BR_HpL_AFC Day 1 - 2 & 3_053109 rev 2.bin

FEC Data (Y:\Active Projects\CH2MHill NorthStar Topock May2009\CH2MHill NorthStar Topock May2009 DATA\CH2MHill Northstar Topock May2009 MW-64BR\053109\CH2MHillNorthstar_Topock_MW64BR_HpL_AFC Day 1 - 2_3_053109 rev 2.bin)

Start Time:
12:08:56
05/29/2009

Figure 21. MW-64BR Summary of Single Daily AFC Logs. Single log collect at beginning of each day. Day 1 left, Day 2 center and Day 3 on right. 4 channel FEC presented.



RAS HPL Analysis Software (v1.40) - FEC Data CH2MHillNorthstar_Topock_MW64BR_HpL_AFC Day 1 - 2 & 3_053109 rev 2.bin

FEC Data (Y:\Active Projects\CH2MHill NorthStar Topock May2009\CH2MHill NorthStar Topock May2009 DATA\CH2MHill Northstar Topock May2009 MW-64BR\053109\CH2MHillNorthstar_Topock_MW64BR_HpL_AFC Day 1 - 2_3_053109 rev 2.bin)

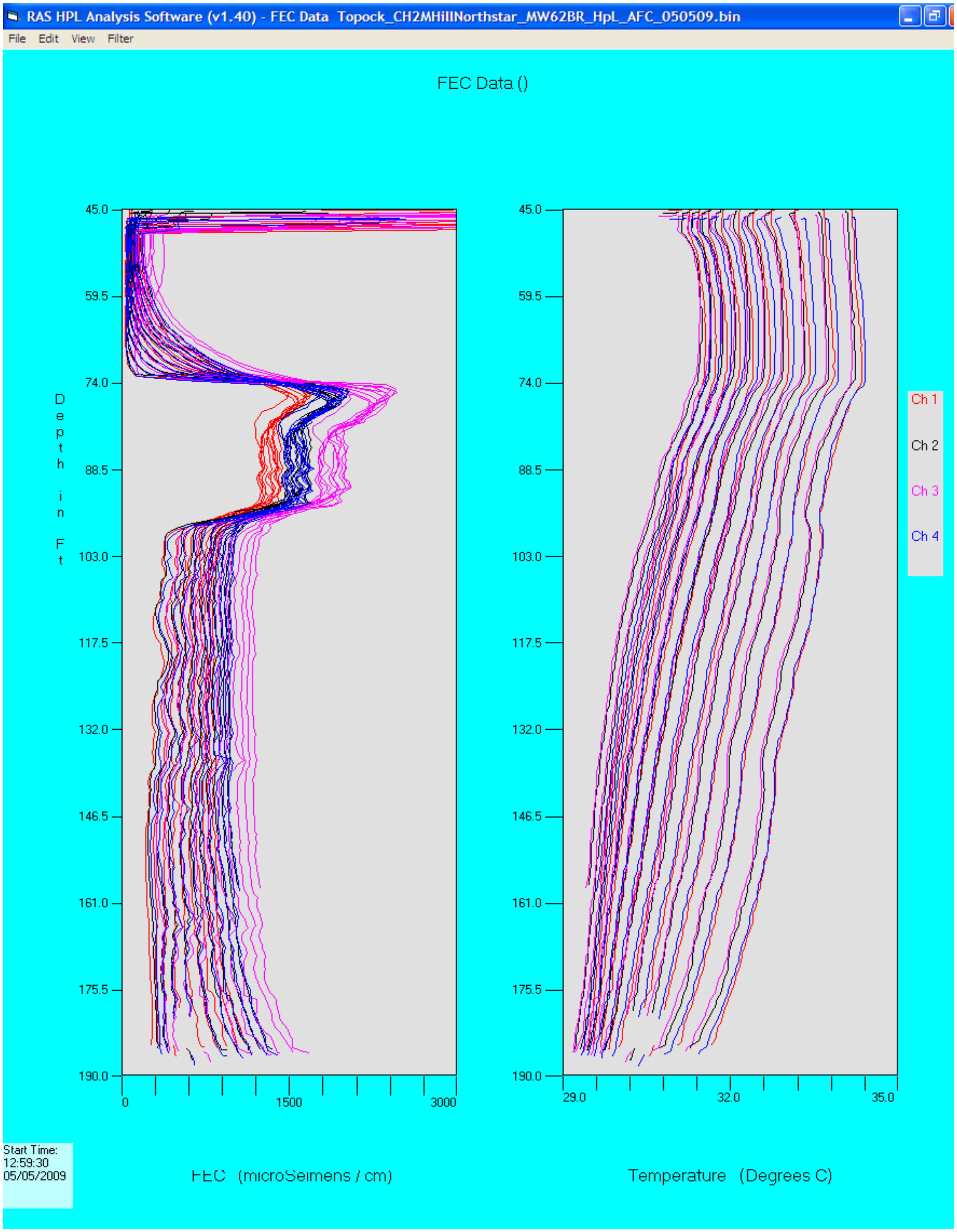
Start Time:
12:08:56
05/29/2009

Figure 22. MW-64BR Summary of Single Daily AFC Logs. Single log collect at beginning of each day. Day 1 left, Day 2 center and Day 3 on right. Single channel (no. 4 bottommost) FEC presented.

Summary of Preliminary HPL Results Conductive Feature (CF) Depths						
			Ambient Conditions Interval Specific Flow Rate	**Pumping Conditions Interval Specific Flow Rate**	**Interval Specific Concen-tration**	**Interval Specific Hydraulic Conductivity**
	Depth (ft)		gpm (US)	gpm (US)	µS/cm	ft/day
CF	top	Bottom				
1	120	253	<0.001	0.008	11,000	6.4E-2
	Sum of Interval Specific Flowrates			0.008		
	Total observed from rising head			0.008		

Table 1. CH2MHill Topock Well MW-64BR, Summary of Results, Ambient Flow Characterization and Slug After Emplacement Tests.

CH2MHill – NorthStar
PG&E Topock Compressor Station
Monitoring Well MW-62BR
HPL PROCESSING NOTES
ALL DEPTHS REFERENCED TO TOP OF PVC CASING



Start Time:
12:59:30
05/05/2009

Figure 2. MW-62BR, Summary of Logs During Ambient Flow Characterization prior to pressure stabilization. Data not used in flow calculations.

CH2MHill – NorthStar
PG&E Topock Compressor Station
Monitoring Well MW-62BR
HPL PROCESSING NOTES
ALL DEPTHS REFERENCED TO TOP OF PVC CASING

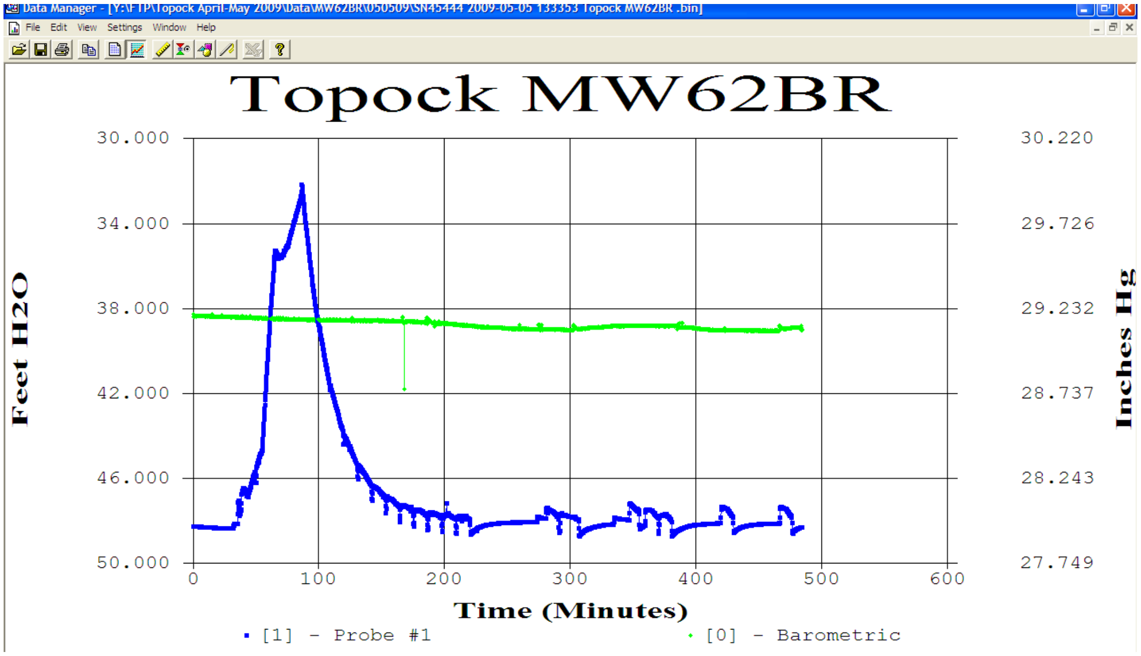


Figure 3. MW-62BR, pressure monitoring T=0 @ 5/5/09 13:34 hours, end of file at 21:38 of same day

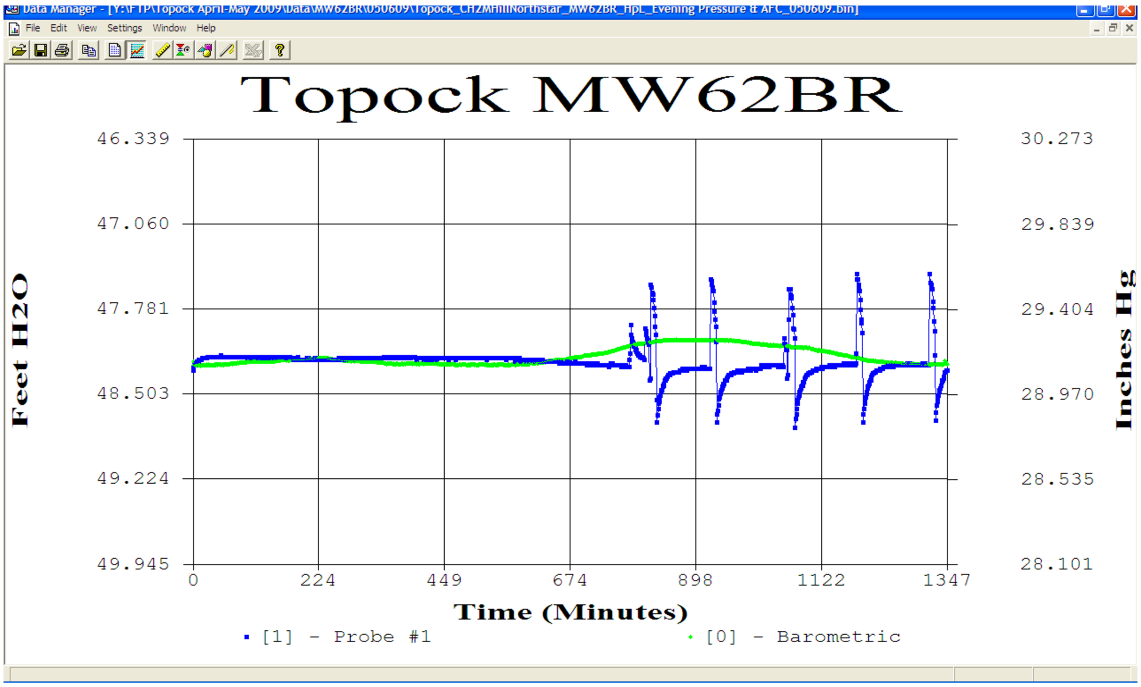


Figure 4. MW-62BR pressure monitoring T=0 @ 5/5/09 21:47 hours (Day 1 overnight and all of day 2 pressure)

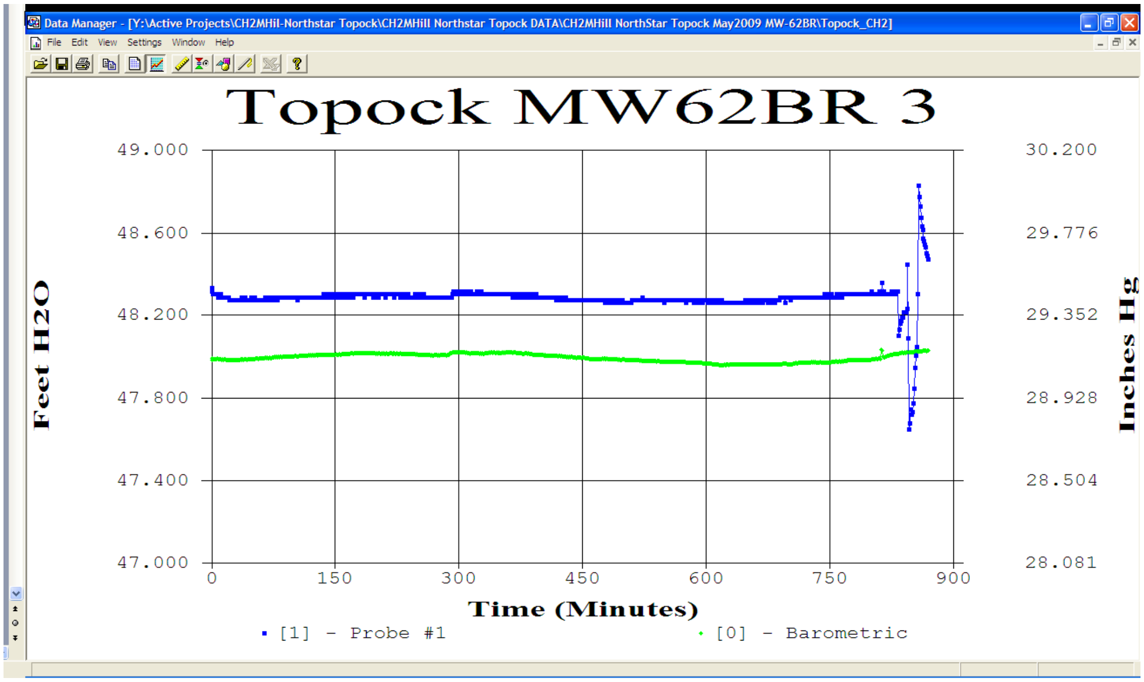


Figure 5. MW-62BR pressure monitoring T=0 @ 5/6/09 20:21 hours (Day 2 overnight and last log of day 3).

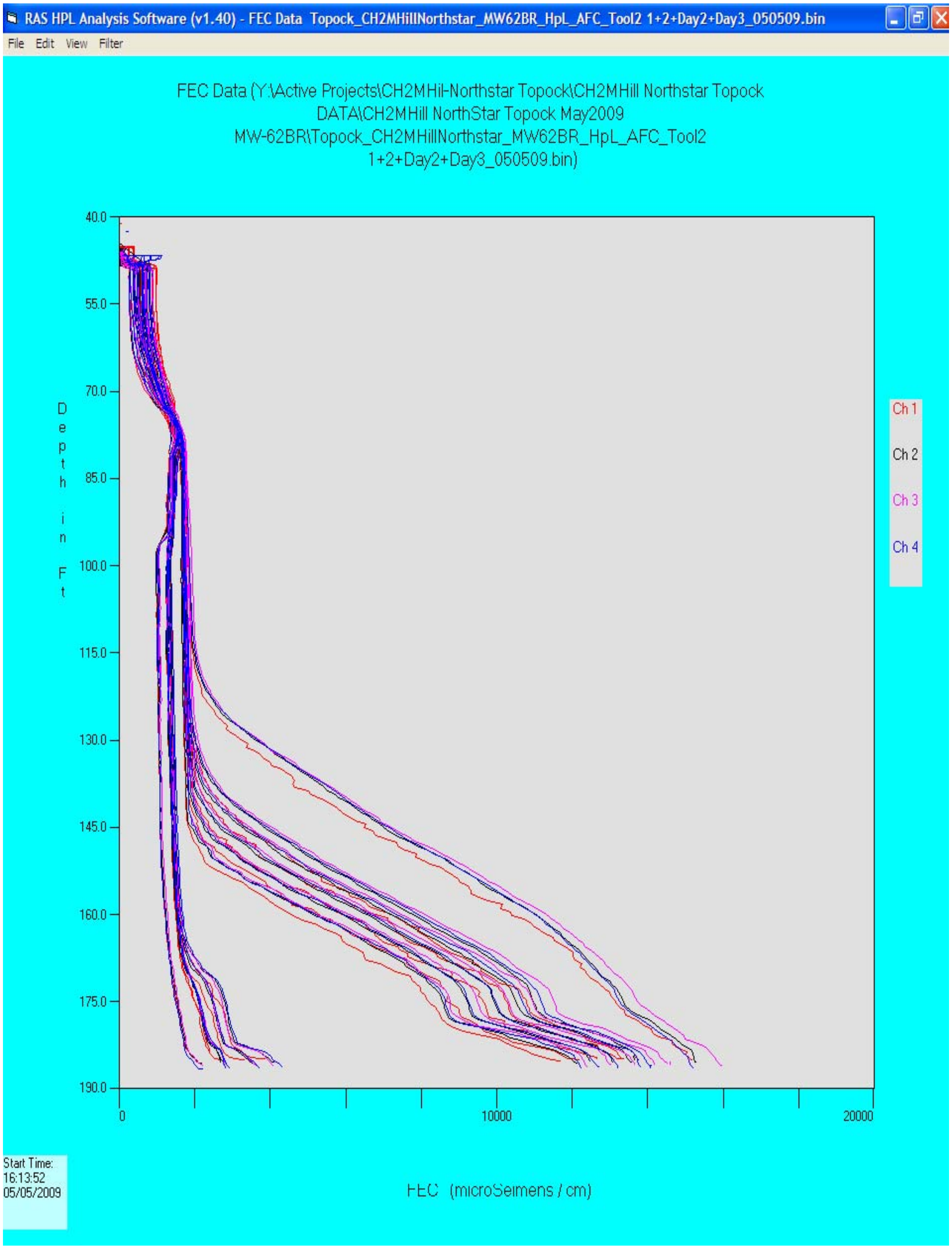
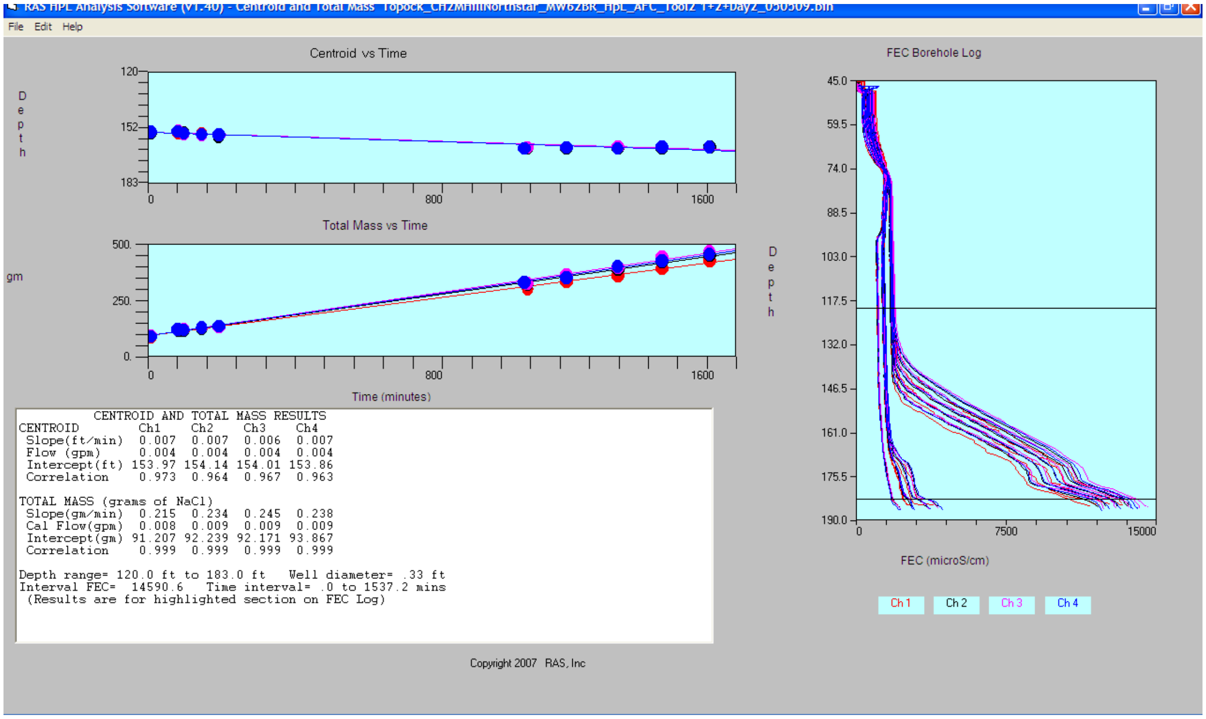


Figure 6. MW-62BR Sumary of FEC logs for AFC. Day 1, Day 2 and morning log only of Day 3 combined. All logs collected during stable pressure conditions.



```
          CENTROID AND TOTAL MASS RESULTS
CENTROID         Ch1    Ch2    Ch3    Ch4
 Slope(ft/min)  0.007  0.007  0.006  0.007
 Flow (gpm)     0.004  0.004  0.004  0.004
 Intercept(ft) 153.97 154.14 154.01 153.86
 Correlation    0.973  0.964  0.967  0.963

TOTAL MASS (grams of NaCl)
 Slope(gm/min)  0.215  0.234  0.245  0.238
 Cal Flow(gpm)  0.008  0.009  0.009  0.009
 Intercept(gm) 91.207 92.239 92.171 93.867
 Correlation    0.999  0.999  0.999  0.999

Depth range= 120.0 ft to 183.0 ft   Well diameter= .33 ft
Interval FEC=  14590.6   Time interval= .0 to 1537.2 mins
 (Results are for highlighted section on FEC Log)
```

Figure 7. MW-62BR, Integral and Centroid Analysis, Ambient Flow Characterization, Day 1 and 2 compiled.

CH2MHill – NorthStar
PG&E Topock Compressor Station
Monitoring Well MW-62BR
HPL PROCESSING NOTES
ALL DEPTHS REFERENCED TO TOP OF PVC CASING

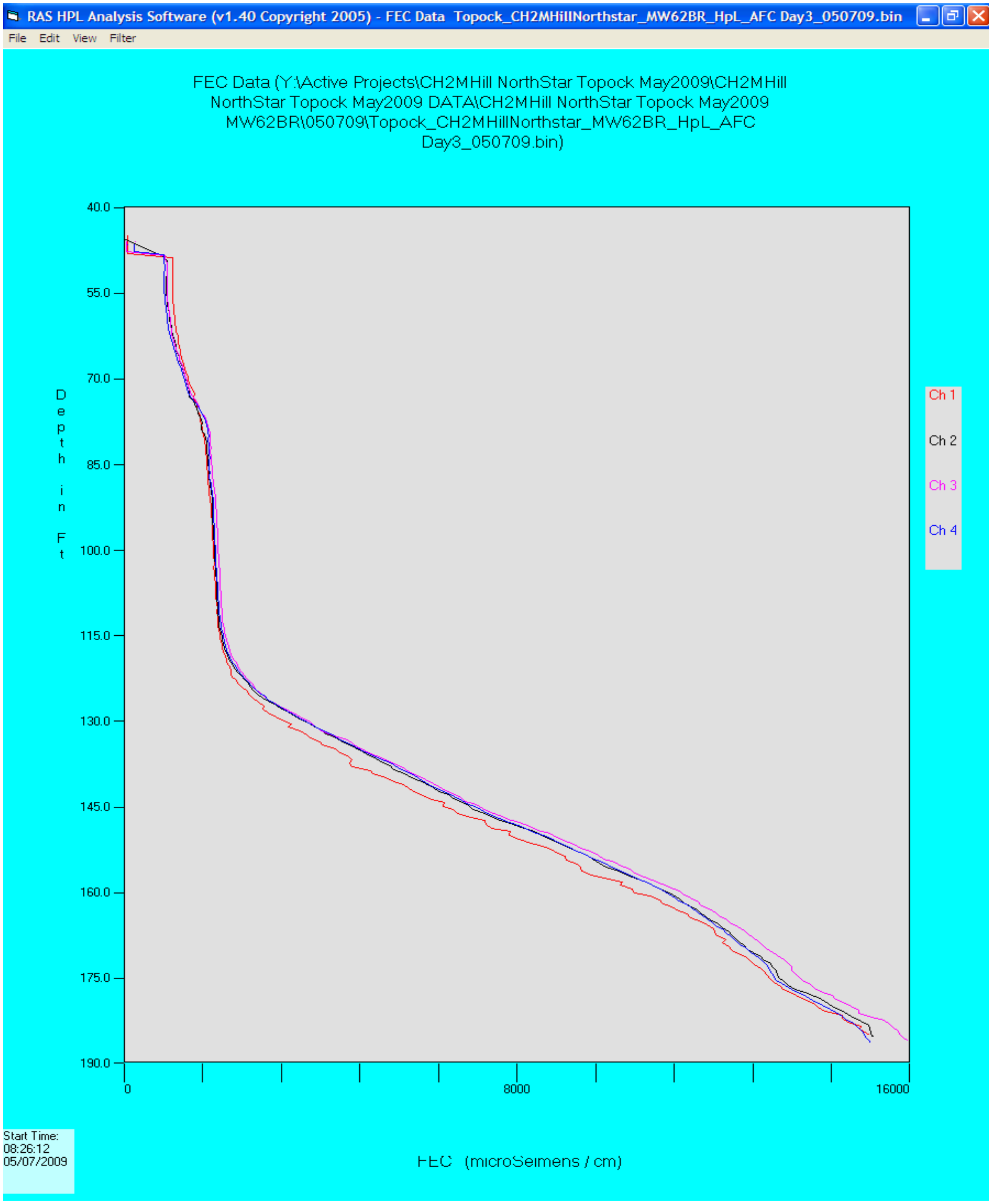
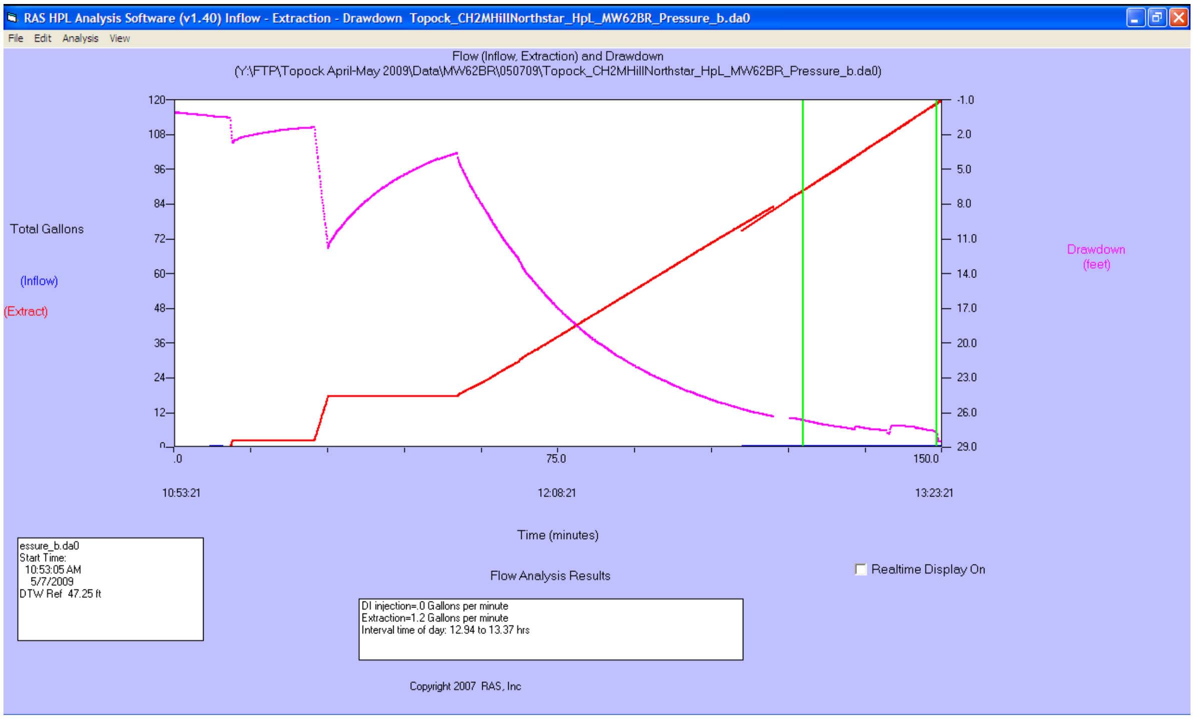


Figure 8. MW-62BR FEC log prior to Ambient Flow Condition Sample at 187 feet.



RAS HPL Analysis Software (v1.40) Inflow - Extraction - Drawdown Topock_CH2MHillNorthstar_HpL_MW62BR_Pressure_b.da0

Flow (Inflow, Extraction) and Drawdown
(Y:\FTP\Topock April-May 2009\Data\MW62BR\050709\Topock_CH2MHillNorthstar_HpL_MW62BR_Pressure_b.da0)

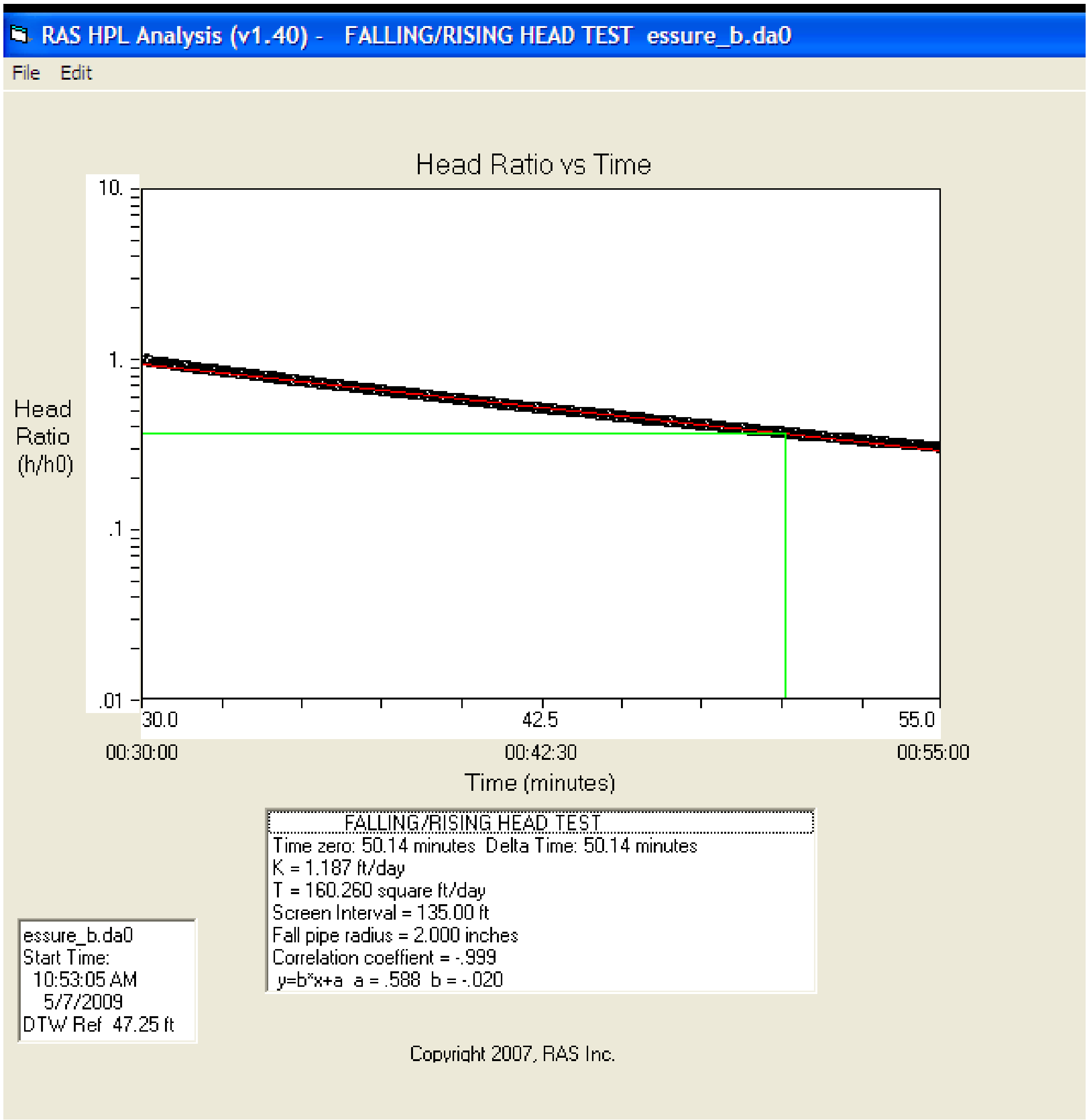
essure_b.da0
Start Time:
10:53:05 AM
5/7/2009
DTW Ref 47.25 ft

Flow Analysis Results

DI injection=.0 Gallons per minute
Extraction=1.2 Gallons per minute
Interval time of day: 12.94 to 13.37 hrs

Copyright 2007 RAS, Inc

Figure 9. MW-62BR HC results (2 slug tests and short term pumping test).

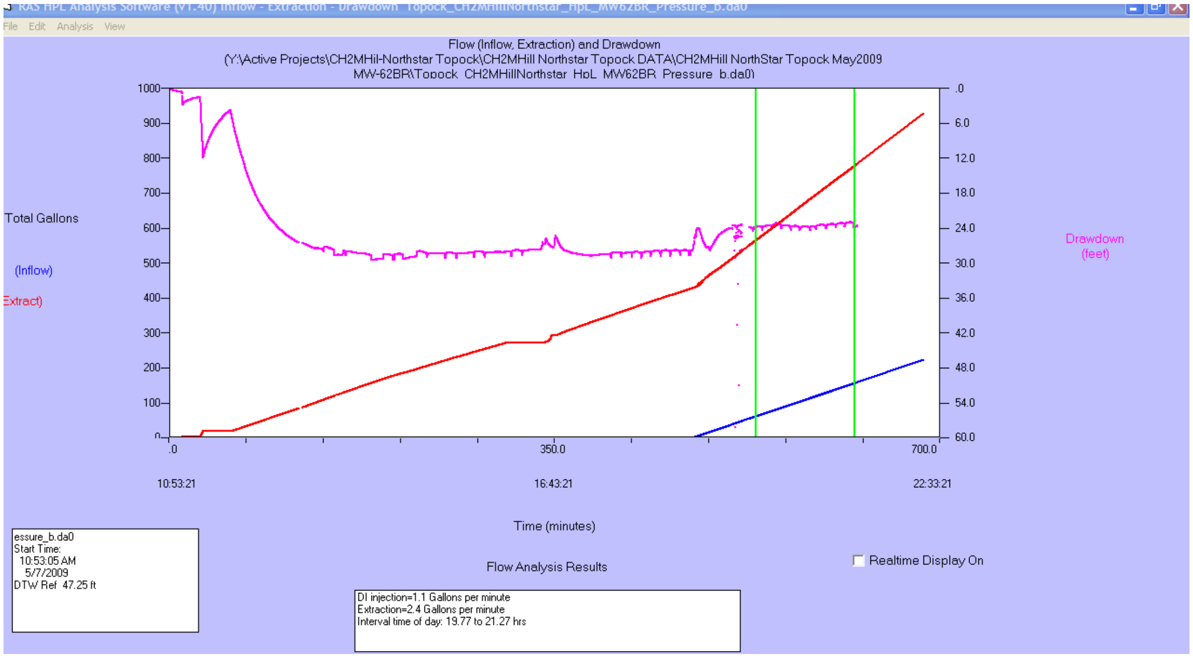


FALLING/RISING HEAD TEST
Time zero: 50.14 minutes Delta Time: 50.14 minutes
K = 1.187 ft/day
T = 160.260 square ft/day
Screen Interval = 135.00 ft
Fall pipe radius = 2.000 inches
Correlation coeffient = -.999
y=b*x+a a = .588 b = -.020

essure_b.da0
Start Time:
10:53:05 AM
5/7/2009
DTW Ref 47.25 ft

Copyright 2007, RAS Inc.

Figure 10. MW-62BR, Results of Rising Head Test Analysis.



RAS HPL Analysis Software (V1.40) Inflow - Extraction - Drawdown Topock_CH2MHillNorthstar_HpL_MW62BR_Pressure_b.da0

Flow (Inflow, Extraction) and Drawdown
(Y:\Active Projects\CH2MHil-Northstar Topock\CH2MHill Northstar Topock DATA\CH2MHill NorthStar Topock May2009
MW-62BR\Topock CH2MHillNorthstar HpL MW62BR Pressure b.da0)

essure_b.da0
Start Time:
10:53:05 AM
5/7/2009
DTW Ref 47.25 ft

Flow Analysis Results

DI injection=1.1 Gallons per minute
Extraction=2.4 Gallons per minute
Interval time of day: 19.77 to 21.27 hrs

☐ Realtime Display On

Figure 11. MW-62BR Pressure and Flow data during PDI test.

CH2MHill – NorthStar
PG&E Topock Compressor Station
Monitoring Well MW-62BR
HPL PROCESSING NOTES
ALL DEPTHS REFERENCED TO TOP OF PVC CASING

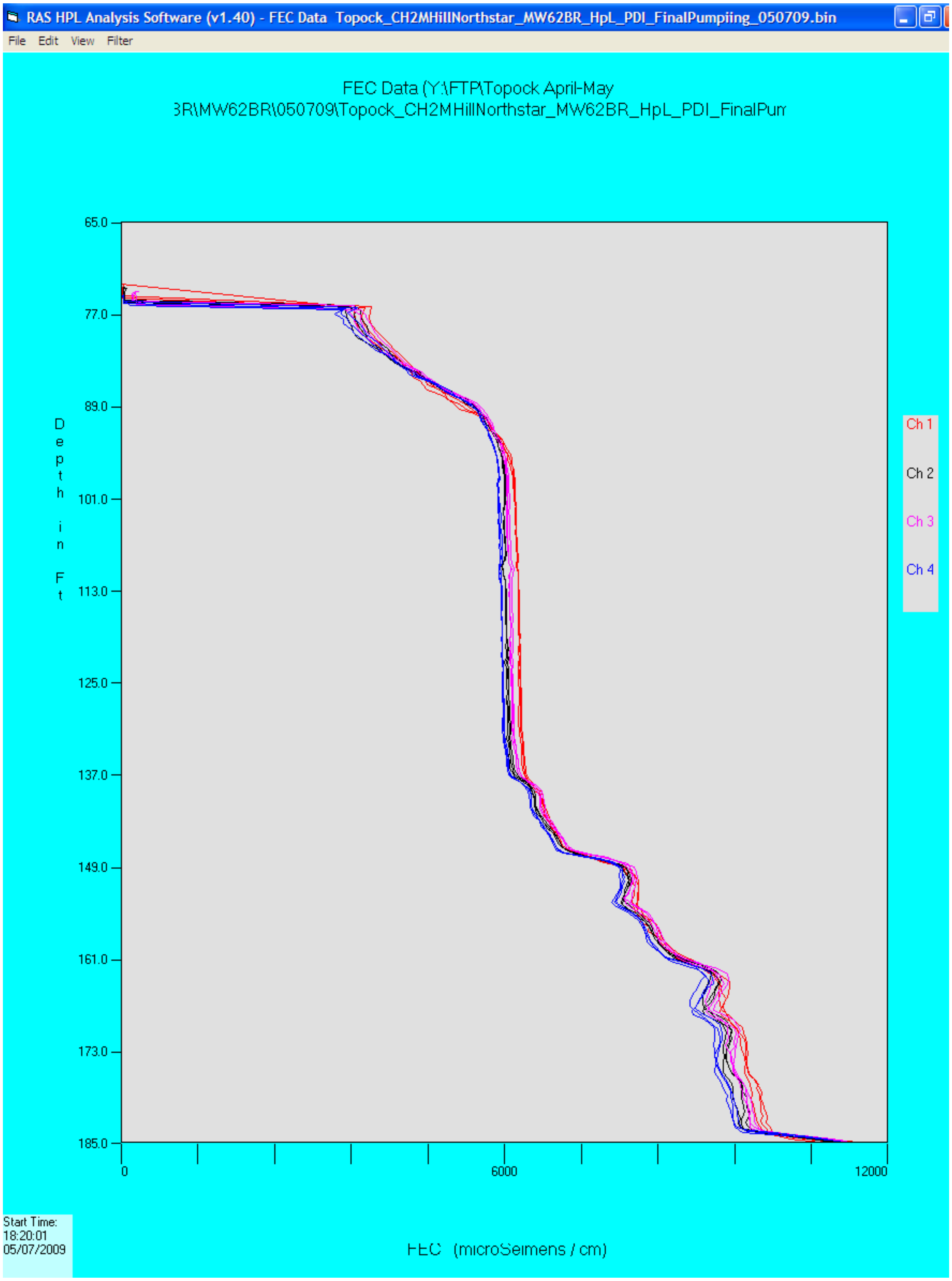


Figure 12. MW-62BR, Final Pumping Logs During PDI testing.

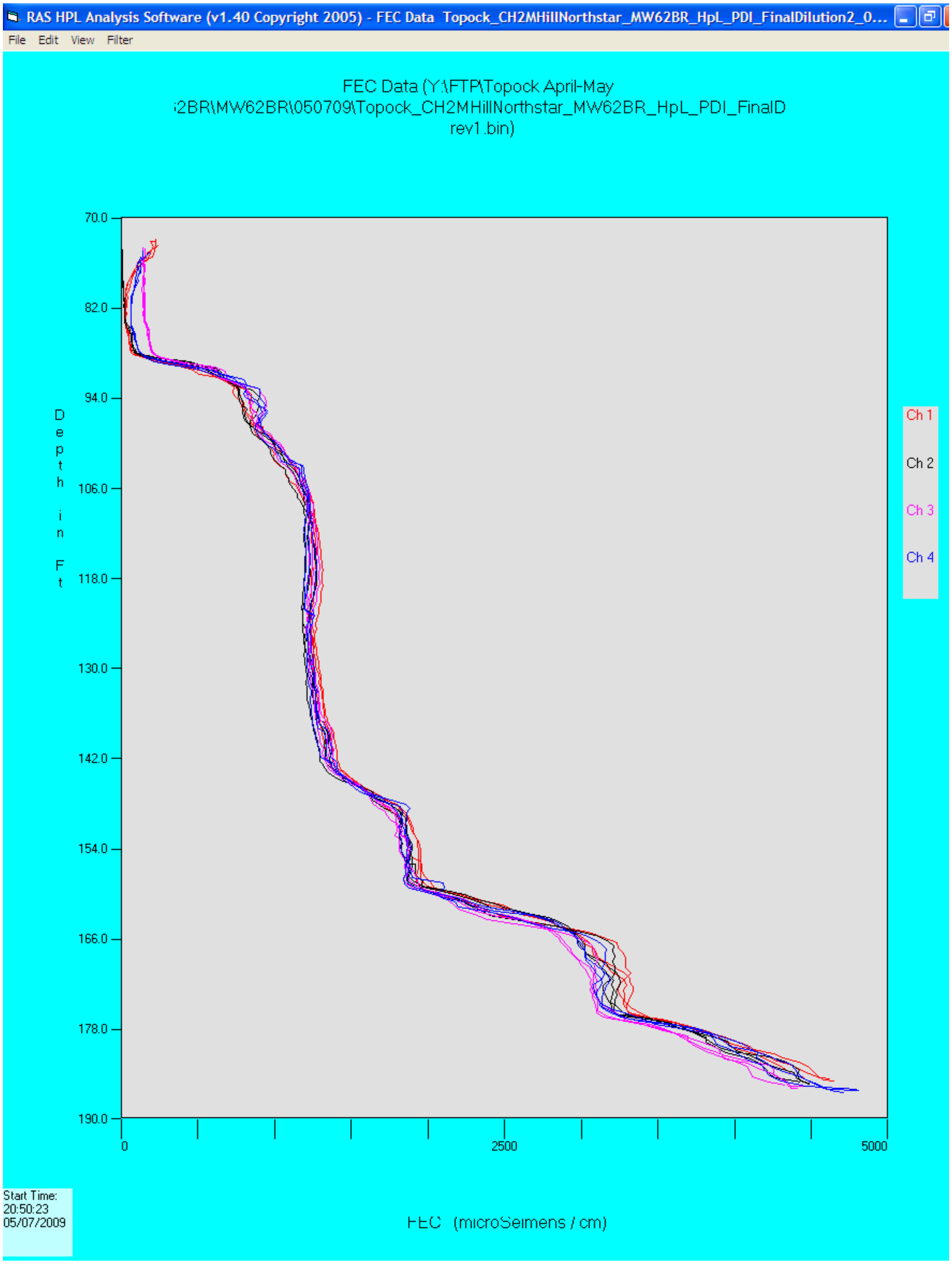
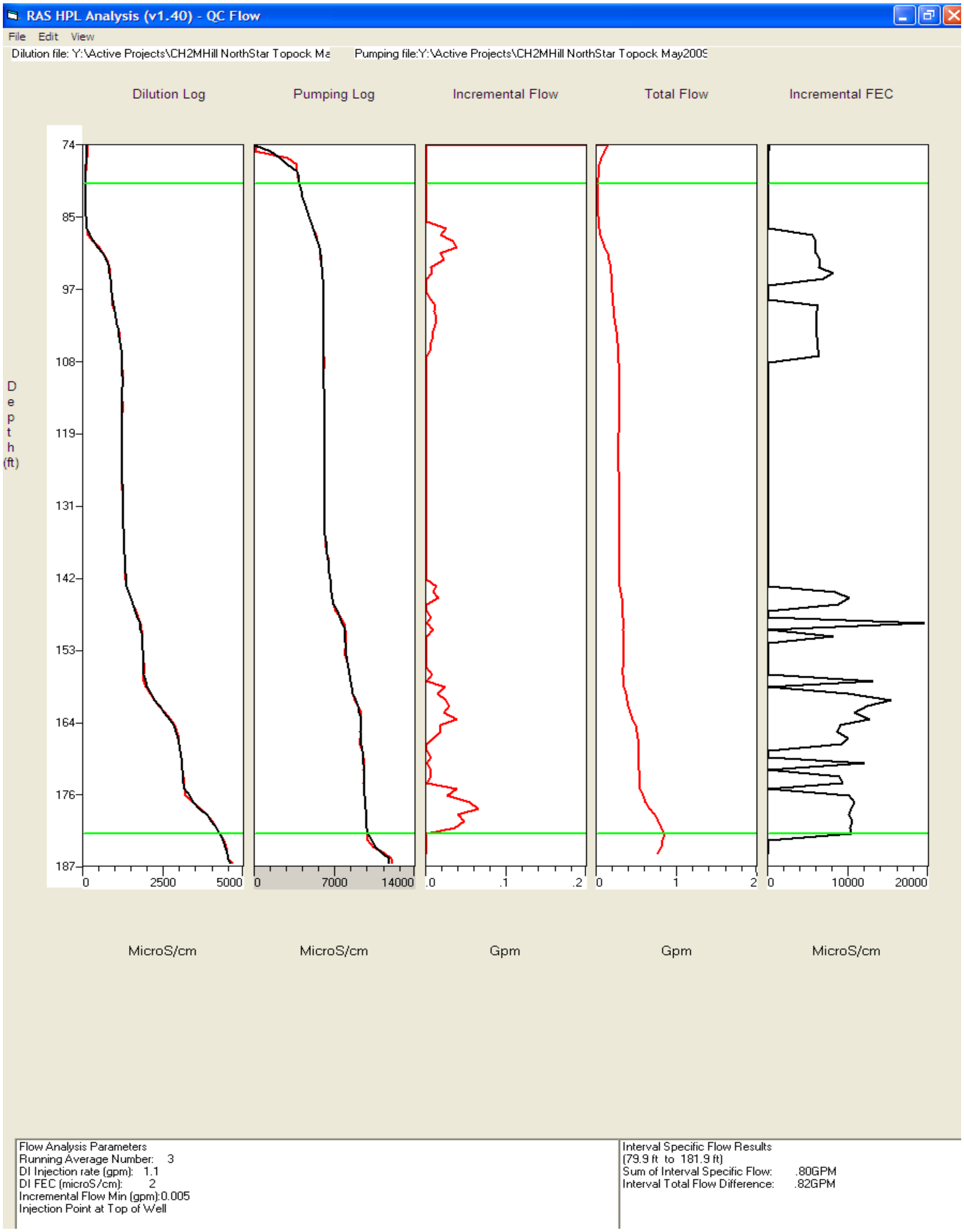


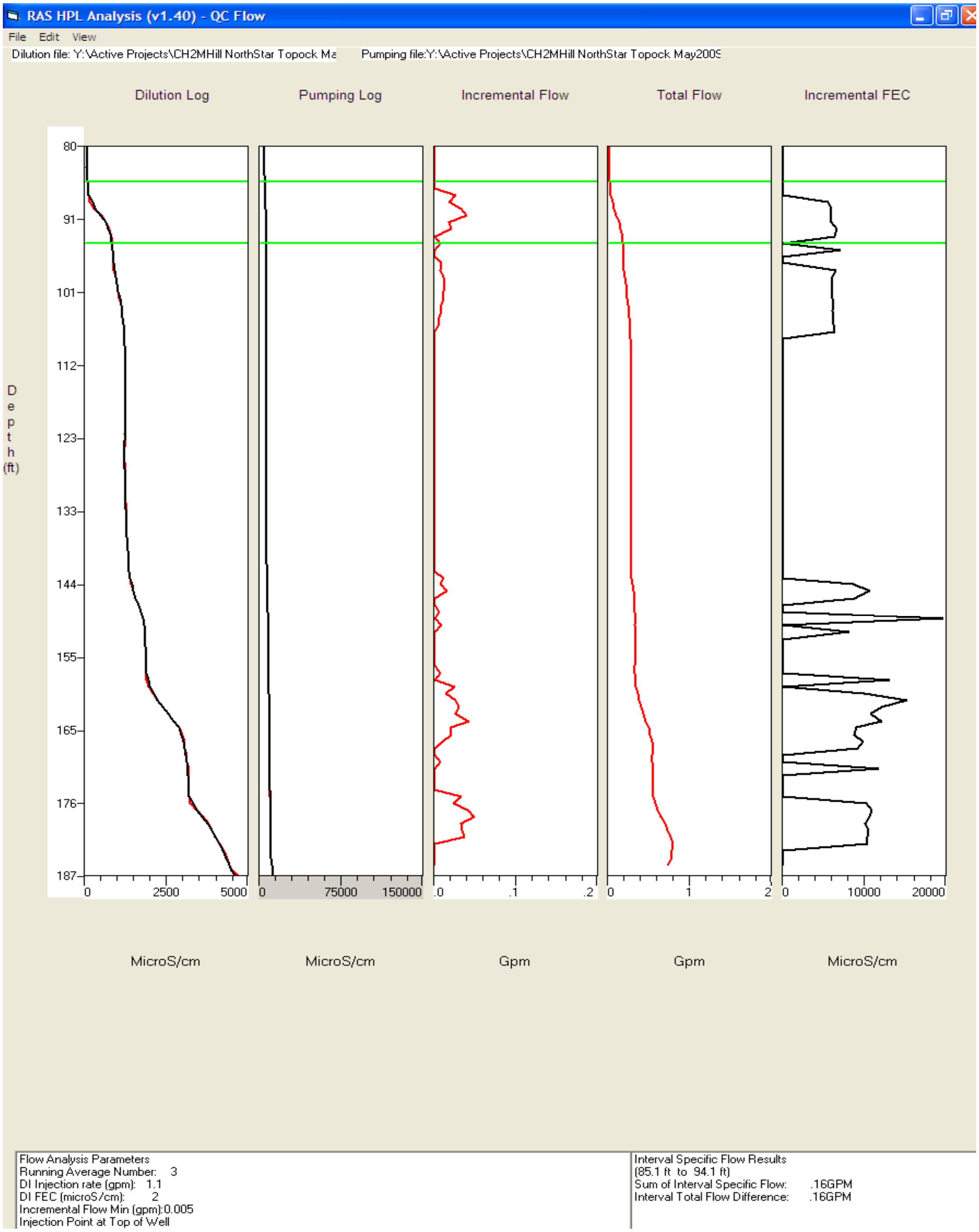
Figure 13. MW-62BR, Final Dilution Logs During PDI testing.



Flow Analysis Parameters
Running Average Number: 3
DI Injection rate (gpm): 1.1
DI FEC (microS/cm): 2
Incremental Flow Min (gpm):0.005
Injection Point at Top of Well

Interval Specific Flow Results
(79.9 ft to 181.9 ft)
Sum of Interval Specific Flow: .80GPM
Interval Total Flow Difference: .82GPM

Figure 14. MW-62BR, Results of QCFLOW analysis. Total flow over interval above pump. Data suggest addition flow coming from interval below pump to TD.



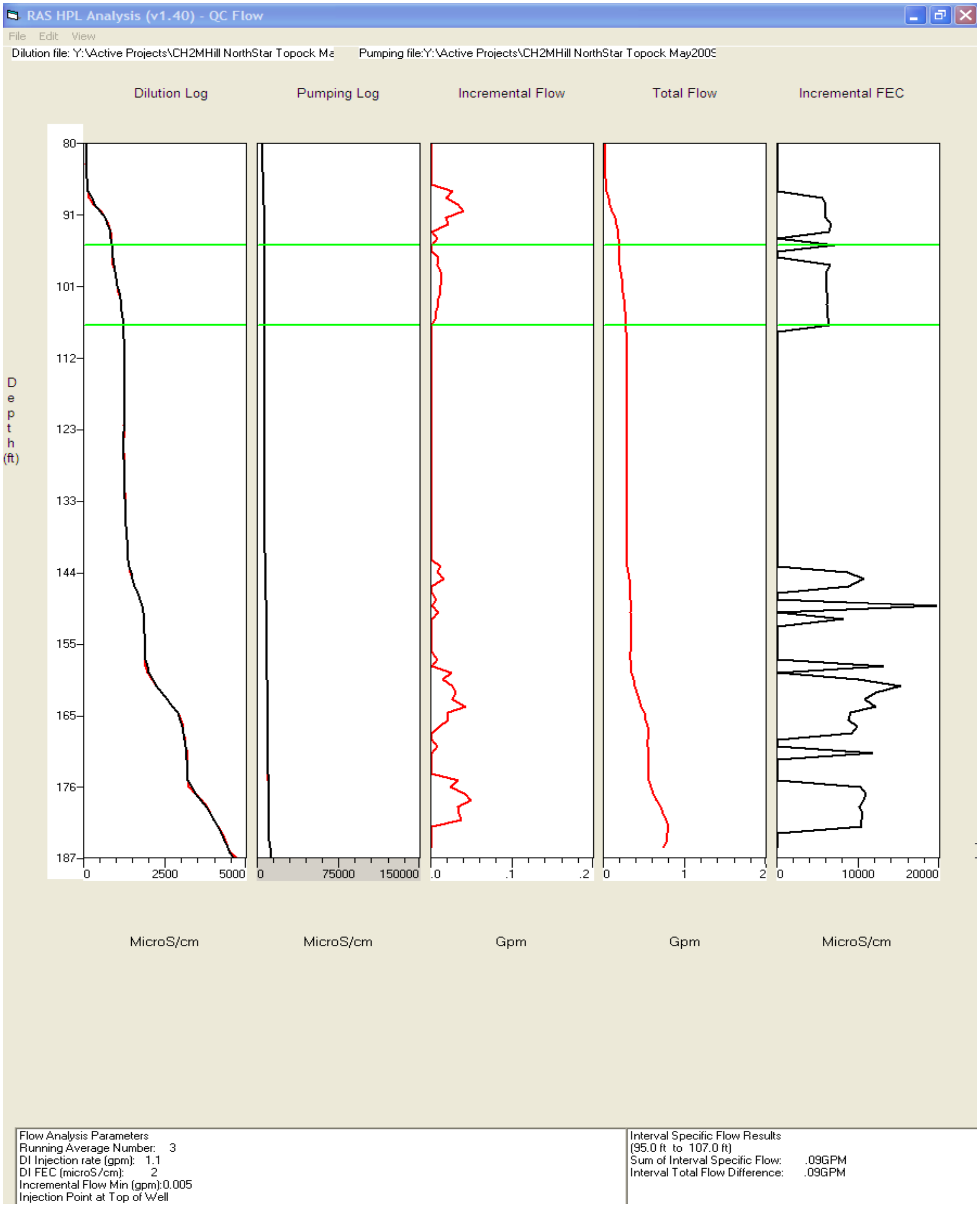
Dilution file: Y:\Active Projects\CH2MHill NorthStar Topock Ma

Pumping file:Y:\Active Projects\CH2MHill NorthStar Topock May2009

Flow Analysis Parameters
Running Average Number: 3
DI Injection rate (gpm): 1.1
DI FEC (microS/cm): 2
Incremental Flow Min (gpm):0.005
Injection Point at Top of Well

Interval Specific Flow Results
(85.1 ft to 94.1 ft)
Sum of Interval Specific Flow: .16GPM
Interval Total Flow Difference: .16GPM

Figure 15. MW-62BR, Results of QCFLOW analysis. Total flow over interval from 85 to 94 ft.



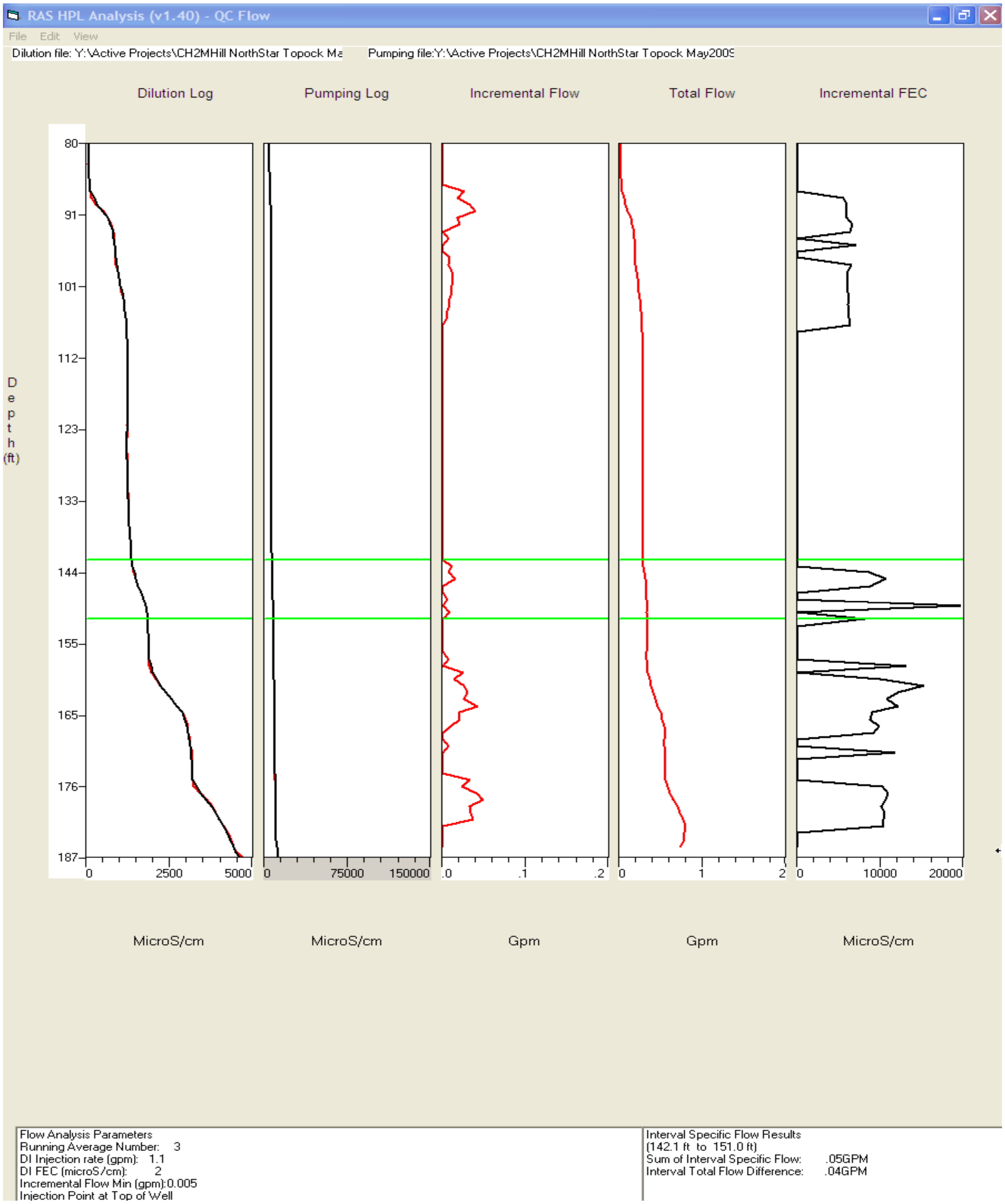
Dilution file: Y:\Active Projects\CH2MHill NorthStar Topock Ma

Pumping file:Y:\Active Projects\CH2MHill NorthStar Topock May2009

Flow Analysis Parameters
Running Average Number: 3
DI Injection rate (gpm): 1.1
DI FEC (microS/cm): 2
Incremental Flow Min (gpm):0.005
Injection Point at Top of Well

Interval Specific Flow Results
(95.0 ft to 107.0 ft)
Sum of Interval Specific Flow: .09GPM
Interval Total Flow Difference: .09GPM

Figure 16. MW-62BR, Results of QCFLOW analysis. Total flow over interval from 95 to 107 ft.



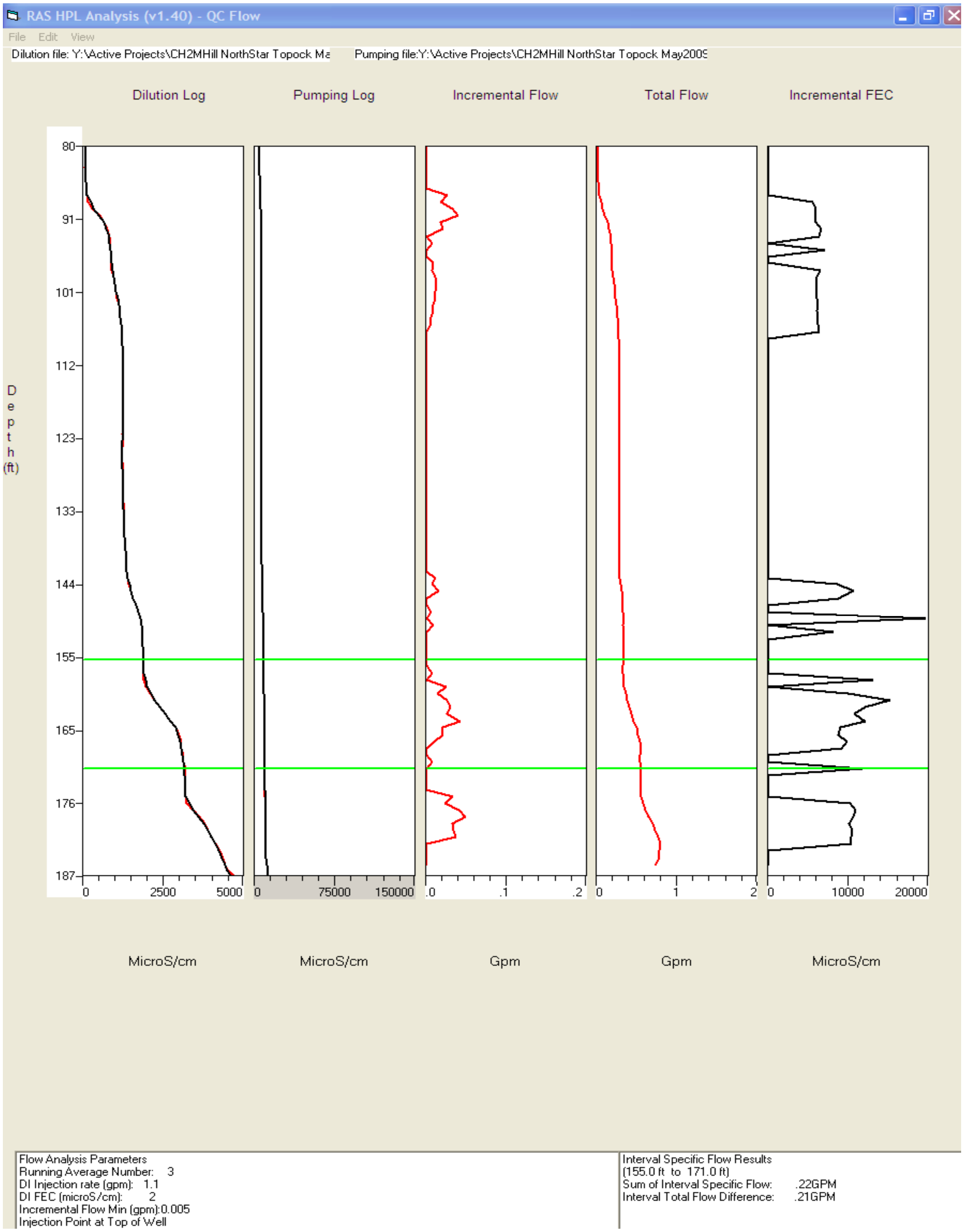
Dilution file: Y:\Active Projects\CH2MHill NorthStar Topock Ma

Pumping file:Y:\Active Projects\CH2MHill NorthStar Topock May2009

Flow Analysis Parameters
Running Average Number: 3
DI Injection rate (gpm): 1.1
DI FEC (microS/cm): 2
Incremental Flow Min (gpm):0.005
Injection Point at Top of Well

Interval Specific Flow Results
(142.1 ft to 151.0 ft)
Sum of Interval Specific Flow: .05GPM
Interval Total Flow Difference: .04GPM

Figure 17. MW-62BR, Results of QCFLOW analysis. Total flow over interval from 142 to 151 ft.



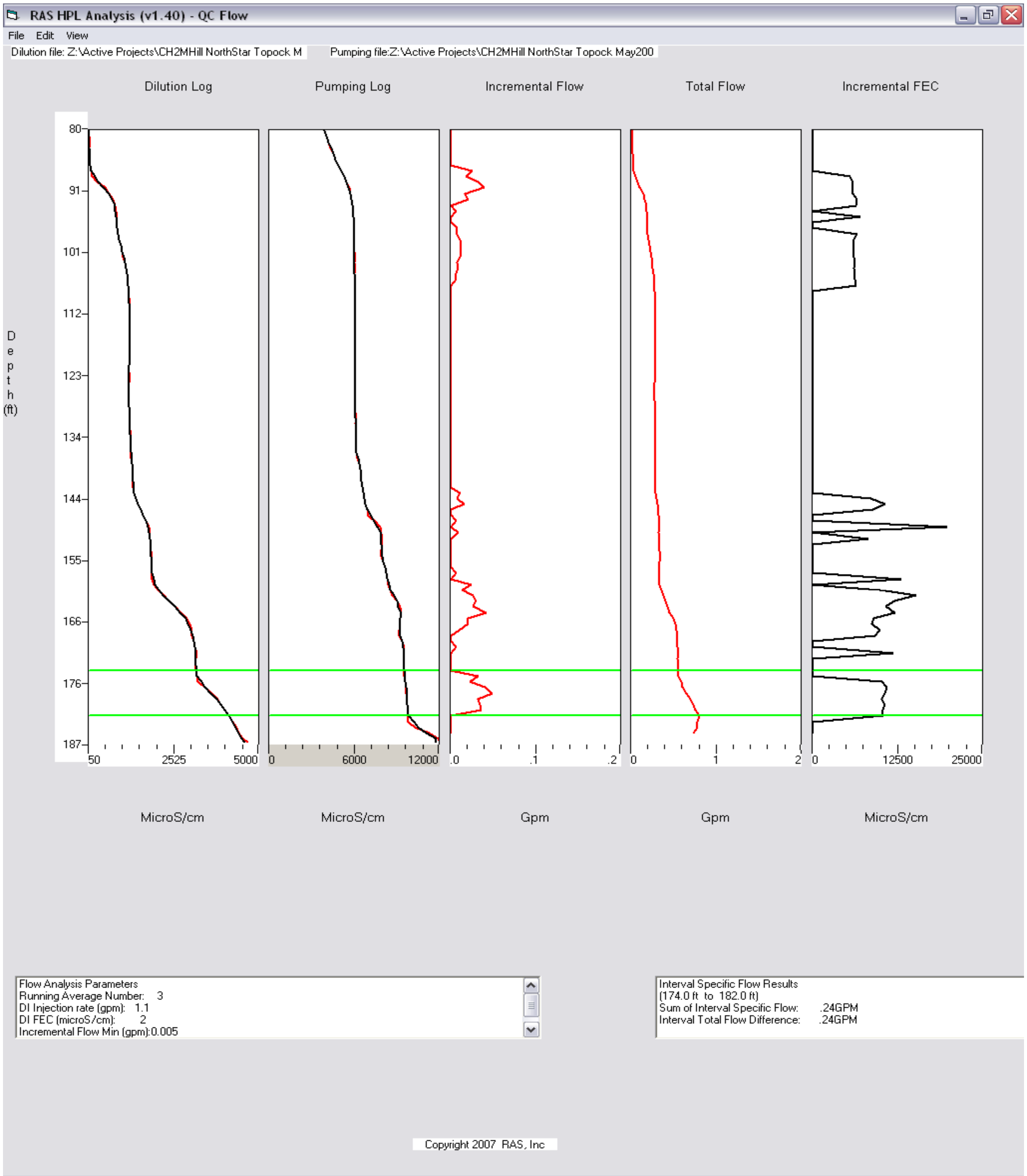
Dilution file: Y:\Active Projects\CH2MHill NorthStar Topock Ma

Pumping file:Y:\Active Projects\CH2MHill NorthStar Topock May200

Flow Analysis Parameters
Running Average Number: 3
DI Injection rate (gpm): 1.1
DI FEC (microS/cm): 2
Incremental Flow Min (gpm):0.005
Injection Point at Top of Well

Interval Specific Flow Results
(155.0 ft to 171.0 ft)
Sum of Interval Specific Flow: .22GPM
Interval Total Flow Difference: .21GPM

Figure 18. MW-62BR, Results of QCFLOW analysis. Total flow over interval from 155 to 171 ft.



Dilution file: Z:\Active Projects\CH2MHill NorthStar Topock M

Pumping file:Z:\Active Projects\CH2MHill NorthStar Topock May200

Flow Analysis Parameters
Running Average Number: 3
DI Injection rate (gpm): 1.1
DI FEC (microS/cm): 2
Incremental Flow Min (gpm):0.005

Interval Specific Flow Results
(174.0 ft to 182.0 ft)
Sum of Interval Specific Flow: .24GPM
Interval Total Flow Difference: .24GPM

Figure 19. MW-62BR, Results of QCFLOW analysis. Total flow over interval from 174 to 182 ft.

Summary of Preliminary HPL Results Conductive Feature (CF) Depths						
			Ambient Conditions Interval Specific Flow Rate	**Pumping Conditions Interval Specific Flow Rate**	**Interval Specific Concen-tration**	**Interval Specific Hydraulic Conductivity**
	Depth (ft)		gpm (US)	gpm (US)	µS/cm	ft/day
CF	top	Bottom				
1	85.8	95.0	-0.01	0.16	6000	1.89E-01
2	95	107	0	0.09	6200	7.68E-02
3	142	151.2	0	0.04	10,200	4.45E-02
4	156	171.2	0	0.21	11,400	1.41E-01
5	173.9	182.1	0	0.24	10,600	3.00E-01
6	185	~190	0.01	0.56	12,200	2.25E-01
	Sum of Interval Specific Flowrates			1.3	$T_{totalHPL}$=1.3E+1 ft^2/day	
	Total observed at from rising head			1.3	$T_{totalSLUG}$=1.6 E+2 ft^2/day	
	ALL DEPTHS REFERENCED TO TOP OF CASING (TOC); CASING STICKUP = 27.25”					

Table 1. CH2MHill Topock Well MW-62BR, Summary of Results, Ambient Flow Characterization and Pumping During DI Injection Tests.

APPENDIX D

WELL DATA MONTAGES

WELL: MW-57BR
PROJECT: CH2M Hill - PG&E Topock Compressor Station - Needles, California

RAS Integrated Subsurface Evaluation
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email: bpedler@rasinc.org • www.rasinc.org

LEGEND

GEOPHYSICAL LOGS

Gamma
Standard gamma ray (includes K, U, and Th)

Resistivity/Conductivity
By Dual Induction Type

Hole Size
Caliper - Drillhole diameter from three arm caliper

All Geophysical Logs conducted after borehole completion??

LITHOLOGY

▨	Unconsolidated Sediment
▨	Conglomerate Bedrock
▨	Metadiorite Bedrock

HYDROPHYSICAL LOGGING RESULTS:

Interval Specific Flow rate derived from Ambient Flow Characterization (AFC) and Pumping During deionized water Injection (PDI) hydrophysical data.

Dilution Fluid Electrical Conductivity (FEC) recorded while Pumping During Injection (PDI).

Horizontal flow observed during ambient conditions, inflows also evaluated during stressed (constant pumping or slug test) conditions. Horizontal flowrates base on integral method for q (Lowe, et. al., 1989).

Fluid Resistivity and Fluid temperature Logs performed during ambient conditions

Hydraulic conductivity estimates based on Hvorslev (1962), (Pedler, *et al*. 1988) and Theim, G. *Hydrolgische Methoden*. Leipzig: Gebhart, 1906, p 56. Flow and velocity estimates based on hydrophysical logging results only.

Flow Zones, in percent of total fluid contribution

▢	<20%
▢	>20% and <35%
▢	>35% and <50%
▢	>50%

HEXAVALENT CHROMIUM EXPLANATION

● Hexavalent Chromium - Cr(VI) Validated IM3 result (µg/L)

Contaminant concentrations based on samples collected in open borehole conditions.

MISCELLANEOUS NOTES:

1. Top of casing elevation: 509.0 feet (NAD83).
2. All depths referenced to top of PVC casing.
3. Coordinates of well:
   Northing: 7616389.44 Easting: 2100899.56
4. Lithology from CH2M Hill.
5. Well construction from CH2M Hill.
6. Geophysical logging conducted by Pacific Surveys on July 15, 2008 & December 2, 2008.
7. Hexavalent chromium results provided by CH2M Hill.
8. Hydrophysical logging conducted by RAS, Inc. from February 25 to March 1, 2008.

Finalized 09/16/2009

WELL: MW-58BR
PROJECT: CH2M Hill - PG&E Topock Compressor Station - Needles, California

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LEGEND

GEOPHYSICAL LOGS

Gamma
Standard gamma ray (includes K, U, and Th)

Resistivity/Conductivity
By Dual Induction Type

Hole Size
Caliper - Drillhole diameter from three arm caliper

All Geophysical Logs conducted after borehole completion??

LITHOLOGY

- ▨ Unconsolidated Sediment
- ▨ Conglomerate Bedrock
- ▨ Metadiorite Bedrock

HYDROPHYSICAL LOGGING RESULTS:

Interval Specific Flow rate derived from Ambient Flow Characterization (AFC) and Slug Test After Emplacement (SAE) hydrophysical data.

HPL FEC logs presented were collected during Slug Test After Emplacement (SAE) conditions.

- FEC 1711
- FEC 1721
- FEC 1730

FEC XXXX where XXXX is military time at start of log.

Horizontal flow observed during ambient conditions, inflows also evaluated during stressed (constant pumping or slug test) conditions. Horizontal flowrates base on integral method for q (Lowe, et. al., 1989).

Fluid Resistivity and Fluid temperature Logs performed during ambient conditions

Hydraulic conductivity estimates based on Hvorslev (1962), (Pedler, *et al.* 1988) and Theim, G. *Hydrolgische Methoden*. Leipzig: Gebhart, 1906, p 56. Flow and velocity estimates based on hydrophysical logging results only.

Flow Zones, in percent of total fluid contribution

- ☐ <20%
- ☐ >20% and <35%
- ☐ >35% and <50%
- ☐ >50%

HEXAVALENT CHROMIUM EXPLANATION

Hexavalent Chromium - Cr (VI), in micrograms per liter (µg/L)

- ▮ Calculated Interval specific concentrations (Intervals)
- ● Observed concentrations ambient conditions (point)
- ● Observed concentrations pumping conditions (points)
- ● Pump after sampling (point)

Contaminant concentrations based on samples collected in open borehole conditions.

MISCELLANEOUS NOTES:

1. Top of casing elevation: 521.4 feet (NAD83).
2. All depths referenced to top of PVC casing.
3. Coordinates of well:
   Northing: 7616131.91 Easting: 2100612.36
4. Lithology from CH2M Hill.
5. Well construction from CH2M Hill.
6. Geophysical logging conducted by Pacific Surveys on July 16, 2008 & December 2, 2008.
7. Hexavalent chromium results provided by CH2M Hill.
8. Hydrophysical logging conducted by RAS, Inc. from March 3 to March 5, 2008.

Finalized 09/22/2009

WELL: MW-62BR
PROJECT: CH2M Hill - PG&E Topock Compressor Station - Needles, California

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LEGEND

LITHOLOGY

▨	Unconsolidated Sediment
🟥	Conglomerate Bedrock
🟩	Metadiorite Bedrock

HYDROPHYSICAL LOGGING RESULTS:

Interval Specific Flow rate derived from Ambient Flow Characterization (AFC) and Pumping During deionized water Injection (PDI) hydrophysical data.

Fluid Resistivity and Fluid temperature Logs performed during ambient conditions

Horizontal flow observed during ambient conditions, inflows also evaluated during stressed (constant pumping or slug test) conditions. Horizontal flowrates base on integral method for q (Lowe, et. al., 1989).

Hydraulic conductivity estimates based on Hvorslev (1962), (Pedler, *et al.* 1988) and Theim, G. *Hydrolgische Methoden*. Leipzig: Gebhart, 1906, p 56. Flow and velocity estimates based on hydrophysical logging results only.

Flow Zones, in percent of total fluid contribution

▨	<20%
▨	>20% and <35%
▨	>35% and <50%
▨	>50%

HEXAVALENT CHROMIUM EXPLANATION

Hexavalent Chromium - Cr (VI), in micrograms per liter (µg/L)

▮	Calculated Interval specific concentrations (Intervals)
●	Observed concentrations ambient conditions (point)
●	Observed concentrations pumping conditions (points)
●	Pump after sampling (point)

Contaminant concentrations based on samples collected in open borehole conditions.

MISCELLANEOUS NOTES:

1. Top of casing elevation: 503.5 feet (NAD83).
2. All depths referenced to top of PVC casing.
3. Coordinates of well:
   Northing: 7616551.06 Easting: 2101068.31
4. Lithology from CH2M Hill.
5. Well construction from CH2M Hill.
6. Hexavalent chromium results provided by CH2M Hill.
7. Hydrophysical logging conducted by RAS, Inc. from May 5 to May 8, 2009.

Finalized 09/22/2009

WELL: MW-64BR

PROJECT: CH2M Hill - PG&E Topock Compressor Station - Needles, California

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LEGEND

LITHOLOGY

▨	Unconsolidated Sediment
▨	Conglomerate Bedrock
🟩	Metadiorite Bedrock

HYDROPHYSICAL LOGGING RESULTS:

Interval Specific Flow rate derived from Ambient Flow Characterization (AFC) and Slug Test After Emplacement (SAE) hydrophysical data.

HPL FEC logs presented were collected during Slug Test after Emplacement conditions.

- FEC 0843
- FEC 1546
- FEC 1835

FEC XXXX where XXXX is military time at start of log.

Horizontal flow observed during ambient conditions, inflows also evaluated during stressed (constant pumping or slug test) conditions. Horizontal flowrates base on integral method for q (Lowe, et. al., 1989).

Fluid Resistivity and Fluid temperature Log performed during ambient conditions

Hydraulic conductivity estimates based on Hvorslev (1962), (Pedler, *et al.* 1988) and Theim, G. *Hydrolgische Methoden*. Leipzig: Gebhart, 1906, p 56. Flow and velocity estimates based on hydrophysical logging results only.

Flow Zones, in percent of total fluid contribution

▢	<20%
▢	>20% and <35%
▢	>35% and <50%
▢	>50%

HEXAVALENT CHROMIUM EXPLANATION

Hexavalent Chromium - Cr (VI), in micrograms per liter (µg/L)

▮	Calculated Interval specific concentrations (Intervals)
●	Observed concentrations ambient conditions (point)
●	Observed concentrations pumping conditions (points)
●	Pump after sampling (point)

Contaminant concentrations based on samples collected in open borehole conditions.

MISCELLANEOUS NOTES:

1. Top of casing elevation: 576.0 feet (NAD83).
2. All depths referenced to top of PVC casing.
3. Coordinates of well:
   Northing: 7616939.41 Easting: 2100520.49
4. Lithology from CH2M Hill.
5. Well construction from CH2M Hill.
6. Hexavalent chromium results provided by CH2M Hill.
7. Hydrophysical logging conducted by RAS, Inc. from May 27 to June 1, 2009.

Finalized 09/16/2009

REPORT, APPENDICES AND DATA

CD-ROM

Attachment A2-3
Screening-level Groundwater Sample Data

ATTACHMENT A2-3
Screening Level Well Development, Aquifer Testing and Depth Specific Groundwater Sample Data
Summary of Findings Associated with the East Ravine Groundwater Investigation
PG&E Topock Compressor Station, Needles, California

					Specific Conductance	Hexavalent Chromium		Total Dissolved Chromium		Dissolved Arsenic
Site	Location	Sample Type	Sample Depth (ft bgs)	Lithologic Interval	IM3 Result (uS/cm)	IM3 Result (ug/L)	Validated ATL result (ug/L)	IM3 Result (ug/L)	Validated ATL result (ug/L)	Validated ATL result (ug/L)
A	MW-58BR_S	From Pump During Development	66 - 115	Metadiorite	16,270	268	---	224	---	---
		Depth-Discrete	92 (pumping at 113)	Metadiorite	---	205	200	---	200	---
		Depth-Discrete	107 (pumping at 113)	Metadiorite	---	188	180	---	180	---
		From Pump	113 (pump depth)	Metadiorite	---	257	230	243	240	25
	MW-58BR_D	Development	67-206	Metadiorite	7,030	57	---	51	---	---
		Depth-Discrete	203 (ambient grab)	Metadiorite	11,060	ND (<1)	ND (<1)	ND (<1)	5.1	---
		Depth-Discrete	125 (pumping at 203)	Metadiorite	10,270	13	8	11	11	---
		Depth-Discrete	140 (pumping at 203)	Metadiorite	9,950	10	8.5	11	13	---
		Depth-Discrete	180 (pumping at 203)	Metadiorite	9,500	19	10	15	14	---
		From Pump	203 (pump depth)	Metadiorite	10,210	96	83	94	91	15
	MW-58-065	Grab	63-64	--		ND (<10)	0.52	ND	3.4	---
B	MW-57-185	From Pump During Development	70 - 185	Conglomerate /Metadiorite	18,610	15	---	15	---	---
		Depth-Discrete	92.5 (pumping at 183)	Miocene Conglomerate	---	14	13	---	14	---
		Depth-Discrete	102 (pumping at 183)	Miocene Conglomerate	---	14	13	---	14	---
		Depth-Discrete	114 (pumping at 183)	Miocene Conglomerate	---	14	13	---	14	---
		Depth-Discrete	154 (pumping at 183)	Miocene Conglomerate	---	41 (re-analysis = 39)	36	38	35	---
		Depth-Discrete	175 (pumping at 183)	Metadiorite	---	16	14	---	19	---
		From Pump	183 (pump depth)	--	---	18	---	---	---	---
		From Pump During Aquifer Test	183 (pump depth)	Conglomerate /Metadiorite	18,570	16	---	15	---	---
	MW-57-070	From Pump During Development	55 - 70	Miocene Conglomerate	2,780	553	---	498	---	---
C	MW-61-110	From Pump During Development	92 - 112	Metadiorite	13,950	1,280 (re-analysis = 1,180)	---	1,240 (re-analysis = 1,160)	---	---
C-Alternate	MW-64BR	Depth-Discrete	130 (ambient grab)	Metadiorite	8,240	90	82	---	120	11
		Depth-Discrete	180 (ambient grab)	Metadiorite	10,470	121	110	---	150	15
		Depth-Discrete	230 (ambient grab)	Metadiorite	11,490	108	95	---	160	16

ATTACHMENT A2-3

Screening Level Well Development, Aquifer Testing and Depth Specific Groundwater Sample Data

Summary of Findings Associated with the East Ravine Groundwater Investigation

PG&E Topock Compressor Station, Needles, California

Site	Location	Sample Type	Sample Depth (ft bgs)	Interval	**Specific Conductance**	**Hexavalent Chromium**		**Total Dissolved Chromium**		**Arsenic**
					IM3 Result (uS/cm)	IM3 Result (ug/L)	Validated ATL result (ug/L)	IM3 Result (ug/L)	Validated ATL result (ug/L)	Validated ATL result (ug/L)
E	MW-62-065	From Pump During Development	45 - 65	Miocene Conglomerate	7,210	1,300	---	1,200	---	---
	MW-62BR	From Pump During Development	75 - 191	Miocene Conglomerate	13,040	238	---	234	---	---
		Depth-Discrete	186.5 (ambient grab)	Miocene Conglomerate	15,960	ND (<3)	ND (<1)	ND (<1)	3.7	---
		From Pump	187 pump depth (before sampling)	Miocene Conglomerate	13,040	414	400	441	420	17
		Depth-Discrete	94.5 (pump at 187)	Miocene Conglomerate	6,180	1,300	1,200	1,265	1,200	---
		Depth-Discrete	108 (pump at 187)	Miocene Conglomerate	6,200	1,315	1,200	1,335	1,300	---
		Depth-Discrete	149 (pump at 187)	Miocene Conglomerate	8,250	1,025	920	940	940	---
		Depth-Discrete	170 (pump at 187)	Miocene Conglomerate	10,770	601	600	617	640	---
		Depth-Discrete	184.5 (pump at 187)	Miocene Conglomerate	11,960	488	520	609	530	---
		From Pump	187 pump effluent (after sampling)	Miocene Conglomerate	13,370	430	430	453	440	17
E-Alternate 2	MW-63-065	From Pump During Development	46 - 66	Miocene Conglomerate		ND (<4)	---	ND (<3)	---	---
F	MW-60-125	From Pump During Development	103 - 123	Metadiorite		1,620 (re-analysis = 1,680)	---	1,680 (re-analysis = 1,640)	---	---
G	MW-59-100	From Pump During Development	86 - 101	Alluvium		5,600	---	5,300	---	---

Note:

1) Sample results reported in this table are considered screening level results.
2) Depth discrete samples collected from the open boreholes (BR) during pumping, may not be representative of non-pumping depth discrete conditions.
3) Samples were obtained: a) upon completion of well development, b) from open boreholes during ambient non-pumping conditions with a depth discrete sampler, or c) during borehole flow characterization with a depth discrete sampler during pumping, or d) from the pump effluent.
3) Screening level samples were analyzed at the on-site laboratory (IM3) and/or at the certified offsite laboratory Advanced Technology Laboratories (ATL).
4) Arsenic samples were analyzed to determine the potential contribution of arsenic from the FLUTe™ multilevel well materials due to elevated sample results once these systems were installed.

Abbreviations:

bgs = below ground surface
ft = feet
µg/L = micrograms per lliter
µS/cm = micro siemens per centimeter

Attachment A3
Complete Analytical Data Set
(This attachment is provided on CD-ROM)

TABLE A3-1
Soil Sample Analytical Results for Samples Collected during the ERGI
Summary of Findings Associated with the East Ravine Groundwater Investigation
PG&E Topock Compressor Station

		Depth (ft bgs)	Site B (MW-57BR) on 1/14/2009				Site A (MW-58BR_S) on 1/29/2009					
			3-4	8-9	8-9	18-19	1.5-2	19-20	29-30	39-40	49-50	59-60
Analyte	**Method**	**Units**			**(FD)**							
Metals												
Antimony	6010B	mg/kg	ND (2.0)	ND (2.1)	ND (2.1)	ND (4.1)	ND (2.1) J	ND (2.1)	ND (2.1)	ND (2.1)	ND (2.1)	ND (2.2)
Arsenic	6010B	mg/kg	9.20	8.00	8.40	9.90	ND (2.1)	12.0	13.0	12.0	8.30	8.40
Barium	6010B	mg/kg	270	85.0	85.0	240	410	240	110	150	180	37.0
Beryllium	6010B	mg/kg	ND (2.0)	ND (1.0)	ND (1.0)	ND (2.1)	ND (2.1)	ND (2.1)	ND (2.1)	ND (2.1)	ND (1.1)	ND (1.1)
Cadmium	6010B	mg/kg	ND (1.0)	ND (1.0)	ND (1.0)	ND (2.1)	ND (1.1)	ND (1.1)	ND (1.1)	ND (1.1)	ND (1.1)	ND (1.1)
Chromium	6010B	mg/kg	26.0	20.0	22.0	25.0	4000	33.0	26.0	35.0	24.0	27.0
Chromium, Hexavalent	7199	mg/kg	ND (0.16)	ND (0.17)	ND (0.16)	ND (0.16)	150	0.43	ND (0.17)	0.43	ND (0.17)	ND (0.18)
Cobalt	6010B	mg/kg	7.80	7.90	8.00	10.0	8.20	12.0	11.0	12.0	8.70	13.0
Copper	6010B	mg/kg	11.0	11.0	11.0	12.0	300	24.0	14.0	17.0	17.0	58.0
Lead	6010B	mg/kg	6.70	2.70	2.90	4.30	160	4.00	3.60	4.20	3.70	3.40
Mercury	7471A	mg/kg	ND (0.1)	ND (0.1)	ND (0.1)	ND (0.1)	0.33	ND (0.11)	ND (0.11)	ND (0.11)	ND (0.11)	ND (0.11)
Molybdenum	6010B	mg/kg	ND (2.0)	1.30	1.30	3.00	3.50	ND (2.1)	ND (2.1)	ND (2.1)	ND (1.1)	ND (1.1)
Nickel	6010B	mg/kg	17.0	16.0	16.0	16.0	24.0	25.0	19.0	22.0	16.0	22.0
Selenium	6010B	mg/kg	ND (1.0)	ND (1.0)	ND (1.0)	ND (2.1)	ND (1.1)	ND (1.1)	ND (1.1)	ND (1.1)	ND (1.1)	ND (1.1)
Silver	6010B	mg/kg	ND (2.0)	ND (1.0)	ND (1.0)	ND (2.1)	ND (2.1)	ND (2.1)	ND (2.1)	ND (2.1)	ND (1.1)	ND (1.1)
Thallium	6010B	mg/kg	ND (4.1)	ND (2.1)	ND (2.1)	ND (4.1)	6.10	4.70	4.80	4.70	ND (2.1)	ND (2.2)
Vanadium	6010B	mg/kg	34.0	28.0	27.0	31.0	23.0	38.0	33.0	34.0	28.0	28.0
Zinc	6010B	mg/kg	52.0	46.0	48.0	68.0	300	63.0	64.0	51.0	46.0	41.0
Polyaromatic Hydrocarbons												
1-Methylnaphthalene	8270SIM	ug/kg	ND (5.1)	ND (5.2)	ND (5.2)	ND (5.2)	---	ND (5.3)	ND (5.3)	ND (5.3)	ND (5.3)	ND (5.5)
2-Methylnaphthalene	8270SIM	ug/kg	ND (5.1)	ND (5.2)	ND (5.2)	ND (5.2)	---	ND (5.3)	ND (5.3)	ND (5.3)	ND (5.3)	ND (5.5)
Acenaphthene	8270SIM	ug/kg	ND (5.1)	ND (5.2)	ND (5.2)	ND (5.2)	---	ND (5.3)	ND (5.3)	ND (5.3)	ND (5.3)	ND (5.5)
Acenaphthylene	8270SIM	ug/kg	ND (5.1)	ND (5.2)	ND (5.2)	ND (5.2)	---	ND (5.3)	ND (5.3)	ND (5.3)	ND (5.3)	ND (5.5)
Anthracene	8270SIM	ug/kg	ND (5.1)	ND (5.2)	ND (5.2)	ND (5.2)	---	ND (5.3)	ND (5.3)	ND (5.3)	ND (5.3)	ND (5.5)
B(a)P Equivalent	8270SIM	ug/kg	ND (4.5)	ND (4.5)	ND (4.5)	ND (4.5)	---	ND (4.6)	ND (4.6)	ND (4.6)	ND (4.6)	ND (4.8)
Benzo (a) anthracene	8270SIM	ug/kg	ND (5.1)	ND (5.2)	ND (5.2)	ND (5.2)	---	ND (5.3)	ND (5.3)	ND (5.3)	ND (5.3)	ND (5.5)
Benzo (a) pyrene	8270SIM	ug/kg	ND (5.1)	ND (5.2)	ND (5.2)	ND (5.2)	---	ND (5.3)	ND (5.3)	ND (5.3)	ND (5.3)	ND (5.5)

TABLE A3-1

Soil Sample Analytical Results for Samples Collected during the ERGI

Summary of Findings Associated with the East Ravine Groundwater Investigation

PG&E Topock Compressor Station

	Depth (ft bgs)		Site B (MW-57BR) on 1/14/2009				Site A (MW-58BR_S) on 1/29/2009					
Analyte	**Method**	**Units**	**3-4**	**8-9**	**8-9 (FD)**	**18-19**	**1.5-2**	**19-20**	**29-30**	**39-40**	**49-50**	**59-60**
Polyaromatic Hydrocarbons												
Benzo (b) fluoranthene	8270SIM	ug/kg	ND (5.1)	ND (5.2)	ND (5.2)	ND (5.2)	---	ND (5.3)	ND (5.3)	ND (5.3)	ND (5.3)	ND (5.5)
Benzo (ghi) perylene	8270SIM	ug/kg	ND (5.1)	ND (5.2)	ND (5.2)	ND (5.2)	---	ND (5.3)	ND (5.3)	ND (5.3)	ND (5.3)	ND (5.5)
Benzo (k) fluoranthene	8270SIM	ug/kg	ND (5.1)	ND (5.2)	ND (5.2)	ND (5.2)	---	ND (5.3)	ND (5.3)	ND (5.3)	ND (5.3)	ND (5.5)
Chrysene	8270SIM	ug/kg	ND (5.1)	ND (5.2)	ND (5.2)	ND (5.2)	---	ND (5.3)	ND (5.3)	ND (5.3)	ND (5.3)	ND (5.5)
Dibenzo (a,h) anthracene	8270SIM	ug/kg	ND (5.1)	ND (5.2)	ND (5.2)	ND (5.2)	---	ND (5.3)	ND (5.3)	ND (5.3)	ND (5.3)	ND (5.5)
Fluoranthene	8270SIM	ug/kg	ND (5.1)	ND (5.2)	ND (5.2)	ND (5.2)	---	ND (5.3)	ND (5.3)	ND (5.3)	ND (5.3)	ND (5.5)
Fluorene	8270SIM	ug/kg	ND (5.1)	ND (5.2)	ND (5.2)	ND (5.2)	---	ND (5.3)	ND (5.3)	ND (5.3)	ND (5.3)	ND (5.5)
Indeno (1,2,3-cd) pyrene	8270SIM	ug/kg	ND (5.1)	ND (5.2)	ND (5.2)	ND (5.2)	---	ND (5.3)	ND (5.3)	ND (5.3)	ND (5.3)	ND (5.5)
Naphthalene	8260	ug/kg	ND (4.3)	ND (4.6)	ND (4.5)	ND (4.2)	---	ND (4.6)	---	ND (4.2)	ND (4.3)	ND (4.8)
Naphthalene	8270SIM	ug/kg	---	---	---	---	---	---	ND (5.3)	---	---	---
PAH High molecular weight	8270SIM	ug/kg	ND (0.0)	ND (0.0)	ND (0.0)	ND (0.0)	---	ND (0.0)	ND (0.0)	ND (0.0)	ND (0.0)	ND (0.0)
PAH Low molecular weight	8270SIM	ug/kg	ND (0.0)	ND (0.0)	ND (0.0)	ND (0.0)	---	ND (0.0)	ND (0.0)	ND (0.0)	ND (0.0)	ND (0.0)
Phenanthrene	8270SIM	ug/kg	ND (5.1)	ND (5.2)	ND (5.2)	ND (5.2)	---	ND (5.3)	ND (5.3)	ND (5.3)	ND (5.3)	ND (5.5)
Pyrene	8270SIM	ug/kg	ND (5.1)	ND (5.2)	ND (5.2)	ND (5.2)	---	ND (5.3)	ND (5.3)	ND (5.3)	ND (5.3)	ND (5.5)
Semivolatile Organic Compounds												
2,4,5-Trichlorophenol	8270C	ug/kg	ND (1600)	ND (1700)	ND (1600)	ND (1600)	---	ND (1700)	ND (1700)	ND (1700)	ND (1700)	ND (1800)
2,4,6-Trichlorophenol	8270C	ug/kg	ND (340)	ND (340)	ND (340)	ND (340)	---	ND (350)	ND (350)	ND (350)	ND (350)	ND (360)
2,4-Dichlorophenol	8270C	ug/kg	ND (340)	ND (340)	ND (340)	ND (340)	---	ND (350)	ND (350)	ND (350)	ND (350)	ND (360)
2,4-Dimethylphenol	8270C	ug/kg	ND (340)	ND (340)	ND (340)	ND (340)	---	ND (350)	ND (350)	ND (350)	ND (350)	ND (360)
2,4-Dinitrophenol	8270C	ug/kg	ND (1600)	ND (1700)	ND (1600)	ND (1600)	---	ND (1700)	ND (1700)	ND (1700)	ND (1700)	ND (1800)
2,4-Dinitrotoluene	8270C	ug/kg	ND (340)	ND (340)	ND (340)	ND (340)	---	ND (350)	ND (350)	ND (350)	ND (350)	ND (360)
2,6-Dinitrotoluene	8270C	ug/kg	ND (340)	ND (340)	ND (340)	ND (340)	---	ND (350)	ND (350)	ND (350)	ND (350)	ND (360)
2-Chloronaphthalene	8270C	ug/kg	ND (340)	ND (340)	ND (340)	ND (340)	---	ND (350)	ND (350)	ND (350)	ND (350)	ND (360)
2-Chlorophenol	8270C	ug/kg	ND (340)	ND (340)	ND (340)	ND (340)	---	ND (350)	ND (350)	ND (350)	ND (350)	ND (360)
2-Methylphenol	8270C	ug/kg	ND (340)	ND (340)	ND (340)	ND (340)	---	ND (350)	ND (350)	ND (350)	ND (350)	ND (360)
2-Nitroaniline	8270C	ug/kg	ND (1600)	ND (1700)	ND (1600)	ND (1600)	---	ND (1700)	ND (1700)	ND (1700)	ND (1700)	ND (1800)
2-Nitrophenol	8270C	ug/kg	ND (340)	ND (340)	ND (340)	ND (340)	---	ND (350)	ND (350)	ND (350)	ND (350)	ND (360)

TABLE A3-1

Soil Sample Analytical Results for Samples Collected during the ERGI

Summary of Findings Associated with the East Ravine Groundwater Investigation

PG&E Topock Compressor Station

	Depth (ft bgs)		Site B (MW-57BR) on 1/14/2009				Site A (MW-58BR_S) on 1/29/2009					
			3-4	8-9	8-9	18-19	1.5-2	19-20	29-30	39-40	49-50	59-60
Analyte	**Method**	**Units**			**(FD)**							
Semivolatile Organic Compounds												
3,3-Dichlorobenzidene	8270C	ug/kg	ND (340)	ND (340)	ND (340)	ND (340)	---	ND (350)	ND (350)	ND (350)	ND (350)	ND (360)
3-Nitroaniline	8270C	ug/kg	ND (1600)	ND (1700)	ND (1600)	ND (1600)	---	ND (1700)	ND (1700)	ND (1700)	ND (1700)	ND (1800)
4,6-Dinitro-2-methylphenol	8270C	ug/kg	ND (1700)	ND (1700)	ND (1700)	ND (1700)	---	ND (1700)	ND (1700)	ND (1800)	ND (1800)	ND (1800)
4-Bromophenyl phenyl ether	8270C	ug/kg	ND (340)	ND (340)	ND (340)	ND (340)	---	ND (350)	ND (350)	ND (350)	ND (350)	ND (360)
4-Chloro-3-methylphenol	8270C	ug/kg	ND (680)	ND (680)	ND (680)	ND (680)	---	ND (700)	ND (700)	ND (700)	ND (700)	ND (720)
4-Chloroaniline	8270C	ug/kg	ND (340)	ND (340)	ND (340)	ND (340)	---	ND (350)	ND (350)	ND (350)	ND (350)	ND (360)
4-Chlorophenyl phenyl ether	8270C	ug/kg	ND (340)	ND (340)	ND (340)	ND (340)	---	ND (350)	ND (350)	ND (350)	ND (350)	ND (360)
4-Methylphenol	8270C	ug/kg	ND (340)	ND (340)	ND (340)	ND (340)	---	ND (350)	ND (350)	ND (350)	ND (350)	ND (360)
4-Nitroaniline	8270C	ug/kg	ND (1600)	ND (1700)	ND (1600)	ND (1600)	---	ND (1700)	ND (1700)	ND (1700)	ND (1700)	ND (1800)
4-Nitrophenol	8270C	ug/kg	ND (1600)	ND (1700)	ND (1600)	ND (1600)	---	ND (1700)	ND (1700)	ND (1700)	ND (1700)	ND (1800)
Benzoic acid	8270C	ug/kg	ND (1700)	ND (1700)	ND (1700)	ND (1700)	---	ND (1700)	ND (1700)	ND (1800)	ND (1800)	ND (1800)
Benzyl alcohol	8270C	ug/kg	ND (680)	ND (680)	ND (680)	ND (680)	---	ND (700)	ND (700)	ND (700)	ND (700)	ND (720)
Bis (2-chloroethoxy) methane	8270C	ug/kg	ND (340)	ND (340)	ND (340)	ND (340)	---	ND (350)	ND (350)	ND (350)	ND (350)	ND (360)
Bis (2-chloroethyl) ether	8270C	ug/kg	ND (340)	ND (340)	ND (340)	ND (340)	---	ND (350)	ND (350)	ND (350)	ND (350)	ND (360)
Bis (2-chloroisopropyl) ether	8270C	ug/kg	ND (340)	ND (340)	ND (340)	ND (340)	---	ND (350)	ND (350)	ND (350)	ND (350)	ND (360)
Bis (2-ethylhexyl) phthalate	8270C	ug/kg	ND (340)	ND (340)	ND (340)	ND (340)	---	ND (350)	ND (350)	ND (350)	ND (350)	ND (360)
Butyl benzyl phthalate	8270C	ug/kg	ND (340)	ND (340)	ND (340)	ND (340)	---	ND (350)	ND (350)	ND (350)	ND (350)	ND (360)
Dibenzofuran	8270C	ug/kg	ND (340)	ND (340)	ND (340)	ND (340)	---	ND (350)	ND (350)	ND (350)	ND (350)	ND (360)
Diethyl phthalate	8270C	ug/kg	ND (340)	ND (340)	ND (340)	ND (340)	---	ND (350)	ND (350)	ND (350)	ND (350)	ND (360)
Dimethyl phthalate	8270C	ug/kg	ND (340)	ND (340)	ND (340)	ND (340)	---	ND (350)	ND (350)	ND (350)	ND (350)	ND (360)
Di-N-butyl phthalate	8270C	ug/kg	ND (340)	ND (340)	ND (340)	ND (340)	---	ND (350)	ND (350)	ND (350)	ND (350)	ND (360)
Di-N-octyl phthalate	8270C	ug/kg	ND (340)	ND (340)	ND (340)	ND (340)	---	ND (350)	ND (350)	ND (350)	ND (350)	ND (360)
Hexachlorobenzene	8270C	ug/kg	ND (340)	ND (340)	ND (340)	ND (340)	---	ND (350)	ND (350)	ND (350)	ND (350)	ND (360)
Hexachloroethane	8270C	ug/kg	ND (340)	ND (340)	ND (340)	ND (340)	---	ND (350)	ND (350)	ND (350)	ND (350)	ND (360)
Isophorone	8270C	ug/kg	ND (340)	ND (340)	ND (340)	ND (340)	---	ND (350)	ND (350)	ND (350)	ND (350)	ND (360)
Nitrobenzene	8270C	ug/kg	ND (340)	ND (340)	ND (340)	ND (340)	---	ND (350)	ND (350)	ND (350)	ND (350)	ND (360)
N-Nitroso-di-n-propylamine	8270C	ug/kg	ND (340)	ND (340)	ND (340)	ND (340)	---	ND (350)	ND (350)	ND (350)	ND (350)	ND (360)

TABLE A3-1

Soil Sample Analytical Results for Samples Collected during the ERGI

Summary of Findings Associated with the East Ravine Groundwater Investigation

PG&E Topock Compressor Station

			Site B (MW-57BR) on 1/14/2009				Site A (MW-58BR_S) on 1/29/2009					
	Depth (ft bgs)		3-4	8-9	8-9	18-19	1.5-2	19-20	29-30	39-40	49-50	59-60
Analyte	**Method**	**Units**			**(FD)**							
Semivolatile Organic Compounds												
N-nitrosodiphenylamine	8270C	ug/kg	ND (340)	ND (340)	ND (340)	ND (340)	---	ND (350)	ND (350)	ND (350)	ND (350)	ND (360)
Pentachloro phenol	8270C	ug/kg	ND (1600)	ND (1700)	ND (1600)	ND (1600)	---	ND (1700)	ND (1700)	ND (1700)	ND (1700)	ND (1800)
Phenol	8270C	ug/kg	ND (340)	ND (340)	ND (340)	ND (340)	---	ND (350)	ND (350)	ND (350)	ND (350)	ND (360)
Total Petroleum Hydrocarbons												
TPH as diesel	8015M	mg/kg	ND (10)	ND (10)	ND (10)	ND (10)	---	ND (11)	ND (11)	ND (11)	ND (11)	ND (11)
TPH as gasoline	8015M	mg/kg	ND (0.96)	ND (0.89)	ND (0.92)	ND (0.83)	---	ND (1.4)	ND (0.84)	ND (0.73)	ND (0.96) J	ND (1.1)
TPH as motor oil	8015M	mg/kg	ND (10)	ND (10)	ND (10)	ND (10)	---	ND (11)	ND (11)	ND (11)	ND (11)	ND (11)
Volatile Organic Compounds												
1,1,1,2-Tetrachloroethane	8260	ug/kg	ND (4.3)	ND (4.6)	ND (4.5)	ND (4.2)	---	ND (4.6)	ND (5.9)	ND (4.2)	ND (4.3)	ND (4.8)
1,1,1-Trichloroethane	8260	ug/kg	ND (4.3)	ND (4.6)	ND (4.5)	ND (4.2)	---	ND (4.6)	ND (5.9)	ND (4.2)	ND (4.3)	ND (4.8)
1,1,2,2-Tetrachloroethane	8260	ug/kg	ND (4.3)	ND (4.6)	ND (4.5)	ND (4.2)	---	ND (4.6)	ND (5.9)	ND (4.2)	ND (4.3)	ND (4.8)
1,1,2-Trichloroethane	8260	ug/kg	ND (4.3)	ND (4.6)	ND (4.5)	ND (4.2)	---	ND (4.6)	ND (5.9)	ND (4.2)	ND (4.3)	ND (4.8)
1,1,2-Trichlorotrifluoroethane (Freon 113)	8260	ug/kg	ND (4.3)	ND (4.6)	ND (4.5)	ND (4.2)	---	ND (4.6)	ND (5.9)	ND (4.2)	ND (4.3)	ND (4.8)
1,1-Dichloroethane	8260	ug/kg	ND (4.3)	ND (4.6)	ND (4.5)	ND (4.2)	---	ND (4.6)	ND (5.9)	ND (4.2)	ND (4.3)	ND (4.8)
1,1-Dichloroethene	8260	ug/kg	ND (4.3)	ND (4.6)	ND (4.5)	ND (4.2)	---	ND (4.6)	ND (5.9)	ND (4.2)	ND (4.3)	ND (4.8)
1,1-Dichloropropene	8260	ug/kg	ND (4.3)	ND (4.6)	ND (4.5)	ND (4.2)	---	ND (4.6)	ND (5.9)	ND (4.2)	ND (4.3)	ND (4.8)
1,2,3-Trichlorobenzene	8260	ug/kg	ND (4.3)	ND (4.6)	ND (4.5)	ND (4.2)	---	ND (4.6)	ND (5.9)	ND (4.2)	ND (4.3)	ND (4.8)
1,2,3-Trichloropropane	8260	ug/kg	ND (4.3)	ND (4.6)	ND (4.5)	ND (4.2)	---	ND (4.6)	ND (5.9)	ND (4.2)	ND (4.3)	ND (4.8)
1,2,4-Trichlorobenzene	8260	ug/kg	ND (4.3)	ND (4.6)	ND (4.5)	ND (4.2)	---	ND (4.6)	ND (5.9)	ND (4.2)	ND (4.3)	ND (4.8)
1,2,4-Trimethylbenzene	8260	ug/kg	ND (4.3)	ND (4.6)	ND (4.5)	ND (4.2)	---	ND (4.6)	ND (5.9)	ND (4.2)	ND (4.3)	ND (4.8)
1,2-Dibromo-3-chloropropane	8260	ug/kg	ND (4.3)	ND (4.6)	ND (4.5)	ND (4.2)	---	ND (4.6)	ND (5.9)	ND (4.2)	ND (4.3)	ND (4.8)
1,2-Dibromoethane	8260	ug/kg	ND (4.3)	ND (4.6)	ND (4.5)	ND (4.2)	---	ND (4.6)	ND (5.9)	ND (4.2)	ND (4.3)	ND (4.8)
1,2-Dichlorobenzene	8260	ug/kg	ND (4.3)	ND (4.6)	ND (4.5)	ND (4.2)	---	ND (4.6)	ND (5.9)	ND (4.2)	ND (4.3)	ND (4.8)
1,2-Dichloroethane	8260	ug/kg	ND (4.3)	ND (4.6)	ND (4.5)	ND (4.2)	---	ND (4.6)	ND (5.9)	ND (4.2)	ND (4.3)	ND (4.8)
1,2-Dichloropropane	8260	ug/kg	ND (4.3)	ND (4.6)	ND (4.5)	ND (4.2)	---	ND (4.6)	ND (5.9)	ND (4.2)	ND (4.3)	ND (4.8)
1,3,5-Trimethylbenzene	8260	ug/kg	ND (4.3)	ND (4.6)	ND (4.5)	ND (4.2)	---	ND (4.6)	ND (5.9)	ND (4.2)	ND (4.3)	ND (4.8)
1,3-Dichlorobenzene	8260	ug/kg	ND (4.3)	ND (4.6)	ND (4.5)	ND (4.2)	---	ND (4.6)	ND (5.9)	ND (4.2)	ND (4.3)	ND (4.8)

TABLE A3-1

Soil Sample Analytical Results for Samples Collected during the ERGI

Summary of Findings Associated with the East Ravine Groundwater Investigation

PG&E Topock Compressor Station

	Depth (ft bgs)		Site B (MW-57BR) on 1/14/2009				Site A (MW-58BR_S) on 1/29/2009					
			3-4	8-9	8-9	18-19	1.5-2	19-20	29-30	39-40	49-50	59-60
Analyte	**Method**	**Units**			**(FD)**							
Volatile Organic Compounds												
1,3-Dichloropropane	8260	ug/kg	ND (4.3)	ND (4.6)	ND (4.5)	ND (4.2)	---	ND (4.6)	ND (5.9)	ND (4.2)	ND (4.3)	ND (4.8)
1,4-Dichlorobenzene	8260	ug/kg	ND (4.3)	ND (4.6)	ND (4.5)	ND (4.2)	---	ND (4.6)	ND (5.9)	ND (4.2)	ND (4.3)	ND (4.8)
2,2-Dichloropropane	8260	ug/kg	ND (4.3)	ND (4.6)	ND (4.5)	ND (4.2)	---	ND (4.6)	ND (5.9)	ND (4.2)	ND (4.3)	ND (4.8)
2-Chlorotoluene	8260	ug/kg	ND (4.3)	ND (4.6)	ND (4.5)	ND (4.2)	---	ND (4.6)	ND (5.9)	ND (4.2)	ND (4.3)	ND (4.8)
4-Isopropyltoluene	8260	ug/kg	ND (4.3)	ND (4.6)	ND (4.5)	ND (4.2)	---	ND (4.6)	ND (5.9)	ND (4.2)	ND (4.3)	ND (4.8)
Acetone	8260	ug/kg	ND (43)	ND (46)	ND (45)	ND (42)	---	ND (46)	ND (59)	ND (42)	ND (43)	ND (48)
Acrolein	8260	ug/kg	ND (86)	ND (91)	ND (90)	ND (84)	---	ND (91)	ND (120)	ND (84)	ND (86)	ND (96)
Acrylonitrile	8260	ug/kg	ND (43)	ND (46)	ND (45)	ND (42)	---	ND (46)	ND (59)	ND (42)	ND (43)	ND (48)
Benzene	8260	ug/kg	ND (4.3)	ND (4.6)	ND (4.5)	ND (4.2)	---	ND (4.6)	ND (5.9)	ND (4.2)	ND (4.3)	ND (4.8)
Bromobenzene	8260	ug/kg	ND (4.3)	ND (4.6)	ND (4.5)	ND (4.2)	---	ND (4.6)	ND (5.9)	ND (4.2)	ND (4.3)	ND (4.8)
Bromochloromethane	8260	ug/kg	ND (4.3)	ND (4.6)	ND (4.5)	ND (4.2)	---	ND (4.6)	ND (5.9)	ND (4.2)	ND (4.3)	ND (4.8)
Bromodichloromethane	8260	ug/kg	ND (4.3)	ND (4.6)	ND (4.5)	ND (4.2)	---	ND (4.6)	ND (5.9)	ND (4.2)	ND (4.3)	ND (4.8)
Bromoform	8260	ug/kg	ND (4.3)	ND (4.6)	ND (4.5)	ND (4.2)	---	ND (4.6)	ND (5.9)	ND (4.2)	ND (4.3)	ND (4.8)
Bromomethane	8260	ug/kg	ND (4.3)	ND (4.6)	ND (4.5)	ND (4.2)	---	ND (4.6)	ND (5.9)	ND (4.2)	ND (4.3)	ND (4.8)
Carbon disulfide	8260	ug/kg	ND (4.3)	ND (4.6)	ND (4.5)	ND (4.2)	---	ND (4.6)	ND (5.9)	ND (4.2)	ND (4.3)	ND (4.8)
Carbon tetrachloride	8260	ug/kg	ND (4.3)	ND (4.6)	ND (4.5)	ND (4.2)	---	ND (4.6)	ND (5.9)	ND (4.2)	ND (4.3)	ND (4.8)
Chlorobenzene	8260	ug/kg	ND (4.3)	ND (4.6)	ND (4.5)	ND (4.2)	---	ND (4.6)	ND (5.9)	ND (4.2)	ND (4.3)	ND (4.8)
Chloroethane	8260	ug/kg	ND (4.3)	ND (4.6)	ND (4.5)	ND (4.2)	---	ND (4.6)	ND (5.9)	ND (4.2)	ND (4.3)	ND (4.8)
Chloroform	8260	ug/kg	ND (4.3)	ND (4.6)	ND (4.5)	ND (4.2)	---	ND (4.6)	ND (5.9)	ND (4.2)	ND (4.3)	ND (4.8)
Chloromethane	8260	ug/kg	ND (4.3)	ND (4.6)	ND (4.5)	ND (4.2)	---	ND (4.6)	ND (5.9)	ND (4.2)	ND (4.3)	ND (4.8)
cis-1,2-Dichloroethene	8260	ug/kg	ND (4.3)	ND (4.6)	ND (4.5)	ND (4.2)	---	ND (4.6)	ND (5.9)	ND (4.2)	ND (4.3)	ND (4.8)
cis-1,3-Dichloropropene	8260	ug/kg	ND (4.3)	ND (4.6)	ND (4.5)	ND (4.2)	---	ND (4.6)	ND (5.9)	ND (4.2)	ND (4.3)	ND (4.8)
Dibromochloromethane	8260	ug/kg	ND (4.3)	ND (4.6)	ND (4.5)	ND (4.2)	---	ND (4.6)	ND (5.9)	ND (4.2)	ND (4.3)	ND (4.8)
Dibromomethane	8260	ug/kg	ND (4.3)	ND (4.6)	ND (4.5)	ND (4.2)	---	ND (4.6)	ND (5.9)	ND (4.2)	ND (4.3)	ND (4.8)
Dichlorodifluoromethane	8260	ug/kg	ND (4.3)	ND (4.6)	ND (4.5)	ND (4.2)	---	ND (4.6)	ND (5.9)	ND (4.2)	ND (4.3)	ND (4.8)
Ethylbenzene	8260	ug/kg	ND (4.3)	ND (4.6)	ND (4.5)	ND (4.2)	---	ND (4.6)	ND (5.9)	ND (4.2)	ND (4.3)	ND (4.8)
Hexachlorobutadiene	8260	ug/kg	ND (4.3)	ND (4.6)	ND (4.5)	ND (4.2)	---	ND (4.6)	ND (5.9)	ND (4.2)	ND (4.3)	ND (4.8)

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PG&E Topock Compressor Station

	Depth (ft bgs)		Site B (MW-57BR) on 1/14/2009				Site A (MW-58BR_S) on 1/29/2009					
			3-4	**8-9**	**8-9**	**18-19**	**1.5-2**	**19-20**	**29-30**	**39-40**	**49-50**	**59-60**
Analyte	**Method**	**Units**			**(FD)**							
Volatile Organic Compounds												
Isopropylbenzene	8260	ug/kg	ND (4.3)	ND (4.6)	ND (4.5)	ND (4.2)	---	ND (4.6)	ND (5.9)	ND (4.2)	ND (4.3)	ND (4.8)
m+p-Xylenes	8260	ug/kg	ND (4.3)	ND (4.6)	ND (4.5)	ND (4.2)	---	ND (4.6)	ND (5.9)	ND (4.2)	ND (4.3)	ND (4.8)
Methyl ethyl ketone	8260	ug/kg	ND (43)	ND (46)	ND (45)	ND (42)	---	ND (46)	ND (59)	ND (42)	ND (43)	ND (48)
Methyl isobutyl ketone	8260	ug/kg	ND (43)	ND (46)	ND (45)	ND (42)	---	ND (46)	ND (59)	ND (42)	ND (43)	ND (48)
Methyl tert-butyl ether (MTBE)	8260	ug/kg	ND (4.3)	ND (4.6)	ND (4.5)	ND (4.2)	---	ND (4.6)	ND (5.9)	ND (4.2)	ND (4.3)	ND (4.8)
Methylene chloride	8260	ug/kg	ND (4.3)	ND (4.6)	ND (4.5)	ND (4.2)	---	ND (4.6)	ND (5.9)	ND (4.2)	ND (4.3)	ND (4.8)
N-Butylbenzene	8260	ug/kg	ND (4.3)	ND (4.6)	ND (4.5)	ND (4.2)	---	ND (4.6)	ND (5.9)	ND (4.2)	ND (4.3)	ND (4.8)
N-Propylbenzene	8260	ug/kg	ND (4.3)	ND (4.6)	ND (4.5)	ND (4.2)	---	ND (4.6)	ND (5.9)	ND (4.2)	ND (4.3)	ND (4.8)
o-Xylene	8260	ug/kg	ND (4.3)	ND (4.6)	ND (4.5)	ND (4.2)	---	ND (4.6)	ND (5.9)	ND (4.2)	ND (4.3)	ND (4.8)
p-Chlorotoluene	8260	ug/kg	ND (4.3)	ND (4.6)	ND (4.5)	ND (4.2)	---	ND (4.6)	ND (5.9)	ND (4.2)	ND (4.3)	ND (4.8)
sec-Butylbenzene	8260	ug/kg	ND (4.3)	ND (4.6)	ND (4.5)	ND (4.2)	---	ND (4.6)	ND (5.9)	ND (4.2)	ND (4.3)	ND (4.8)
Styrene	8260	ug/kg	ND (4.3)	ND (4.6)	ND (4.5)	ND (4.2)	---	ND (4.6)	ND (5.9)	ND (4.2)	ND (4.3)	ND (4.8)
tert-Butylbenzene	8260	ug/kg	ND (4.3)	ND (4.6)	ND (4.5)	ND (4.2)	---	ND (4.6)	ND (5.9)	ND (4.2)	ND (4.3)	ND (4.8)
Tetrachloroethene	8260	ug/kg	ND (4.3)	ND (4.6)	ND (4.5)	ND (4.2)	---	ND (4.6)	ND (5.9)	ND (4.2)	ND (4.3)	ND (4.8)
Toluene	8260	ug/kg	ND (4.3)	ND (4.6)	ND (4.5)	ND (4.2)	---	ND (4.6)	ND (5.9)	ND (4.2)	ND (4.3)	ND (4.8)
trans-1,2-Dichloroethene	8260	ug/kg	ND (4.3)	ND (4.6)	ND (4.5)	ND (4.2)	---	ND (4.6)	ND (5.9)	ND (4.2)	ND (4.3)	ND (4.8)
trans-1,3-Dichloropropene	8260	ug/kg	ND (4.3)	ND (4.6)	ND (4.5)	ND (4.2)	---	ND (4.6)	ND (5.9)	ND (4.2)	ND (4.3)	ND (4.8)
Trichloroethene	8260	ug/kg	ND (4.3)	ND (4.6)	ND (4.5)	ND (4.2)	---	ND (4.6)	ND (5.9)	ND (4.2)	ND (4.3)	ND (4.8)
Trichlorofluoromethane (Freon 11)	8260	ug/kg	ND (4.3)	ND (4.6)	ND (4.5)	ND (4.2)	---	ND (4.6)	ND (5.9)	ND (4.2)	ND (4.3)	ND (4.8)
Vinyl chloride	8260	ug/kg	ND (4.3)	ND (4.6)	ND (4.5)	ND (4.2)	---	ND (4.6)	ND (5.9)	ND (4.2)	ND (4.3)	ND (4.8)
Xylenes, total	8260	ug/kg	ND (4.3)	ND (4.6)	ND (4.5)	ND (4.2)	---	ND (4.6)	ND (5.9)	ND (4.2)	ND (4.3)	ND (4.8)

NOTES:

FD	field duplicate
ft bgs	feet below ground surface
ND	not detected at listed reporting limit
ug/kg	micrograms per kilogram
mg/kg	milligrams per kilogram

TABLE A3-2

Complete Groundwater Analytical Results for New ERGI Monitoring Wells, Inorganic Constituents

Summary of Findings Associated with the East Ravine Groundwater Investigation

PG&E Topock Compressor Station

Analyte	Method	Units	MW-57-070 2/11/09	MW-59-100 3/18/09	MW-60-125 3/20/09	MW-61-110 3/23/09	MW-62-065 3/27/09	MW-63-065 4/15/09
Anions								
Chloride	300	mg/L	710	3300 J	2500	4700	1900	1500
Nitrate as Nitrogen	300	mg/L	8.00	4.20	4.40	ND (2.5)	4.80	ND (1.0)
Sulfate	300	mg/L	130 J	760 J	450 J	620 J	400	540 J
General Chemistry								
Alkalinity, as carbonate	2320B	mg/L	ND (5.0) J	ND (5.0)	ND (5.0)	ND (5.0) J	ND (5.0) J	ND (5.0) J
Alkalinity, bicarb. as CaCO3	2320B	mg/L	81.0	110	58.0	52.0	110	200
Alkalinity, hydroxide	2320B	mg/L	ND (5.0)	ND (5.0)	ND (5.0)	ND (5.0)	ND (5.0)	ND (5.0)
Alkalinity, total as CaCO3	2320B	mg/L	81.0	110	58.0	52.0	110	200
Ammonia as nitrogen	SM4500NH3C	mg/L	ND (0.1)	ND (0.5)	ND (0.5)	ND (0.5)	ND (0.5)	ND (0.1)
Deuterium	CFIRM	0/00	-64.5	-62.4	-70.5	-75.7	-67	---
Oxygen 18	CFIRM	0/00	-8.58	-7.84	-9.28	-9.86	-8.91	---
Total dissolved solids	SM2540C	mg/L	1700	7800	5400	9100	3800	3400
Total organic carbon	SM5310B	mg/L	1.60	3.40	1.20	3.30	2.70	6.40
Metals								
Aluminum, dissolved	6010B	µg/L	---	---	---	---	---	---
Antimony, dissolved	6020A\6010B	µg/L	ND (0.5)	ND (2.5)	ND (2.5)	ND (5.0)	ND (2.5)	ND (0.5)
Arsenic, dissolved	6020A	µg/L	4.10	13.0	8.70	17.0	6.10	5.20
Barium, dissolved	6010B	µg/L	67.0	160	63.0	120	45.0	69.0
Beryllium, dissolved	6010B	µg/L	ND (3.0)	ND (6.0)	ND (3.0)	ND (6.0)	ND (3.0)	ND (3.0)
Cadmium, dissolved	6010B	µg/L	ND (3.0)	ND (3.0)	ND (3.0)	ND (3.0)	ND (3.0)	ND (3.0)
Chromium, dissolved	6010B	µg/L	720	4800	840	670	740	2.30
Chromium, Hexavalent	2186	µg/L	660	4300	810	620	720	ND (0.2)
Cobalt, dissolved	6010B	µg/L	ND (3.0)	ND (6.0)	ND (3.0)	ND (6.0)	ND (3.0)	ND (3.0)
Copper, dissolved	6010B	µg/L	ND (5.0)	ND (10)	ND (5.0)	ND (10)	ND (5.0)	ND (5.0)
Lead, dissolved	6010B	µg/L	ND (10)	ND (10)	ND (10)	ND (10)	ND (10)	ND (10)
Mercury, dissolved	7470A	µg/L	ND (0.2)	ND (0.2)	ND (0.2)	ND (0.2)	ND (0.2)	ND (0.2)
Molybdenum, dissolved	6010B	µg/L	13.0	38.0	25.0	38.0	23.0	41.0
Nickel, dissolved	6010B	µg/L	ND (5.0)	13.0	ND (5.0)	ND (5.0)	ND (5.0)	ND (5.0)
Selenium, dissolved	6020A\6010B	µg/L	ND (10)	ND (10)	ND (10)	ND (10)	ND (10)	ND (10)
Silver, dissolved	6010B	µg/L	ND (3.0)	ND (6.0)	ND (3.0)	ND (6.0)	ND (3.0)	ND (3.0)
Thallium, dissolved	6020A	µg/L	ND (0.5)	ND (2.5)	ND (2.5)	ND (5.0)	ND (2.5)	ND (0.5)
Vanadium, dissolved	6010B	µg/L	ND (3.0)	ND (6.0)	ND (3.0)	ND (6.0)	ND (3.0)	ND (3.0)
Zinc, dissolved	6010B	µg/L	ND (10)	ND (20)	ND (10)	ND (20)	ND (10)	ND (10)
General Metals								
Calcium, dissolved	6010B	mg/L	340	870	450 J	510	200	150

TABLE A3-2

Complete Groundwater Analytical Results for New ERGI Monitoring Wells, Inorganic Constituents

Summary of Findings Associated with the East Ravine Groundwater Investigation

PG&E Topock Compressor Station

Analyte	Method	Units	MW-57-070 2/11/09	MW-59-100 3/18/09	MW-60-125 3/20/09	MW-61-110 3/23/09	MW-62-065 3/27/09	MW-63-065 4/15/09
General Metals								
Iron, dissolved	6010B	mg/L	ND (0.5)	ND (1.0)	ND (0.5)	ND (1.0)	ND (0.5)	ND (0.5)
Magnesium, dissolved	6010B	mg/L	24.0	31.0	29.0	22.0	24.0	21.0
Manganese, dissolved	6010B	mg/L	0.031	2.40	0.12	0.70	0.037	0.52
Potassium, dissolved	6010B	mg/L	11.0	46.0	39.0	58.0	29.0	26.0
Sodium, dissolved	6010B	mg/L	110	1500	1500 J	2800	1400	1200

NOTES:

FD	field duplicate
ND	not detected at listed reporting limit
ug/L	micrograms per liter
mg/L	milligrams per liter
J	concentration estimated by laboratory or data validation

TABLE A3-2

Complete Groundwater Analytical Results for New ERGI Monitoring Wells, Inorganic Constituents

Summary of Findings Associated with the East Ravine Groundwater Investigation

PG&E Topock Compressor Station

Analyte	Method	Units	MW-23-060 7/21/09	MW-23-080 7/21/09	MW-57-070 7/21/09	MW-57-185 7/20/09	MW-58-115 7/22/09	MW-58-205 7/22/09	MW-59-100 7/22/09	MW-59-100 7/22/09 (FD)	MW-60-125 7/21/09	MW-61-110 7/21/09	MW-62-065 7/22/09	MW-62-110 7/22/09	MW-62-190 7/22/09	MW-63-065 7/20/09	MW-63-065 7/20/09 (FD)	MW-64-150 7/22/09	MW-64-205 7/22/09	MW-64-260 7/22/09
Anions																				
Chloride	300	mg/L	5500	5400	840	6100	4000	2800	3500	3500	2600	5200	1600	2500	6300	1800	1700	2600	4500	3200
Nitrate as Nitrogen	300	mg/L	3.90	6.30	9.10	ND (2.5)	ND (2.5)	ND (2.5)	4.40	4.50	3.30	ND (2.5)	2.90	ND (1.0)	ND (2.5)	ND (1.0)	ND (1.0)	ND (1.0)	ND (2.5)	ND (1.0)
Sulfate	300	mg/L	540	650	100	680	550	490	750	750	390	640	360	450	690	570	560	450	580	470
General Chemistry																				
Alkalinity, as carbonate	2320B	mg/L	ND (5.0)	25.0	ND (5.0) J	6.30	ND (5.0) J	ND (5.0)	ND (5.0)	ND (5.0)	ND (5.0)	ND (5.0)	ND (5.0)	ND (5.0)	ND (5.0)	ND (5.0)	ND (5.0)	ND (5.0)	ND (5.0)	ND (5.0)
Alkalinity, bicarb. as CaCO3	2320B	mg/L	28.0	ND (5.0)	75.0	20.0	43.0	45.0	110	110	77.0	51.0	120	74.0	49.0	210	210	57.0	54.0	66.0
Alkalinity, hydroxide	2320B	mg/L	ND (5.0)	110	ND (5.0)	ND (5.0)	ND (5.0)	ND (5.0)	ND (5.0)	ND (5.0)	ND (5.0)	ND (5.0)	ND (5.0)	ND (5.0)	ND (5.0)	ND (5.0)	ND (5.0)	ND (5.0)	ND (5.0)	ND (5.0)
Alkalinity, total as CaCO3	2320B	mg/L	28.0	140	75.0	26.0	43.0	45.0	110	110	77.0	51.0	120	74.0	49.0	210	210	57.0	54.0	66.0
Ammonia as nitrogen	SM4500NH3C	mg/L	ND (0.1)	ND (0.1)	ND (0.1)	ND (0.1)	ND (0.1)	ND (0.1)	ND (0.1)	ND (0.1)	ND (0.1)	0.15	0.12	ND (0.1)	ND (0.1)	ND (0.1)	ND (0.1)	0.20	0.14	0.18
Deuterium	CFIRM	0/00	-75.3	-73.4	-65.9	-79.1	-77.5	-76.9	-63	-62.4	-72.7	-76.5	-70.6	-70.5	-79.4	-98	-98.3	-78.2	-77.8	-78.7
Oxygen 18	CFIRM	0/00	-8.96	-8.67	-9.29	-10.3	-10.4	-10.5	-8.4	-7.79	-9.51	-10	-9.75	-9.27	-10.6	-12	-12.4	-10.2	-9.73	-9.91
Total dissolved solids	SM2540C	mg/L	11000	11000	2000	11000	7800	5700	7500	7500	5200	9600	3600	5000	11000	4100	4100	5100	8000	6200
Total organic carbon	SM5310B	mg/L	1.60	1.70	1.30	0.57	17.0 J	18.0 J	ND (0.6) J	0.80 J	0.42	1.90	0.95 J	25.0 J	58.0 J	0.69	ND (1.2)	16.0 J	19.0 J	25.0 J
Metals																				
Aluminum, dissolved	6010B	µg/L	ND (200)	250	ND (200)	ND (200)	ND (200)	ND (200)	ND (200)	ND (200)	ND (200)	ND (200)	ND (200)	ND (200)	ND (200)	ND (200)	ND (200)	ND (200)	ND (200)	ND (200)
Antimony, dissolved	6020A\6010B	µg/L	ND (10)	ND (10)	ND (10)	ND (10)	ND (10)	ND (10)	ND (10)	ND (10)	ND (10)	ND (10)	ND (10)	ND (10)	ND (10)	ND (10)	ND (10)	ND (10)	ND (10)	ND (10)
Arsenic, dissolved	6020A	µg/L	25.0	24.0	5.00	30.0	110 R'	340 R'	18.0	17.0	11.0	22.0	6.50	430 R'	270 R'	6.70	6.60	450 R'	550 R'	770 R'
Barium, dissolved	6010B	µg/L	200	170	110	82.0	190	120	72.0	70.0	45.0	110	34.0	69.0	120	35.0	35.0	140	140	170
Beryllium, dissolved	6010B	µg/L	ND (2.5)	ND (2.5)	ND (2.5)	ND (2.5)	ND (2.5)	ND (2.5)	ND (2.5)	ND (2.5)	ND (2.5)	ND (2.5)	ND (2.5)	ND (2.5)	ND (2.5)	ND (2.5)	ND (2.5)	ND (2.5)	ND (2.5)	ND (2.5)
Cadmium, dissolved	6010B	µg/L	ND (3.0)	ND (3.0)	ND (3.0)	ND (3.0)	ND (3.0)	ND (3.0)	ND (3.0)	ND (3.0)	ND (3.0)	ND (3.0)	ND (3.0)	ND (3.0)	ND (3.0)	ND (3.0)	ND (3.0)	ND (3.0)	ND (3.0)	ND (3.0)
Chromium, dissolved	6010B	µg/L	30.0	44.0	350	ND (4.9)	3.00	6.30	4900	4800	810	260	300	71.0	2.00	ND (2.9)	ND (3.0)	5.20	17.0	4.80
Chromium, Hexavalent	2186	µg/L	26.0	34.0	340	1.40	ND (1.0)	ND (1.0)	5100	5100	780	240	290	74.0	ND (1.0)	0.54	0.54	ND (1.0)	5.70	ND (1.0)
Cobalt, dissolved	6010B	µg/L	ND (3.0)	ND (3.0)	ND (3.0)	ND (3.0)	ND (3.0)	ND (3.0)	ND (3.0)	ND (3.0)	ND (3.0)	ND (3.0)	ND (3.0)	ND (3.0)	ND (3.0)	ND (3.0)	ND (3.0)	ND (3.0)	ND (3.0)	ND (3.0)
Copper, dissolved	6010B	µg/L	67.0	36.0	9.70	11.0	ND (5.0)	6.80	ND (5.0)	ND (5.0)	6.70	10.0	ND (5.0)	ND (5.0)	ND (5.0)	5.50	7.80	ND (5.0)	31.0	ND (5.0)
Lead, dissolved	6010B	µg/L	ND (10)	ND (10)	ND (10)	ND (10)	ND (10)	ND (10)	ND (10)	ND (10)	ND (10)	ND (10)	ND (10)	ND (10)	ND (10)	ND (10)	ND (10)	ND (10)	ND (10)	ND (10)
Mercury, dissolved	7470A	µg/L	ND (0.2)	ND (0.2)	ND (0.2)	ND (0.2)	ND (0.2) J	ND (0.2) J	ND (0.2) J	ND (0.2) J	ND (0.2)	ND (0.2)	ND (0.2) J	ND (0.2) J	ND (0.2) J	ND (0.2)	ND (0.2)	ND (0.2) J	ND (0.2) J	ND (0.2) J
Molybdenum, dissolved	6010B	µg/L	50.0	95.0	22.0	99.0	62.0	51.0	38.0	39.0	45.0	60.0	28.0	110	100	50.0	49.0	110	93.0	85.0
Nickel, dissolved	6010B	µg/L	ND (5.0)	ND (5.0)	ND (5.0)	ND (5.0)	ND (5.0)	ND (5.0)	ND (5.0)	ND (5.0)	ND (5.0)	ND (5.0)	ND (5.0)	ND (5.0)	ND (5.0)	ND (5.0)	ND (5.0)	ND (5.0)	ND (5.0)	ND (5.0)
Selenium, dissolved	6020A\6010B	µg/L	2.70	0.82	4.40	ND (2.5) J	ND (0.5)	ND (0.5)	5.10	ND (0.5)	4.20	ND (0.5)	2.70	1.40	ND (0.5)	ND (0.5)	ND (0.5)	ND (0.5)	ND (0.5)	ND (0.5)
Silver, dissolved	6010B	µg/L	ND (3.0)	ND (3.0)	ND (3.0)	ND (3.0)	ND (3.0)	ND (3.0)	ND (3.0)	ND (3.0)	ND (3.0)	ND (3.0)	ND (3.0)	ND (3.0)	ND (3.0)	ND (3.0)	ND (3.0)	ND (3.0)	ND (3.0)	ND (3.0)
Thallium, dissolved	6020A	µg/L	ND (0.5)	ND (0.5)	ND (0.5)	ND (2.5)	ND (0.5)	ND (0.5)	ND (0.5)	ND (0.5)	0.99	ND (0.5)	ND (0.5)	ND (0.5)	ND (0.5)	0.94	0.91	ND (0.5)	ND (0.5)	ND (0.5)
Vanadium, dissolved	6010B	µg/L	ND (3.0)	12.0	ND (3.0)	ND (3.0)	ND (3.0)	ND (3.0)	ND (3.0)	ND (3.0)	ND (3.0)	ND (3.0)	ND (3.0)	ND (3.0)	ND (3.0)	ND (3.0)	ND (3.0)	ND (3.0)	ND (3.0)	ND (3.0)
Zinc, dissolved	6010B	µg/L	ND (75)	ND (120)	ND (48)	ND (63)	ND (40)	ND (23)	ND (20)	ND (58)	ND (27)	ND (38)	ND (19)	ND (12)	ND (33)	ND (34)	ND (54)	ND (21)	ND (41)	ND (11)
General Metals																				
Calcium, dissolved	6010B	mg/L	830	900	420	330	610	470	830	820	480	630	200	150	350	200	200	230	330	270

TABLE A3-2

Complete Groundwater Analytical Results for New ERGI Monitoring Wells, Inorganic Constituents
Summary of Findings Associated with the East Ravine Groundwater Investigation
PG&E Topock Compressor Station

			MW-23-060	MW-23-080	MW-57-070	MW-57-185	MW-58-115	MW-58-205	MW-59-100	MW-59-100	MW-60-125	MW-61-110	MW-62-065	MW-62-110	MW-62-190	MW-63-065	MW-63-065	MW-64-150	MW-64-205	MW-64-260
Analyte	**Method**	**Units**	**7/21/09**	**7/21/09**	**7/21/09**	**7/20/09**	**7/22/09**	**7/22/09**	**7/22/09**	**7/22/09 (FD)**	**7/21/09**	**7/21/09**	**7/22/09**	**7/22/09**	**7/22/09**	**7/20/09**	**7/20/09 (FD)**	**7/22/09**	**7/22/09**	**7/22/09**
General Metals																				
Iron, dissolved	6010B	mg/L	ND (0.04)	ND (0.04)	ND (0.04)	ND (0.04)	0.13	0.057	ND (0.04)	ND (0.04)	ND (0.04)	ND (0.04)	ND (0.04)	ND (0.04)	0.055	ND (0.04)	ND (0.04)	0.05	ND (0.04)	0.13
Magnesium, dissolved	6010B	mg/L	49.0	0.19	28.0	3.30	33.0	25.0	26.0	25.0	29.0	23.0	25.0	7.00	14.0	21.0	21.0	15.0	15.0	17.0
Manganese, dissolved	6010B	mg/L	ND (0.01)	ND (0.01)	0.086	1.10	2.50	0.31	0.29	0.29	0.14	0.82	0.062	0.44	2.20	0.24	0.23	0.47	0.27	0.33
Potassium, dissolved	6010B	mg/L	100	94.0	12.0	66.0	47.0	33.0	55.0	51.0	41.0	73.0	36.0	35.0	62.0	33.0	32.0	36.0	47.0	41.0
Sodium, dissolved	6010B	mg/L	2700	2900	110	3600	1700	1100	1300	1300	1100	2700	860	1400	3500	1200	1200	1400	2100	1600

NOTES:

FD	field duplicate
ND	not detected at listed reporting limit
ug/L	micrograms per liter
mg/L	milligrams per liter
J	concentration estimated by laboratory or data validation

TABLE A3-3

Complete Groundwater Analytical Results for New ERGI Monitoring Wells, Organic Constituents
Summary of Findings Associated with the East Ravine Groundwater Investigation
PG&E Topock Compressor Station

Analyte	Method	Units	MW-57-070 2/11/09	MW-59-100 3/18/09	MW-60-125 3/20/09	MW-61-110 3/23/09	MW-62-065 3/27/09	MW-63-065 4/15/09
Volatile Organic Compounds								
1,1,1,2-Tetrachloroethane	8260	µg/L	ND (1.0)	ND (1.0)	ND (1.0)	ND (1.0)	ND (1.0)	ND (1.0)
1,1,1-Trichloroethane	8260	µg/L	ND (1.0)	ND (1.0)	ND (1.0)	ND (1.0)	ND (1.0)	ND (1.0) J
1,1,2,2-Tetrachloroethane	8260	µg/L	ND (1.0)	ND (1.0)	ND (1.0)	ND (1.0)	ND (1.0)	ND (1.0)
1,1,2-Trichloroethane	8260	µg/L	ND (1.0)	ND (1.0)	ND (1.0)	ND (1.0)	ND (1.0)	ND (1.0)
1,1,2-Trichlorotrifluoroethane (Freon 113)	8260	µg/L	ND (1.0)	ND (1.0)	ND (1.0)	ND (1.0)	ND (1.0)	ND (1.0)
1,1-Dichloroethane	8260	µg/L	ND (1.0)	ND (1.0)	ND (1.0)	ND (1.0)	ND (1.0)	ND (1.0)
1,1-Dichloroethene	8260	µg/L	ND (1.0)	ND (1.0)	ND (1.0)	ND (1.0)	ND (1.0)	ND (1.0)
1,1-Dichloropropene	8260	µg/L	ND (1.0)	ND (1.0)	ND (1.0)	ND (1.0)	ND (1.0)	ND (1.0)
1,2,3-Trichlorobenzene	8260	µg/L	ND (1.0)	ND (1.0)	ND (1.0)	ND (1.0)	ND (1.0)	ND (1.0)
1,2,3-Trichloropropane	8260	µg/L	ND (1.0)	ND (1.0)	ND (1.0)	ND (1.0)	ND (1.0)	ND (1.0)
1,2,4-Trichlorobenzene	8260	µg/L	ND (1.0)	ND (1.0)	ND (1.0)	ND (1.0)	ND (1.0)	ND (1.0)
1,2,4-Trimethylbenzene	8260	µg/L	ND (1.0)	ND (1.0)	ND (1.0)	ND (1.0)	ND (1.0)	ND (1.0)
1,2-Dibromo-3-chloropropane	8260	µg/L	ND (2.0)	ND (2.0)	ND (2.0)	ND (2.0)	ND (2.0)	ND (2.0)
1,2-Dibromoethane	8260	µg/L	ND (1.0)	ND (1.0)	ND (1.0)	ND (1.0)	ND (1.0)	ND (1.0)
1,2-Dichlorobenzene	8260	µg/L	ND (1.0)	ND (1.0)	ND (1.0)	ND (1.0)	ND (1.0)	ND (1.0)
1,2-Dichloroethane	8260	µg/L	ND (1.0)	ND (1.0)	ND (1.0)	ND (1.0)	ND (1.0)	ND (1.0)
1,2-Dichloropropane	8260	µg/L	ND (1.0)	ND (1.0)	ND (1.0)	ND (1.0)	ND (1.0)	ND (1.0)
1,3,5-Trimethylbenzene	8260	µg/L	ND (1.0)	ND (1.0)	ND (1.0)	ND (1.0)	ND (1.0)	ND (1.0)
1,3-Dichlorobenzene	8260	µg/L	ND (1.0)	ND (1.0)	ND (1.0)	ND (1.0)	ND (1.0)	ND (1.0)
1,3-Dichloropropane	8260	µg/L	ND (1.0)	ND (1.0)	ND (1.0)	ND (1.0)	ND (1.0)	ND (1.0)
1,4-Dichlorobenzene	8260	µg/L	ND (1.0)	ND (1.0)	ND (1.0)	ND (1.0)	ND (1.0)	ND (1.0)
2,2-Dichloropropane	8260	µg/L	ND (1.0)	ND (1.0)	ND (1.0)	ND (1.0)	ND (1.0)	ND (1.0) J
2-Chlorotoluene	8260	µg/L	ND (1.0)	ND (1.0)	ND (1.0)	ND (1.0)	ND (1.0)	ND (1.0)
4-Isopropyltoluene	8260	µg/L	ND (1.0)	ND (1.0)	ND (1.0)	ND (1.0)	ND (1.0)	ND (1.0)
Acetone	8260	µg/L	ND (10) J	ND (10)	ND (10)	ND (10)	ND (10)	ND (10)
Acrolein	8260	µg/L	ND (20) J	ND (20)	ND (20)	ND (20)	ND (20)	ND (20)
Acrylonitrile	8260	µg/L	ND (20) J	ND (20)	ND (20)	ND (20)	ND (20)	ND (20)
Benzene	8260	µg/L	ND (1.0)	ND (1.0)	ND (1.0)	ND (1.0)	ND (1.0)	ND (1.0)
Bromobenzene	8260	µg/L	ND (1.0)	ND (1.0)	ND (1.0)	ND (1.0)	ND (1.0)	ND (1.0)
Bromochloromethane	8260	µg/L	ND (1.0)	ND (1.0)	ND (1.0)	ND (1.0)	ND (1.0)	ND (1.0)
Bromodichloromethane	8260	µg/L	ND (1.0)	ND (1.0)	ND (1.0)	ND (1.0)	ND (1.0)	ND (1.0)
Bromoform	8260	µg/L	ND (1.0)	ND (1.0)	ND (1.0)	ND (1.0)	ND (1.0)	ND (1.0)
Bromomethane	8260	µg/L	ND (1.0)	ND (1.0)	ND (1.0)	ND (1.0)	ND (1.0)	ND (1.0)
Carbon disulfide	8260	µg/L	ND (1.0)	ND (1.0)	ND (1.0)	ND (1.0)	ND (1.0)	ND (1.0)
Carbon tetrachloride	8260	µg/L	ND (1.0)	ND (1.0)	ND (1.0)	ND (1.0)	ND (1.0)	ND (1.0)
Chlorobenzene	8260	µg/L	ND (1.0)	ND (1.0)	ND (1.0)	ND (1.0)	ND (1.0)	ND (1.0)
Chloroethane	8260	µg/L	ND (1.0)	ND (1.0) J	ND (1.0)	ND (1.0) J	ND (1.0)	ND (1.0)

TABLE A3-3

Complete Groundwater Analytical Results for New ERGI Monitoring Wells, Organic Constituents

Summary of Findings Associated with the East Ravine Groundwater Investigation

PG&E Topock Compressor Station

Analyte	Method	Units	MW-57-070	MW-59-100	MW-60-125	MW-61-110	MW-62-065	MW-63-065
			2/11/09	**3/18/09**	**3/20/09**	**3/23/09**	**3/27/09**	**4/15/09**
Volatile Organic Compounds								
Chloroform	8260	µg/L	ND (1.0)	ND (1.0)	ND (1.0)	ND (1.0)	ND (1.0)	ND (1.0)
Chloromethane	8260	µg/L	ND (1.0)	ND (1.0)	ND (1.0)	ND (1.0)	ND (1.0)	ND (1.0)
cis-1,2-Dichloroethene	8260	µg/L	ND (1.0)	ND (1.0)	ND (1.0)	ND (1.0)	ND (1.0)	ND (1.0)
cis-1,3-Dichloropropene	8260	µg/L	ND (1.0)	ND (1.0)	ND (1.0)	ND (1.0)	ND (1.0)	ND (1.0)
Dibromochloromethane	8260	µg/L	ND (1.0)	ND (1.0)	ND (1.0)	ND (1.0)	ND (1.0)	ND (1.0)
Dibromomethane	8260	µg/L	ND (1.0)	ND (1.0)	ND (1.0)	ND (1.0)	ND (1.0)	ND (1.0)
Dichlorodifluoromethane	8260	µg/L	ND (1.0)	ND (1.0)	ND (1.0)	ND (1.0)	ND (1.0)	ND (1.0)
Ethylbenzene	8260	µg/L	ND (1.0)	ND (1.0)	ND (1.0)	ND (1.0)	ND (1.0)	ND (1.0)
Hexachlorobutadiene	8260	µg/L	ND (1.0)	ND (1.0)	ND (1.0)	ND (1.0)	ND (1.0)	ND (1.0)
Isopropylbenzene	8260	µg/L	ND (1.0)	ND (1.0)	ND (1.0)	ND (1.0)	ND (1.0)	ND (1.0)
m+p-Xylenes	8260	µg/L	ND (1.0)	ND (1.0)	ND (1.0)	ND (1.0)	ND (1.0)	ND (1.0)
Methyl ethyl ketone	8260	µg/L	ND (10) J	ND (10)	ND (10)	ND (10)	ND (10)	ND (10)
Methyl isobutyl ketone	8260	µg/L	ND (10)	ND (10)	ND (10)	ND (10)	ND (10)	ND (10)
Methyl tert-butyl ether (MTBE)	8260	µg/L	ND (1.0)	ND (1.0)	ND (1.0)	ND (1.0)	ND (1.0)	ND (1.0)
Methylene chloride	8260	µg/L	ND (5.0)	ND (5.0)	ND (5.0)	ND (5.0)	ND (5.0)	ND (5.0)
Naphthalene	8260	µg/L	ND (1.0)	ND (1.0)	ND (1.0)	ND (1.0)	ND (1.0)	ND (1.0)
N-Butylbenzene	8260	µg/L	ND (1.0)	ND (1.0)	ND (1.0)	ND (1.0)	ND (1.0)	ND (1.0)
N-Propylbenzene	8260	µg/L	ND (1.0)	ND (1.0)	ND (1.0)	ND (1.0)	ND (1.0)	ND (1.0)
o-Xylene	8260	µg/L	ND (1.0)	ND (1.0)	ND (1.0)	ND (1.0)	ND (1.0)	ND (1.0)
p-Chlorotoluene	8260	µg/L	ND (1.0)	ND (1.0)	ND (1.0)	ND (1.0)	ND (1.0)	ND (1.0)
sec-Butylbenzene	8260	µg/L	ND (1.0)	ND (1.0)	ND (1.0)	ND (1.0)	ND (1.0)	ND (1.0)
Styrene	8260	µg/L	ND (1.0)	ND (1.0)	ND (1.0)	ND (1.0)	ND (1.0)	ND (1.0)
tert-Butylbenzene	8260	µg/L	ND (1.0)	ND (1.0)	ND (1.0)	ND (1.0)	ND (1.0)	ND (1.0)
Tetrachloroethene	8260	µg/L	ND (1.0)	ND (1.0)	ND (1.0)	ND (1.0)	ND (1.0)	ND (1.0)
Toluene	8260	µg/L	ND (2.5)	ND (2.5)	ND (2.5)	ND (2.5)	ND (2.5)	ND (2.5)
trans-1,2-Dichloroethene	8260	µg/L	ND (1.0)	ND (1.0)	ND (1.0)	ND (1.0)	ND (1.0)	ND (1.0)
trans-1,3-Dichloropropene	8260	µg/L	ND (1.0)	ND (1.0)	ND (1.0)	ND (1.0)	ND (1.0)	ND (1.0)
Trichloroethene	8260	µg/L	ND (1.0)	ND (1.0)	ND (1.0)	ND (1.0)	ND (1.0)	ND (1.0)
Trichlorofluoromethane (Freon 11)	8260	µg/L	ND (1.0)	ND (1.0)	ND (1.0)	ND (1.0)	ND (1.0)	ND (1.0)
Vinyl chloride	8260	µg/L	ND (1.0)	ND (1.0)	ND (1.0)	ND (1.0)	ND (1.0)	ND (1.0)
Xylenes, total	8260	µg/L	ND (2.0)	ND (2.0)	ND (2.0)	ND (2.0)	ND (2.0)	ND (2.0)

NOTES:

FD	field duplicate
ND	not detected at listed reporting limit
ug/L	micrograms per liter
mg/L	milligrams per liter
J	concentration estimated by laboratory or data validation
R	rejected

TABLE A3-3

Complete Groundwater Analytical Results for New ERGI Monitoring Wells, Organic Constituents

Summary of Findings Associated with the East Ravine Groundwater Investigation

PG&E Topock Compressor Station

Analyte	Method	Units	MW-23-060 7/21/09	MW-23-080 7/21/09	MW-57-070 7/21/09	MW-57-185 7/20/09	MW-58-115 7/22/09	MW-58-205 7/22/09	MW-59-100 7/22/09	MW-59-100 7/22/09 (FD)	MW-60-125 7/21/09	MW-61-110 7/21/09	MW-62-065 7/22/09	MW-62-110 7/22/09	MW-62-190 7/22/09	MW-63-065 7/20/09	MW-63-065 7/20/09 (FD)	MW-64-150 7/22/09	MW-64-205 7/22/09	MW-64-260 7/22/09
Volatile Organic Compounds																				
1,1,1,2-Tetrachloroethane	8260	µg/L	ND (1.0)	ND (1.0)	ND (1.0)	ND (1.0)	ND (1.0)	ND (1.0)	ND (1.0)	ND (1.0)	ND (1.0)	ND (1.0)	ND (1.0)	ND (1.0)	ND (1.0)	ND (1.0)	ND (1.0)	ND (1.0)	ND (1.0)	ND (1.0)
1,1,1-Trichloroethane	8260	µg/L	ND (1.0)	ND (1.0)	ND (1.0)	ND (1.0)	ND (1.0)	ND (1.0)	ND (1.0)	ND (1.0)	ND (1.0)	ND (1.0)	ND (1.0)	ND (1.0)	ND (1.0)	ND (1.0)	ND (1.0)	ND (1.0)	ND (1.0)	ND (1.0)
1,1,2,2-Tetrachloroethane	8260	µg/L	ND (1.0)	ND (1.0)	ND (1.0)	ND (1.0)	ND (1.0)	ND (1.0)	ND (1.0)	ND (1.0)	ND (1.0)	ND (1.0)	ND (1.0)	ND (1.0)	ND (1.0)	ND (1.0)	ND (1.0)	ND (1.0)	ND (1.0)	ND (1.0)
1,1,2-Trichloroethane	8260	µg/L	ND (1.0)	ND (1.0)	ND (1.0)	ND (1.0)	ND (1.0)	ND (1.0)	ND (1.0)	ND (1.0)	ND (1.0)	ND (1.0)	ND (1.0)	ND (1.0)	ND (1.0)	ND (1.0)	ND (1.0)	ND (1.0)	ND (1.0)	ND (1.0)
1,1,2-Trichlorotrifluoroethane (Freon 113)	8260	µg/L	ND (1.0)	ND (1.0)	ND (1.0)	ND (1.0)	ND (1.0)	ND (1.0)	ND (1.0)	ND (1.0)	ND (1.0)	ND (1.0)	ND (1.0)	ND (1.0)	ND (1.0)	ND (1.0)	ND (1.0)	ND (1.0)	ND (1.0)	ND (1.0)
1,1-Dichloroethane	8260	µg/L	ND (1.0)	ND (1.0)	ND (1.0)	ND (1.0)	ND (1.0)	ND (1.0)	ND (1.0)	ND (1.0)	ND (1.0)	ND (1.0)	ND (1.0)	ND (1.0)	ND (1.0)	ND (1.0)	ND (1.0)	ND (1.0)	ND (1.0)	ND (1.0)
1,1-Dichloroethene	8260	µg/L	ND (1.0)	ND (1.0)	ND (1.0)	ND (1.0)	ND (1.0)	ND (1.0)	ND (1.0)	ND (1.0)	ND (1.0)	ND (1.0)	ND (1.0)	ND (1.0)	ND (1.0)	ND (1.0)	ND (1.0)	ND (1.0)	ND (1.0)	ND (1.0)
1,1-Dichloropropene	8260	µg/L	ND (1.0)	ND (1.0)	ND (1.0)	ND (1.0)	ND (1.0)	ND (1.0)	ND (1.0)	ND (1.0)	ND (1.0)	ND (1.0)	ND (1.0)	ND (1.0)	ND (1.0)	ND (1.0)	ND (1.0)	ND (1.0)	ND (1.0)	ND (1.0)
1,2,3-Trichlorobenzene	8260	µg/L	ND (1.0)	ND (1.0)	ND (1.0)	ND (1.0)	ND (1.0)	ND (1.0)	ND (1.0)	ND (1.0)	ND (1.0)	ND (1.0)	ND (1.0)	ND (1.0)	ND (1.0)	ND (1.0)	ND (1.0)	ND (1.0)	ND (1.0)	ND (1.0)
1,2,3-Trichloropropane	8260	µg/L	ND (1.0)	ND (1.0)	ND (1.0)	ND (1.0)	ND (1.0)	ND (1.0)	ND (1.0)	ND (1.0)	ND (1.0)	ND (1.0)	ND (1.0)	ND (1.0)	ND (1.0)	ND (1.0)	ND (1.0)	ND (1.0)	ND (1.0)	ND (1.0)
1,2,4-Trichlorobenzene	8260	µg/L	ND (1.0)	ND (1.0)	ND (1.0)	ND (1.0)	ND (1.0)	ND (1.0)	ND (1.0)	ND (1.0) J	ND (1.0)	ND (1.0)	ND (1.0)	ND (1.0) J	ND (1.0) J	ND (1.0)	ND (1.0)	ND (1.0) J	ND (1.0) J	ND (1.0) J
1,2,4-Trimethylbenzene	8260	µg/L	ND (1.0)	ND (1.0)	ND (1.0)	ND (1.0) J	ND (1.0)	ND (1.0)	ND (1.0)	ND (1.0)	ND (1.0)	ND (1.0)	ND (1.0)	ND (1.0)	ND (1.0)	ND (1.0)	ND (1.0)	ND (1.0)	ND (1.0)	ND (1.0)
1,2-Dibromo-3-chloropropane	8260	µg/L	ND (2.0)	ND (2.0)	ND (2.0)	ND (2.0)	ND (2.0)	ND (2.0)	ND (2.0)	ND (2.0)	ND (2.0)	ND (2.0)	ND (2.0)	ND (2.0)	ND (2.0)	ND (2.0)	ND (2.0)	ND (2.0)	ND (2.0)	ND (2.0)
1,2-Dibromoethane	8260	µg/L	ND (1.0)	ND (1.0)	ND (1.0)	ND (1.0)	ND (1.0)	ND (1.0)	ND (1.0)	ND (1.0)	ND (1.0)	ND (1.0)	ND (1.0)	ND (1.0)	ND (1.0)	ND (1.0)	ND (1.0)	ND (1.0)	ND (1.0)	ND (1.0)
1,2-Dichlorobenzene	8260	µg/L	ND (1.0)	ND (1.0)	ND (1.0)	ND (1.0)	ND (1.0)	ND (1.0)	ND (1.0)	ND (1.0)	ND (1.0)	ND (1.0)	ND (1.0)	ND (1.0)	ND (1.0)	ND (1.0)	ND (1.0)	ND (1.0)	ND (1.0)	ND (1.0)
1,2-Dichloroethane	8260	µg/L	ND (1.0)	ND (1.0)	ND (1.0)	ND (1.0)	ND (1.0)	ND (1.0)	ND (1.0)	ND (1.0)	ND (1.0)	ND (1.0)	ND (1.0)	ND (1.0)	ND (1.0)	ND (1.0)	ND (1.0)	ND (1.0)	ND (1.0)	ND (1.0)
1,2-Dichloropropane	8260	µg/L	ND (1.0)	ND (1.0)	ND (1.0)	ND (1.0)	ND (1.0)	ND (1.0)	ND (1.0)	ND (1.0)	ND (1.0)	ND (1.0)	ND (1.0)	ND (1.0)	ND (1.0)	ND (1.0)	ND (1.0)	ND (1.0)	ND (1.0)	ND (1.0)
1,3,5-Trimethylbenzene	8260	µg/L	ND (1.0)	ND (1.0)	ND (1.0)	ND (1.0)	ND (1.0)	ND (1.0)	ND (1.0)	ND (1.0)	ND (1.0)	ND (1.0)	ND (1.0)	ND (1.0)	ND (1.0)	ND (1.0)	ND (1.0)	ND (1.0)	ND (1.0)	ND (1.0)
1,3-Dichlorobenzene	8260	µg/L	ND (1.0)	ND (1.0)	ND (1.0)	ND (1.0)	ND (1.0)	ND (1.0)	ND (1.0)	ND (1.0)	ND (1.0)	ND (1.0)	ND (1.0)	ND (1.0)	ND (1.0)	ND (1.0)	ND (1.0)	ND (1.0)	ND (1.0)	ND (1.0)
1,3-Dichloropropane	8260	µg/L	ND (1.0)	ND (1.0)	ND (1.0)	ND (1.0)	ND (1.0)	ND (1.0)	ND (1.0)	ND (1.0)	ND (1.0)	ND (1.0)	ND (1.0)	ND (1.0)	ND (1.0)	ND (1.0)	ND (1.0)	ND (1.0)	ND (1.0)	ND (1.0)
1,4-Dichlorobenzene	8260	µg/L	ND (1.0)	ND (1.0)	ND (1.0)	ND (1.0)	ND (1.0)	ND (1.0)	ND (1.0)	ND (1.0)	ND (1.0)	ND (1.0)	ND (1.0)	ND (1.0)	ND (1.0)	ND (1.0)	ND (1.0)	ND (1.0)	ND (1.0)	ND (1.0)
2,2-Dichloropropane	8260	µg/L	ND (1.0)	ND (1.0)	ND (1.0)	ND (1.0)	ND (1.0)	ND (1.0)	ND (1.0)	ND (1.0)	ND (1.0)	ND (1.0)	ND (1.0)	ND (1.0)	ND (1.0)	ND (1.0)	ND (1.0)	ND (1.0)	ND (1.0)	ND (1.0)
2-Chlorotoluene	8260	µg/L	ND (1.0)	ND (1.0)	ND (1.0)	ND (1.0)	ND (1.0)	ND (1.0)	ND (1.0)	ND (1.0)	ND (1.0)	ND (1.0)	ND (1.0)	ND (1.0)	ND (1.0)	ND (1.0)	ND (1.0)	ND (1.0)	ND (1.0)	ND (1.0)
4-Isopropyltoluene	8260	µg/L	ND (1.0)	ND (1.0)	ND (1.0)	ND (1.0)	ND (1.0)	ND (1.0)	ND (1.0)	ND (1.0)	ND (1.0)	ND (1.0)	ND (1.0)	ND (1.0)	ND (1.0)	ND (1.0)	ND (1.0)	ND (1.0)	ND (1.0)	ND (1.0)
Acetone	8260	µg/L	ND (10)	ND (10)	ND (10)	ND (10)	10.0 R	15.0 R	ND (10)	ND (10) J	ND (10)	ND (10)	ND (10)	49.0 R	25.0 R	ND (10)	ND (10)	39.0 R	31.0 R	50.0 R
Acrolein	8260	µg/L	ND (20) J	ND (20) J	ND (20) J	ND (20) J	ND (20) J	ND (20) J	ND (20) J	ND (20) J	ND (20) J	ND (20) J	ND (20) J	ND (20) J	ND (20) J	ND (20) J	ND (20) J	ND (20) J	ND (20) J	ND (20) J
Acrylonitrile	8260	µg/L	ND (20)	ND (20)	ND (20)	ND (20) J	ND (20)	ND (20)	ND (20)	ND (20)	ND (20)	ND (20)	ND (20)	ND (20) J	ND (20)	ND (20)	ND (20)	ND (20)	ND (20)	ND (20)
Benzene	8260	µg/L	ND (1.0)	ND (1.0)	ND (1.0)	ND (1.0)	ND (1.0)	ND (1.0)	ND (1.0)	ND (1.0)	ND (1.0)	ND (1.0)	ND (1.0)	ND (1.0)	ND (1.0)	ND (1.0)	ND (1.0)	ND (1.0)	ND (1.0)	ND (1.0)
Bromobenzene	8260	µg/L	ND (1.0)	ND (1.0)	ND (1.0)	ND (1.0)	ND (1.0)	ND (1.0)	ND (1.0)	ND (1.0)	ND (1.0)	ND (1.0)	ND (1.0)	ND (1.0)	ND (1.0)	ND (1.0)	ND (1.0)	ND (1.0)	ND (1.0)	ND (1.0)
Bromochloromethane	8260	µg/L	ND (1.0)	ND (1.0)	ND (1.0)	ND (1.0)	ND (1.0)	ND (1.0)	ND (1.0)	ND (1.0)	ND (1.0)	ND (1.0)	ND (1.0)	ND (1.0)	ND (1.0)	ND (1.0)	ND (1.0)	ND (1.0)	ND (1.0)	ND (1.0)
Bromodichloromethane	8260	µg/L	ND (1.0)	ND (1.0)	ND (1.0)	ND (1.0)	ND (1.0)	ND (1.0)	ND (1.0)	ND (1.0)	ND (1.0)	ND (1.0)	ND (1.0)	ND (1.0)	ND (1.0)	ND (1.0)	ND (1.0)	ND (1.0)	ND (1.0)	ND (1.0)
Bromoform	8260	µg/L	ND (1.0)	ND (1.0)	ND (1.0)	ND (1.0)	ND (1.0)	ND (1.0)	ND (1.0)	ND (1.0)	ND (1.0)	ND (1.0)	ND (1.0)	ND (1.0)	ND (1.0)	ND (1.0)	ND (1.0)	ND (1.0)	ND (1.0)	ND (1.0)
Bromomethane	8260	µg/L	ND (1.0)	ND (1.0)	ND (1.0)	ND (1.0)	ND (1.0)	ND (1.0)	ND (1.0)	ND (1.0)	ND (1.0)	ND (1.0)	ND (1.0)	ND (1.0)	ND (1.0)	ND (1.0)	ND (1.0)	ND (1.0)	ND (1.0)	ND (1.0)
Carbon disulfide	8260	µg/L	ND (1.0)	ND (1.0)	ND (1.0)	ND (1.0)	ND (1.0)	ND (1.0)	ND (1.0)	ND (1.0)	ND (1.0)	ND (1.0)	ND (1.0)	ND (1.0)	ND (1.0)	ND (1.0)	ND (1.0)	ND (1.0)	ND (1.0)	ND (1.0)
Carbon tetrachloride	8260	µg/L	ND (1.0) J	ND (1.0) J	ND (1.0) J	ND (1.0) J	ND (1.0) J	ND (1.0) J	ND (1.0) J	ND (1.0)	ND (1.0) J	ND (1.0) J	ND (1.0) J	ND (1.0)	ND (1.0)	ND (1.0) J	ND (1.0) J	ND (1.0)	ND (1.0) J	ND (1.0)
Chlorobenzene	8260	µg/L	ND (1.0)	ND (1.0)	ND (1.0)	ND (1.0)	ND (1.0)	ND (1.0)	ND (1.0)	ND (1.0)	ND (1.0)	ND (1.0)	ND (1.0)	ND (1.0)	ND (1.0)	ND (1.0)	ND (1.0)	ND (1.0)	ND (1.0)	ND (1.0)
Chloroethane	8260	µg/L	ND (1.0)	ND (1.0)	ND (1.0)	ND (1.0)	ND (1.0)	ND (1.0)	ND (1.0)	ND (1.0) J	ND (1.0)	ND (1.0)	ND (1.0)	ND (1.0) J	ND (1.0) J	ND (1.0)	ND (1.0)	ND (1.0) J	ND (1.0) J	ND (1.0) J

TABLE A3-3
Complete Groundwater Analytical Results for New ERGI Monitoring Wells, Organic Constituents
Summary of Findings Associated with the East Ravine Groundwater Investigation
PG&E Topock Compressor Station

Analyte	Method	Units	MW-23-060 7/21/09	MW-23-080 7/21/09	MW-57-070 7/21/09	MW-57-185 7/20/09	MW-58-115 7/22/09	MW-58-205 7/22/09	MW-59-100 7/22/09	MW-59-100 7/22/09 (FD)	MW-60-125 7/21/09	MW-61-110 7/21/09	MW-62-065 7/22/09	MW-62-110 7/22/09	MW-62-190 7/22/09	MW-63-065 7/20/09	MW-63-065 7/20/09 (FD)	MW-64-150 7/22/09	MW-64-205 7/22/09	MW-64-260 7/22/09
Volatile Organic Compounds																				
Chloroform	8260	µg/L	ND (1.0)	ND (1.0)	ND (1.0)	ND (1.0)	ND (1.0)	ND (1.0)	ND (1.0)	ND (1.0)	ND (1.0)	ND (1.0)	ND (1.0)	ND (1.0)	ND (1.0)	ND (1.0)	ND (1.0)	ND (1.0)	ND (1.0)	ND (1.0)
Chloromethane	8260	µg/L	ND (1.0)	ND (1.0)	ND (1.0)	ND (1.0)	ND (1.0)	ND (1.0)	ND (1.0)	ND (1.0)	ND (1.0)	ND (1.0)	ND (1.0)	ND (1.0)	ND (1.0)	ND (1.0)	ND (1.0)	ND (1.0)	ND (1.0)	ND (1.0)
cis-1,2-Dichloroethene	8260	µg/L	ND (1.0)	ND (1.0)	ND (1.0)	ND (1.0)	ND (1.0)	ND (1.0)	ND (1.0)	ND (1.0)	ND (1.0)	ND (1.0)	ND (1.0)	ND (1.0)	ND (1.0)	ND (1.0)	ND (1.0)	ND (1.0)	ND (1.0)	ND (1.0)
cis-1,3-Dichloropropene	8260	µg/L	ND (1.0)	ND (1.0)	ND (1.0)	ND (1.0)	ND (1.0)	ND (1.0)	ND (1.0)	ND (1.0)	ND (1.0)	ND (1.0)	ND (1.0)	ND (1.0)	ND (1.0)	ND (1.0)	ND (1.0)	ND (1.0)	ND (1.0)	ND (1.0)
Dibromochloromethane	8260	µg/L	ND (1.0)	ND (1.0)	ND (1.0)	ND (1.0)	ND (1.0)	ND (1.0)	ND (1.0)	ND (1.0)	ND (1.0)	ND (1.0)	ND (1.0)	ND (1.0)	ND (1.0)	ND (1.0)	ND (1.0)	ND (1.0)	ND (1.0)	ND (1.0)
Dibromomethane	8260	µg/L	ND (1.0)	ND (1.0)	ND (1.0)	ND (1.0)	ND (1.0)	ND (1.0)	ND (1.0)	ND (1.0)	ND (1.0)	ND (1.0)	ND (1.0)	ND (1.0)	ND (1.0)	ND (1.0)	ND (1.0)	ND (1.0)	ND (1.0)	ND (1.0)
Dichlorodifluoromethane	8260	µg/L	ND (1.0)	ND (1.0)	ND (1.0)	ND (1.0)	ND (1.0)	ND (1.0)	ND (1.0)	ND (1.0)	ND (1.0)	ND (1.0)	ND (1.0)	ND (1.0)	ND (1.0)	ND (1.0)	ND (1.0)	ND (1.0)	ND (1.0)	ND (1.0)
Ethylbenzene	8260	µg/L	ND (1.0)	ND (1.0)	ND (1.0)	ND (1.0)	ND (1.0)	ND (1.0)	ND (1.0)	ND (1.0)	ND (1.0)	ND (1.0)	ND (1.0)	ND (1.0)	ND (1.0)	ND (1.0)	ND (1.0)	ND (1.0)	ND (1.0)	ND (1.0)
Hexachlorobutadiene	8260	µg/L	ND (1.0)	ND (1.0)	ND (1.0)	ND (1.0)	ND (1.0)	ND (1.0)	ND (1.0)	ND (1.0)	ND (1.0)	ND (1.0)	ND (1.0)	ND (1.0)	ND (1.0)	ND (1.0)	ND (1.0)	ND (1.0)	ND (1.0)	ND (1.0)
Isopropylbenzene	8260	µg/L	ND (1.0)	ND (1.0)	ND (1.0)	ND (1.0)	ND (1.0)	ND (1.0)	ND (1.0)	ND (1.0)	ND (1.0)	ND (1.0)	ND (1.0)	ND (1.0)	ND (1.0)	ND (1.0)	ND (1.0)	ND (1.0)	ND (1.0)	ND (1.0)
m+p-Xylenes	8260	µg/L	ND (1.0)	ND (1.0)	ND (1.0)	ND (1.0)	ND (1.0)	ND (1.0)	ND (1.0)	ND (1.0)	ND (1.0)	ND (1.0)	ND (1.0)	ND (1.0)	ND (1.0)	ND (1.0)	ND (1.0)	ND (1.0)	ND (1.0)	ND (1.0)
Methyl ethyl ketone	8260	µg/L	ND (10) J	ND (10) J	ND (10) J	ND (10) J	ND (10) J	ND (10)	ND (10) J	ND (10) J	ND (10) J	ND (10) J	ND (10) J	ND (10) J	ND (10)	ND (10) J	ND (10) J	ND (10) J	ND (10) J	ND (10) J
Methyl isobutyl ketone	8260	µg/L	ND (10)	ND (10)	ND (10)	ND (10)	ND (10)	ND (10)	ND (10)	ND (10)	ND (10)	ND (10)	ND (10)	ND (10)	ND (10)	ND (10)	ND (10)	ND (10)	ND (10)	ND (10)
Methyl tert-butyl ether (MTBE)	8260	µg/L	ND (1.0)	ND (1.0)	ND (1.0)	ND (1.0)	ND (1.0)	ND (1.0)	ND (1.0)	ND (1.0)	ND (1.0)	ND (1.0)	ND (1.0)	ND (1.0)	ND (1.0)	ND (1.0)	ND (1.0)	ND (1.0)	ND (1.0)	ND (1.0)
Methylene chloride	8260	µg/L	ND (5.0)	ND (5.0)	ND (5.0)	ND (5.0)	ND (5.0)	ND (5.0)	ND (5.0)	ND (5.0)	ND (5.0)	ND (5.0)	ND (5.0)	ND (5.0)	ND (5.0)	ND (5.0)	ND (5.0)	ND (5.0)	ND (5.0)	ND (5.0)
Naphthalene	8260	µg/L	ND (1.0)	ND (1.0)	ND (1.0)	ND (1.0)	ND (1.0)	ND (1.0)	ND (1.0)	ND (1.0)	ND (1.0)	ND (1.0)	ND (1.0)	ND (1.0)	ND (1.0)	ND (1.0)	ND (1.0)	ND (1.0)	ND (1.0)	ND (1.0)
N-Butylbenzene	8260	µg/L	ND (1.0)	ND (1.0)	ND (1.0)	ND (1.0)	ND (1.0)	ND (1.0)	ND (1.0)	ND (1.0)	ND (1.0)	ND (1.0)	ND (1.0)	ND (1.0)	ND (1.0)	ND (1.0)	ND (1.0)	ND (1.0)	ND (1.0)	ND (1.0)
N-Propylbenzene	8260	µg/L	ND (1.0)	ND (1.0)	ND (1.0)	ND (1.0)	ND (1.0)	ND (1.0)	ND (1.0)	ND (1.0)	ND (1.0)	ND (1.0)	ND (1.0)	ND (1.0)	ND (1.0)	ND (1.0)	ND (1.0)	ND (1.0)	ND (1.0)	ND (1.0)
o-Xylene	8260	µg/L	ND (1.0)	ND (1.0)	ND (1.0)	ND (1.0)	ND (1.0)	ND (1.0)	ND (1.0)	ND (1.0)	ND (1.0)	ND (1.0)	ND (1.0)	ND (1.0)	ND (1.0)	ND (1.0)	ND (1.0)	ND (1.0)	ND (1.0)	ND (1.0)
p-Chlorotoluene	8260	µg/L	ND (1.0)	ND (1.0)	ND (1.0)	ND (1.0)	ND (1.0)	ND (1.0)	ND (1.0)	ND (1.0)	ND (1.0)	ND (1.0)	ND (1.0)	ND (1.0)	ND (1.0)	ND (1.0)	ND (1.0)	ND (1.0)	ND (1.0)	ND (1.0)
sec-Butylbenzene	8260	µg/L	ND (1.0)	ND (1.0)	ND (1.0)	ND (1.0)	ND (1.0)	ND (1.0)	ND (1.0)	ND (1.0)	ND (1.0)	ND (1.0)	ND (1.0)	ND (1.0)	ND (1.0)	ND (1.0)	ND (1.0)	ND (1.0)	ND (1.0)	ND (1.0)
Styrene	8260	µg/L	ND (1.0)	ND (1.0)	ND (1.0)	ND (1.0) J	ND (1.0)	ND (1.0)	ND (1.0)	ND (1.0)	ND (1.0)	ND (1.0)	ND (1.0)	ND (1.0)	ND (1.0) J	ND (1.0)	ND (1.0)	ND (1.0)	ND (1.0)	ND (1.0)
tert-Butylbenzene	8260	µg/L	ND (1.0)	ND (1.0)	ND (1.0)	ND (1.0)	ND (1.0)	ND (1.0)	ND (1.0)	ND (1.0)	ND (1.0)	ND (1.0)	ND (1.0)	ND (1.0)	ND (1.0)	ND (1.0)	ND (1.0)	ND (1.0)	ND (1.0)	ND (1.0)
Tetrachloroethene	8260	µg/L	ND (1.0)	ND (1.0)	ND (1.0)	ND (1.0)	ND (1.0)	ND (1.0)	ND (1.0)	ND (1.0)	ND (1.0)	ND (1.0)	ND (1.0)	ND (1.0)	ND (1.0)	ND (1.0)	ND (1.0)	ND (1.0)	ND (1.0)	ND (1.0)
Toluene	8260	µg/L	ND (2.5)	ND (2.5)	ND (2.5)	ND (2.5)	61.0 R	21.0 R	ND (2.5)	ND (2.5)	ND (2.5)	ND (2.5)	ND (2.5)	27.0 R	8.60 R	ND (2.5)	ND (2.5)	14.0 R	21.0 R	25.0 R
trans-1,2-Dichloroethene	8260	µg/L	ND (1.0)	ND (1.0)	ND (1.0)	ND (1.0)	ND (1.0)	ND (1.0)	ND (1.0)	ND (1.0)	ND (1.0)	ND (1.0)	ND (1.0)	ND (1.0)	ND (1.0)	ND (1.0)	ND (1.0)	ND (1.0)	ND (1.0)	ND (1.0)
trans-1,3-Dichloropropene	8260	µg/L	ND (1.0)	ND (1.0)	ND (1.0)	ND (1.0)	ND (1.0)	ND (1.0)	ND (1.0)	ND (1.0)	ND (1.0)	ND (1.0)	ND (1.0)	ND (1.0)	ND (1.0)	ND (1.0)	ND (1.0)	ND (1.0)	ND (1.0)	ND (1.0)
Trichloroethene	8260	µg/L	ND (1.0)	ND (1.0)	ND (1.0)	ND (1.0)	ND (1.0)	ND (1.0)	ND (1.0)	ND (1.0)	ND (1.0)	ND (1.0)	ND (1.0)	ND (1.0)	ND (1.0)	ND (1.0)	ND (1.0)	ND (1.0)	ND (1.0)	ND (1.0)
Trichlorofluoromethane (Freon 11)	8260	µg/L	ND (1.0)	ND (1.0)	ND (1.0)	ND (1.0)	ND (1.0)	ND (1.0)	ND (1.0)	ND (1.0)	ND (1.0)	ND (1.0)	ND (1.0)	ND (1.0)	ND (1.0)	ND (1.0)	ND (1.0)	ND (1.0)	ND (1.0)	ND (1.0)
Vinyl chloride	8260	µg/L	ND (1.0)	ND (1.0)	ND (1.0)	ND (1.0)	ND (1.0)	ND (1.0)	ND (1.0)	ND (1.0)	ND (1.0)	ND (1.0)	ND (1.0)	ND (1.0)	ND (1.0)	ND (1.0)	ND (1.0)	ND (1.0)	ND (1.0)	ND (1.0)
Xylenes, total	8260	µg/L	ND (2.0)	ND (2.0)	ND (2.0)	ND (2.0)	ND (2.0)	ND (2.0)	ND (2.0)	ND (2.0)	ND (2.0)	ND (2.0)	ND (2.0)	ND (2.0)	ND (2.0)	ND (2.0)	ND (2.0)	ND (2.0)	ND (2.0)	ND (2.0)

NOTES:

FD	field duplicate
ND	not detected at listed reporting limit
ug/L	micrograms per liter
mg/L	milligrams per liter
J	concentration estimated by laboratory or data validation
R	rejected

TABLE A3-4

Groundwater Sample Results for Additional Analyses at MW-57-070 and MW-59-100

Summary of Findings Associated with the East Ravine Groundwater Investigation

PG&E Topock Compressor Station

Location	Date	Analyte	Method	Units	Result	Qualifier
MW-57-070	5/4/2009	1,2,3,4,6,7,8-HpCDD	SW8290	pg/L	2.5	ND
		1,2,3,4,6,7,8-HpCDF	SW8290	pg/L	10	ND
		1,2,3,4,7,8,9-HpCDF	SW8290	pg/L	1.9	ND
		1,2,3,4,7,8-HxCDD	SW8290	pg/L	2	ND
		1,2,3,4,7,8-HxCDF	SW8290	pg/L	1.2	ND
		1,2,3,6,7,8-HxCDD	SW8290	pg/L	5.7	ND
		1,2,3,6,7,8-HxCDF	SW8290	pg/L	1.1	ND
		1,2,3,7,8,9-HxCDD	SW8290	pg/L	2	ND
		1,2,3,7,8,9-HxCDF	SW8290	pg/L	4.7	ND
		1,2,3,7,8-PeCDD	SW8290	pg/L	2.1	ND
		1,2,3,7,8-PeCDF	SW8290	pg/L	0.5	ND
		2,3,4,6,7,8-HxCDF	SW8290	pg/L	1.3	ND
		2,3,4,7,8-PeCDF	SW8290	pg/L	0.5	ND
		2,3,7,8-TCDD	SW8290	pg/L	0.63	ND
		2,3,7,8-TCDF	SW8290	pg/L	0.5	ND
		OCDD	SW8290	pg/L	150	ND
		OCDF	SW8290	pg/L	23	ND
MW-57-070	6/10/2009	1-Methylnaphthalene	8270SIM	µg/L	0.2	ND
		2-Methylnaphthalene	8270SIM	µg/L	0.2	ND
		Acenaphthene	8270SIM	µg/L	0.2	ND
		Acenaphthylene	8270SIM	µg/L	0.2	ND
		Anthracene	8270SIM	µg/L	0.2	ND
		Benzo (a) anthracene	8270SIM	µg/L	0.2	ND
		Benzo (a) pyrene	8270SIM	µg/L	0.2	ND
		Benzo (b) fluoranthene	8270SIM	µg/L	0.2	ND
		Benzo (ghi) perylene	8270SIM	µg/L	0.2	ND
		Benzo (k) fluoranthene	8270SIM	µg/L	0.2	ND
		Chrysene	8270SIM	µg/L	0.2	ND
		Dibenzo (a,h) anthracene	8270SIM	µg/L	0.2	ND
		Fluoranthene	8270SIM	µg/L	0.2	ND
		Fluorene	8270SIM	µg/L	0.2	ND
		Indeno (1,2,3-cd) pyrene	8270SIM	µg/L	0.2	ND
		Naphthalene	8270SIM	µg/L	0.2	ND
		Phenanthrene	8270SIM	µg/L	0.2	ND
		Pyrene	8270SIM	µg/L	0.2	ND
MW-57-070	6/10/2009	Aroclor 1016	8082	µg/L	0.5	ND
		Aroclor 1221	8082	µg/L	1	ND
		Aroclor 1232	8082	µg/L	0.5	ND

TABLE A3-4

Groundwater Sample Results for Additional Analyses at MW-57-070 and MW-59-100

Summary of Findings Associated with the East Ravine Groundwater Investigation

PG&E Topock Compressor Station

Location	Date	Analyte	Method	Units	Result	Qualifier
MW-57-070	6/10/2009	Aroclor 1242	8082	µg/L	0.5	ND
		Aroclor 1248	8082	µg/L	0.5	ND
		Aroclor 1254	8082	µg/L	0.5	ND
		Aroclor 1260	8082	µg/L	0.5	ND
MW-57-070	6/10/2009	4,4-DDD	8081A	µg/L	0.05	ND
		4,4-DDE	8081A	µg/L	0.05	ND
		4,4-DDT	8081A	µg/L	0.05	ND
		Aldrin	8081A	µg/L	0.025	ND
		alpha-BHC	8081A	µg/L	0.025	ND
		alpha-Chlordane	8081A	µg/L	0.025	ND
		beta-BHC	8081A	µg/L	0.025	ND
		delta-BHC	8081A	µg/L	0.025	ND
		Dieldrin	8081A	µg/L	0.05	ND
		Endo sulfan I	8081A	µg/L	0.025	ND
		Endo sulfan II	8081A	µg/L	0.05	ND
		Endosulfan sulfate	8081A	µg/L	0.05	ND
		Endrin	8081A	µg/L	0.05	ND
		Endrin aldehyde	8081A	µg/L	0.05	ND
		gamma-BHC	8081A	µg/L	0.025	ND
		gamma-Chlordane	8081A	µg/L	0.025	ND
		Heptachlor	8081A	µg/L	0.025	ND
		Heptachlor Epoxide	8081A	µg/L	0.025	ND
		Methoxy chlor	8081A	µg/L	0.25	ND
		Toxaphene	8081A	µg/L	2.5	ND
MW-57-070	6/10/2009	1,2,4-Trichlorobenzene	8270C	µg/L	10	ND
		1,2-Dichlorobenzene	8270C	µg/L	10	ND
		1,3-Dichlorobenzene	8270C	µg/L	10	ND
		1,4-Dichlorobenzene	8270C	µg/L	10	ND
		2,4,5-Trichlorophenol	8270C	µg/L	10	ND
		2,4,6-Trichlorophenol	8270C	µg/L	10	ND
		2,4-Dichlorophenol	8270C	µg/L	10	ND
		2,4-Dimethylphenol	8270C	µg/L	10	ND
		2,4-Dinitrophenol	8270C	µg/L	50	ND
		2,4-Dinitrotoluene	8270C	µg/L	10	ND
		2,6-Dinitrotoluene	8270C	µg/L	10	ND
		2-Chloronaphthalene	8270C	µg/L	10	ND
		2-Chlorophenol	8270C	µg/L	10	ND
		2-Methylphenol	8270C	µg/L	10	ND

Location	Date	Analyte	Method	Units	Result	Qualifier
MW-57-070	6/10/2009	2-Nitroaniline	8270C	µg/L	50	ND
		2-Nitrophenol	8270C	µg/L	10	ND
		3,3-Dichlorobenzidene	8270C	µg/L	20	ND
		3-Nitroaniline	8270C	µg/L	50	ND
		4,6-Dinitro-2-methylphenol	8270C	µg/L	50	ND
		4-Bromophenyl phenyl ether	8270C	µg/L	10	ND
		4-Chloro-3-methylphenol	8270C	µg/L	50	ND
		4-Chloroaniline	8270C	µg/L	20	ND
		4-Chlorophenyl phenyl ether	8270C	µg/L	10	ND
		4-Methylphenol	8270C	µg/L	10	ND
		4-Nitroaniline	8270C	µg/L	20	ND
		4-Nitrophenol	8270C	µg/L	50	ND
		Benzoic acid	8270C	µg/L	50	ND
		Benzyl alcohol	8270C	µg/L	20	ND
		Bis (2-chloroethoxy) methane	8270C	µg/L	10	ND
		Bis (2-chloroethyl) ether	8270C	µg/L	10	ND
		Bis (2-chloroisopropyl) ether	8270C	µg/L	10	ND
		Bis (2-ethylhexyl) phthalate	8270C	µg/L	10	ND
		Butyl benzyl phthalate	8270C	µg/L	10	ND
		Dibenzofuran	8270C	µg/L	10	ND
		Diethyl phthalate	8270C	µg/L	10	ND
		Dimethyl phthalate	8270C	µg/L	10	ND
		Di-N-butyl phthalate	8270C	µg/L	10	ND
		Di-N-octyl phthalate	8270C	µg/L	10	ND
		Hexachlorobenzene	8270C	µg/L	10	ND
		Hexachlorobutadiene	8270C	µg/L	20	ND
		Hexachloroethane	8270C	µg/L	10	ND
		Isophorone	8270C	µg/L	10	ND
		Nitrobenzene	8270C	µg/L	10	ND
		N-Nitroso-di-n-propylamine	8270C	µg/L	10	ND
		N-nitrosodiphenylamine	8270C	µg/L	10	ND
		Pentachloro phenol	8270C	µg/L	50	ND
		Phenol	8270C	µg/L	10	ND
MW-57-070	6/10/2009	TPH as diesel	8015M	µg/L	50	ND
		TPH as motor oil	8015M	µg/L	50	ND
MW-59-100	5/4/2009	1,2,3,4,6,7,8-HpCDD	SW8290	pg/L	1.2	ND
		1,2,3,4,6,7,8-HpCDF	SW8290	pg/L	0.65	ND
		1,2,3,4,7,8,9-HpCDF	SW8290	pg/L	0.98	ND

Location	Date	Analyte	Method	Units	Result	Qualifier
MW-59-100	5/4/2009	1,2,3,4,7,8-HxCDD	SW8290	pg/L	1	ND
		1,2,3,4,7,8-HxCDF	SW8290	pg/L	0.53	ND
		1,2,3,6,7,8-HxCDD	SW8290	pg/L	1	ND
		1,2,3,6,7,8-HxCDF	SW8290	pg/L	0.49	ND
		1,2,3,7,8,9-HxCDD	SW8290	pg/L	1	ND
		1,2,3,7,8,9-HxCDF	SW8290	pg/L	0.72	ND
		1,2,3,7,8-PeCDD	SW8290	pg/L	1.2	ND
		1,2,3,7,8-PeCDF	SW8290	pg/L	0.34	ND
		2,3,4,6,7,8-HxCDF	SW8290	pg/L	0.56	ND
		2,3,4,7,8-PeCDF	SW8290	pg/L	0.34	ND
		2,3,7,8-TCDD	SW8290	pg/L	0.53	ND
		2,3,7,8-TCDF	SW8290	pg/L	0.34	ND
		OCDD	SW8290	pg/L	1.3	ND
		OCDF	SW8290	pg/L	2.4	ND
MW-59-100	6/10/2009	1-Methylnaphthalene	8270SIM	µg/L	0.2	ND
		2-Methylnaphthalene	8270SIM	µg/L	0.2	ND
		Acenaphthene	8270SIM	µg/L	0.2	ND
		Acenaphthylene	8270SIM	µg/L	0.2	ND
		Anthracene	8270SIM	µg/L	0.2	ND
		Benzo (a) anthracene	8270SIM	µg/L	0.2	ND
		Benzo (a) pyrene	8270SIM	µg/L	0.2	ND
		Benzo (b) fluoranthene	8270SIM	µg/L	0.2	ND
		Benzo (ghi) perylene	8270SIM	µg/L	0.2	ND
		Benzo (k) fluoranthene	8270SIM	µg/L	0.2	ND
		Chrysene	8270SIM	µg/L	0.2	ND
		Dibenzo (a,h) anthracene	8270SIM	µg/L	0.2	ND
		Fluoranthene	8270SIM	µg/L	0.2	ND
		Fluorene	8270SIM	µg/L	0.2	ND
		Indeno (1,2,3-cd) pyrene	8270SIM	µg/L	0.2	ND
		Naphthalene	8270SIM	µg/L	0.2	ND
		Phenanthrene	8270SIM	µg/L	0.2	ND
		Pyrene	8270SIM	µg/L	0.2	ND
MW-59-100	6/10/2009	Aroclor 1016	8082	µg/L	0.5	ND
		Aroclor 1221	8082	µg/L	1	ND
		Aroclor 1232	8082	µg/L	0.5	ND
		Aroclor 1242	8082	µg/L	0.5	ND
		Aroclor 1248	8082	µg/L	0.5	ND
		Aroclor 1254	8082	µg/L	0.5	ND

TABLE A3-4

Groundwater Sample Results for Additional Analyses at MW-57-070 and MW-59-100

Summary of Findings Associated with the East Ravine Groundwater Investigation

PG&E Topock Compressor Station

Location	Date	Analyte	Method	Units	Result	Qualifier
MW-59-100	6/10/2009	Aroclor 1260	8082	µg/L	0.5	ND
MW-59-100	6/10/2009	4,4-DDD	8081A	µg/L	0.05	ND
		4,4-DDE	8081A	µg/L	0.05	ND
		4,4-DDT	8081A	µg/L	0.05	ND
		Aldrin	8081A	µg/L	0.025	ND
		alpha-BHC	8081A	µg/L	0.025	ND
		alpha-Chlordane	8081A	µg/L	0.025	ND
		beta-BHC	8081A	µg/L	0.025	ND
		delta-BHC	8081A	µg/L	0.025	ND
		Dieldrin	8081A	µg/L	0.05	ND
		Endo sulfan I	8081A	µg/L	0.025	ND
		Endo sulfan II	8081A	µg/L	0.05	ND
		Endosulfan sulfate	8081A	µg/L	0.05	ND
		Endrin	8081A	µg/L	0.05	ND
		Endrin aldehyde	8081A	µg/L	0.05	ND
		gamma-BHC	8081A	µg/L	0.025	ND
		gamma-Chlordane	8081A	µg/L	0.025	ND
		Heptachlor	8081A	µg/L	0.025	ND
		Heptachlor Epoxide	8081A	µg/L	0.025	ND
		Methoxy chlor	8081A	µg/L	0.25	ND
		Toxaphene	8081A	µg/L	2.5	ND
MW-59-100	6/10/2009	1,2,4-Trichlorobenzene	8270C	µg/L	10	ND
		1,2-Dichlorobenzene	8270C	µg/L	10	ND
		1,3-Dichlorobenzene	8270C	µg/L	10	ND
		1,4-Dichlorobenzene	8270C	µg/L	10	ND
		2,4,5-Trichlorophenol	8270C	µg/L	10	ND
		2,4,6-Trichlorophenol	8270C	µg/L	10	ND
		2,4-Dichlorophenol	8270C	µg/L	10	ND
		2,4-Dimethylphenol	8270C	µg/L	10	ND
		2,4-Dinitrophenol	8270C	µg/L	50	ND
		2,4-Dinitrotoluene	8270C	µg/L	10	ND
		2,6-Dinitrotoluene	8270C	µg/L	10	ND
		2-Chloronaphthalene	8270C	µg/L	10	ND
		2-Chlorophenol	8270C	µg/L	10	ND
		2-Methylphenol	8270C	µg/L	10	ND
		2-Nitroaniline	8270C	µg/L	50	ND
		2-Nitrophenol	8270C	µg/L	10	ND
		3,3-Dichlorobenzidene	8270C	µg/L	20	ND

TABLE A3-4

Groundwater Sample Results for Additional Analyses at MW-57-070 and MW-59-100

Summary of Findings Associated with the East Ravine Groundwater Investigation

PG&E Topock Compressor Station

Location	Date	Analyte	Method	Units	Result	Qualifier
MW-59-100	6/10/2009	3-Nitroaniline	8270C	µg/L	50	ND
		4,6-Dinitro-2-methylphenol	8270C	µg/L	50	ND
		4-Bromophenyl phenyl ether	8270C	µg/L	10	ND
		4-Chloro-3-methylphenol	8270C	µg/L	50	ND
		4-Chloroaniline	8270C	µg/L	20	ND
		4-Chlorophenyl phenyl ether	8270C	µg/L	10	ND
		4-Methylphenol	8270C	µg/L	10	ND
		4-Nitroaniline	8270C	µg/L	20	ND
		4-Nitrophenol	8270C	µg/L	50	ND
		Benzoic acid	8270C	µg/L	50	ND
		Benzyl alcohol	8270C	µg/L	20	ND
		Bis (2-chloroethoxy) methane	8270C	µg/L	10	ND
		Bis (2-chloroethyl) ether	8270C	µg/L	10	ND
		Bis (2-chloroisopropyl) ether	8270C	µg/L	10	ND
		Bis (2-ethylhexyl) phthalate	8270C	µg/L	10	ND
		Butyl benzyl phthalate	8270C	µg/L	10	ND
		Dibenzofuran	8270C	µg/L	10	ND
		Diethyl phthalate	8270C	µg/L	10	ND
		Dimethyl phthalate	8270C	µg/L	10	ND
		Di-N-butyl phthalate	8270C	µg/L	10	ND
		Di-N-octyl phthalate	8270C	µg/L	10	ND
		Hexachlorobenzene	8270C	µg/L	10	ND
		Hexachlorobutadiene	8270C	µg/L	20	ND
		Hexachloroethane	8270C	µg/L	10	ND
		Isophorone	8270C	µg/L	10	ND
		Nitrobenzene	8270C	µg/L	10	ND
		N-Nitroso-di-n-propylamine	8270C	µg/L	10	ND
		N-nitrosodiphenylamine	8270C	µg/L	10	ND
		Pentachloro phenol	8270C	µg/L	50	ND
		Phenol	8270C	µg/L	10	ND
MW-59-100	6/10/2009	TPH as diesel	8015M	µg/L	50	ND
		TPH as motor oil	8015M	µg/L	50	ND

NOTES:

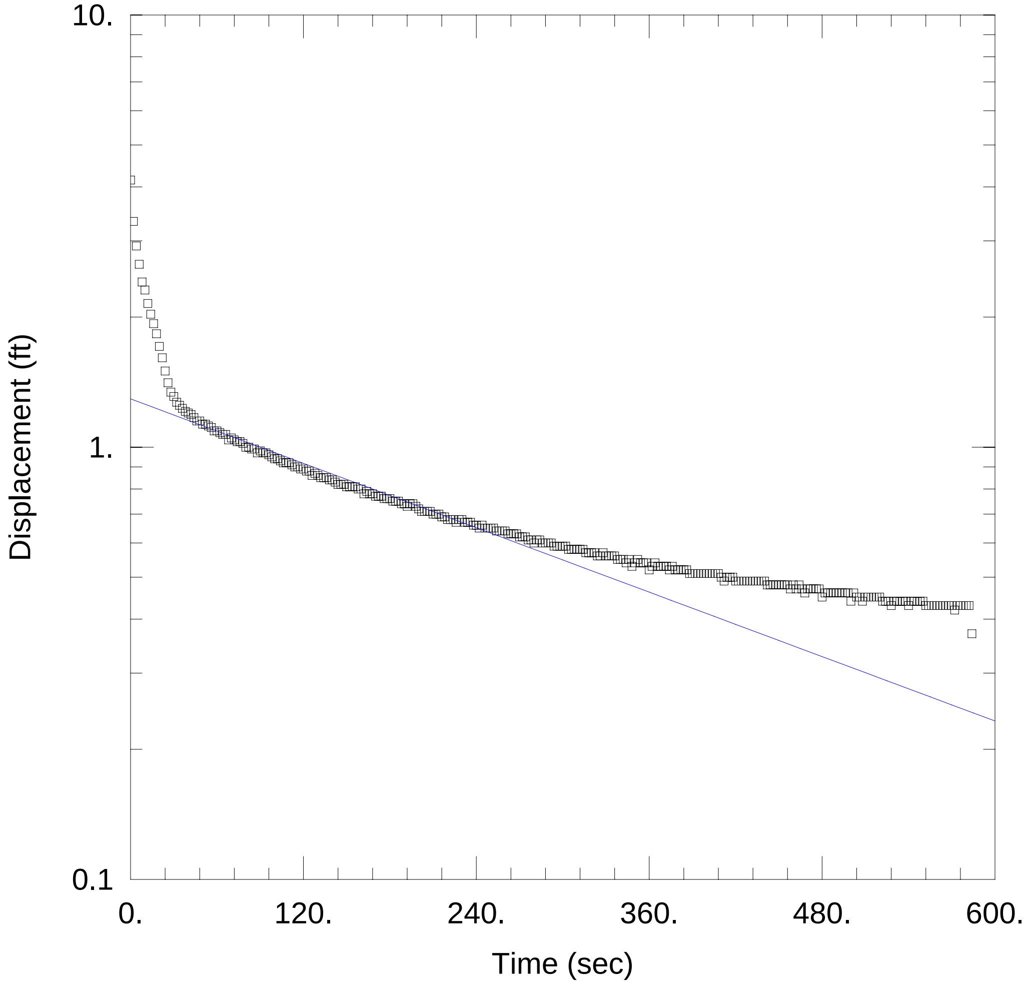
ND	not detected at listed reporting limit
pg/L	picograms per liter
µg/L	micrograms per liter

Attachment A4

Aquifer Monitoring Data

(This attachment is provided on CD-ROM)

Attachment A4-1
Slug Test Results



MW-57-070 SLUG TEST

Data Set: \...\MW-57-070.aqt
Date: 09/01/09 Time: 14:44:48

PROJECT INFORMATION

Company: CH2MHILL
Client: PG&E
Project: 382653
Test Location: Topock East Ravine
Test Well: MW-57-070
Test Date: 4/4/2009

AQUIFER DATA

Saturated Thickness: 16.67 ft
Anisotropy Ratio (Kz/Kr): 1.

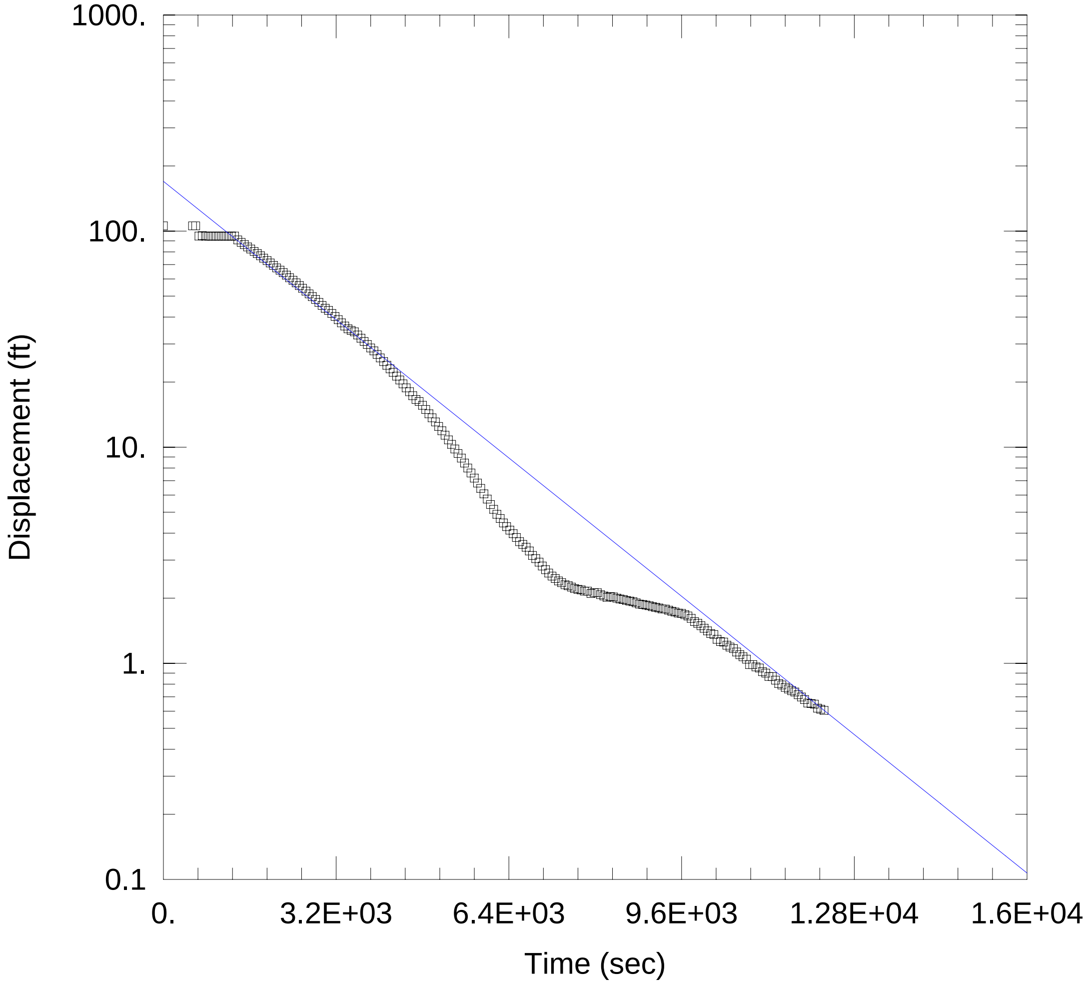
WELL DATA (MW-57-070)

Initial Displacement: 4.15 ft
Casing Radius: 0.0833 ft
Wellbore Radius: 0.25 ft
Well Skin Radius: 0.25 ft
Screen Length: 15. ft
Total Well Penetration Depth: 16.67 ft
Gravel Pack Porosity: 0.3

SOLUTION

Aquifer Model: Unconfined
Solution Method: Bouwer-Rice

K = 0.1833 ft/day
y0 = 1.293 ft



MW-58BR DEVELOPMENT RECOVERY

Data Set: \...\MW-58BR.aqt
Date: 09/01/09
Time: 14:48:11

PROJECT INFORMATION

Company: CH2MHILL
Client: PG&E
Project: 382653
Test Location: Topock East Ravine
Test Well: MW-58BR
Test Date: 3/31/2009

AQUIFER DATA

Saturated Thickness: 140.3 ft
Anisotropy Ratio (Kz/Kr): 1.

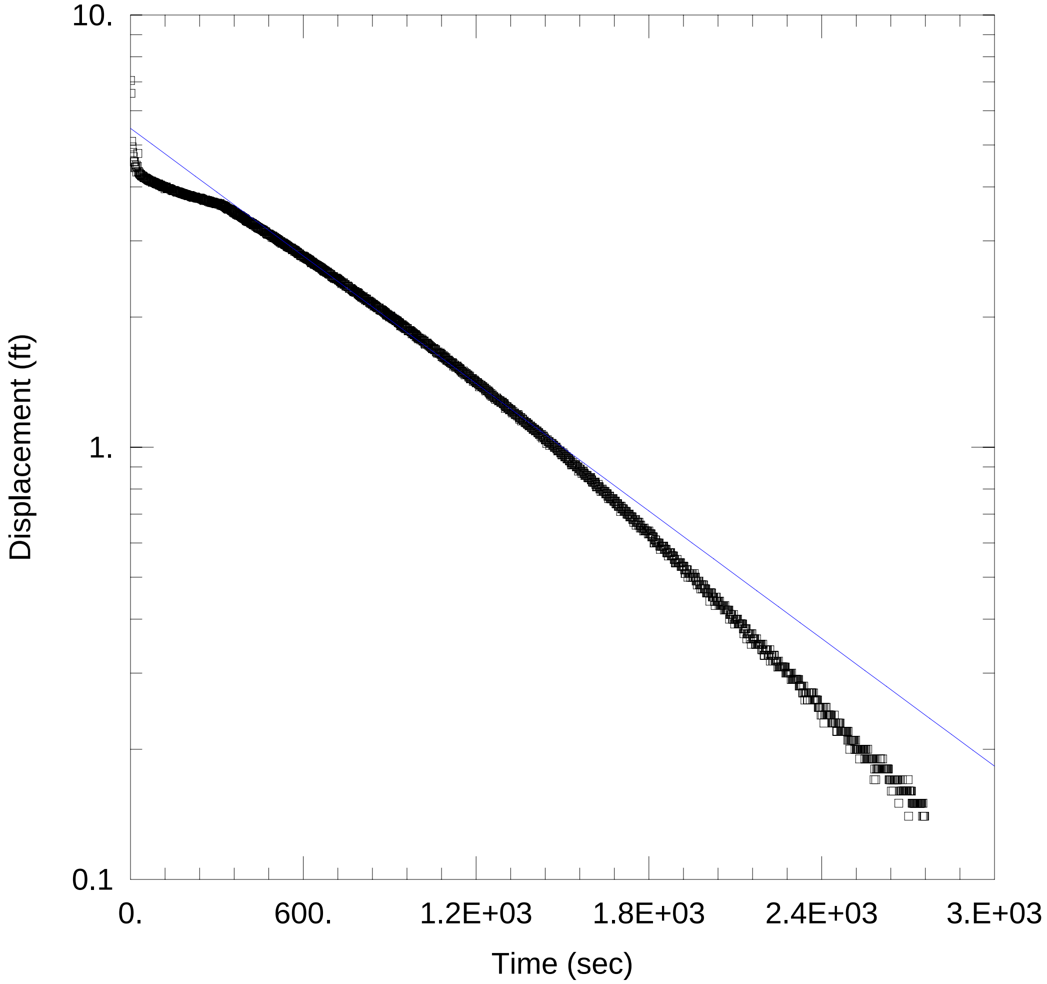
WELL DATA (MW-58BR)

Initial Displacement: 105.7 ft
Casing Radius: 0.125 ft
Wellbore Radius: 0.158 ft
Well Skin Radius: 0.158 ft
Screen Length: 145. ft
Total Well Penetration Depth: 140.3 ft

SOLUTION

Aquifer Model: Unconfined
Solution Method: Bouwer-Rice

K = 0.01223 ft/day
y0 = 169.9 ft



MW-60-125 SLUG TEST

Data Set: \...\MW-60-125.aqt
Date: 09/01/09
Time: 14:50:09

PROJECT INFORMATION

Company: CH2MHILL
Client: PG&E
Project: 382653
Test Location: Topock East Ravine
Test Well: MW-60-125
Test Date: 4/4/2009

AQUIFER DATA

Saturated Thickness: 24.05 ft
Anisotropy Ratio (Kz/Kr): 1.

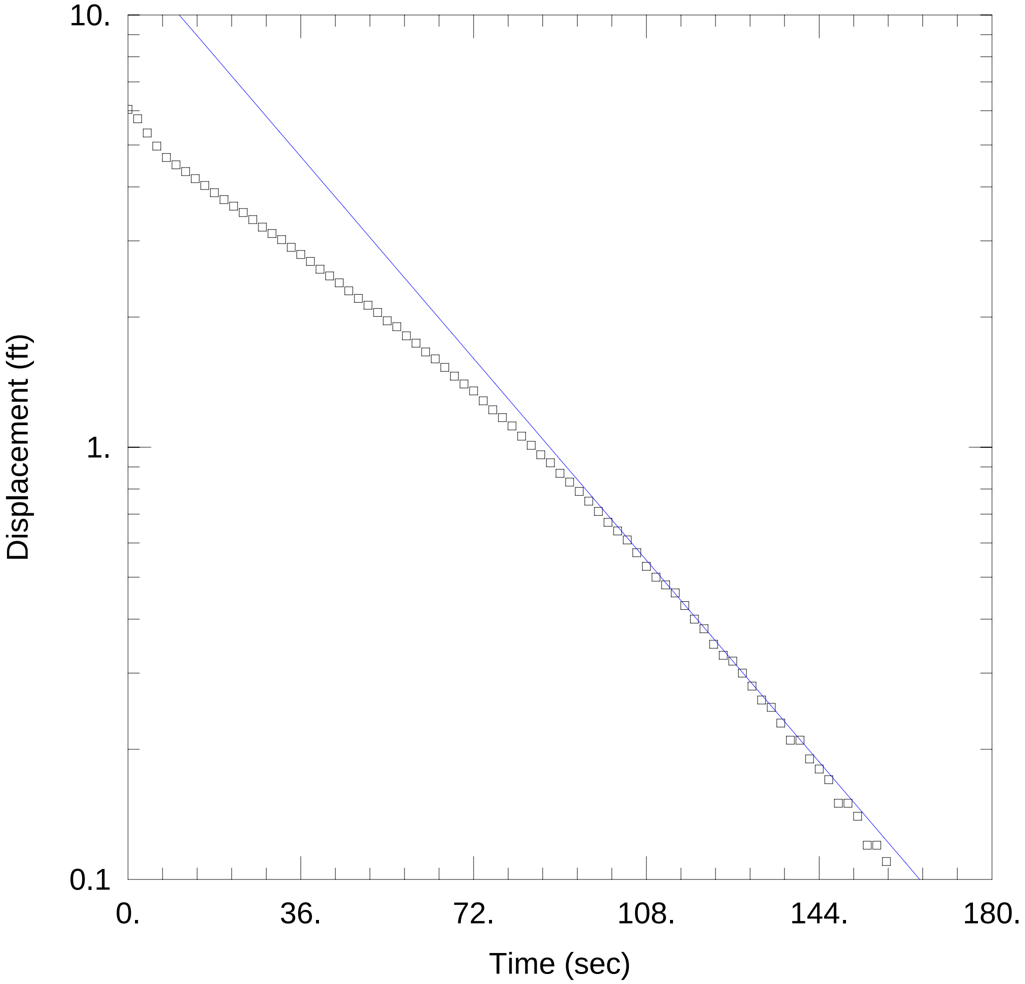
WELL DATA (MW-60-125)

Initial Displacement: 7.05 ft
Casing Radius: 0.0833 ft
Wellbore Radius: 0.25 ft
Well Skin Radius: 0.25 ft
Screen Length: 20. ft
Total Well Penetration Depth: 24.05 ft
Gravel Pack Porosity: 0.3

SOLUTION

Aquifer Model: Unconfined
Solution Method: Bouwer-Rice

K = 0.05918 ft/day
y0 = 5.467 ft



MW-61-110 SLUG TEST

Data Set: \...\MW-61-110.aqt
Date: 09/01/09 Time: 14:54:29

PROJECT INFORMATION

Company: CH2MHILL
Client: PG&E
Project: 382653
Test Location: Topock East Ravine
Test Well: MW-61-110
Test Date: 4/3/2009

AQUIFER DATA

Saturated Thickness: 24.48 ft Anisotropy Ratio (Kz/Kr): 1.

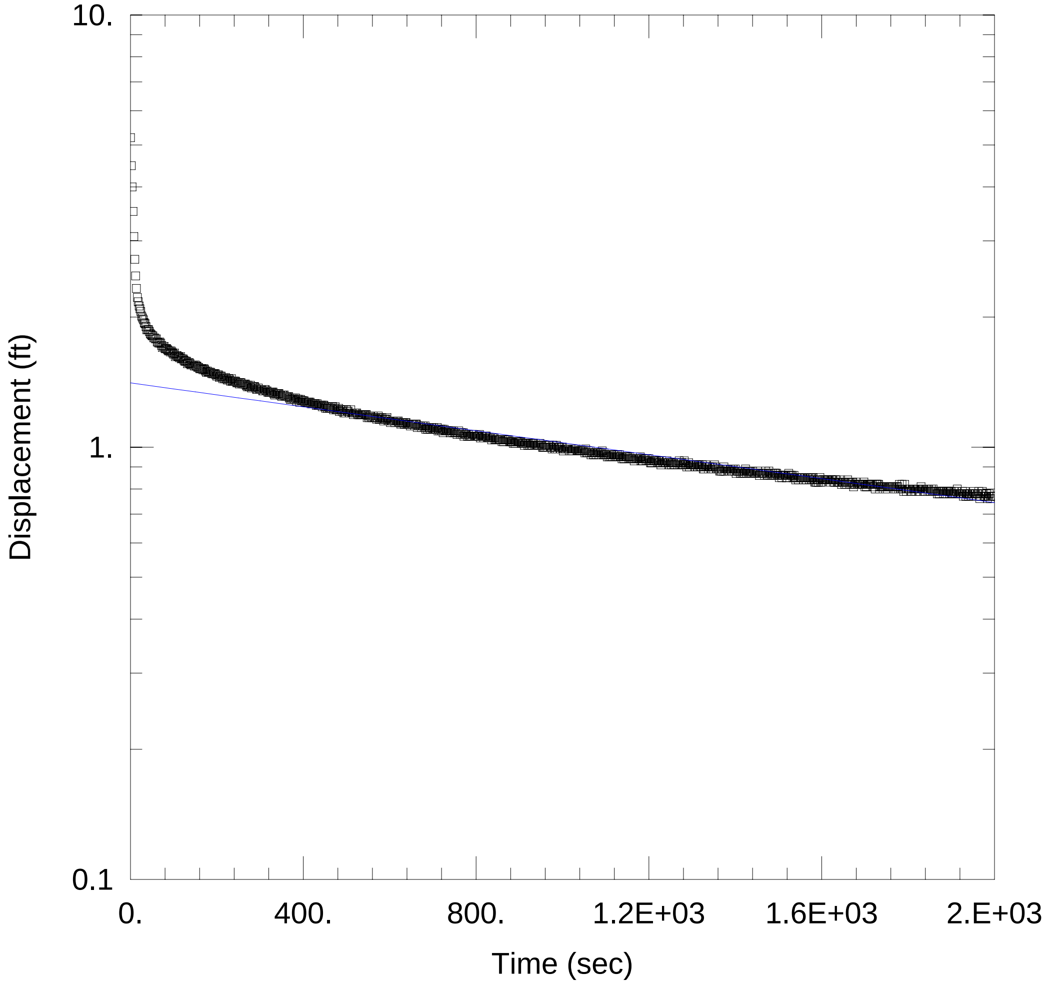
WELL DATA (MW-61-110)

Initial Displacement: 6.05 ft Casing Radius: 0.0833 ft
Wellbore Radius: 0.25 ft Well Skin Radius: 0.25 ft
Screen Length: 20. ft Total Well Penetration Depth: 24.28 ft
Gravel Pack Porosity: 0.3

SOLUTION

Aquifer Model: Unconfined Solution Method: Bouwer-Rice

K = 1.555 ft/day y0 = 13.76 ft



MW-62-065 SLUG TEST

Data Set: \...\MW-62-065.aqt
Date: 09/01/09
Time: 14:56:09

PROJECT INFORMATION

Company: CH2MHILL
Client: PG&E
Project: 382653
Test Location: Topock East Ravine
Test Well: MW-62-065
Test Date: 4/4/2009

AQUIFER DATA

Saturated Thickness: 17.52 ft
Anisotropy Ratio (Kz/Kr): 1.

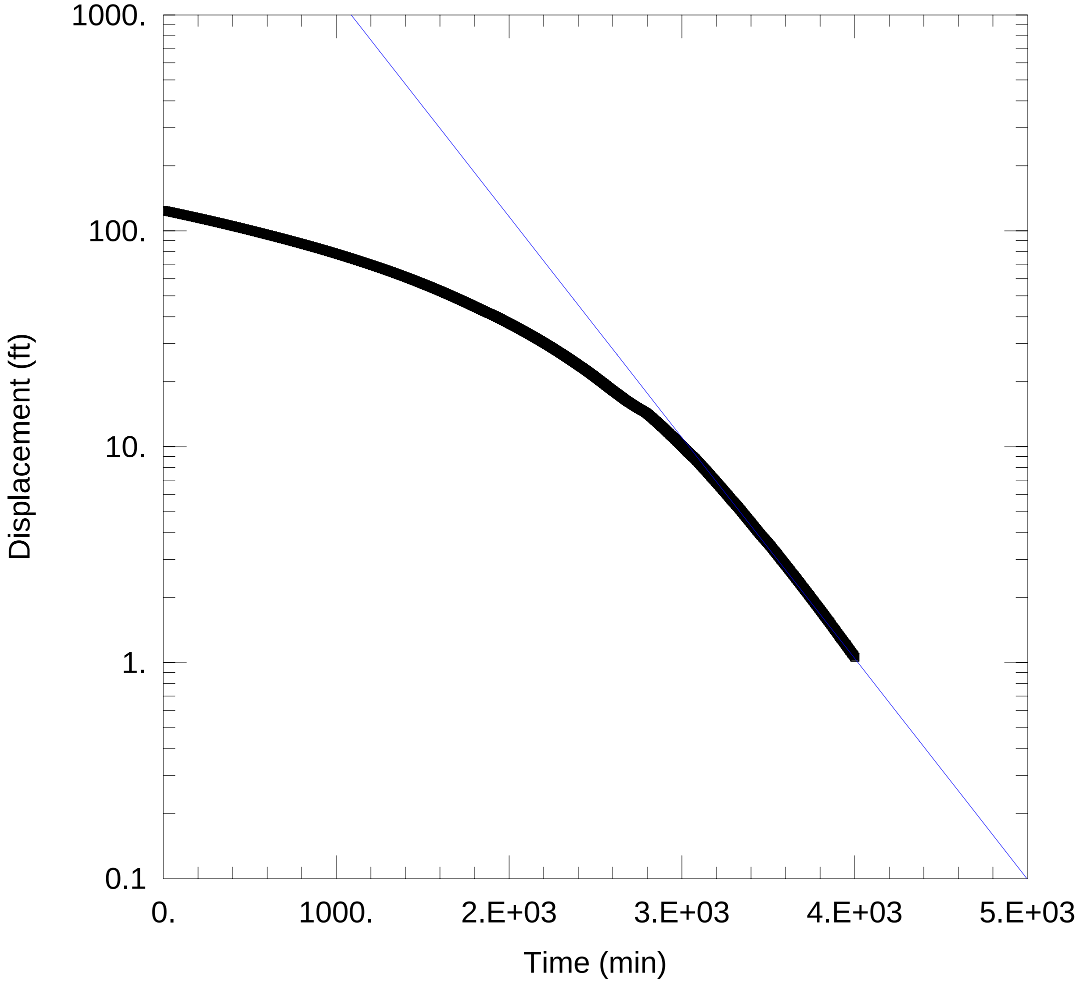
WELL DATA (MW-62-065)

Initial Displacement: 5.2 ft
Casing Radius: 0.0833 ft
Wellbore Radius: 0.25 ft
Well Skin Radius: 0.26 ft
Screen Length: 20. ft
Total Well Penetration Depth: 17.52 ft
Gravel Pack Porosity: 0.3

SOLUTION

Aquifer Model: Unconfined
Solution Method: Bouwer-Rice

K = 0.01567 ft/day
y0 = 1.408 ft



MW-64BR SLUG TEST

Data Set: \...\MW-64BR.aqt

Date: 09/01/09 Time: 14:58:12

PROJECT INFORMATION

Company: CH2MHILL
Test Location: PG&E Topock
Test Well: MW-64BR
Test Date: 6/1/2009

AQUIFER DATA

Saturated Thickness: 138. ft
Anisotropy Ratio (Kz/Kr): 1.

WELL DATA (MW-64BR)

Initial Displacement: 124.2 ft
Casing Radius: 0.125 ft
Wellbore Radius: 0.158 ft
Well Skin Radius: 0.158 ft
Screen Length: 138. ft
Total Well Penetration Depth: 138. ft

SOLUTION

Aquifer Model: Unconfined
Solution Method: Bouwer-Rice

K = 0.001089 ft/day
y0 = 1.292E+04 ft

Attachment A4-2
MW-57BR Constant Rate Test

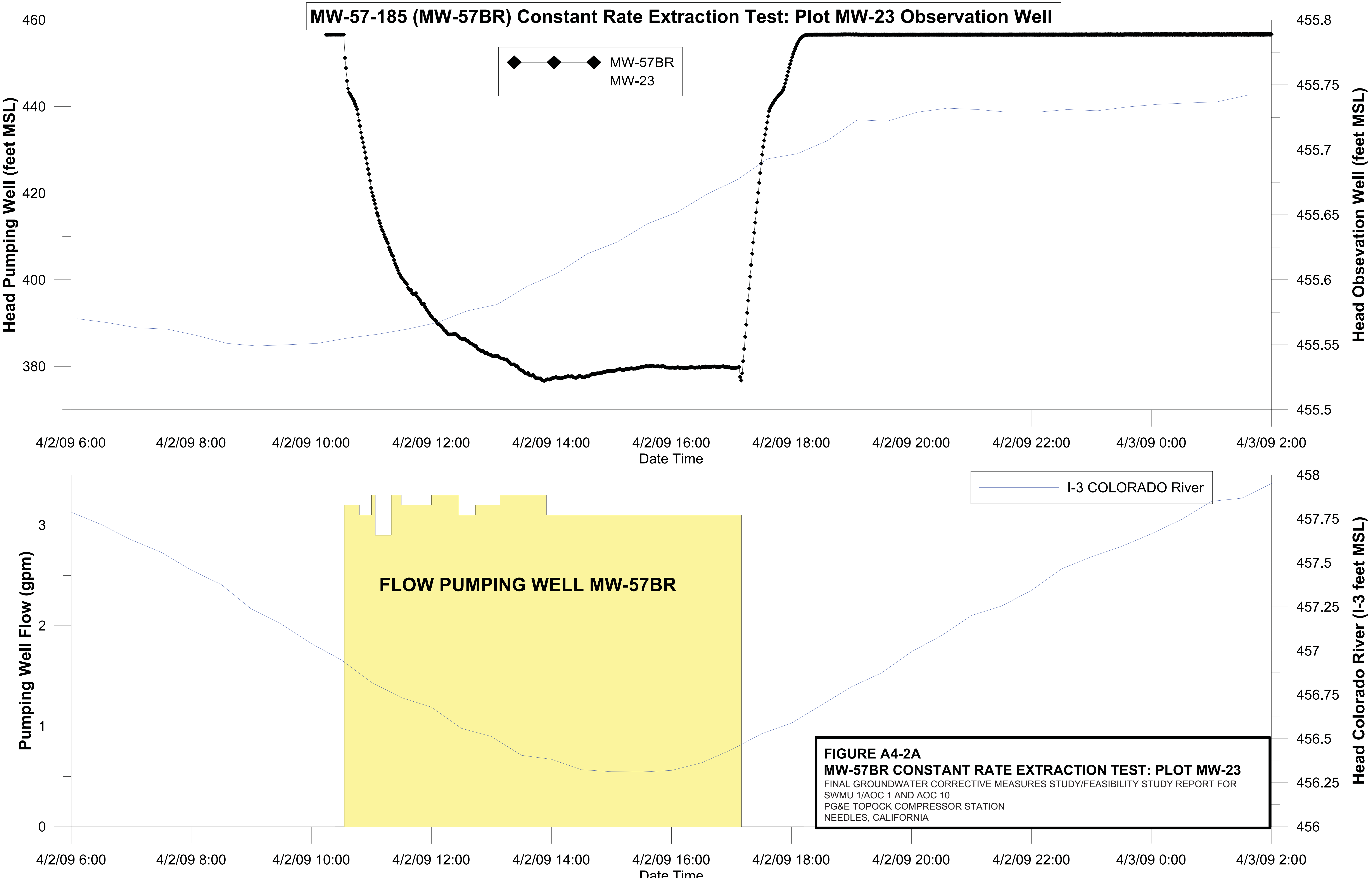


FIGURE A4-2A
MW-57BR CONSTANT RATE EXTRACTION TEST: PLOT MW-23
FINAL GROUNDWATER CORRECTIVE MEASURES STUDY/FEASIBILITY STUDY REPORT FOR SWMU 1/AOC 1 AND AOC 10
PG&E TOPOCK COMPRESSOR STATION
NEEDLES, CALIFORNIA

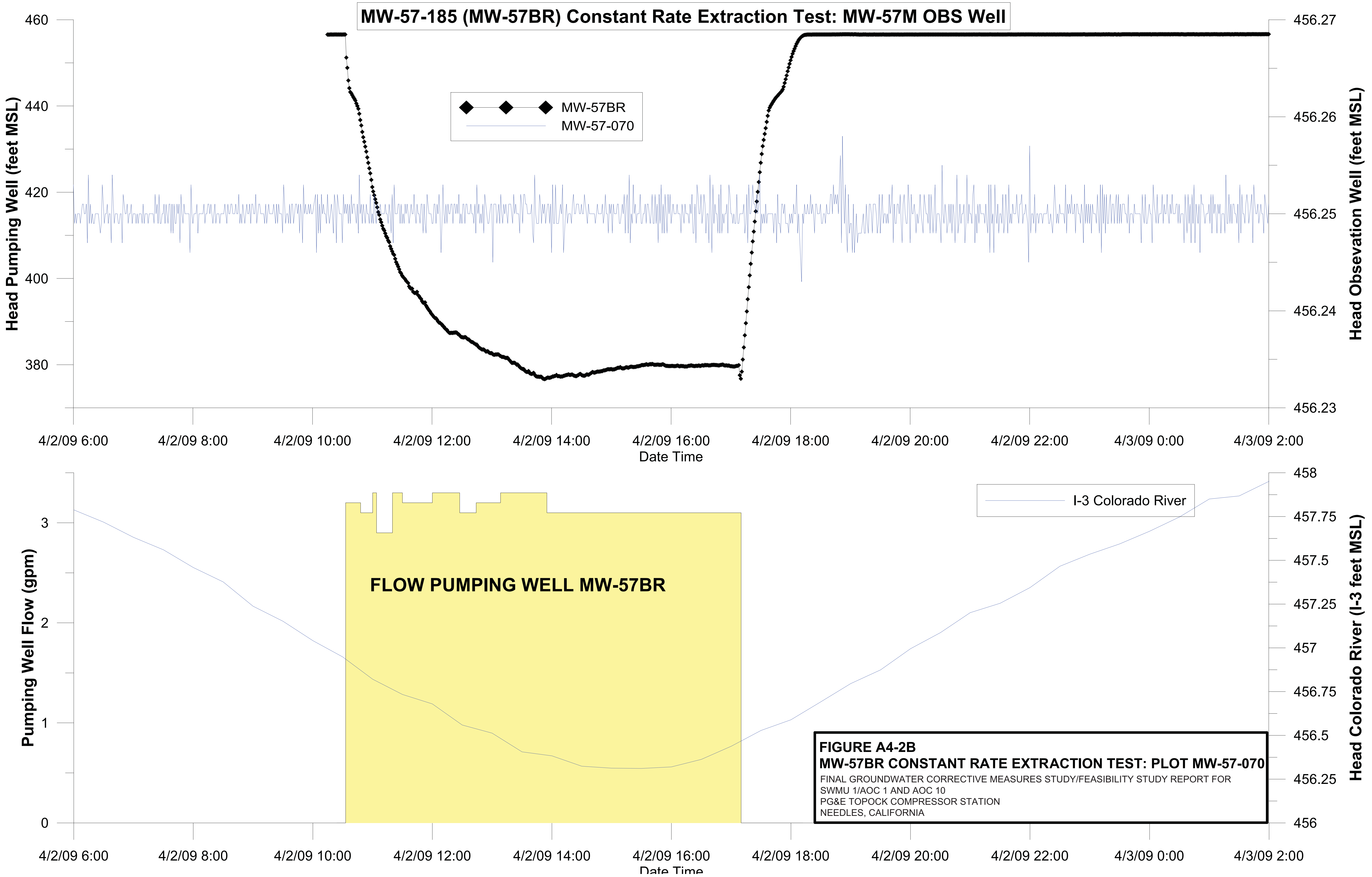


FIGURE A4-2B
MW-57BR CONSTANT RATE EXTRACTION TEST: PLOT MW-57-070
FINAL GROUNDWATER CORRECTIVE MEASURES STUDY/FEASIBILITY STUDY REPORT FOR
SWMU 1/AOC 1 AND AOC 10
PG&E TOPOCK COMPRESSOR STATION
NEEDLES, CALIFORNIA

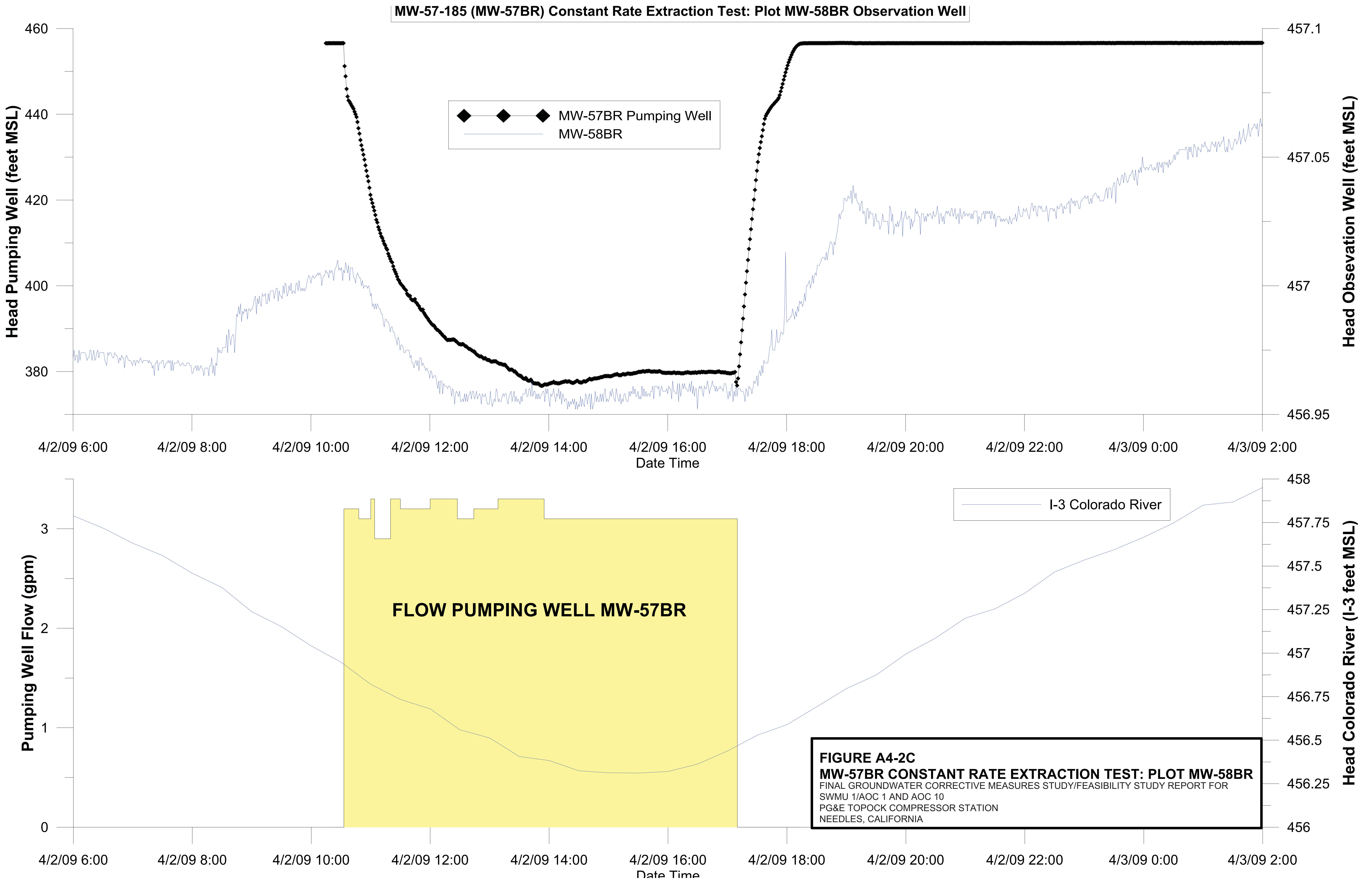


FIGURE A4-2C

MW-57BR CONSTANT RATE EXTRACTION TEST: PLOT MW-58BR

FINAL GROUNDWATER CORRECTIVE MEASURES STUDY/FEASIBILITY STUDY REPORT FOR
SWMU 1/AOC 1 AND AOC 10
PG&E TOPOCK COMPRESSOR STATION
NEEDLES, CALIFORNIA

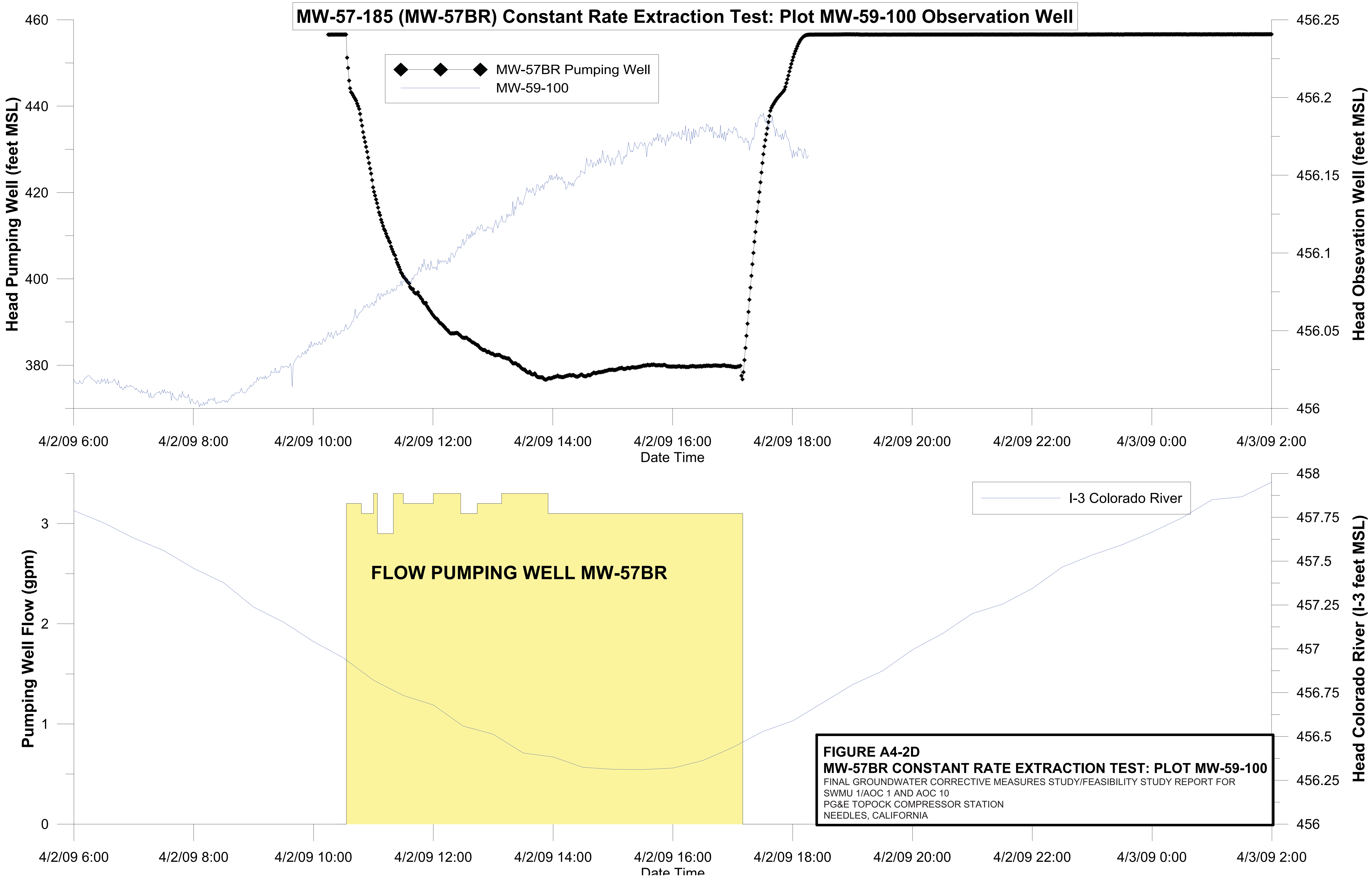


FIGURE A4-2D
MW-57BR CONSTANT RATE EXTRACTION TEST: PLOT MW-59-100
FINAL GROUNDWATER CORRECTIVE MEASURES STUDY/FEASIBILITY STUDY REPORT FOR
SWMU 1/AOC 1 AND AOC 10
PG&E TOPOCK COMPRESSOR STATION
NEEDLES, CALIFORNIA

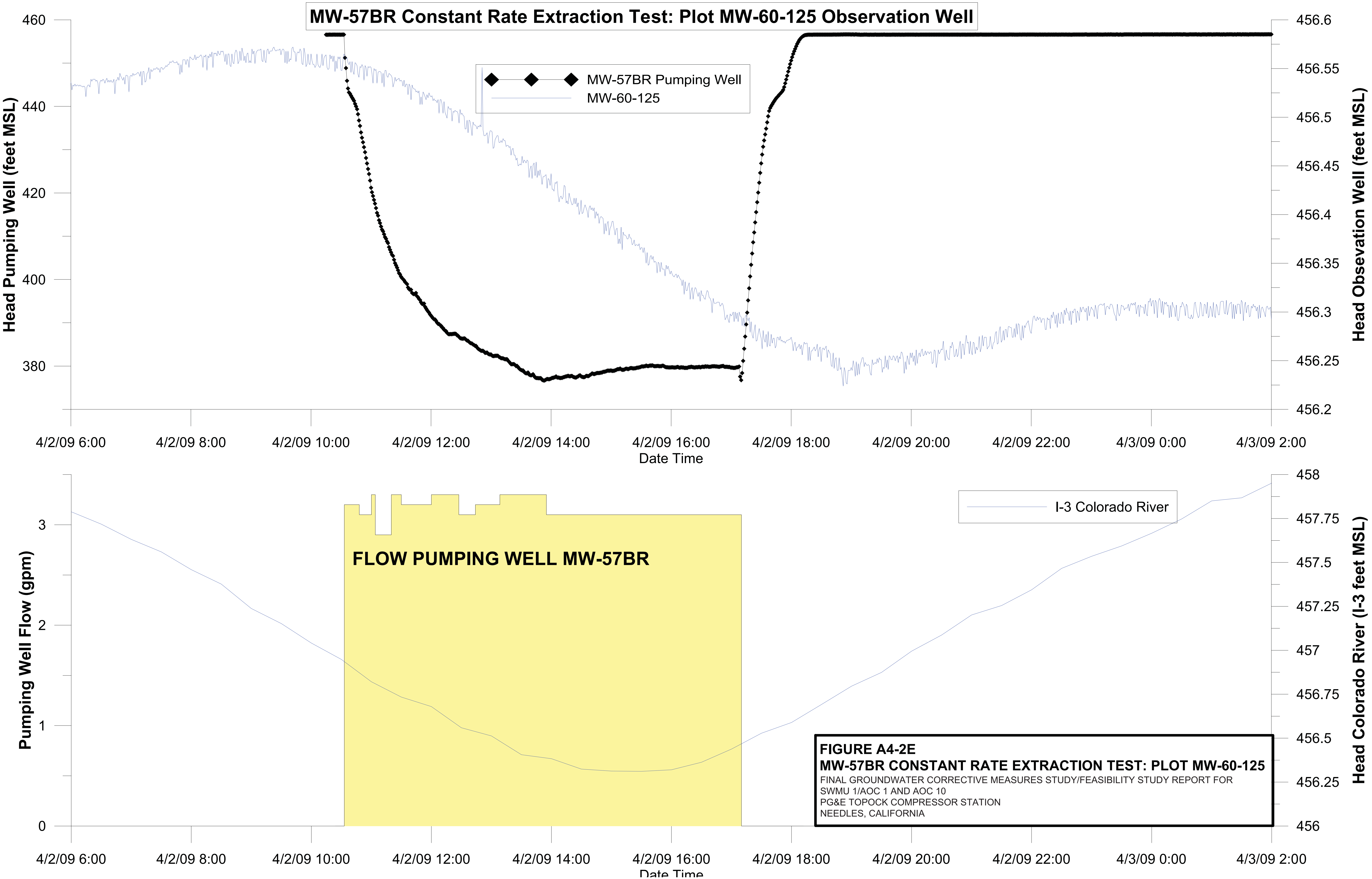


FIGURE A4-2E
MW-57BR CONSTANT RATE EXTRACTION TEST: PLOT MW-60-125
FINAL GROUNDWATER CORRECTIVE MEASURES STUDY/FEASIBILITY STUDY REPORT FOR
SWMU 1/AOC 1 AND AOC 10
PG&E TOPOCK COMPRESSOR STATION
NEEDLES, CALIFORNIA

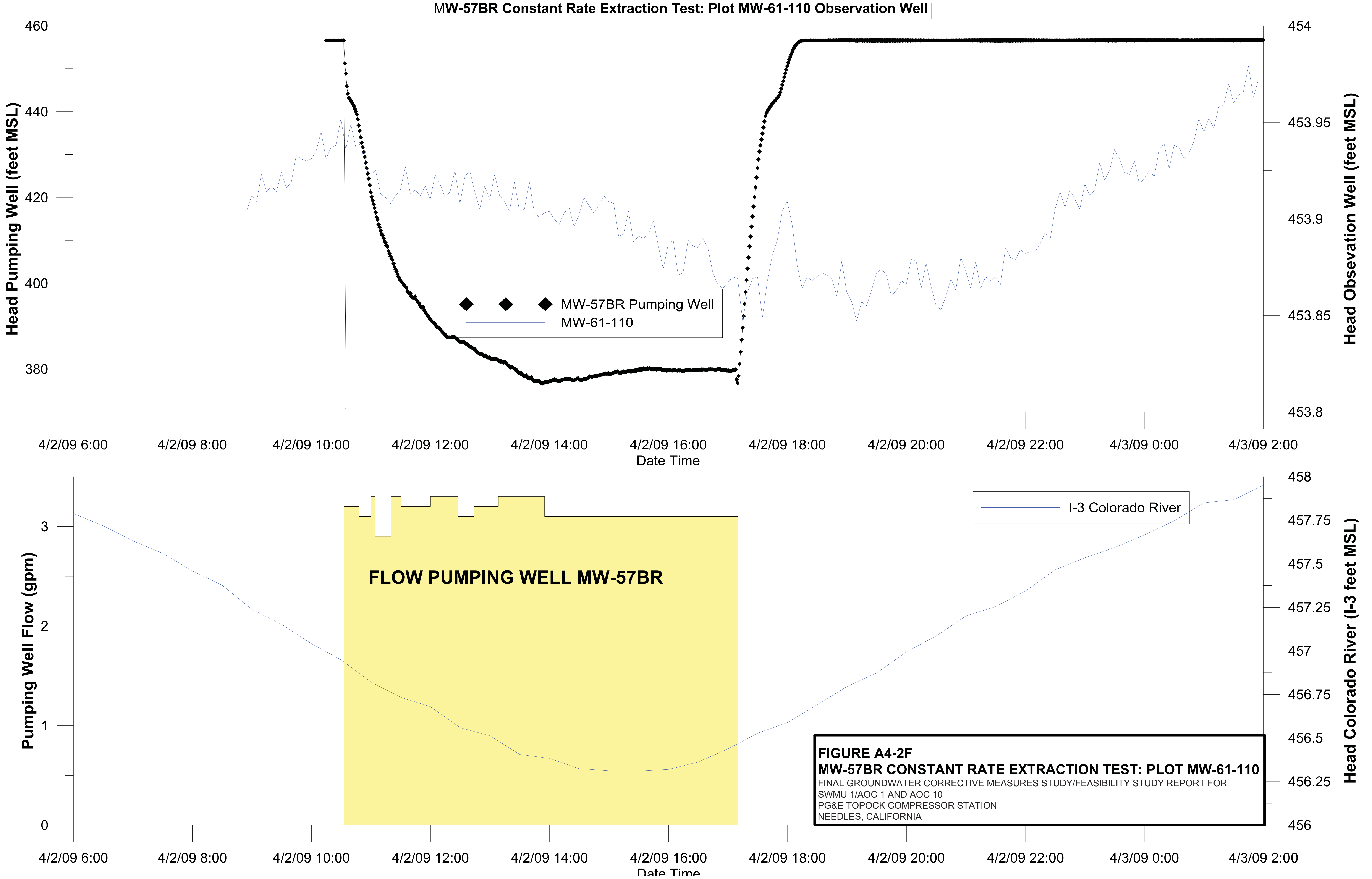


FIGURE A4-2F
MW-57BR CONSTANT RATE EXTRACTION TEST: PLOT MW-61-110
FINAL GROUNDWATER CORRECTIVE MEASURES STUDY/FEASIBILITY STUDY REPORT FOR
SWMU 1/AOC 1 AND AOC 10
PG&E TOPOCK COMPRESSOR STATION
NEEDLES, CALIFORNIA

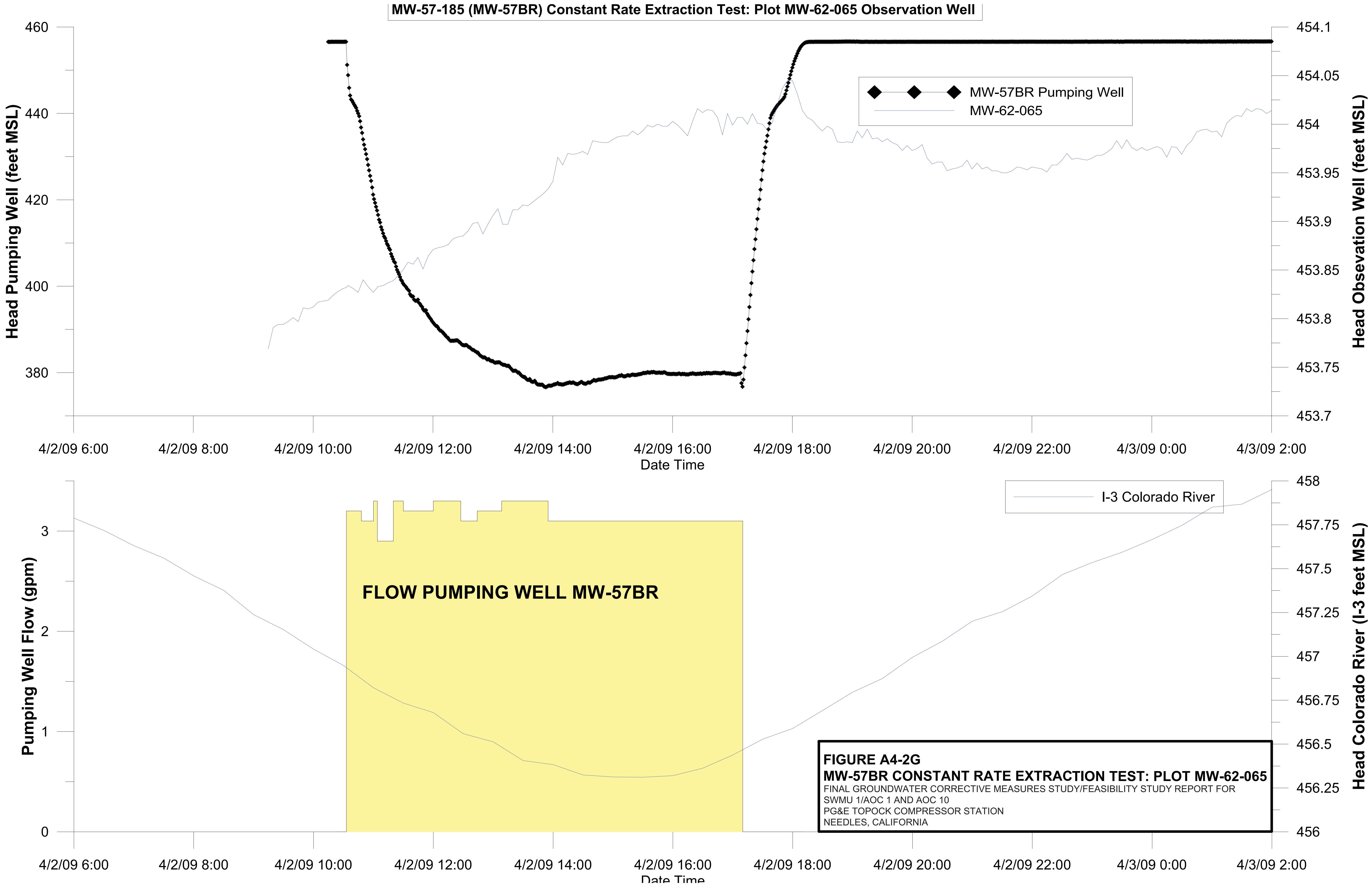
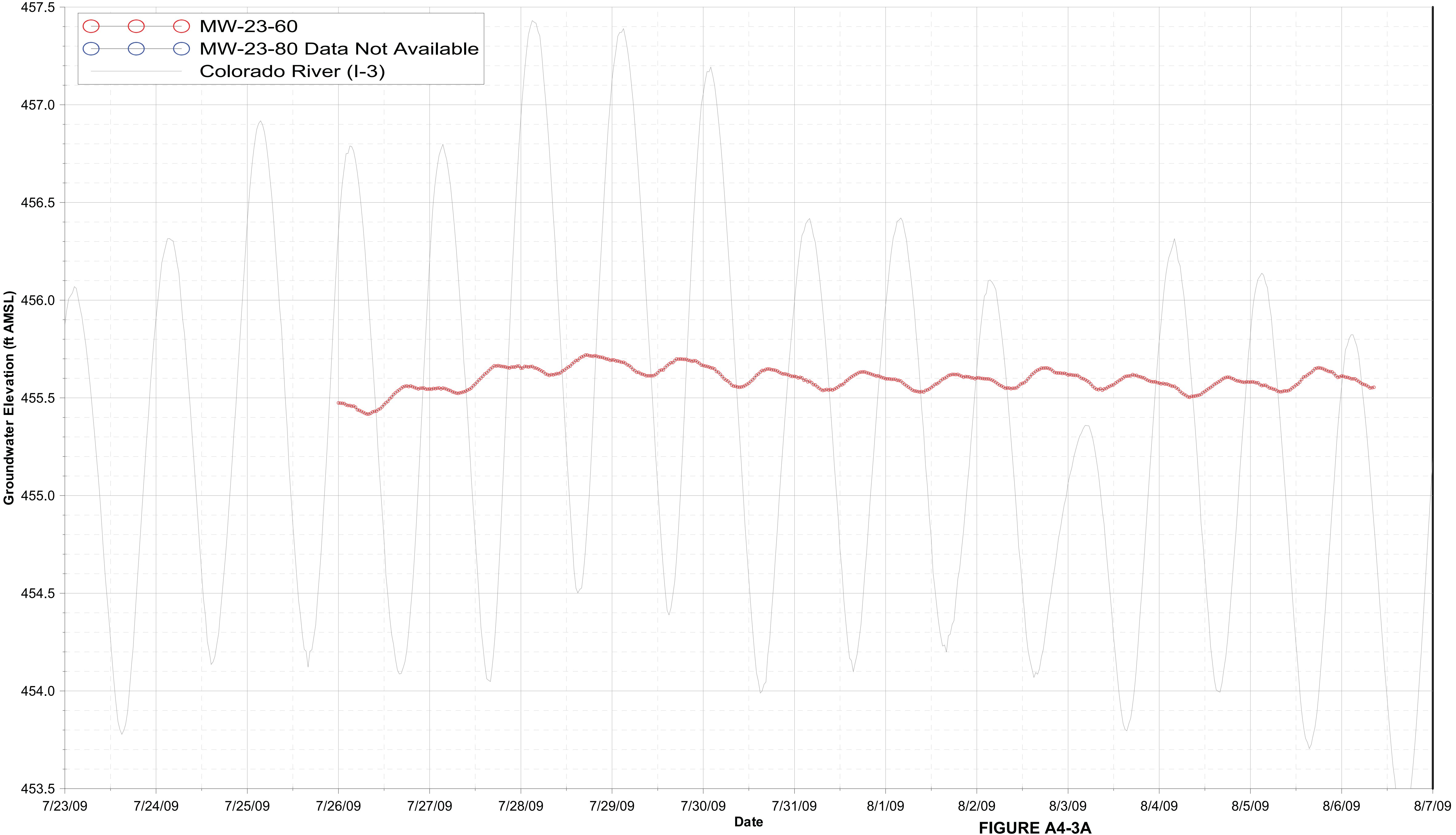


FIGURE A4-2G
MW-57BR CONSTANT RATE EXTRACTION TEST: PLOT MW-62-065
FINAL GROUNDWATER CORRECTIVE MEASURES STUDY/FEASIBILITY STUDY REPORT FOR
SWMU 1/AOC 1 AND AOC 10
PG&E TOPOCK COMPRESSOR STATION
NEEDLES, CALIFORNIA

Attachment A4-3
Well Hydrographs

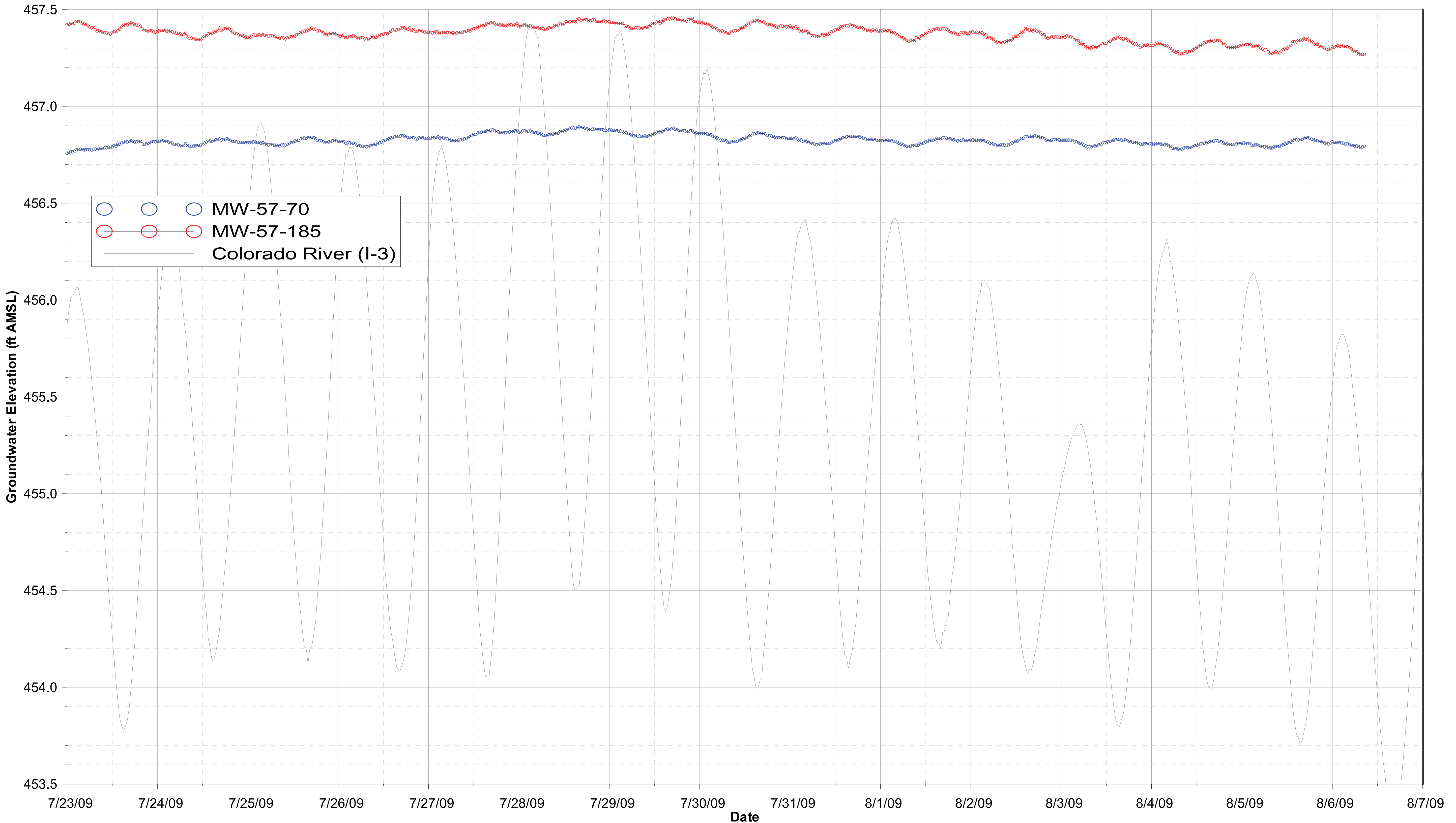


Note: Water levels represent the equivalent fresh water heads, adjusted from raw data using salinity and temperature measurements.
Data subject to review.

FIGURE A4-3A
MW-23 CLUSTER HYDROGRAPHS
FINAL GROUNDWATER CORRECTIVE MEASURES STUDY/
FEASIBILITY STUDY REPORT FOR SWMU 1/AOC 1 AND AOC 10
PG&E TOPOCK COMPRESSOR STATION
NEEDLES, CALIFORNIA

CH2MHILL

\\zinfandel\proj\PacificGasElectricCo\TopockProgram\Project_2009FieldActivities\ERGI\Field_Work\Working_DataFiles\Hydraulic_Data\Hydraulic_Data_Summary\ERGI_PT_Hydrographs



Note: Water levels represent the equivalent fresh water heads, adjusted from raw data using salinity and temperature measurements.
Data subject to review.

FIGURE A4-3B
MW-57 CLUSTER HYDROGRAPHS
FINAL GROUNDWATER CORRECTIVE MEASURES STUDY/
FEASIBILITY STUDY REPORT FOR SWMU 1/AOC 1 AND AOC 10
PG&E TOPOCK COMPRESSOR STATION
NEEDLES, CALIFORNIA

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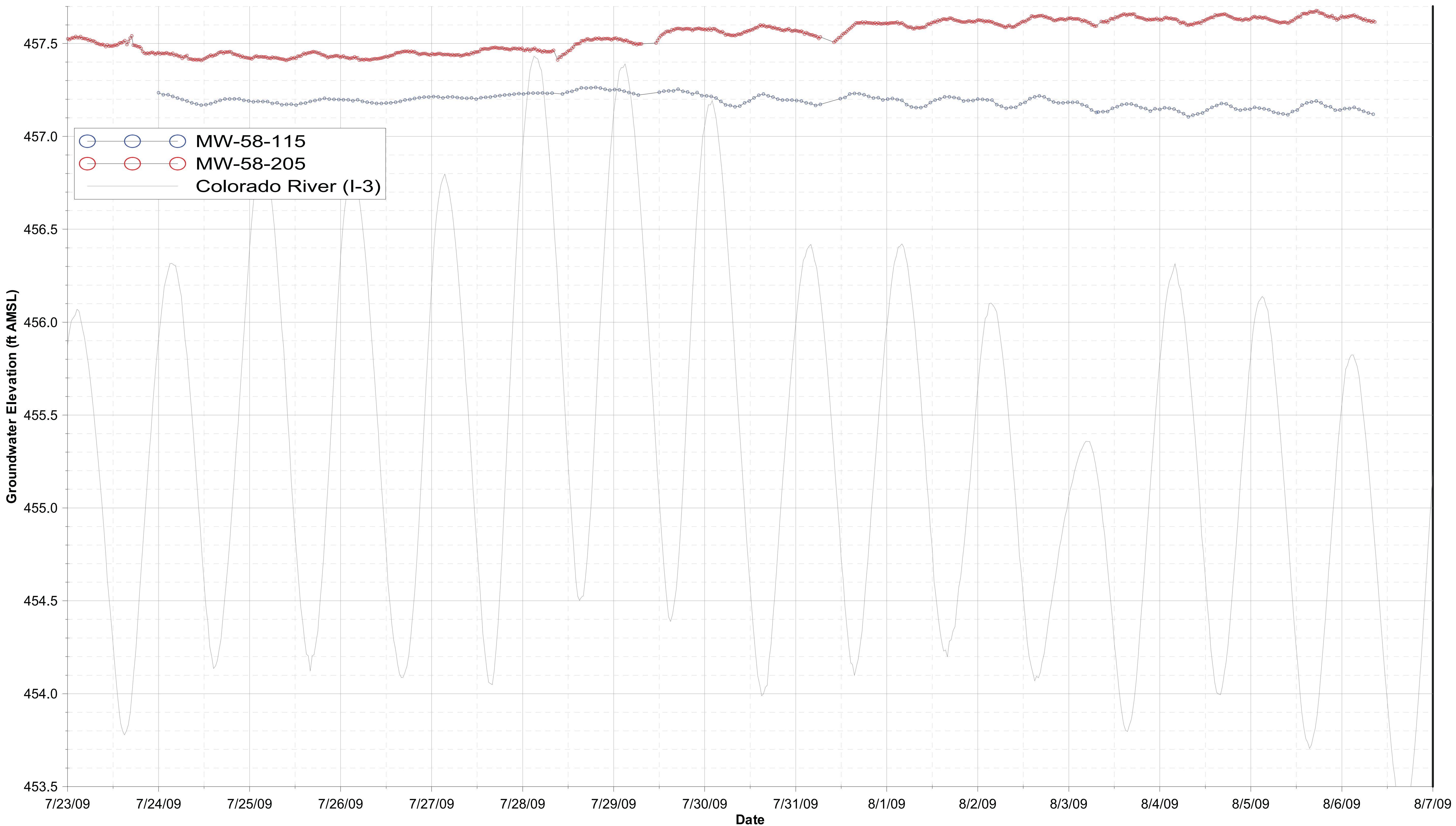

Note: Water levels represent the equivalent fresh water heads, adjusted from raw data using salinity and temperature measurements.
Data subject to review.

FIGURE A4-3C
MW-58 CLUSTER HYDROGRAPHS
FINAL GROUNDWATER CORRECTIVE MEASURES STUDY/
FEASIBILITY STUDY REPORT FOR SWMU 1/AOC 1 AND AOC 10
PG&E TOPOCK COMPRESSOR STATION
NEEDLES, CALIFORNIA

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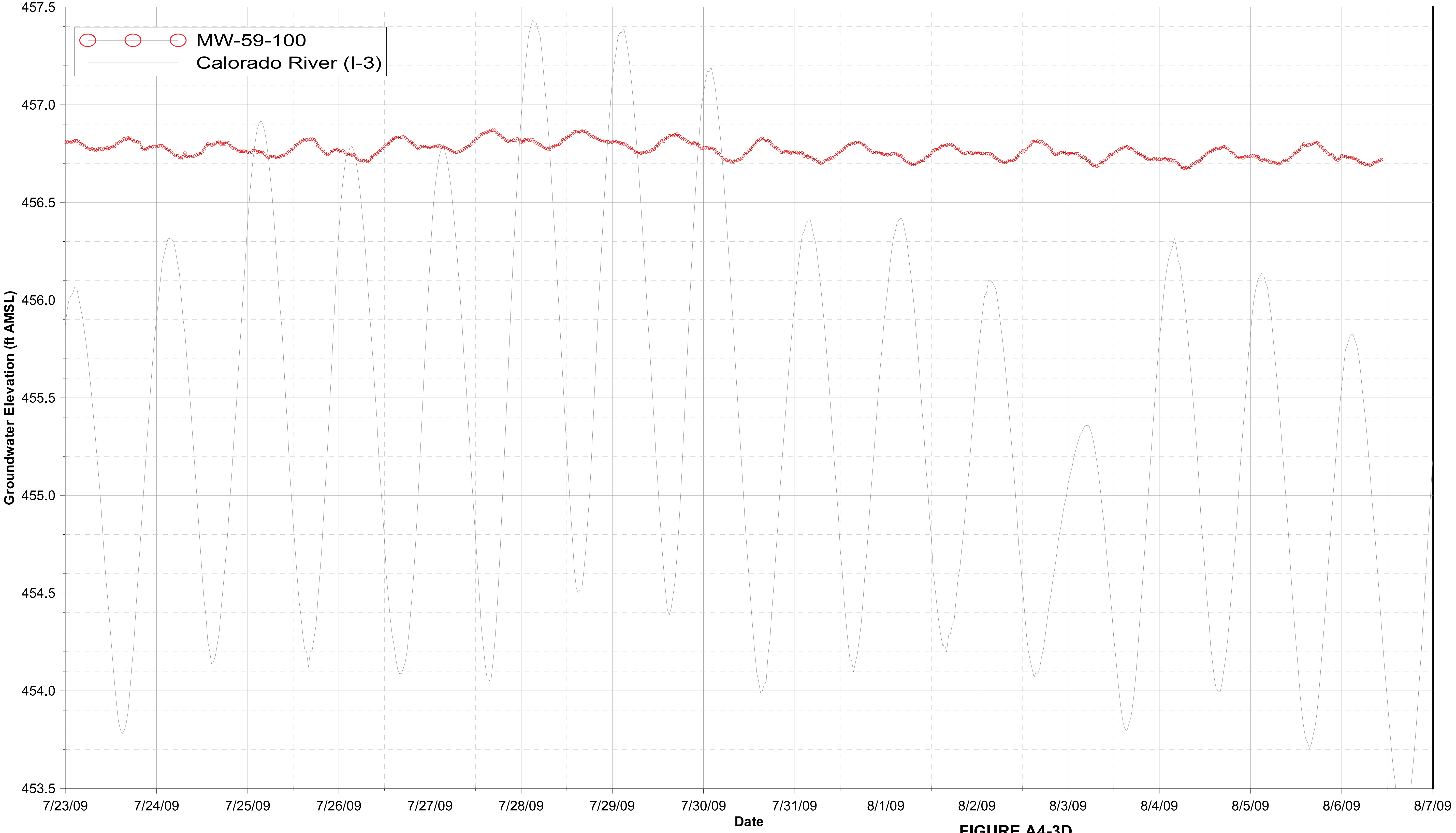

Note: Water levels represent the equivalent fresh water heads, adjusted from raw data using salinity and temperature measurements.
Data subject to review.

FIGURE A4-3D
MW-59-100 HYDROGRAPH

FINAL GROUNDWATER CORRECTIVE MEASURES STUDY/
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PG&E TOPOCK COMPRESSOR STATION
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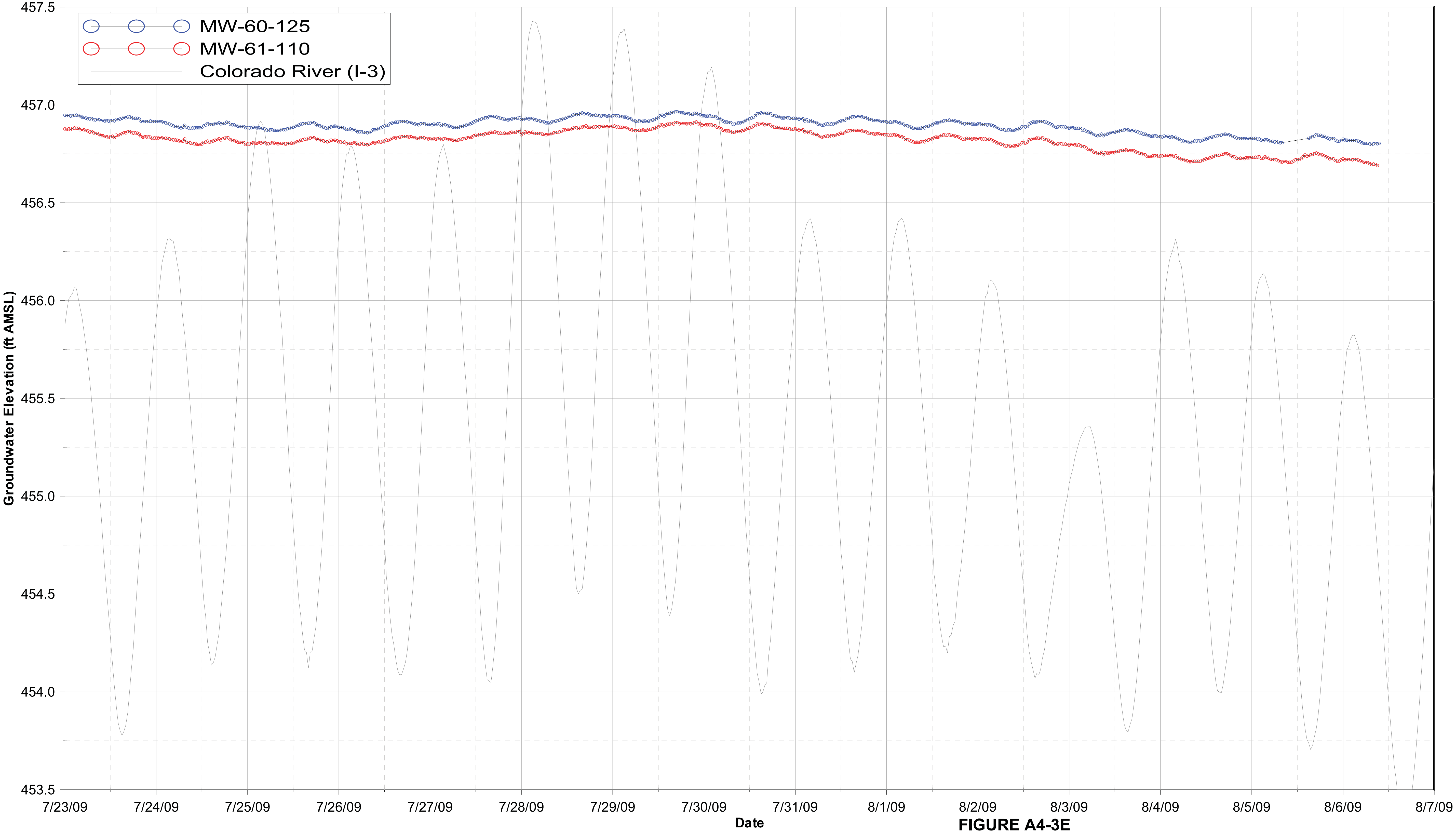

Note: Water levels represent the equivalent fresh water heads, adjusted from raw data using salinity and temperature measurements.
Data subject to review.

FIGURE A4-3E
MW-60-125 & MW-61-110 HYDROGRAPHS

FINAL GROUNDWATER CORRECTIVE MEASURES STUDY/
FEASIBILITY STUDY REPORT FOR SWMU 1/AOC 1 AND AOC 10
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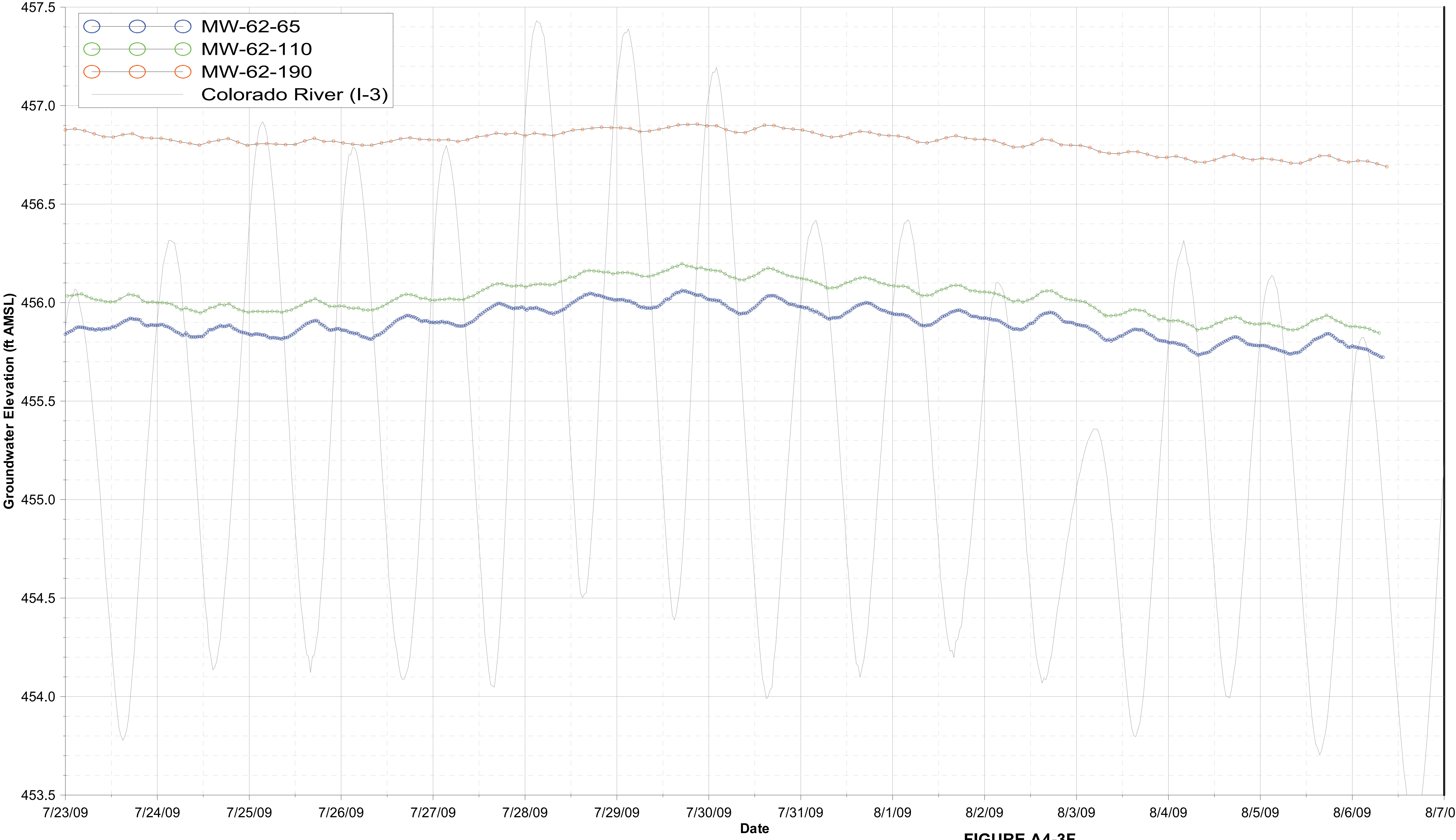

Note: Water levels represent the equivalent fresh water heads, adjusted from raw data using salinity and temperature measurements.
Data subject to review.

FIGURE A4-3F
MW-62 CLUSTER HYDROGRAPHS
FINAL GROUNDWATER CORRECTIVE MEASURES STUDY/
FEASIBILITY STUDY REPORT FOR SWMU 1/AOC 1 AND AOC 10
PG&E TOPOCK COMPRESSOR STATION
NEEDLES, CALIFORNIA

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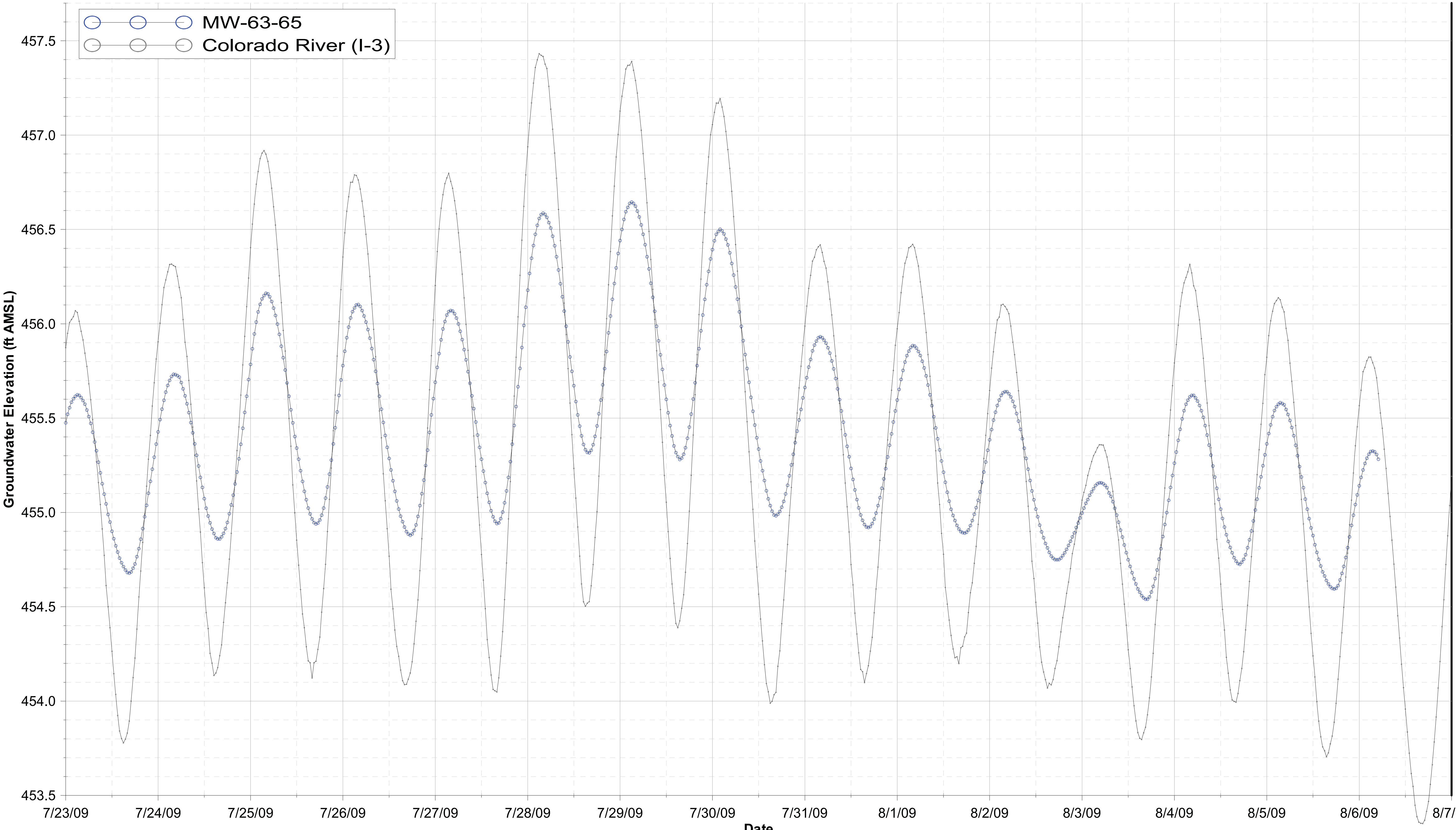

Note: Water levels represent the equivalent fresh water heads, adjusted from raw data using salinity and temperature measurements.
Data subject to review.

FIGURE A4-3G
MW-63-65 WELL HYDROGRAPH
FINAL GROUNDWATER CORRECTIVE MEASURES STUDY/
FEASIBILITY STUDY REPORT FOR SWMU 1/AOC 1 AND AOC 10
PG&E TOPOCK COMPRESSOR STATION
NEEDLES, CALIFORNIA

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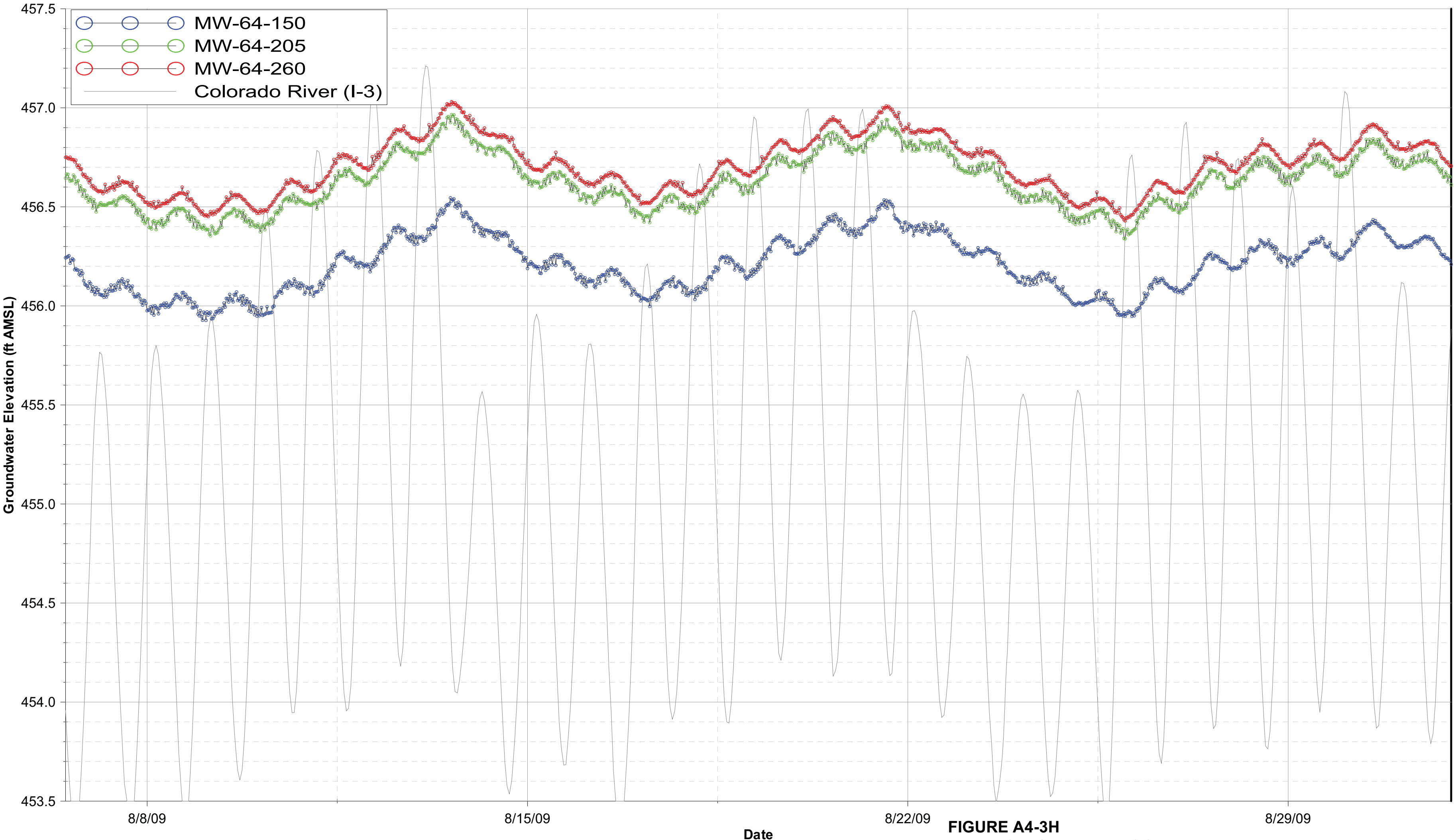

Note: Water levels represent the equivalent fresh water heads, adjusted from raw data using salinity and temperature measurements.
Data subject to review.

FIGURE A4-3H
MW-64 CLUSTER HYDROGRAPH
FINAL GROUNDWATER CORRECTIVE MEASURES STUDY/
FEASIBILITY STUDY REPORT FOR SWMU 1/AOC 1 AND AOC 10
PG&E TOPOCK COMPRESSOR STATION
NEEDLES, CALIFORNIA

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Attachment A5
Data Quality Evaluation
(This attachment is provided on CD-ROM)

Attachment A5

Review of Analytical Data for the 2009 East Ravine Groundwater Investigation, PG&E Topock Compressor Station

Prepared for

Pacific Gas and Electric Company

December 16, 2009

CH2MHILL
155 Grand Avenue, Suite 1000
Oakland, CA 94612

Contents

Section **Page**

Tables

Acronyms and Abbreviations

ATL	Advanced Technology Laboratories
CCV	continuing calibration verification
LCL	lower control limit
LCS	laboratory control sample
MS/MSD	matrix spike/matrix spike duplicate
µg/L	micrograms per liter
PARCC	precision, accuracy, representativeness, completeness, and comparability
PG&E	Pacific Gas and Electric Company
QAPP	Quality Assurance Project Plan
RPD	relative percent difference
TOC	total organic carbon
TPH	total petroleum hydrocarbons
UCL	upper control limit
USEPA	United States Environmental Protection Agency

1.0 Introduction

This Data Quality Evaluation report assesses the data quality of analytical results for the 2009 East Ravine groundwater investigation at the Pacific Gas & Electric Company (PG&E) Topock Compressor Station near Needles, California, between January 14, 2009 and July 22, 2009. Samples were collected and analyzed as requested by the California Environmental Protection Agency, Department of Toxic Substance Control. The Draft PG&E Quality Assurance Program Plan (QAPP) and subsequent updates (CH2M HILL, 2008a-c), individual method requirements, internal laboratory quality control criteria, guidelines from the United States Environmental Protection Agency (USEPA) *Contract Laboratory National Functional Guidelines for Inorganic Data Review* (USEPA, 2002) and the *Contract Laboratory National Functional Guidelines for Organic Data Review* (USEPA, 1999) were used in this assessment.

2.0 Analytical Data

This Data Quality Evaluation report covers 48 normal groundwater and water samples, 11 normal soil samples, two field duplicate groundwater samples, and one field duplicate soil sample. These samples were reported by the laboratories in 23 sample delivery groups identified in Table A5-1 below:

TABLE A5-1
Sample Delivery Groups

41426	41453	41473	41513
41583	N002487	N002488	N002516
N002547	N002584	N002601	N002602
N002639	N002647	N002649	N002656
N002693	N002724	N002746	N002782
N002955	N002962	N003232	

Advanced Technology Laboratories (ATL) of Signal Hill, California; the ATL satellite laboratory of Las Vegas, Nevada; and Zymax Forensics (Zymax) of San Luis Obispo, California performed the required analyses. All laboratories are certified by the California Department of Health Service’s Environmental Laboratory Accreditation Program for the analyses included in Table A5-2, where appropriate. Samples were analyzed for one or more of the analytes/methods provided in Table A5-2.

TABLE A5-2
Analytical Parameters

Parameter	Method	Laboratory
Stable isotopes of deuterium and oxygen	CF-IRMS	Zymax
Hexavalent Chromium	E218.6 [a]	ATL
Chloride, Nitrate, Sulfate	E300.0 [a]	ATL
Alkalinity (Carbonate and Bicarbonate)	SM2320 B [c]	ATL
Total Dissolved Solids	SM2540 C [c]	ATL
Ammonia as Nitrogen	SM4500NH3 C [c]	ATL
Total Organic Carbon	SM5310B [c]	ATL
Hexavalent Chromium	SW7199 [b]	ATL
Cations	SW6010B [b]	ATL
Cations	SW6020A [b]	ATL
Mercury	SW7470A/SW7471A [b]	TLI
TPH–gasoline	SW8015B [b]	ATL
TPH-diesel and TPH-motor-oil	SW8015B [b]	ATL
Volatile Organic Compounds	SW8260B [b]	ATL
Semivolatile Organic Compounds	SW8270C [b]	ATL
Polynuclear Aromatic Hydrocarbons	SW8270-Selected Ion Monitoring[b]	ATL

[a] USEPA Methods for Chemical Analysis of Water and Wastes, Revised March 1983.

[b] SW-846 Test Methods for Evaluating Solid Waste, 3rd Edition, revision 4, 1996.

[c] Standard Methods for the Examination of Water and Wastewater 20th Edition, 1998.
TPH = total petroleum hydrocarbons.

The sample delivery groups were assessed by reviewing the following: (1) the chain-of-custody documentation; (2) holding-time compliance; (3) initial and continuing calibration criteria; (4) method blanks and field blanks; (5) laboratory control sample (LCS)/laboratory control sample duplicate recoveries; (6) matrix spike/matrix spike duplicate (MS/MSD) recoveries; (7) laboratory duplicate precision; (8) surrogate spike recoveries; (9) internal standard recoveries; (10) field duplicate precision; and (11) the required quality control samples at the specified frequencies.

Data flags were assigned as defined in the QAPP. These flags, as well as the reason for each flag, are entered into the electronic database and can be found in Tables A5-3 through A5-5 at the end of this appendix (sorted by validation reason and then analyte). Multiple flags are routinely applied to specific sample method/matrix/analyte combinations, but there will be only one final flag. A final flag is applied to the data and is the most conservative of the applied validation flags. The final flag also includes matrix and blank sample effects.

The data flags are listed and defined below:

- J = Analyte was present but the reported value might not be accurate or precise (estimated).

- R = Data were unusable due to deficiencies in the ability to analyze the sample and meet quality control criteria.
- U = Analyte was not detected at the specified detection limit.
- UJ = Analyte was not detected and the specified detection limit might not be accurate or precise (estimated).

3.0 Data Assessment

Data assessment includes a review of the activities described in the following sections.

3.1 Holding Times

Holding-time exceedences result in the possible loss of target analytes due to degradation or chemical reactions that usually cause a negative bias to sample results.

One depth-discrete dissolved arsenic (SW6020B) sample was analyzed outside the recommended holding-time of 180 days by approximately 12 days. The analysis was requested outside the recommended holding-time to clarify subsequent arsenic results that varied significantly from historical norms. The detected result was qualified as estimated and was flagged "J."

All other holding times were met.

3.2 Method Blanks

Method blanks are used to monitor each preparation or analytical batch for contamination throughout the entire analytical process from sources such as glassware, reagents, instrumentation and other potential contaminant sources within the laboratory. If a target analyte is detected in the method blank, similar detections in the samples are possibly artifacts of laboratory contamination.

Method blanks were analyzed at the required frequency. No target analytes were detected at or above the reporting limit.

3.3 Field Blanks

Chromium (SW6010B) was detected above the reporting limit in one equipment blank and zinc (SW6010B) was detected above the reporting limit in four equipment blanks. Following the criteria in Table 6-3 *Flagging Conventions – Minimum Data Evaluation Criteria for Inorganic Methods,* from the QAPP (CH2M HILL, 2008) the associated samples with a result less than five times the concentration of the equipment blank detect are qualified as non-detect and flagged "U".

Three chromium results and 18 zinc results from groundwater monitoring samples were qualified as not detected at the reported concentrations and were flagged "U."

3.4 Quantitation and Sensitivity

Due to a demonstrated matrix effect for the hexavalent chromium analyses, which is discussed in Section 3.14, the reporting limits for Method E218.6 for the non-detected sample results were raised by the laboratory for the following locations: MW-58-115-GW2, MW-58-205-GW2, MW-58BR-HYD4, MW-62-190-GW2, MW-62BR-HYD1, MW64-150-GW2, and MW64-260-GW2 No flags were applied, but the "ValAdj" reason was noted.

All other method/analyte combinations not mentioned in Field Duplicates (Section 3.9) or Quantitation and Sensitivity (Section 3.4) met the project reporting limit objectives.

3.5 Calibration

Initial calibration and periodic verification are essential to generating defensible analytical data. Initial calibrations that do not meet method requirements result in data that may be either positively or negatively biased. Periodic calibration verification ensures that the instrument has not been adversely affected by the sample matrix or other instrument failures that would increase or decrease the sensitivity or accuracy of the method. The inability to meet initial or continuing calibration analyses may result in qualifying the data as estimated or rejecting the data for project decision-making purposes.

Initial and continuing calibrations were performed as required by the methods. Calibration criteria were met, with the following exceptions:

- Initial calibration verification standards for chloride and sulfate (E300.0) were greater than the upper control limit (UCL). One chloride detected result and five sulfate detected results from the groundwater monitoring samples were qualified as estimated and were flagged "J."
- 1,1,1-trichloroethane, 2,2-dichloropropane, and chloroethane (SW8260B) initial calibration exceeded the relative standard deviation and/or first order regression criteria. Four non-detected results from the groundwater monitoring samples were qualified as estimated concentrations and were flagged "UJ."
- The initial calibration relative response factor was below the lower control limit (LCL) for acrolein (SW8260B). Eighteen non-detected results from the groundwater monitoring samples were flagged "UJ" as estimated values.
- The continuing calibration verification (CCV) was also less than the LCL for six acrolein non-detected results, six 1,2,4-trichlorobenzene non-detected results, and five carbon tetrachloride non-detected results, all from the groundwater monitoring samples (SW8260B). These results were considered estimated values and were flagged "UJ."
- Acetone (SW8260B) had a high-biased CCV. Five detected results from the groundwater monitoring samples were qualified as estimated and were flagged "J."
- Five hexavalent chromium samples (E218.6) were analyzed with greater than 10 samples between CCVs. Two non-detected and three detected hexavalent chromium results from the groundwater monitoring samples were qualified as estimated values for the laboratory accuracy and precision error.

3.6 Internal Standard Recoveries

Internal standards are used for organic analyses and have similar chemical characteristics to the target analytes and provide an analytical response which is distinct from the analyte and not normally subject to interference. The internal standards are added prior to analysis for the purpose of determining analyte concentrations. The internal standard's response is referenced against a relative response factor, enabling the sample analyte concentration to be corrected for matrix effects.

All internal response factors met method acceptance criteria.

3.7 Surrogate Recoveries

Surrogates are primarily used in organic chromatography methods and are added prior to sample preparation. The surrogates are added to all samples, standards, and blanks in a preparation batch and provide a measurement to determine recovery for every sample matrix. Surrogate compounds are chosen to represent the various chemistries of the target analytes in a specific method. They are often specified by the method and are deliberately selected for their improbability of occurring as environmental contaminants. The results are compared to the acceptance criteria as established by the method or the QAPP.

Surrogate recoveries met the acceptance criteria with the following exception.

One TPH-gasoline (SW8015B) soil sample had a slightly low-biased surrogate recovery. The non-detected result was flagged "UJ" as an estimated value.

3.8 Matrix Spike Samples

Matrix spike recoveries are used to evaluate the affect of the sample matrix on the recovery of target analytes. A sample is fortified with a known quantity of a target analyte and is carried through the same preparation and analytical procedures as the unspiked sample. Matrix spike recoveries outside the quality control limits may indicate that the sample's matrix is affecting the method's ability to accurately quantify the target analyte in the associated sample or samples from similar locations. A low matrix spike recovery generally indicates a negative bias in the sample data, while a high matrix spike recovery indicates a potential positive bias to the associated sample data. If duplicate matrix spike analyses are performed, a relative percent difference (RPD) greater than quality control criteria may further indicate that the sample matrix is affecting the precision of the method for the target analyte that did not meet criteria. Therefore, when the matrix spike does not meet criteria, results are usually considered estimated.

MS/ MSD acceptance criteria were met, with the following exceptions:

- MS/MSD recoveries for six groundwater monitoring samples were less than the LCL for the carbonate alkalinity fraction (SM2320B). The parent non-detected results were flagged "UJ."
- MS and/or MSD recoveries for 1,2,4-trimethylbenzene, 2-butanone, acetone, acrolein, acrylonitrile, and styrene (SW8260B) were less than the LCL. Twelve non-detected groundwater monitoring parent sample results were flagged "UJ."
- One antimony (SW6010B) soil sample had low-biased MS/MSD recoveries. The parent non-detected result was qualified as estimated and was flagged "UJ."

- Barium (SW601B) was detected above the UCL in a soil MSD. The parent detected result was flagged "J."
- The RPD for one chromium (SW6010B) soil MS/MSD exceeded criterion. The detected parent result was qualified as estimated.
- Dissolved calcium and dissolved sodium (SW6010B) MS and/or MSD recoveries were greater than the UCL. Two detected groundwater monitoring sample parent results were flagged "J."
- One dissolved selenium (SW6020A) MS/MSD pair had low-biased recoveries. The non-detected groundwater monitoring sample parent result was "UJ" flagged as an estimated value.

3.9 Field Duplicates

Field duplicates are collected and analyzed to determine if field collection activities or the sample matrix influences the precision of the analytical measurements obtained at the sample site.

All field duplicate acceptance criteria were met.

3.10 Laboratory Duplicates

Laboratory duplicates measure laboratory precision. RPDs that exceed method criteria indicate imprecision in some aspect of the analytical procedure.

The laboratory analyzed duplicate aliquots of field samples at the required frequency. The quality control acceptance criteria were met for all methods.

3.11 Laboratory Control Samples

An LCS measures laboratory accuracy. Accuracy is the degree of agreement between a measured value and the expected value. The LCS is prepared from laboratory deionized or reagent-grade water and spiked with known amounts of the target analytes of interest. Recovery of analytes outside of quality control limits generally indicates a problem with the analytical procedure. A low LCS recovery indicates that the target analyte in associated samples is likely biased low. Likewise, a high LCS recovery indicates that the target analyte in associated samples is likely biased high. Results associated with LCS recovery criteria exceedences are considered estimated.

LCSs were analyzed at the required frequency and were recovered within quality control limits.

3.12 Chain of Custody/Sample Receipt

Samples are collected under chain of custody to ensure that sample integrity is documented and known from the time of collection through receipt at the laboratory where custody is relinquished to the laboratory.

Each sample was documented in a completed chain of custody and received at the laboratory in good condition. All discrepancies identified in laboratory custody were promptly resolved.

Samples for total organic carbon (TOC) (SM5310B) and dissolved mercury (SW7470A) were received above the USEPA recommended upper temperature of six degrees Celsius but at less than 8 degrees Celsius. Nine detected TOC results, one non-detected TOC result, and 10 detected dissolved mercury results from the groundwater monitoring samples were qualified as estimated values.

3.13 Historical Discrepancies.

Seven FLUTe™ wells were installed at the site. The acetone (SW8260B), toluene (SW8260B), and arsenic (SW6020A) results from the FLUTe™ wells were found to be inconsistent with site wide historical data. After further review of available literature (see section 3.7.2 *Summary of Findings Associated with the East Ravine Groundwater Investigation*, CH2M HILL, 2009), it was determined that the FLUTe™ well construction materials contained these three analytes at varying levels that exceeded the site wide historical values at Topock. Therefore, the results of each of these compounds from the groundwater monitoring samples were demonstrated to be unusable and flagged “R.”

3.14 Other

Matrix interference has been encountered at the Topock site, in selected monitoring wells, that affected the sensitivity for hexavalent chromium by the E218.6 and SW7199 methods. CH2M HILL directed the laboratory to perform additional quality assurance/quality control analyses to aid in assessing if there is any effect on method sensitivity for each well location due to the sample matrix.

The laboratory was instructed to analyze a matrix spike of all samples by spiking the samples with 1 micrograms per liter (µg/L) of hexavalent chromium to ensure that identification is accurate for detected results. For non-detected results, the matrix spike should verify there are not false negatives that go undetected.

If the matrix spike is not recovered or the peak is outside of the established retention time window for either detected or non-detected results, the laboratory will make a fivefold dilution of two aliquots of the sample. The first aliquot will be analyzed without the spike, and the second will be spiked with 1 µg/L of hexavalent chromium, and the recovery and peak retention time will be evaluated. If this matrix spike recovery is not within laboratory quality control limits and/or the peak is not within the laboratory retention time window, the laboratory will dilute two additional aliquots of sample tenfold, spike one of the aliquots, analyze the sample/matrix spike, and perform successively greater dilutions of 25:1, 50:1, or 100:1 until the peak identified in the post spike analysis is within the established retention time window for hexavalent chromium and the recovery of the spike is within laboratory quality control limits.

The detected result that is reported by the laboratory on the final data package is chosen from the dilution where both the peak detected in the unspiked and the spiked sample fall within the appropriate retention time and the matrix spike is recovered with quality control control limits. The reporting limits are raised to the level of the appropriate dilution.

For non-detected results, the dilution selected by the laboratory for reporting is taken from the smallest dilution that yields a matrix spike recovery within quality control control limits and within the appropriate retention time window.

4.0 Overall Review

The goal of this review is to demonstrate that a sufficient number of representative samples were collected and the resulting analytical data can be used to support the decision-making process. The procedures for assessing the precision, accuracy, representativeness, completeness, and comparability parameters (PARCC) are addressed in the QAPP. The following summary highlights the PARCC findings for the above-defined events:

1. The completeness objective for the PG&E program is 95 percent for aqueous samples and 90 percent for soil samples. The completeness objectives were met for all method/analyte combinations collected, with the exception of arsenic (77 percent), acetone (71 percent), and toluene (71 percent) water samples.
2. Samples were collected and analyzed based on approved methods/procedures, and the results are reported using industry-standardized units.
3. The routinely acceptable performance of field and laboratory quality control indicators (field duplicates, field blanks, laboratory blanks, LCS, MS/MSD, surrogate, and calibrations) generally show that the accuracy and precision of the data meet the project objectives.
    - Three chromium and 18 zinc (SW6010B) results were qualified as not detected due to equipment blank contamination.
    - Carbonate alkalinity (SM2320B), volatile organic compounds (SW8260B), and cations (SW6010B and SW6020A) were qualified as estimated values due to MS/MSD exceedances.
    - One TPH gasoline (SW8015B) soil sample was qualified due to a low-biased surrogate recovery.
    - Chloride and sulfate results (E300.0) and several volatile organic compounds (SW8260B) were qualified as estimated values due to calibration exceedances.
4. One arsenic (SW6020A) result was qualified as estimated due to holding-time exceedence.
5. Ten TOC (SM5310B) and 10 dissolved mercury (SW7470A) results were qualified as estimated due to a temperature exceedance.
6. Seven arsenic (SW6020A), seven acetone (SW8260B), and seven toluene (SW8260B) results were unusable due to FLUTe™ well contamination associated with the construction materials.
7. Matrix effects were identified in seven samples for hexavalent chromium (E218.6) analyses and the reporting limits were raised to the concentrations where the matrix effects were overcome, as indicated by acceptable matrix spike analyses.

8. Analytical data as qualified meet the data quality objectives and may be used in project decision making.

5.0 References

CH2M HILL. 2008a. *PG&E Program Quality Assurance Project Plan, Rev 1*. December. (Draft)

__________. 2008b. *Addendum to the PG&E Program Quality Assurance Project Plan for the Topock Groundwater Monitoring and Investigation Projects*. (Draft.) December.

__________. 2008c. *Addendum to PG&E Program Quality Assurance Project Plan for the RCRA Facility Investigation/Remedial Investigation*. (Draft.) December.

United States Environmental Protection Agency (USEPA). 1999. *Contract Laboratory National Functional Guidelines for Organic Data Review*. October.

__________. 2002. *Contract Laboratory National Functional Guidelines for Inorganic Data Review* July.

TABLE A5-3
Data Qualification Summary

Method	Sample ID	COC Number	Analyte	Units	Final Result	Final Validation Flag[a]	Validation Reason
SW8260	MW-62-110-GW2	N002962	1,2,4-Trichlorobenzene	µg/L	1	UJ	CCV<LCL
SW8260	MW-62-190-GW2	N002962	1,2,4-Trichlorobenzene	µg/L	1	UJ	CCV<LCL
SW8260	MW-64-150-GW2	N002962	1,2,4-Trichlorobenzene	µg/L	1	UJ	CCV<LCL
SW8260	MW-64-205-GW2	N002962	1,2,4-Trichlorobenzene	µg/L	1	UJ	CCV<LCL
SW8260	MW-64-260-GW2	N002962	1,2,4-Trichlorobenzene	µg/L	1	UJ	CCV<LCL
SW8260	MW-90-GW2	N002962	1,2,4-Trichlorobenzene	µg/L	1	UJ	CCV<LCL
SW8260	MW-62-110-GW2	N002962	Acrolein	µg/L	20	UJ	CCV<LCL
SW8260	MW-62-190-GW2	N002962	Acrolein	µg/L	20	UJ	CCV<LCL
SW8260	MW-64-150-GW2	N002962	Acrolein	µg/L	20	UJ	CCV<LCL
SW8260	MW-64-205-GW2	N002962	Acrolein	µg/L	20	UJ	CCV<LCL
SW8260	MW-64-260-GW2	N002962	Acrolein	µg/L	20	UJ	CCV<LCL
SW8260	MW-90-GW2	N002962	Acrolein	µg/L	20	UJ	CCV<LCL
SW8260	MW-58-115-GW2	N002962	Carbon tetrachloride	µg/L	1	UJ	CCV<LCL
SW8260	MW-58-205-GW2	N002962	Carbon tetrachloride	µg/L	1	UJ	CCV<LCL
SW8260	MW-59-100-GW2	N002962	Carbon tetrachloride	µg/L	1	UJ	CCV<LCL
SW8260	MW-62-065-GW2	N002962	Carbon tetrachloride	µg/L	1	UJ	CCV<LCL
SW8260	MW-64-205-GW2	N002962	Carbon tetrachloride	µg/L	1	UJ	CCV<LCL
SW8260	MW-23-060-GW2	N002955	Carbon tetrachloride	µg/L	1	UJ	CCV<UCL
SW8260	MW-23-080-GW2	N002955	Carbon tetrachloride	µg/L	1	UJ	CCV<UCL
SW8260	MW-57-070-GW2	N002955	Carbon tetrachloride	µg/L	1	UJ	CCV<UCL
SW8260	MW-57-185-GW2	N002955	Carbon tetrachloride	µg/L	1	UJ	CCV<UCL
SW8260	MW-60-125-GW2	N002955	Carbon tetrachloride	µg/L	1	UJ	CCV<UCL
SW8260	MW-61-110-GW2	N002955	Carbon tetrachloride	µg/L	1	UJ	CCV<UCL
SW8260	MW-63-065-GW2	N002955	Carbon tetrachloride	µg/L	1	UJ	CCV<UCL

TABLE A5-3
Data Qualification Summary

Method	Sample ID	COC Number	Analyte	Units	Final Result	Final Validation Flag[a]	Validation Reason
SW8260	MW-91-GW2	N002955	Carbon tetrachloride	µg/L	1	UJ	CCV<UCL
SW8260	MW-62-110-GW2	N002962	Acetone	µg/L	49	R	CCV>UCL
SW8260	MW-62-190-GW2	N002962	Acetone	µg/L	25	R	CCV>UCL
SW8260	MW-64-150-GW2	N002962	Acetone	µg/L	39	R	CCV>UCL
SW8260	MW-64-205-GW2	N002962	Acetone	µg/L	31	R	CCV>UCL
SW8260	MW-64-260-GW2	N002962	Acetone	µg/L	50	R	CCV>UCL
SW6010B	MW-57-185-GW2	N002955	Chromium, dissolved	µg/L	4.9	U	EB>RL
SW6010B	MW-63-065-GW2	N002955	Chromium, dissolved	µg/L	2.9	U	EB>RL
SW6010B	MW-91-GW2	N002955	Chromium, dissolved	µg/L	3	U	EB>RL
SW6010B	MW-23-060-GW2	N002955	Zinc, dissolved	µg/L	75	U	EB>RL
SW6010B	MW-23-080-GW2	N002955	Zinc, dissolved	µg/L	120	U	EB>RL
SW6010B	MW-57-070-GW2	N002955	Zinc, dissolved	µg/L	48	U	EB>RL
SW6010B	MW-57-185-GW2	N002955	Zinc, dissolved	µg/L	63	U	EB>RL
SW6010B	MW-58-115-GW2	N002962	Zinc, dissolved	µg/L	40	U	EB>RL
SW6010B	MW-58-205-GW2	N002962	Zinc, dissolved	µg/L	23	U	EB>RL
SW6010B	MW-59-100-GW2	N002962	Zinc, dissolved	µg/L	20	U	EB>RL
SW6010B	MW-60-125-GW2	N002955	Zinc, dissolved	µg/L	27	U	EB>RL
SW6010B	MW-61-110-GW2	N002955	Zinc, dissolved	µg/L	38	U	EB>RL
SW6010B	MW-62-065-GW2	N002962	Zinc, dissolved	µg/L	19	U	EB>RL
SW6010B	MW-62-110-GW2	N002962	Zinc, dissolved	µg/L	12	U	EB>RL
SW6010B	MW-62-190-GW2	N002962	Zinc, dissolved	µg/L	33	U	EB>RL
SW6010B	MW-63-065-GW2	N002955	Zinc, dissolved	µg/L	34	U	EB>RL
SW6010B	MW-64-150-GW2	N002962	Zinc, dissolved	µg/L	21	U	EB>RL
SW6010B	MW-64-205-GW2	N002962	Zinc, dissolved	µg/L	41	U	EB>RL
SW6010B	MW-64-260-GW2	N002962	Zinc, dissolved	µg/L	11	U	EB>RL
SW6010B	MW-90-GW2	N002962	Zinc, dissolved	µg/L	58	U	EB>RL
SW6010B	MW-91-GW2	N002955	Zinc, dissolved	µg/L	54	U	EB>RL
SW8260	MW-23-060-GW2	N002955	Acrolein	µg/L	20	UJ	IC RRF
SW8260	MW-23-080-GW2	N002955	Acrolein	µg/L	20	UJ	IC RRF
SW8260	MW-57-070-GW2	N002955	Acrolein	µg/L	20	UJ	IC RRF
SW8260	MW-57-185-GW2	N002955	Acrolein	µg/L	20	UJ	IC RRF
SW8260	MW-58-115-GW2	N002962	Acrolein	µg/L	20	UJ	IC RRF
SW8260	MW-58-205-GW2	N002962	Acrolein	µg/L	20	UJ	IC RRF
SW8260	MW-59-100-GW2	N002962	Acrolein	µg/L	20	UJ	IC RRF
SW8260	MW-60-125-GW2	N002955	Acrolein	µg/L	20	UJ	IC RRF
SW8260	MW-61-110-GW2	N002955	Acrolein	µg/L	20	UJ	IC RRF
SW8260	MW-62-065-GW2	N002962	Acrolein	µg/L	20	UJ	IC RRF
SW8260	MW-62-110-GW2	N002962	Acrolein	µg/L	20	UJ	IC RRF
SW8260	MW-62-190-GW2	N002962	Acrolein	µg/L	20	UJ	IC RRF
SW8260	MW-63-065-GW2	N002955	Acrolein	µg/L	20	UJ	IC RRF

TABLE A5-3
Data Qualification Summary

Method	Sample ID	COC Number	Analyte	Units	Final Result	Final Validation Flag[a]	Validation Reason
SW8260	MW-64-150-GW2	N002962	Acrolein	µg/L	20	UJ	IC RRF
SW8260	MW-64-205-GW2	N002962	Acrolein	µg/L	20	UJ	IC RRF
SW8260	MW-64-260-GW2	N002962	Acrolein	µg/L	20	UJ	IC RRF
SW8260	MW-90-GW2	N002962	Acrolein	µg/L	20	UJ	IC RRF
SW8260	MW-91-GW2	N002955	Acrolein	µg/L	20	UJ	IC RRF
SW8260	MW-61-GW1	N002649	Chloroethane	µg/L	1	UJ	IC>RSD&R2
SW8260	MW-63-GW1	N002693	1,1,1-Trichloroethane	µg/L	1	UJ	ICV>R2
SW8260	MW-63-GW1	N002693	2,2-Dichloropropane	µg/L	1	UJ	ICV>R2
SW8260	MW-59-GW1	N002639	Chloroethane	µg/L	1	UJ	ICV>R2
E300.0	MW-59-GW1	N002639	Chloride	mg/L	3300	J	ICVS>UCL
E300.0	MW-57BR-M-GW1	N002547	Sulfate	mg/L	130	J	ICVS>UCL
E300.0	MW-59-GW1	N002639	Sulfate	mg/L	760	J	ICVS>UCL
E300.0	MW-60-GW1	N002647	Sulfate	mg/L	450	J	ICVS>UCL
E300.0	MW-61-GW1	N002649	Sulfate	mg/L	620	J	ICVS>UCL
E300.0	MW-63-GW1	N002693	Sulfate	mg/L	540	J	ICVS>UCL
SW8260	MW-57BR-M-GW1	N002547	2-Butanone	µg/L	10	UJ	MS<LCL
SW8260	MW-57BR-M-GW1	N002547	Acetone	µg/L	10	UJ	MS<LCL
SW8260	MW-57-185-GW2	N002955	Acrolein	µg/L	20	UJ	MS<LCL
SW8260	MW-57BR-M-GW1	N002547	Acrolein	µg/L	20	UJ	MS<LCL
SW8260	MW-62-110-GW2	N002962	Acrolein	µg/L	20	UJ	MS<LCL
SW8260	MW-62-190-GW2	N002962	Acrolein	µg/L	20	UJ	MS<LCL
SW8260	MW-57-185-GW2	N002955	Acrylonitrile	µg/L	20	UJ	MS<LCL
SW8260	MW-57BR-M-GW1	N002547	Acrylonitrile	µg/L	20	UJ	MS<LCL
SW8260	MW-62-110-GW2	N002962	Acrylonitrile	µg/L	20	UJ	MS<LCL
SM2320B	MW-57-070-GW2	N002955	Alkalinity, Carbonate	mg/L	5	UJ	MS<LCL
SM2320B	MW-57BR-M-GW1	N002547	Alkalinity, Carbonate	mg/L	5	UJ	MS<LCL
SM2320B	MW-58-115-GW2	N002962	Alkalinity, Carbonate	mg/L	5	UJ	MS<LCL
SM2320B	MW-61-GW1	N002649	Alkalinity, Carbonate	mg/L	5	UJ	MS<LCL
SM2320B	MW-62-GW1	N002656	Alkalinity, Carbonate	mg/L	5	UJ	MS<LCL
SM2320B	MW-63-GW1	N002693	Alkalinity, Carbonate	mg/L	5	UJ	MS<LCL
SW6020A	MW-57-185-GW2	N002955	Selenium, dissolved	µg/L	2.5	UJ	MS<LCL
SW6010B	MW-60-GW1	N002647	Calcium, dissolved	µg/L	450000	J	MS>UCL
SW6010B	MW-60-GW1	N002647	Sodium, dissolved	µg/L	1500000	J	MS>UCL
SW8260	MW-58-115-GW2	N002962	Acetone	µg/L	10	R	Reject
SW8260	MW-58-205-GW2	N002962	Acetone	µg/L	15	R	Reject
SW8260	MW-62-110-GW2	N002962	Acetone	µg/L	49	R	Reject
SW8260	MW-62-190-GW2	N002962	Acetone	µg/L	25	R	Reject
SW8260	MW-64-150-GW2	N002962	Acetone	µg/L	39	R	Reject
SW8260	MW-64-205-GW2	N002962	Acetone	µg/L	31	R	Reject
SW8260	MW-64-260-GW2	N002962	Acetone	µg/L	50	R	Reject

TABLE A5-3
Data Qualification Summary

Method	Sample ID	COC Number	Analyte	Units	Final Result	Final Validation Flag[a]	Validation Reason
SW6020A	MW-58-115-GW2	N002962	Arsenic, dissolved	µg/L	110	R	Reject
SW6020A	MW-58-205-GW2	N002962	Arsenic, dissolved	µg/L	340	R	Reject
SW6020A	MW-62-110-GW2	N002962	Arsenic, dissolved	µg/L	430	R	Reject
SW6020A	MW-62-190-GW2	N002962	Arsenic, dissolved	µg/L	270	R	Reject
SW6020A	MW-64-150-GW2	N002962	Arsenic, dissolved	µg/L	450	R	Reject
SW6020A	MW-64-205-GW2	N002962	Arsenic, dissolved	µg/L	550	R	Reject
SW6020A	MW-64-260-GW2	N002962	Arsenic, dissolved	µg/L	770	R	Reject
SW8260	MW-58-115-GW2	N002962	Toluene	µg/L	61	R	Reject
SW8260	MW-58-205-GW2	N002962	Toluene	µg/L	21	R	Reject
SW8260	MW-62-110-GW2	N002962	Toluene	µg/L	27	R	Reject
SW8260	MW-62-190-GW2	N002962	Toluene	µg/L	8.6	R	Reject
SW8260	MW-64-150-GW2	N002962	Toluene	µg/L	14	R	Reject
SW8260	MW-64-205-GW2	N002962	Toluene	µg/L	21	R	Reject
SW8260	MW-64-260-GW2	N002962	Toluene	µg/L	25	R	Reject
SW8260	MW-57-185-GW2	N002955	1,2,4-Trimethylbenzene	µg/L	1	UJ	SD<LCL
SW8260	MW-57BR-M-GW1	N002547	2-Butanone	µg/L	10	UJ	SD<LCL
SW8260	MW-57BR-M-GW1	N002547	Acetone	µg/L	10	UJ	SD<LCL
SW8260	MW-57-185-GW2	N002955	Acrolein	µg/L	20	UJ	SD<LCL
SW8260	MW-57BR-M-GW1	N002547	Acrolein	µg/L	20	UJ	SD<LCL
SW8260	MW-62-110-GW2	N002962	Acrolein	µg/L	20	UJ	SD<LCL
SW8260	MW-62-190-GW2	N002962	Acrolein	µg/L	20	UJ	SD<LCL
SW8260	MW-57BR-M-GW1	N002547	Acrylonitrile	µg/L	20	UJ	SD<LCL
SM2320B	MW-57-070-GW2	N002955	Alkalinity, Carbonate	mg/L	5	UJ	SD<LCL
SM2320B	MW-57BR-M-GW1	N002547	Alkalinity, Carbonate	mg/L	5	UJ	SD<LCL
SM2320B	MW-58-115-GW2	N002962	Alkalinity, Carbonate	mg/L	5	UJ	SD<LCL
SM2320B	MW-61-GW1	N002649	Alkalinity, Carbonate	mg/L	5	UJ	SD<LCL
SM2320B	MW-62-GW1	N002656	Alkalinity, Carbonate	mg/L	5	UJ	SD<LCL
SM2320B	MW-63-GW1	N002693	Alkalinity, Carbonate	mg/L	5	UJ	SD<LCL
SW6020A	MW-57-185-GW2	N002955	Selenium, dissolved	µg/L	2.5	UJ	SD<LCL
SW8260	MW-57-185-GW2	N002955	Styrene	µg/L	1	UJ	SD<LCL
SW8260	MW-62-190-GW2	N002962	Styrene	µg/L	1	UJ	SD<LCL
SW6010B	MW-60-GW1	N002647	Sodium, dissolved	µg/L	1500000	J	SD>UCL
SW7470A	MW-58-115-GW2	N002962	Mercury, dissolved	µg/L	0.2	UJ	TEMP>6C
SW7470A	MW-58-205-GW2	N002962	Mercury, dissolved	µg/L	0.2	UJ	TEMP>6C
SW7470A	MW-59-100-GW2	N002962	Mercury, dissolved	µg/L	0.2	UJ	TEMP>6C
SW7470A	MW-62-065-GW2	N002962	Mercury, dissolved	µg/L	0.2	UJ	TEMP>6C
SW7470A	MW-62-110-GW2	N002962	Mercury, dissolved	µg/L	0.2	UJ	TEMP>6C
SW7470A	MW-62-190-GW2	N002962	Mercury, dissolved	µg/L	0.2	UJ	TEMP>6C
SW7470A	MW-64-150-GW2	N002962	Mercury, dissolved	µg/L	0.2	UJ	TEMP>6C
SW7470A	MW-64-205-GW2	N002962	Mercury, dissolved	µg/L	0.2	UJ	TEMP>6C

TABLE A5-3
Data Qualification Summary

Method	Sample ID	COC Number	Analyte	Units	Final Result	Final Validation Flag[a]	Validation Reason
SW7470A	MW-64-260-GW2	N002962	Mercury, dissolved	µg/L	0.2	UJ	TEMP>6C
SW7470A	MW-90-GW2	N002962	Mercury, dissolved	µg/L	0.2	UJ	TEMP>6C
SM5310B	MW-58-115-GW2	N002962	Total Organic Carbon	mg/L	17	J	TEMP>6C
SM5310B	MW-58-205-GW2	N002962	Total Organic Carbon	mg/L	18	J	TEMP>6C
SM5310B	MW-59-100-GW2	N002962	Total Organic Carbon	mg/L	0.6	UJ	TEMP>6C
SM5310B	MW-62-065-GW2	N002962	Total Organic Carbon	mg/L	0.95	J	TEMP>6C
SM5310B	MW-62-110-GW2	N002962	Total Organic Carbon	mg/L	25	J	TEMP>6C
SM5310B	MW-62-190-GW2	N002962	Total Organic Carbon	mg/L	58	J	TEMP>6C
SM5310B	MW-64-150-GW2	N002962	Total Organic Carbon	mg/L	16	J	TEMP>6C
SM5310B	MW-64-205-GW2	N002962	Total Organic Carbon	mg/L	19	J	TEMP>6C
SM5310B	MW-64-260-GW2	N002962	Total Organic Carbon	mg/L	25	J	TEMP>6C
SM5310B	MW-90-GW2	N002962	Total Organic Carbon	mg/L	0.8	J	TEMP>6C
E218.6	MW-58-115-GW2	N002962	Hexavalent Chromium	µg/L	1	U	ValAdj
E218.6	MW-58-205-GW2	N002962	Hexavalent Chromium	µg/L	1	U	ValAdj
E218.6	MW-62-190-GW2	N002962	Hexavalent Chromium	µg/L	1	U	ValAdj
E218.6	MW-64-150-GW2	N002962	Hexavalent Chromium	µg/L	1	U	ValAdj
E218.6	MW-64-260-GW2	N002962	Hexavalent Chromium	µg/L	1	U	ValAdj

[a] This is the final qualifier flag for this analyte/method combination. If more than one flag was applied, this is the most conservative.

Validation Reasons:

CCV<LCL = Continuing calibration recovery less than lower control limit.
CCV<UCL = Continuing calibration recovery greater than upper control limit.
EB>RL = Equipment blank concentration greater than the reporting limit.
IC RRF = Initial calibration relative response factor less than lower control limit.
IC>RSD&R2 = Exceeds relative standard deviation and initial calibration ‘R squared’ criteria.
ICV>R2 = Exceeds initial calibration ‘R squared’ criteria.
ICVS>UCL = Second source verification standard recovery, greater than upper control limit.
MS>UCL = Matrix spike recovery greater than upper control limit.
Reject = results rejected due to documented contamination from the materials used in construction of the wells.
SD>UCL = Spike duplicate recovery greater than upper control limit.
TEMP>6C = Sample received at sub-lab, temperature greater than 6ºC.
ValAdj = Value reported by laboratory adjusted due to matrix issues.

TABLE A5-4
Data Qualification Summary

Method	Sample ID	COC Number	Analyte	Units	Final Result	Final Validation Flag[a]	Validation Reason
SW6020A	MW-58BR-Hyd1	N003232	Arsenic, dissolved	µg/L	25	J	HT>UCL
E218.6	MW-58BR-HYD4	N002746	Hexavalent Chromium	µg/L	1	UJ	LabA&P
E218.6	MW-58BR-HYD7	N002746	Hexavalent Chromium	µg/L	10	J	LabA&P
E218.6	MW-62BR-HYD1	N002746	Hexavalent Chromium	µg/L	1	UJ	LabA&P
E218.6	MW-62BR-HYD6	N002746	Hexavalent Chromium	µg/L	600	J	LabA&P
E218.6	MW-62BR-HYD7	N002746	Hexavalent Chromium	µg/L	520	J	LabA&P
E218.6	MW-58BR-HYD4	N002746	Hexavalent Chromium	µg/L	1	UJ	ValAdj
E218.6	MW-62BR-HYD1	N002746	Hexavalent Chromium	µg/L	1	UJ	ValAdj

[a] This is the final qualifier flag for this analyte/method combination. If more than one flag was applied, this is the most conservative.

Validation Reasons:

HT>UCL = Holding time exceeded.
LabA&P = Laboratory accuracy and precision criteria not met.
ValAdj = Value reported by laboratory adjusted due to matrix issues.

TABLE A5-5
Data Qualification Summary

Method	Sample ID	COC Number	Analyte	Units	Final Result	Final Validation Flag[a]	Validation Reason
SW6010B	MW-58-BR-SS01	N002516	Antimony	mg/kg	2.1	UJ	MS<LCL
SW6010B	MW-58-BR-SS01	N002516	Antimony	mg/kg	2.1	UJ	SD<LCL
SW8015-P	MW-58-BR-SS05	N002516	TPH-Gasoline	µg/kg	960	UJ	Sur<LCL

[a] This is the final qualifier flag for this analyte/method combination. If more than one flag was applied, this is the most conservative.

Validation Reasons:

MS<LCL = Matrix spike recovery less than lower control limit.
SD<LCL = Spike duplicate recovery less than lower control limit.
Sur<LCL = Surrogate recovery less than lower control limit.

Appendix B
Applicable or Relevant and Appropriate Requirements

United States Department of the Interior

OFFICE OF THE SOLICITOR

Preliminary Determination of Applicable, or Relevant and Appropriate, Requirements
Pacific Gas & Electric Topock CERCLA Site

The United States Department of the Interior, the Bureau of Land Management, the U.S. Fish and Wildlife Service, and the Bureau of Reclamation (collectively, the "Federal Agencies"), have made the following preliminary determination of the applicable, or relevant and appropriate, requirements ("ARARs") that must be attained by any remedial action selected to address the release of a hazardous substance from the Pacific Gas and Electric ("PG&E") Compressor Station located near Topock, Arizona (the "Site"). Attached to this narrative is a table showing the Federal Agencies' preliminary determination of ARARs for the Site.

Background – General ARARs Information

The identification of ARARs is performed pursuant to Section 121(d) of the Comprehensive Environmental Response, Compensation, and Liability Act ("CERCLA"), which states that a remedial action selected for a CERCLA site shall attain a degree of cleanup which assures protection of human health and the environment, and attains "legally applicable or relevant and appropriate standard(s), requirement(s), criteria, or limitation(s)."

There are four basic criteria that define ARARs. ARARs are: (1) substantive rather than administrative, (2) applicable *or* relevant and appropriate, (3) promulgated State requirements which are more stringent than comparable federal standards, and (4) categorized as Chemical-specific, Location-specific, or Action-specific.

First, ARARs are substantive requirements, meaning that they are requirements that pertain directly to actions or conditions in the environment at the subject property. Examples of substantive requirements include: quantitative health- or risk-based restrictions on concentrations of hazardous substances (e.g. water quality standards), technology-based requirements for actions taken upon hazardous substances, or restrictions upon certain activities in certain special locations. Conversely, administrative or procedural obligations do not qualify as ARARs. Administrative requirements include requirements which facilitate identification and implementation of the substantive requirements, such as permitting procedures or recordkeeping.

Second, ARARs must be either Applicable or Relevant and Appropriate. Applicable requirements are laws and regulations that would be enforceable at the particular site even if there were no CERCLA remedial action taking place. These could include requirements applicable to a particular hazardous substance, remedial action, location, or other circumstance found at the site. Determining applicable ARARs, therefore, is an objective, site-specific analysis. Relevant and appropriate requirements, on the other hand, are obligations that, while not "applicable," address situations sufficiently similar and are well suited to the particular site. A relevant and appropriate determination can necessitate more subjective analysis.

Third, in addition to federal regulations, relevant State laws may be determined to be ARARs. In order to be considered an ARAR, state standards must be: promulgated, identified by the state in a timely manner, and more stringent than any comparable federal standard, requirement, criteria, or limitation.

Finally, once statutes and regulations have been determined as ARARs, they may be grouped into three categories: Chemical-specific, Location-specific, and Action-specific. There will be situations where a particular requirement will fall in two or more categories. Ultimately, if a requirement is deemed an ARAR, it will not be relevant in which category it resides.

Once an analysis is complete, there may be materials which do not meet all of the requirements of an ARAR, but which still may be considered when determining what is protective when evaluating the remedial action alternatives for a CERCLA site. These documents to be considered, or "TBCs," can include guidance documents, advisories, or other criteria.

Identification of ARARs for the Topock CERCLA Site

On April 28, 2006, the Federal Agencies invited support agencies and the numerous stakeholders involved with the Site to participate in the ARARs identification process by submitting proposed ARARs for the Federal Agencies' consideration.[1] The Federal Agencies received responses from five parties. In addition to evaluating the ARARs proposed by the interested parties, the Federal Agencies supplemented the list with additional potential ARARs. The identification of ARARs is a site-specific process, therefore, the list of ARARs for a site is refined and augmented with increasing certainty as the Remedial Investigation and Feasibility Study ("RI/FS") process proceeds and more specific information is available. As more information is gathered during the Topock Site RI/FS, and as more comments are received from all of the interested parties, the ARARs list is likely to be further refined.

An important final note: ARARs are requirements which must be attained within the CERCLA remedial action process; even if a law or regulation does not qualify as an ARAR, it may still be necessary to satisfy that law or regulation outside of the CERCLA remedial process.

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[1] The April 28, 2006 request for potential ARARs was distributed to the following parties: Fort Mojave Indian Tribe, Chemehuevi Indian Tribe, Twenty-Nine Palms Indian Tribe, Yavapai-Prescott Tribe, Cocopah Tribe, Colorado River India Tribes, Havasupai Tribe, Hualapai Tribe, Ft. Yuma Quechan Tribe, California Department of Toxic Substances Control, Arizona Department of Environmental Quality, State Water Resources Control Board, Metropolitan Water District of Southern California, U.S. Environmental Protection Agency (Region 9), and the Topock Site Consultative Workgroup members.

Applicable or Relevant and Appropriate Requirements (ARARs)
and other factors To Be Considered (TBCs)

Appendix B - Corrective Measures Study/Feasibility Study Report for Chromium in Groundwater,
PG&E Topock Compressor Station, Needles, California

Note: Only substantive requirements of the statutes and regulations listed here must be attained for on-site remedial actions. Compliance with administrative, procedural, and permitting requirements of these statutes and regulations is not required for on-site actions.

FEDERAL REQUIREMENTS			
	ARAR or TBC and Citation	**Determination**	**Description and Applicability**
CHEMICAL-SPECIFIC			
1.	Federal Safe Drinking Water Act • 42 USC § 300f, *et seq.* • 40 CFR 141 -- Subpart F– Maximum Contaminant Level Goals (MCLGs)	ARAR Relevant and Appropriate	MCLGs are not federally enforceable drinking water standards, but CERCLA § 121(d) identifies MCLGs as relevant and appropriate requirements.
2.	Federal Safe Drinking Water Act • 42 USC § 300g-1 • 40 CFR 141 -- Subpart G – National Primary Drinking Water Regulations (MCLs)	ARAR Relevant and Appropriate	These MCLs are relevant and appropriate standards, which establish the maximum permissible level of contaminants (eg. Chromium) in sources (or potential sources) of drinking water. MCLs may be applicable where water at a CERCLA site is delivered through a public water supply system.
3.	Federal Water Pollution Control Act (CWA) • 33 USC §§ 1251-1387 • 40 CFR 131.38	ARAR Applicable	These are federally promulgated Water Quality Standards for surface waters. Such water quality standards include specific criteria for water bodies in California, including standards for Hexavalent Chromium.
4.	Occupational Safety and Health Act • 29 USC § 651, *et seq.* • 29 CFR 1910.1026	TBC	This Act provides standards for workers engaged in field activities associated with remedial actions under the NCP, including occupational exposure to Hexavalent Chromium. Pursuant to the NCP preamble, OSHA standards are not ARARs but may be included as TBCs.

LOCATION-SPECIFIC			
5.	Federal Land Policy and Management Act (FLPMA) • 43 USC § 1701, *et seq.* • 43 CFR 2800	ARAR Applicable	In managing public lands, BLM is directed to take any action necessary to prevent unnecessary or undue degradation of the lands. Actions taken on the public land (i.e. BLM-managed land) portions of the Topock site should provide the "optimal balance between authorized resource use and the protection and long-term sustainability of sensitive resources."
6.	U.S. Department of Interior, Bureau of Land Management, *Approved Resource Management Plan and Final Environmental Impact Statement*, May 2007	TBC	The Resource Management Plan provides further direction on how FLPMA requirements will be satisfied.
7.	National Wildlife Refuge System Administration Act, as amended • 16 USC §§ 668dd-ee • 50 CFR Part 27	ARAR Applicable	This Act governs the use and management of National Wildlife Refuges. The Act requires that FWS evaluate ongoing and proposed activities and uses to ensure that such activities are appropriate and compatible with both the mission of the overall National Wildlife Refuge System, as well as the specific purposes for which the Havasu National Wildlife Refuge was established. The Topock site includes portions of the Havasu National Wildlife Refuge. Prior to selection of a remedial action by DOI/FWS, that remedial action must be found by the Refuge Manager to be both an appropriate use of the Refuge and compatible with the mission of the Refuge and the Refuge System as a whole. Any remedial action proposed to be implemented on the Refuge that was not selected by DOI/FWS would be subject to the formal appropriate use/compatibility determination process.
8.	Executive Order 8647; 6 FR 593	TBC	This Executive Order establishes the Havasu National Wildlife Refuge and describes the purposes for which it was created.
9.	Appropriate Use Policy • 603 FW 1	TBC	This policy elaborates on the appropriate uses of a National Wildlife Refuge, ensuring that such uses contribute to fulfilling the specific refuge's purposes and the National Refuge System's mission.
10.	Compatibility Policy • 603 FW 2	TBC	This policy specifies the guidelines for determining the compatibility of proposed uses of a National Wildlife Refuge. This determination is done once a proposed use is deemed appropriate (see number 9 above).

11.	<u>Lower Colorado River National Wildlife Refuges, Comprehensive Management Plan (1994-2014)</u>	<u>TBC</u>	The Comprehensive Management Plan provides further direction on how compliance with the National Wildlife Refuge System Administration Act, as amended, shall be achieved.
12.	<u>Fish and Wildlife Conservation Act</u> • 16 USC §§ 2901-2911	<u>TBC</u>	Federal departments and agencies are encouraged to utilize their authority to conserve nongame fish and wildlife and their habitats and assist States in the development of their conservation plans.
13.	<u>Fish and Wildlife Coordination Act</u> • 16 USC §§ 661-667e • 40 CFR 6.302(g)	<u>ARAR</u> Applicable	This Act requires that any federally-funded or authorized modification of a stream or other water body must provide adequate provisions for conservation, maintenance, and management of wildlife resources and their habitat. Necessary measures should be taken to mitigate, prevent, and compensate for project-related losses of wildlife resources. Any remedial action selected for the Topock site that includes any modification of a water body will be subject to these requirements.
14.	<u>National Historic Preservation Act</u> • 16 USC § 470, *et seq.* • 40 CFR 6.301(b) • 36 CFR 800.1, *et seq.*	<u>ARAR</u> Applicable	This statute and the implementing regulations direct federal agencies to consider the effects of their undertakings on historic properties included in or eligible for inclusion in the National Register of Historic Places and to consult with certain parties before moving forward with the undertaking. The agency must determine, based on consultation, if an undertaking's effects would be adverse and seek ways to avoid, mitigate, or minimize such adverse effects on a National Register or eligible property. The agency must then specify how adverse effects will be avoided or mitigated or acknowledge that such effects cannot be avoided or mitigated. The Topock site includes historic properties in or eligible for inclusion in the National Register and remedial action selected for the Topock site qualifies as an undertaking pursuant to the NHPA. Measures to avoid or mitigate adverse effects of any selected remedial action that are adopted by the agency through consultation must be implemented by the remedial action to comply with the NHPA.
15.	National Register Bulletin 38	<u>TBC</u>	Guidelines for evaluating and documenting traditional cultural properties.
16.	Preservation Brief 36	<u>TBC</u>	Guidelines for planning, treating, and managing historic landscapes.
17.	<u>National Archaeological and Historic Preservation Act</u> • 16 USC § 469, *et seq.* • 36 CFR 65 • 40 CFR 6.301(c)	<u>ARAR</u> Applicable	This statute requires the evaluation and preservation of historical and archaeological data which might otherwise be irreparably lost or destroyed through any alteration of terrain as a result of federal construction projects or a federally-licensed activity. The Topock site includes historical and archaeological data. Any remedial action selected for the Topock site must include measures for the evaluation and preservation of historical and archaeological data that might be lost or destroyed as a result of the remedial action.

18.	Archaeological Resources Protection Act • 16 USC § 470aa-ii, *et seq*. • 43 CFR 7.1, *et seq.*	ARAR Applicable	This statute provides for the protection of archeological resources located on public and tribal lands. The Act establishes criteria which must be met for the land manager's approval of any excavation or removal of archaeological resources if a proposed activity involves soil disturbances. The Topock site includes archaeological resources on public land. Any remedial action selected for the Topock site must satisfy the criteria applicable to excavation or removal of archaeological resources that might be affected as a result of the remedial action.
19.	Historic Sites Act • 16 USC §§ 461-467 • 40 CFR 6.301(a)	ARAR Applicable	Pursuant to this Act, federal agencies are to consider the existence and location of historic sites, buildings, and objects of national significance using information provided by the National Park Service to avoid undesirable impacts upon such landmarks. There are no designated historic landmarks within the APE, although 16 USC 461, through Public Law 106-45, provides for a cooperative program "for the preservation of the Route 66 corridor" through grants and other measures. Undesirable impacts on this site that might result from any remedial action selected for the Topock site will be evaluated and mitigated to the maximum extent practicable.
20.	Executive Order No. 11593	TBC	This Order directs the Federal Agencies to initiate measures for the protection and enhancement of the cultural environment. These measures include assuring that steps are taken to make records, drawings, and/or maps and have such items deposited in the Library of Congress when, as the result of a Federal action, a property listed on the National Register of Historic Places is to be substantially altered.
21.	Native American Graves Protection and Repatriation Act (NAGPRA) • 25 USC § 3001, *et seq.* • 43 CFR 10.1, *et seq.*	ARAR Applicable	NAGPRA establishes requirements regulating the removal and trafficking of human remains and cultural items, including funerary and sacred objects. The Topock site may contain human remains. If remediation activities result in the discovery of Indian human remains or related objects, NAGPRA requirements must be met.
22.	American Indian Religious Freedom Act • 42 USC § 1996, *et seq.*	ARAR Relevant and Appropriate	The United States must "protect and preserve for American Indians their inherent right of freedom to believe, express, and exercise [their] traditional religions…" Any remedial action selected for the Topock site must satisfy this requirement.
23.	Executive Order No. 13007	TBC	In managing federal lands, the United States "shall, to the extent practicable, permitted by law, and not clearly inconsistent with essential agency functions, (1) accommodate access to and ceremonial use of Indian sacred sites by Indian religious practitioners, and (2) avoid adversely affecting the physical integrity of such sacred sites."

24.	Executive Order No. 13175	TBC	Federal Agencies are to conduct regular and meaningful consultation and collaboration with tribal officials in the development and implementation of Federal policies that have tribal implications.
25.	Executive Order No. 12898	TBC	Federal agencies shall conduct "activities that substantially affect human health or the environment, in a manner that ensures that such programs, policies, and activities do not have the effect of excluding persons (including populations) from participation in, denying persons (including populations) the benefits of, or subjecting persons (including populations) to discrimination under such programs, policies, and activities, because of their race, color, or national origin."
26.	Executive Order No. 13352	TBC	The Department of Interior shall, to the extent permitted by law, "implement laws relating to the environment and natural resources in a manner that promotes cooperative conservation."
27.	Resource Conservation and Recovery Act • 42 USC § 6901, *et.seq.* • 40 CFR 264.18	ARAR Applicable	These regulations promulgated under RCRA establish Seismic and Floodplain considerations which must be followed for treatment, storage, or disposal facilities constructed, operated, or maintained within certain distances of fault lines and floodplains. Portions of the Topock site are located on or near a 100-year floodplain.
28.	Floodplain Management and Wetlands Protection • 40 CFR § 6.302(a) & (b) • 40 CFR 6, Appendix A	ARAR Applicable	Before undertaking an action, agencies are required to perform certain measures in order to avoid the long and short term impacts associated with the destruction of wetlands and the occupancy and modification of floodplains and wetlands. The regulation sets forth requirements as means of carrying out the provisions of Executive Orders 11988 and 11990.
29.	Executive Order 11988 – Floodplain Management	TBC	Executive Order 11988 requires evaluation of the potential effects of actions that take place in a floodplain to avoid, to the extent possible, adverse impacts.
30.	Executive Order 11990 -- Responsibilities of Federal Agencies to Protect Wetlands	TBC	Executive Order 11990 requires that potential impacts to wetlands be considered, and as practical, destruction, loss, or degradation of wetlands be avoided.

ACTION-SPECIFIC			
31.	Federal Safe Drinking Water Act - 42 USC §300f, *et seq.* Part C – Protection of Underground Sources of Drinking Water - 40 CFR 144 -148	ARAR Applicable	These Underground Injection Control Regulations assure that any underground injection performed on-site will not endanger drinking water sources. Substantive requirements include, but are not limited to, regulation of well construction and well operation. These requirements will be applicable if underground injection is proposed as a part of a site remedy.
32.	Federal Water Pollution Control Act (Clean Water Act) - 33 USC § 1344 - 40 CFR 230.10	ARAR Applicable	This section of the Clean Water Act prohibits certain activities with respect to on-site wetlands and waterways. No discharge of dredged or fill material shall be permitted if there is a practicable alternative to the proposed activity which would have less adverse impact to the aquatic ecosystem.
33.	Federal Water Pollution Control Act (Clean Water Act) - 33 U.S.C. § 1342 - 40 CFR 122 - 40 CFR 125	ARAR Applicable	These National Pollutant Discharge Elimination System (NPDES) requirements regulate discharges of pollutants from any point source into waters of the United States.
34.	Federal Water Pollution Control Act (Clean Water Act) - 40 CFR 122.26	ARAR Applicable	These regulations define the necessary requirements with respect to the discharge of storm water under the NPDES program. These regulations will apply if proposed remedial actions result in storm water runoff which comes in contact with any construction activity from the site remediation.
35.	River and Harbor Act of 1899 - 33 USC §§ 401 and 403	ARAR Applicable	This Act prohibits the creation of any obstruction in navigable waters, in addition to banning activities such as depositing refuse, excavating, filling, or in any manner altering the course, condition, or capacity of navigable waters. These requirements will apply if proposed activities at the Topock site have the potential of affecting any navigable waters on the site.
36.	Colorado River Front Work and Levee System Act - 44 Stat. 1010 (1927)	TBC	Any proposed remediation activities shall not interfere with the water operations or related water management activities and responsibilities of the Bureau of Reclamation.

37.	Clean Air Act • 42 USC §§ 7401, *et seq.* National Ambient Air Quality Standards (NAAQS) • 40 CFR 50	TBC	These ambient air quality standards define levels of air quality to protect the public health. NAAQSs are not enforceable in and of themselves, but they may be used as guidance if remediation activities create potential air quality impacts.
38.	Clean Air Act • 42 USC §§ 7401, *et seq.* National Emission Standards for Hazardous Air Pollutants (NESHAP) • 40 CFR 61 • 40 CFR 63	ARAR Applicable	NESHAPs are regulations which establish emissions standards for certain hazardous air pollutants (HAPs) identified in the regulations. NESHAPs will apply if remediation activities on the site produce identified HAP emissions.
39.	Religious Freedom Restoration Act • 42 USC § 2000bb	ARAR Applicable	Pursuant to this Act, the government shall not substantially burden a person's exercise of religion, unless the application of the burden is in furtherance of a compelling government interest, and it is the least restrictive means of furthering that interest. To constitute a "substantial burden" on the exercise of religion, a government action must (1) force individuals to choose between following the tenets of their religion and receiving a governmental benefit or (2) coerce individuals to act contrary to their religious beliefs by the threat of civil or criminal sanctions. If any remedial action selected imposes a substantial burden on a person's exercise of religion, it must be in furtherance of a compelling government interest and be the least restrictive means of achieving that interest.
40.	Endangered Species Act of 1973 • 16 USC §§ 1531-1544 • 50 CFR 402	ARAR Applicable	The ESA makes it unlawful to remove or "take" threatened and endangered plants and animals and protects their habitats by prohibiting certain activities. Examples of such species in or around the Topock site may include, but are not limited to, southwestern willow flycatcher, Mojave Desert tortoise, Yuma clapper rail, Colorado pike minnow, razorback sucker, and bonytail chub. Any remedial action selected for the Topock site will not result in the take of, or adverse impacts to, threatened and endangered species or their habitats, as determined based on consultation with the Fish and Wildlife Service under section 7 of the ESA.

41.	Migratory Bird Treaty Act - 16 USC §§ 703-712	ARAR Applicable	This Act makes it unlawful to “take, capture, kill,” or otherwise impact a migratory bird or any nest or egg of a migratory bird. The Havasu National Wildlife Refuge, which is part of the Topock site, was created as a refuge and breeding ground for migratory birds and other wildlife, therefore, there is potential for contact with migratory birds during proposed remediation activities. Any remedial action selected for the Topock site will be designed and implemented so as to not take, capture, kill, or otherwise impact a migratory bird, nest, or egg.
42.	Executive Order 13186: Responsibilities of Federal Agencies To Protect Migratory Birds	TBC	This Order directs executive departments and agencies to take certain actions to further implement the Migratory Bird Treaty Act, including supporting the conservation intent of the migratory bird conventions by integrating bird conservation principles, measures, and practices into agency activities and by avoiding or minimizing, to the extent practicable, adverse impacts on migratory bird resources when conducting agency actions.
ARIZONA REQUIREMENTS			
	ARAR or TBC and Citation	**Determination**	**Description and Applicability**
LOCATION-SPECIFIC			
43.	Archeological Discoveries - A.R.S. § 41-841 through 847	ARAR	This Act prohibits any person from knowingly excavating on Arizona State or State agency owned land which is a historic or prehistoric ruin, burial ground, archaeological or paleontological site. These requirements will apply if the selected remedy involves excavation in Arizona.
44.	Historic Preservation - A.R.S. § 41-865	ARAR	This Act restricts any person from disturbing human remains or funerary objects on land owned or controlled by the State. These requirements will apply if the selected remedy involves excavation in Arizona.

ACTION-SPECIFIC			
45.	Arizona Well Standards • A.A.C. R-12-15-850	ARAR	These requirements on the placement of wells will apply if the selected remedy includes placement of wells in Arizona.
46.	Design criteria for treatment units • A.A.C. R18-5-(501-502)	ARAR	These minimum design criteria will apply if the selected remedy includes construction of a groundwater treatment plant.
47.	Requirements for wells, groundwater withdrawal, treatment, and reinjection • A.R.S. §45-454.01	ARAR	This statute exempts new well construction, withdrawal, treatment, and reinjection into a groundwater aquifer as a part of a CERCLA Remedial Action from the requirements of the Arizona Groundwater Code, except that they must comply with the substantive requirements of A.R.S. 45-594, 45-595, 45-596, and 45-600. If groundwater that is withdrawn is not reinjected into the aquifer, the groundwater shall be put to reasonable and beneficial use.
48.	Well construction standards • A.R.S. §45-594 and 595	ARAR	These provisions identify the well construction standards and requirements for new well construction in the State of Arizona. These requirements will apply if the selected remedy involves the construction of wells in Arizona.
49.	Notice of intention to drill • A.R.S. §45-596	ARAR	Substantive requirements will apply if the selected remedy involves the construction of wells in Arizona.
50.	Report by driller • A.R.S. §45-600	ARAR	Substantive requirements will apply if the selected remedy involves the construction of wells in Arizona.
51.	Arizona Remedial Action Requirements • A.R.S. §49-282.06(A)(2)	ARAR	Any treatment of groundwater must be conducted in a manner to provide for the maximum beneficial use of the waters of the state.

CALIFORNIA REQUIREMENTS

	ARAR or TBC and Citation	**Determination**	**Description and Applicability**
CHEMICAL-SPECIFIC			
52.	California Safe Drinking Water Act • Title 22, CCR, Div 4, Ch 15, §64431, §64444	ARAR Applicable	Maximum Contaminant Levels (MCLs) which shall not be exceeded in the water supplied to the public. California state MCLs for drinking water standards are more stringent than primary federal standards.
53.	Secondary MCLs list for drinking water • Title 22, CCR, Div 4, Ch 15, §64449	ARAR Relevant and Appropriate	State secondary MCLs for drinking water standards are more stringent than federal standards. These secondary MCLs are relevant and appropriate standards, which establish the maximum permissible level of contaminants in sources (or potential sources) of drinking water. These secondary MCLs would be applicable if water at the site was used as drinking water and delivered through a community water supply system.
54.	Characteristics of Hazardous Waste • Title 22, CCR, Div 4.5, Ch 11, Article 3, §66261.20- §66261.24	TBC	These criteria do not establish substantive requirements, but instead describe the analysis by which waste is determined to be hazardous. These regulations outline Toxicity Characteristic Leaching Procedure (TCLP) regulatory levels, persistent and bioaccumulative toxic substances total threshold limit concentrations (TTLC), and soluble threshold limit concentration (STLC).
55.	Groundwater and vadose zone protection standards • Title 22, CCR, Div 4.5, Ch 15, Article 6, §66265.94	ARAR Applicable	RCRA hazardous waste Interim Status TSD facilities shall comply and ensure that hazardous constituents entering the groundwater, surface water, and soil from a regulated unit do not exceed the concentration limit from contaminants of concern in the uppermost aquifer underlying the waste management area beyond the point of compliance.
56.	State Water Quality Control Policy Porter-Cologne Water Quality Control Act (California Water Code Sections 13140, *et seq.*)	TBC	

57.	Regional Water Quality Control Plan Objectives Porter-Cologne Water Quality Control Act (California Water Code Sections 13240, 13241)	TBC	
58.	Regional Water Quality Control Plan Implementation Porter-Cologne Water Quality Control Act (California Water Code Sections 13242)	TBC	
59.	*Guidance for Ecological Risk Assessment at Hazardous Waste Sites and Permitted Facilities* DTSC Human and Ecological Risk Division July 1996	TBC	
60.	*Supplemental Guidance for Human Health Multimedia Risk Assessments of Hazardous Waste Sites and Permitted Facilities* DTSC Human and Ecological Risk Division July 1992	TBC	
61.	*Risk Assessment Guidance for Superfund, Volume I, Human Health Evaluation Manual – Interim Final (EPA/540/1-89/002)* United States Environmental Protection Agency December 1989	TBC	
62.	*Selecting Inorganic Constituents As Chemicals Of Potential Concern At Risk Assessments At Hazardous Waste Sites And Permitted Facilities* DTSC Final Policy, February 1997	TBC	

LOCATION-SPECIFIC			
63.	Seismic and Floodplain standards • Title 22, CCR, Div 4.5, Ch 14, Article 2, §66264.18	ARAR Relevant and Appropriate	These standards are relevant and appropriate for TSD facilities constructed, operated, or maintained within certain distances of fault lines, floodplains, or the maximum high tide.
64.	*Drilling, Coring, Sampling and Logging at Hazardous Substance Release sites* Guidance Manual for Ground Water Investigations, Cal/EPA, July 1995	TBC	
65.	*Reporting Hydrogeologic Characterization Data at Hazardous Substance Release sites* Guidance Manual for Ground Water Investigations, Cal/EPA, July 1995	TBC	
66.	*Guidelines for Hydrogeologic Characterization of Hazardous Substance Release Sites, Volume 1 & 2,* Cal/EPA, July 1995	TBC	
67.	*Aquifer Testing for Hydrogeologic Characterization* Guidance Manual for Ground Water Investigations, Cal/EPA, July 1995	TBC	
68.	*Application of Borehole Geophysics at Hazardous Substance Release Sites* Guidance Manual for Ground Water Investigations, Cal/EPA, July 1995	TBC	
69.	*Ground Water Modeling for Hydrogeologic Characterization* Guidance Manual for Ground Water Investigations Cal/EPA, July 1995	TBC	
70.	*Monitoring Well Design and Construction for Hydrogeologic Characterization* Guidance Manual for Ground Water Investigations, Cal/EPA, July 1995	TBC	

71.	*Advisory – Active Soil Gas Investigation* DTSC/CRWQCB-Los Angeles Region, January 2003	TBC	
72.	*Representative Sampling of Ground Water for Hazardous Substances,* Cal/EPA, July 1995	TBC	
73.	*Accumulating Hazardous Waste at Generator Sites,* Cal/EPA, July 1995	TBC	
ACTION-SPECIFIC			
74.	Hazardous Waste Control Act (HWCA) Standards applicable to generators of hazardous waste • Title 22, CCR, Div 4.5, Ch 12, Article 1, §66262.11	ARAR Applicable	Owners or operators who generate waste shall determine whether waste is a hazardous waste. Applicable for any operation where waste is generated. The determination of whether wastes generated during remedial activities are hazardous shall be made when the wastes are generated.
75.	Hazardous Waste Control Act (HWCA) • Title 22, CCR, Div 4.5, Ch 12, Article 1, §66262.12	ARAR Applicable	A generator shall not treat, store, dispose of, transport or offer for transportation, hazardous waste without having received an identification number. Substantive requirements will be applicable for any operation where waste is generated. The determination of whether wastes generated during remedial activities are hazardous shall be made when the wastes are generated.
76.	Hazardous Waste Control Act (HWCA) Standards for owners and operators of hazardous waste transfer and TSD facilities • Title 22, CCR, Div 4.5, Ch 14, Article 2	ARAR Applicable	Establish requirements for a hazardous waste treatment facility to have a plan for waste analysis, develop a security system, conduct regular inspections, provide training to facility personnel, and use a quality assurance program during construction. The requirements may be applicable if CERCLA response action includes treatment, storage, or disposal as defined under RCRA, or may be relevant and appropriate if the requirements address problems or situations sufficiently similar to the specific circumstances at the site that their usage will be well suited.
77.	Hazardous Waste Control Act (HWCA) Standards applicable to generators of hazardous waste • Title 22, CCR, Div 4.5, Ch 12, Article 2, §66262.20, §66262.22	ARAR Applicable	A generator of hazardous waste who transports or offers hazardous waste for transportation shall prepare a manifest. Substantive requirements will be applicable for any operation where waste is generated. The determination of whether wastes generated during remedial activities are hazardous shall be made when the wastes are generated.

78.	Hazardous Waste Control Act (HWCA) Standards applicable to generators of hazardous waste • Title 22, CCR, Div 4.5, Ch 12, Article 3, §66262.30, §66262.31, §66262.32, §66262.33	ARAR Applicable	Before transporting hazardous waste or offering hazardous waste for transportation off-site, the generator must do the following in accordance with DOT regulations: package the waste, label and mark each package of hazardous waste, and ensure that the transport vehicle is correctly placarded.
79.	Hazardous Waste Control Act (HWCA) Standards applicable to generators of hazardous waste • Title 22, CCR, Div 4.5, Ch 12, Article 3, §66262.34	ARAR Applicable	Requirements with respect to accumulation of waste on-site.
80.	Hazardous Waste Control Act (HWCA) Standards applicable to generators of hazardous waste • Title 22, CCR, Div 4.5, Ch 12, Article 4, §66262.40, §66262.41	ARAR Applicable	Establishes requirements for record keeping of manifests, test results, waste analyses, and Biennial Reports. Any substantive requirements shall be attained.
81.	Corrective Action • Title 22, CCR, Div 4.5, Ch 14, Article 6, §66264.100 (a) through (d), (f), (g)(1), and (h)	ARAR Relevant and Appropriate	The owner or operator is required to take corrective action under Title 22, CCR, §66264.91 to remediate releases from the regulated unit and to ensure that the regulated unit achieves compliance with the water quality protection standard. Substantive technical requirements are potentially relevant and appropriate for remedial action including groundwater monitoring.
82.	Corrective action for Waste Management Units • Title 22, CCR, Div 4.5, Ch 14, Article 6, §66264.101	ARAR Relevant and Appropriate	The owner or operator is required to take corrective action to remediate releases from any solid or hazardous waste management unit at the facility to protect public health and the environment. Substantive technical requirements are potentially relevant and appropriate for remedial action including groundwater monitoring.
83.	Closure and post-closure care • Title 22, CCR, Div 4.5, Ch 14, Article 7, §66264.111, §66264.112, §66264.115 through 120	ARAR	Owners and operators shall close a facility and perform post-closure care when contaminated subsurface soil cannot be practically removed or decontaminated. Contaminated soil, residues, or groundwater from remedial action at a site will achieve clean closure; otherwise, post-closure care requirements will be relevant and appropriate.

84.	Use and management of containers • Title 22, CCR, Div 4.5, Ch 14, Article 9	ARAR Applicable	Containers used for the transfer or storage of hazardous waste must be in good condition, compatible with the waste, kept closed except to add or remove materials and be inspected weekly. The area used to store the containers must provide adequate secondary containment and be designed with runoff controls. Also, appropriate closure of the containers must take place.
85.	Tank systems • Title 22, CCR, Div 4.5, Ch 14, Article 10	ARAR Applicable	The remedial activities may involve storage and/or treatment in tanks. These tanks are required to have secondary containment, be monitored and inspected, be provided with overfill and spill protection controls, and operated with adequate freeboard. Also, appropriate closure must take place.
86.	Waste piles • Title 22, CCR, Div 4.5, Ch 14, Article 12	ARAR Applicable	The waste piles should be placed upon a lined foundation or base with a leachate system, protected from precipitation and wind dispersal, designed to prevent run on and run off. Also, closure and post-closure care requirements. Remedial action may involve soil excavation and the compiling of soil in a temporary waste pile. This requirement is applicable if the excavated waste meets RCRA hazardous waste criteria.
87.	Landfills • Title 22, CCR, Div 4.5, Ch 14, Article 14	ARAR Relevant and Appropriate	The requirements for landfills include the design and operation, action leakage rate, monitoring and inspection, response actions, surveying and recordkeeping and closure and post-closure care.
88.	Miscellaneous Units • Title 22, CCR, Div 4.5, Ch 14, Article 16	ARAR Applicable	Applies to waste management unit not otherwise regulated under RCRA. It may include pumps, auxiliary equipment, air strippers, etc. The substantive requirements include design, construction, operation, maintenance and closure of the unit that will ensure protection of human health and the environment. The actions include general inspections for safety and operation efficiency, testing and maintenance of the equipment (including testing of warning systems). Applicable if pumps are used for extraction and treatment of leachate that meets RCRA hazardous waste criteria.

89.	Land Disposal Restrictions (LDR) for RCRA wastes and non-RCRA wastes • Title 22, CCR, Div 4.5, Ch 18, Articles 1, 3, 4, 10, 11	ARAR Applicable	Movement of hazardous waste to new locations and placed in or on land will trigger LDR. General applicability, dilution prohibited, waste analysis and record keeping, and special rules apply for wastes that exhibit a characteristic waste. Best Demonstrated Available Technology (BDA) standards for each hazardous constituent in each listed waste, if residual is to be disposed. Utilize treatment standards table when necessary. Where applicable, hazardous waste generated from remedial activities must comply with LDR and meet the treatment standards or notify the disposal facility of the treatment standards before disposal at an appropriate offsite disposal facility.
90.	Hazardous Waste Control Act (HWCA) Standards for owners and operators of hazardous waste transfer and TSD facilities • Title 22, CCR, Div 4.5, Ch 14, Articles 3 and 4	ARAR Applicable	Establish requirements for a facility to plan for emergency conditions. In addition, the design and operation of the facility must be done to prevent releases. Other requirements include testing and maintenance of equipment and incorporation of communication and alarm systems and contingency plan. The requirements may be applicable if CERCLA response action includes treatment, storage, or disposal as defined under RCRA, or may be relevant and appropriate if the requirements address problems or situations sufficiently similar to the specific circumstances at the site that their usage will be well suited.
91.	Hazardous Waste Control Act (HWCA) Groundwater monitoring and response • Title 22, CCR, Div 4.5, Ch 14, Article 6, §66264.91 (a) and (c)	ARAR Relevant and Appropriate	Owners or operators of a RCRA surface impoundment, waste pile, land treatment unit, or landfill shall conduct a monitoring and response program for each regulated unit. Substantive technical requirements are potentially relevant and appropriate for remedial action including groundwater monitoring.
92.	Hazardous Waste Control Act (HWCA) Monitoring • Title 22, CCR, Div 4.5, Ch 14, Article 6, §66264.97 (b), (c), (d) and (e)(1) through (e)(5)	ARAR Relevant and Appropriate	Requirements for monitoring groundwater, surface water, and vadose zone. Substantive technical requirements are potentially relevant and appropriate for remedial action including groundwater monitoring.
93.	Hazardous Waste Control Act (HWCA) Detection Monitoring • Title 22, CCR, Div 4.5, Ch 14, Article 6, §66264.98	ARAR Relevant and Appropriate	Requires the owner or operator of a regulated unit to develop a detection monitoring program that will provide reliable indication of a release. Substantive technical requirements are potentially relevant and appropriate for remedial action including groundwater monitoring.

94.	Hazardous Waste Control Act (HWCA) Evaluation Monitoring • Title 22, CCR, Div 4.5, Ch 14, Article 6, §66264.99	ARAR Relevant and Appropriate	Requires the owner or operator of a regulated unit to develop an evaluation monitoring program that can be used to assess the nature and extent of a release from the unit. Substantive technical requirements are potentially relevant and appropriate for remedial action including groundwater monitoring.
95.	Discharges of Waste to Land • Title 23 CCR, Div 3, Ch 15	ARAR Relevant and Appropriate	The regulations in this chapter pertain to water quality aspects of hazardous waste discharge to land, establishing waste and site classifications and waste management requirements for waste treatment, storage, or disposal in landfills, surface impoundments, waste piles, and land treatment facilities. Requirements in this chapter are minimum standards for proper management of each waste category. Pursuant to Section 2511 (Exemptions), because this remediation constitutes actions taken by public agencies to cleanup unauthorized releases of waste, these regulations will only apply if the proposed remedial activities include (1) removal of waste from the immediate place of release, or (2) keeping some contamination in place.
96.	Consolidated Regulations for Storage, Treatment, Processing, or Disposal of Solid Waste • Title 27 CCR, Div 2, Subdivision 1	ARAR Relevant and Appropriate	The regulations in this subdivision (promulgated by the State Water Resources Control Board (SWRCB)) pertain to water quality aspects of discharges of solid waste to land for treatment, storage, or disposal. Pursuant to Section 20090 (Exemptions), because this remediation constitutes actions taken by public agencies to cleanup unauthorized releases of waste, these regulations will only apply if the proposed remedial activities include (1) removal of waste from the immediate place of release, or (2) keeping some contamination in place.
97.	Requirements for land-use covenants • Cal. Code Regs. Title 22, § 67391.1	ARAR Applicable	This regulation requires appropriate restrictions on use of property in the event that a proposed remedial alternative results in hazardous materials remaining at the property at levels which are not suitable for unrestricted use of the land. This is an ARAR with respect to PG&E-owned land at the Topock site.
98.	California Water Code Section 13801(c) • California Well Standards, Bulletin 74-90 (Supplement to Bulletin 74-81)	ARAR Applicable	These standards for water, cathodic, and monitoring wells will be applicable if the remediation requires use of such wells.

99.	State Water Resources Control Board Resolution No. 88-63 Adoption of Policy Entitled "Sources of Drinking Water"	ARAR Applicable	With certain exceptions, all surface and ground waters of the State of California are to be considered suitable, or potentially suitable, for municipal or domestic water supply. The Regional Water Quality Control Board and State Water Resources Board have designated the beneficial use of the ground and surface waters in the Topock Site area as "municipal and domestic water supply." This designation is set forth in the Basin Plan.
100.	Water Quality Control Plan; Colorado River Basin-Region 7, June 2006 (Basin Plan)	ARAR Applicable	This Basin Plan designates the Colorado River and the Colorado Hydrologic unit as having the beneficial use of "MUN" (or, municipal or domestic water supply). The Basin Plan also prescribes General Surface Water Objectives and Ground Water Objectives, in addition to Specific Surface Water Objectives for the Colorado River, which include a flow-weighted average annual numeric criterion for salinity for the portion of the Colorado River on the Topock Site of 723 mg/L. This TDS value must not be exceeded in any remedial alternative being considered.
101.	State Water Resources Control Board Resolution No. 68-16 ("Antidegradation Policy") Statement of Policy with respect to Maintaining High Quality of Waters in California	ARAR Applicable	Any activity which produces or may produce a waste or increased volume or concentration of waste and which discharges or proposes to discharge to existing high quality waters will be required to meet waste discharge requirements which will result in the best practicable treatment or control of the discharge necessary to assure that (a) a pollution or nuisance will not occur and (b) the highest water quality consistent with maximum benefit to the people of the State will be maintained.
102.	State Water Resources Control Board Resolution No. 92-49 Policies and Procedures for investigation and Cleanup and Abatement of Discharges under Water Code Section 13304	ARAR Relevant and Appropriate	Section III.A of this Resolution states that the Regional Water Board shall" "concur with any investigative and abatement proposal which the discharger demonstrates and the Regional Water Board finds to have a substantial likelihood to achieve compliance within a reasonable time frame…"
103.	State Water Resources Control Board Resolution No. 77-1 Policy with Respect to Water Reclamation in California	TBC	
104.	*Transportation Plan* Preparation Guidance for Site Remediation DTSC, May 1994	TBC	

Appendix C

Responses to Comments on the *Corrective Measures Study/Feasibility Study Report for Chromium in Groundwater, PG&E Topock Compressor Station*

Appendix C-1

Responses to Comments on the January 27, 2009 Draft Corrective Measures Study/Feasibility Study Report

TABLE C-1 RESPONSES TO COMMENTS
Comments on the January 27, 2009 *Draft Corrective Measures Study/Feasibility Study Report For Chromium In Groundwater*
PG&E Topock Compressor Station, Needles, California

	Comment Number	Section/ Page	Commenter	Comment	PG&E Response	DTSC Response	DOI Response	Final Comment Resolution
General Comments								
1	HA-5	General Comments	Hargis & Associates, Inc. (on behalf of Fort Mojave Indian Tribe)	Tribal Consultations and Transparency in the Decision Process between DTSC and DOI This regulatory process to date has typically involved consultations between DTSC and DOI with participation by PG&E on demand. The tribes become aware of project decisions at a late stage, generally at the same time as other stakeholders. The problem with this is that the tribes should be consulted on a government-to-government level whenever an agency of the U.S. or State government (*e.g.,* DOI or DTSC) is involved and in anticipation of a decision process. Otherwise, tribes do not have an opportunity to weigh in on aspects of the decisions that impact cultural and spiritual matters until a late stage of the process. At that point, tribal concerns often are relegated to a lesser priority. This CMS/FS document is a prime example of how not allowing earlier input from the tribes can potentially impact the process. As will be discussed later in these comments, several of the remedial alternatives cannot be designed as presented and still meet the necessary requirements of identified ARARs, and therefore the overall analysis within the document is flawed.	PG&E provided a “Discussion Draft” version of the draft CMS/FS Report to stakeholder tribes, and conducted briefings on the conceptual alternatives presented, several weeks in advance of the submittal of the draft CMS/FS Report. The Discussion Draft and briefings were intended to introduce the range of conceptual alternatives currently being evaluated, as well as the level of detail and breadth to be included. These pre-CMS/FS materials and discussions were not intended to replace or substitute for any consultative process, but rather to provide a background understanding of the upcoming draft CMS/FS that would enhance the tribes’ level of preparation for future consultations.	DTSC believes that all Tribes, including the Fort Mojave Indian Tribe were provided early opportunity for input into the CMS/FS report. PG&E prepared a discussion draft CMS/FS specifically for agency and tribal review which was provided to the tribes on 12/15/08. This is the same date that agencies learned of the proposed content of the CMS/FS document. DTSC understands that PG&E met with representatives of the tribes regarding the discussion draft prior to release of the formal draft CMS/FS on January 27, 2009 for agency, CWG, and Tribal review. To ensure timely review, DTSC immediately forwarded the document to the entire stakeholder group, including the tribes on January 28, 2009. To further assist the review of the document, DTSC also held a focused CWG meeting on February 11, 2009 to provide a summary of the CMS/FS. DTSC believes that we have afforded the earliest input to the tribes on this matter as possible.	DOI has consulted with the tribes to solicit tribal input on the draft Corrective Measures Study/ Feasibility Study (CMS/FS) Report including face-to-face meetings with four tribes. This consultation on the draft study that first identifies and evaluates remedial alternatives is early in the CERCLA remedy selection process. This consultation will inform DOI’s perspective as it directs PG&E on revisions to be made in the final CMF/FS Report (including revisions related to attainment of applicable or relevant and appropriate requirements (ARARs)), and as it proposes and then selects a remedy from among the alternatives now being evaluated. The Bureau of Land Management conducted formal Section 106 consultation on the Draft CMS/FS Report with the nine federally recognized Tribes from 2/6/2009 through 3/20/2009.	Comment addressed. Agencies approved PG&E response. No changes to the CMS/FS Report are required.
2	CRIT-6	General Comments	Envirometrix (on behalf of the Colorado River Indian Tribe)	Does the DTSC settlement agreement identify any process, actions or activities that may prevent, compromise or limit DTSC from acting as a responsible unbiased, neutral regulatory agency or alter DTSC's mission to protect of human health and the environment related to the RCRA corrective action evaluation and decision making process? With the required reduction in staff work hours required by the Governor as a result of the budget crisis, does DTSC have the necessary staff and resources to assign to this project?	PG&E defers response to DTSC.	DTSC’s settlement agreement with the Fort Mojave Indian Tribe did not preclude or in any way constrain the consideration of any remedial alternatives. DTSC’s direction to PG&E is to develop a CMS/FS report that is first and foremost technically sound and protective of human health and the environment. While there has been a reduction in staff work hours mandated by the Governor, selection of the groundwater remedy in an expedited manner is a top priority to DTSC and we are committed to dedicating the resources necessary to achieve this goal. In fact, an additional project manager has been added to DTSC’s team since the work reduction began to ensure adequate resources are available.		Comment addressed. No changes to the CMS/FS Report are required.

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	Comment Number	Section/ Page	Commenter	Comment	PG&E Response	DTSC Response	DOI Response	Final Comment Resolution
3	DTSC-1	Cover Letter	California Department of Toxic Substances Control	The cover letter indicates that the CMS/FS addresses only chromium. The document should also comment on the affect of remedial alternatives on molybdenum, selenium, and possibly nitrate as they are identified as COPCs in RCRA RFI/RI documents. At a minimum and regardless of the outcome of the risk assessment, the anticipated affect of the proposed chromium remedies on these three other COPCs should be discussed.	In response to this comment, Section 3.0 of the CMS/FS will be revised to include the results of the groundwater risk assessment and to discuss molybdenum, selenium, and nitrate in the development of non-numerical remedial action objectives, consistent with DTSC's July 8, 2009 direction to PG&E.	DTSC considers these to be COCs based on well by well risks. Where the HI is greater than 1, PG&E must address the risk.	DOI concurs with the response pending review of the revised language for approval.	Comment resolved following agency review and input during finalization of Section 3.0 of the CMS/FS Report text. Redline final submitted to agencies on November 13, 2009. Agencies approved the report revisions.
3.5	CRIT-48	General	Colorado River Indian Tribe via BLM	Michael Tsosie mentioned that greater clarification is needed on who needs to make decisions and identify the roles and responsibilities of those in power.	PG&E defers response to DTSC and DOI	DTSC will continue to be the lead agency overseeing PG&E's Topock Compressor Station environmental investigation and clean-up under the Resource Conservation and Recovery Act. Department of the Interior also has similar authority under the Comprehensive Environmental Response, Compensation, and Liability Act; therefore, DOI and DTSC will independently decide on the final remedial action for the AOC1, SWMU 1 and AOC 10 groundwater contamination. However, DTSC and DOI are in communication and partnership to ensure that the investigation and cleanup process is as integrated as possible. For DTSC, decision making authority over all activities related to the PG&E Topock Facility have been delegated to Karen Baker by the Acting Director, Maziar Movassaghi.	The investigation of site contamination, the evaluation of remedial alternatives, and the selection of site remedies are being undertaken under both State and federal law. DTSC and DOI are coordinating their respective State and federal requirements in an integrated CMS/FS process and approval of the CMS/FS report. Subsequent decisions concerning site remedies will be made independently by both DTSC and DOI, in consultation with tribes, with input from stakeholders and interested members of the public, and in accordance with the legal requirements applicable to DTSC and DOI, respectively.	Comment addressed. No changes to the CMS/FS Report are required.
Section 1 Comments - Introduction								
4	DTSC-2	Title page and rest of Report	California Department of Toxic Substances Control	Change title of CMS/FS to: Corrective Measures Study/Feasibility Study Report for SWMU/AOC 1 Contamination in Groundwater PG&E Topock Compressor Station Needles, California. Rest of Report: Change all occurrences of references to chromium groundwater to chromium groundwater from SWMU/AOC 1.	Due to the decision to incorporate data collected from the East Ravine into the target remediation area for chromium, no changes are proposed to the CMS/FS report title.	DTSC disagrees with PG&E's response and request that PG&E changes the CMS/FS title to reflect that the scope of the report is on contamination at AOC1, SWMU1 and AOC 10	DOI accepts the response	The report title was changed to "Groundwater Corrective Measures Study/Feasibility Study Report for SWMU 1/AOC 1 and AOC 10." Comment resolved. DTSC and DOI reviewed and accepted the report title revisions.
5	CRIT-4	Section 1 - report title	Envirometrix (on behalf of the Colorado River Indian Tribe)	Since this CMS/FS is only related to SWMU1 and AOC1, we recommend it is clearly stated in the title of the CMS/FS report.	Due to the decision to incorporate data collected from the East Ravine into the target remediation area for chromium, no changes are proposed to the CMS/FS report title.	See DTSC comment above.	The title should reflect that the CMS/FS is addressing Chromium in Groundwater. DOI accepts the response.	The report title was changed to "Groundwater Corrective Measures Study/Feasibility Study Report for SWMU 1/AOC 1 and AOC 10." Comment resolved. DTSC and DOI reviewed and accepted the report

TABLE C-1 RESPONSES TO COMMENTS
Comments on the January 27, 2009 *Draft Corrective Measures Study/Feasibility Study Report For Chromium In Groundwater*
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	Comment Number	Section/ Page	Commenter	Comment	PG&E Response	DTSC Response	DOI Response	Final Comment Resolution
								title revisions.
6	DTSC -3	Page 1-1, Paragraph 1	California Department of Toxic Substances Control	The CMS/FS only addresses chromium. PG&E should, at a minimum, evaluate affect of remedy alternatives to other COPCs identified in the RFI/RI Volume 2.	In response to this comment, Section 3.0 of the CMS/FS will be revised to include the results of the groundwater risk assessment and to discuss molybdenum, selenium, and nitrate in the development of non-numerical remedial action objectives, consistent with DTSC's July 8, 2009 direction to PG&E.	DTSC will await the final revised language to Section 3. DTSC, however, conceptually agrees with PG&E that the COCs of the CMS/FS will include non-numeric remedial action objectives for hexavalent chromium, molybdenum, selenium, and nitrate.	DOI concurs with the response pending review of the revised language for approval.	Comment resolved following agency review and input during finalization of Section 3.0 of the CMS/FS Report text. Redline final submitted to agencies on November 13, 2009. Agencies approved the report revisions.
7	DOI-1	Section 1.0, Page 1-1: Figure 1-1, flow diagram	U.S. Department of the Interior	Please insert separate boxes following the "CMS/FS" box that read "Proposed Plan," "Public Review and Comment," "ROD Issuance," and "Remedial Design."	In response to this comment, and also in consideration of comments #8 and #9, Figure 1-1 will be modified to add in the CERCLA Proposed Plan, the CERCLA Record of Decision, the RCRA Statement of Basis, and the Remedial Design steps.	Agree with RTC	DOI accepts the response and directs PG&E to make the changes to the document as proposed.	Comment resolved. Agencies approve PG&E response. Changes noted to Figure 1-1 in the response have been made to the CMS/FS Report.
8	HA-15	Section 1.0 Figure 1-1 Page 1-1	Hargis & Associates, Inc. (on behalf of Fort Mojave Indian Tribe)	Figure 1-1 in this section, illustrating the site cleanup process, should be revised to include the "RCRA Statement of Basis and CERCLA Record of Decision" step in the process. In addition, the arrow that illustrates the end of "Interim Measures" should not stop after the CMS/FS, but will likely have to continue through the CMI/Remedial Action.	In response to this comment, and also in consideration of comments #7 and #9, Figure 1-1 will be modified to add in the CERCLA Proposed Plan, the CERCLA Record of Decision, the RCRA Statement of Basis, and the Remedial Design Steps. The Interim Measure is shown as continuing until the Corrective Measure Implementation step.	Agree with RTC	DOI concurs with the response.	Comment resolved. Agencies approve PG&E response. Changes noted to Figure 1-1 in the response have been made to the CMS/FS Report.
9	CRIT-12	Section 1.0 Figure 1-1 Page 1-1	Envirometrix (on behalf of the Colorado River Indian Tribe)	**Figure 1-1** states that it represents the normal cleanup process. However, the current bifurcated process that is being conducted is significantly different from the normal process depicted on Figure 1. An additional figure should be included that illustrates the actual revised segmented process and the multiple RFI/RI, Risk Assessments and CMS/FS that will be conducted for clarification and comparison with the normal standard process.	In response to this comment, and also in consideration of comments #7 and #8, Figure 1-1 will be modified to add in the CERCLA Proposed Plan, the CERCLA Record of Decision, the RCRA Statement of Basis, and the Remedial Design steps. The process shown in Figure 1-1 applies to all SWMUs/AOCs at the Topock Compressor Station, whether they are addressed in RFI/RI Volume 2 Report or RFI/RI Volume 3 Report.	The current process does follow the normal cleanup process. Although we have tried to work in parallel instead of in series to expedite reaching final remedy. All conclusions are still reached after its appropriate process phase.	DOI recognizes the difficulties of the current process and has expressed concerns regarding the sequence. We do, however, concur with the response provided by PG&E.	Comment resolved. Agencies approve PG&E response. Changes noted to Figure 1-1 in the response have been made to the CMS/FS Report.
10	DOI-2	Section 1.1, Page 1-2	U.S. Department of the Interior	Please revise the second sentence of the first paragraph to read "The United States Department of the Interior (DOI) is the lead federal agency overseeing response action addressing the release of hazardous substances on or from land under its jurisdiction, custody, or control near the compressor station pursuant to CERCLA."	The sentence will be revised as requested.	Agree with RTC	DOI accepts the response and directs PG&E to make the changes to the document as proposed.	Comment resolved. Agencies approve PG&E response. Changes to Section 1.1 noted in the response have been made to the CMS/FS Report.
11	DOI-3	Section 1.1, Page 1-2	U.S. Department of the Interior	Please revise footnote one to read "Pursuant to the Administrative Consent Agreement between PG&E and the federal agencies, remedial actions at the site must comply with the requirements of CERCLA and the National Oil and Hazardous Substances Pollution Contingency Plan ((NCP), Title 40 of the Code of Federal Regulations Part	The footnote will be revised as requested.	Agree with RTC	DOI accepts the response and directs PG&E to make the changes to the document as proposed.	Comment resolved. Agencies approve PG&E response. Changes to the footnote in Section 1.1 noted in the response have been made to the CMS/FS

TABLE C-1 RESPONSES TO COMMENTS
Comments on the January 27, 2009 *Draft Corrective Measures Study/Feasibility Study Report For Chromium In Groundwater*
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	Comment Number	Section/ Page	Commenter	Comment	PG&E Response	DTSC Response	DOI Response	Final Comment Resolution
				300.”				Report.
12	DOI-4	Section 1.1, Page 1-2, Paragraph 3	U.S. Department of the Interior	Provide a figure showing all SWMUs for reference purposes.	In response to this comment, a Figure 1-2 will be added to Section 1.0 as Figure 1-2 (it will be the same as Figure 1-2 in the CMS/FS work plan).	Agree with RTC	DOI accepts the response and directs PG&E to make the changes to the document as proposed.	Comment resolved. Agencies approve PG&E response. Figure 1-2 added to the CMS/FS Report.
13	DOI-5	Section 1.1, Page 1-3	U.S. Department of the Interior	Please delete in its entirety the paragraph that begins "The DOI has led the solicitation and evaluation of applicable or relevant and appropriate requirements ..."	The paragraph will be revised as requested.	DOI to provide response.	DOI requests that the subject paragraph be replaced with “Applicable or relevant and appropriate requirements (ARARs) for the Topock site have been identified through an iterative process. A preliminary list of ARARs was issued by DOI in December 2007 (DOI 20007b), updated in June 2008 DOI 2008a), and updated again to reflect comments submitted on the Draft CMS/FS. The ARARs for the Topock site are listed in Appendix A of this CMS/FS.” DOI directs PG&E to make the change as proposed.	Comment resolved. The DOI text has been added to the CMS/FS Report as requested. and updated to include the ARARs list provided in October 2009. Redline final submitted to agencies on November 13, 2009. Agencies approved the report revisions.
14	DOI-6	Section 1.1.1, Page 1-3, Paragraph 1, Footnote 2	U.S. Department of the Interior	The agencies have not yet approved PG&E’s recommendations in the RFI/RI Volume 2 regarding SWMU 2. Revise the footnote to read ”Based on site history and site characterization data, the RFI/RI Volume 2 report recommended that SWMU 2 (Inactive Injection Well PGE-8) not be carried forward into this CMS/FS.”	As of February 2009, both DTSC and DOI have approved the recommendations in the RFI/RI Volume 2 Report for SWMU 2. The report will be revised to state: “Based on site history and site characterization data, SWMU 2 (Inactive Injection Well PGE-8) will not be carried forward into this CMS/FS.”	Agree with RTC	DOI accepts the response and directs PG&E to make the changes to the document as proposed.	Comment resolved. Agencies approve PG&E response. Changes to Section 1.1.1 noted in the response have been made to the CMS/FS Report.
15	DTSC-4	Page 1-3, Paragraph 1, Section 1.1.1 and rest of Report.	California Department of Toxic Substances Control	The sentence, *“At the time of publication of this Draft CMS/FS, DTSC and DOI have approved neither the RFI/RI Volume 2 report nor its Addendum.”,* will need to be updated. The latest or final version of the RFI/RI Volume 2 and its Addendum should be cited in the revised CMS Report. The Addendum should also be cited when the Report makes general reference to RFI/RI conclusions.	This paragraph will be updated to cite the final version of the RFI/RI Volume 2 Report and agency approvals of RFI/RI Volume 2 Report; this paragraph will also be updated to cite the final version of the RFI/RI Volume 2 Addendum and agency approvals of RFI/RI Volume 2 Addendum.	Agree with RTC	DOI concurs with the response pending review of the final text.	Comment resolved following agency review and input during finalization of the CMS/FS Report text. Redline final submitted to agencies on November 13, 2009. Agencies approved the report revisions.
16	DOI-7	Section 1.1.1, Page 1-3, Paragraph 2, Sentence 2	U.S. Department of the Interior	Volume 3 addresses the remaining AOCs/UAs, including any soil and (presumably) groundwater impacts. Revise 2^{nd} sentence to read “RFI/RI Volume 3 will include final characterization data to complete the RFI/RI requirements for remaining Topock Compressor Station operations, including the results of Investigations of all other AOCs and undesignated areas.”	The sentence will be revised as requested.	Agree with RTC	DOI accepts the response and directs PG&E to make the changes to the document as proposed.	Changes to Section 1.1.1 noted in the response have been made to the CMS/FS Report, as further modified by DTSC (see comment 453).
17	DTSC-5	Page 1-3, Paragraph 2, Section 1.1.1	California Department of Toxic Substances	Due to the newly identified groundwater contamination in the East Ravine area, DTSC is concerned how the proposed remedial alternatives may affect the contamination at East	As directed by DTSC and DOI, initial data collected from the East Ravine area (as of July 2009) will be incorporated into the site hydrogeologic characterization and the target area for Cr(VI) remediation. The remedial alternatives in the	Agree with RTC, but caution that the final remedy should not exacerbate the contamination either in lateral or vertical extent.	East Ravine is to be included in the CMS/FS evaluation under the direction of DOI and DTSC. DOI concurs with the response pending review of the appendix	Comment resolved following agency review and input during finalization of the

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	Comment Number	Section/ Page	Commenter	Comment	PG&E Response	DTSC Response	DOI Response	Final Comment Resolution
			Control	Ravine. DTSC recommends further discussion regarding this issue.	CMS/FS report will be revised to address the updated Cr(VI) target remediation area.		and additional CMS/FS alternative text for approval.	CMS/FS Report text. Redline final submitted to agencies on November 13, 2009. Agencies approved the report revisions.
18	DOI-8	Section 1.1.1, Page 1-3, Paragraph 5, Sentence 2	U.S. Department of the Interior	Clarification is needed to address the absence of a federal or California standard for Cr(VI). Revise 2nd paragraph to read "This document addresses chromium contamination in groundwater resulting from the historic discharge of wastewater to the percolation beds in Bat Cave Wash. The area of the chromium plume is approximately 90 acres. Concentrations of Cr(T) in groundwater are greater than federal and California regulatory standards, and concentrations of Cr(VI) exceed background levels [there are no federal or California regulatory standards for Cr(VI) in groundwater]. Based on Cr(VI) concentrations detected in groundwater at the site, the ongoing groundwater risk assessment is expected to find that Cr(VI) in groundwater poses an unacceptable risk. A determination will be made at the conclusion of the ongoing groundwater risk assessment as to whether the additional groundwater COPCs (molybdenum and selenium) identified in the Revised Final RFI/RI Volume 2 report, will need to be addressed in the CMS/FS.	The subject paragraph will be revised in the following manner: (1) the first sentence will be clarified to note that the chromium contamination in East Ravine is also addressed in this document; (2) the area of the chromium plume in the second sentence will be modified to incorporate data collected from the East Ravine wells; and (3) as the risk assessment will be completed at the time of the Final CMS/FS, the last sentence will be clarified to state that the results of the risk assessment have been incorporated into the report.	Agree with RTC, will await final language.	DOI concurs with the response pending review of the revised text for approval	Changes to Section 1.1.1 noted in the response have been made to the CMS/FS Report, as further modified by DTSC (see comment 454).
19	DOI-9	Section 1.1.2, Page 1-3, Paragraph 1, Sentence 2	U.S. Department of the Interior	It has been discussed that the IM may be retained during implementation of the remedy as a backup hydraulic control system, and one of the alternatives involves operation of the IM system. Revise sentence to read "Implementation of the IM is expected to continue at least until a final corrective action/remedial action is operating and performing successfully."	In response to this comment, and also in consideration of comments #20 and #21, this sentence will be revised as follows: "Implementation of the IM is expected to continue until a final corrective action/remedial action for the site is operating properly and successfully, and the regulatory agencies terminate the requirement for IM."	Agree with RTC as revised	DOI accepts the response.	Comment resolved. Agencies approve PG&E response. Changes to Section 1.1.2 noted in the response have been made to the CMS/FS Report.
20	DTSC-6	Page 1-3, Paragraph 6, Section 1.1.2	California Department of Toxic Substances Control	The sentence (and any other related sentences throughout the Repot) should be modified as follows: "*Implementation of the IM is expected to continue until a final corrective action/remedial action is in place at the site and functioning adequately.*"	In response to this comment, and also in consideration of comments #19 and #21, this sentence will be revised as follows: "Implementation of the IM is expected to continue until a final corrective action/remedial action for the site is operating properly and successfully, and the regulatory agencies terminate the requirement for IM."	Agree with RTC as revised	DOI concurs with the comment response.	Comment resolved. Agencies approve PG&E response. Changes to Section 1.1.2 noted in the response have been made to the CMS/FS Report.
21	SDCWA-2	Section 1.1.2 Page 1-3	San Diego County Water Authority	The second sentence states, "Implementation of the IM is expected to continue until a final corrective action/remedial action is in place at the site". It should also be noted that the IM would continue until the final corrective action/remedial action has proven to be in place and working as planned.	In response to this comment, and also in consideration of comments #19 and #20, this sentence will be revised as follows: "Implementation of the IM is expected to continue until a final corrective action/remedial action for the site is operating properly and successfully, and the regulatory agencies terminate the requirement for IM."	Agree with RTC as revised	DOI concurs with the comment response.	Comment resolved. Agencies approve PG&E response. Changes to Section 1.1.2 noted in the response have been made to the CMS/FS Report.

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	Comment Number	Section/ Page	Commenter	Comment	PG&E Response	DTSC Response	DOI Response	Final Comment Resolution
22	DOI-10	Section 1.1.2, Page 1-3, Paragraph 2	U.S. Department of the Interior	All Interim Measures (IM-1, and IM-2) need to be addressed and discussed.	In response to this comment, the following sentence will be added: "The Interim Measure at the Topock site has held various designations since 2004 as IM-1, IM-2 and IM-3, which collectively are refereed to in this report as the Interim Measure or IM."	Agree with RTC.	DOI accepts the response and directs PG&E to make the changes to the document as proposed.	Comment resolved. Agencies approve PG&E response. Changes to Section 1.1.2 noted in the response have been made to the CMS/FS Report.
23	DOI-11	Section 1.1.2, Page 1-4, Bullet 2	U.S. Department of the Interior	Anaerobic core testing of floodplain sediments is mentioned here. A comparison of the reducing capacity of floodplain sediments compared to the mass of Cr(VI) in the plume would be useful in evaluating remediation alternatives in the floodplain. Is there sufficient organic carbon to reduce the entire mass of Cr(VI) in the plume? This discussion could be near the beginning of section 5.0.	In response to this comment, the following will be added to Section 2.3.2: "The estimate of total plume Cr(VI) mass is approximately 34,000 pounds. Using this value and assuming a total porosity of 0.35 and soil particle density of 2.65 grams per cubic centimeter, the range of measured capacities (CH2M Hill 2007 - the Phase II Anaerobic Core Study) indicates that between 3.1 and 13.5 million cubic feet of anaerobic aquifer material would be needed to reduce all of the Cr(VI) in the plume. To determine if such a volume of material is available, the following calculations can be made. The plume width along Park Moabi Road is approximately 2,300 feet, and the thickness of anaerobic fluvial material (based on groundwater data) ranges from 40 to 80 feet in the floodplain. Assuming 2,300 feet by 60 feet as the average cross-sectional area through which historical plume groundwater flowed into anaerobic material, the measured capacities indicate that the west-to-east length of aquifer required to reduce all plume Cr(VI) is between 23 and 98 feet. This constitutes a relatively narrow strip of the known anaerobic zone of the floodplain, which stretches about 400 feet east to west. These calculations, although only approximate, suggest that there is capacity within the floodplain and beneath the river to reduce at least a significant portion of the Cr(VI) plume were the plume to reach the anaerobic portions of the floodplain and beneath the river."	Agree with RTC. However, see comment 68.	DOI accepts the response and directs PG&E to make the changes to the document as proposed.	Comment resolved. Proposed revisions to Section 2.3.2 further modified to include revised estimated plume mass. Redline final submitted to agencies on November 13, 2009. Agencies approved the Section 2.3.3 revisions as modified by DTSC (see comment 469).
24	DOI-12	Section 1.1.2, Page 1-4, Bullet 4	U.S. Department of the Interior	These studies have not necessarily addressed the permeability of bedrock at each boring location, nor do seismic surveys address permeability. Not all bedrock has been shown to have low permeability. Revise bullet to read "Soil borings and seismic surveys to determine presence of and depth to bedrock."	The sentence will be revised as requested.	Agree with RTC	DOI accepts the response and directs PG&E to make the changes to the document as proposed.	Comment resolved. Agencies approved PG&E response. Changes noted in the response to bullet in Section 1.1.2 have been made to the CMS/FS Report.
25	DOI-13	Section 1.1.2, Page 1-4, Paragraph 1	U.S. Department of the Interior	The Cr isotope study should be mentioned here.	In response to this comment, the following bullet will be added to Section 1.1.2: • "Chromium isotope study to evaluate isotope results in on-site and off-site wells."	Agree with RTC	DOI accepts the response and directs PG&E to make the changes to the document as proposed.	Comment resolved. Proposed revisions to bullet in Section 1.1.2 further modified. Redline final submitted to agencies on November 13, 2009. Agencies approved the Section

TABLE C-1 RESPONSES TO COMMENTS
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								1.1.2 revisions.
26	DTSC-7	Page 1-4, Section 1.2	California Department of Toxic Substances Control	The section on the history of wastewater discharge should also acknowledge the various PG&E spills to Bat Cave Wash that have been documented to occur periodically.	The text below from the RFI/RI Volume 2 Report will be added to Section 1.2, second paragraph: "In addition, there have been several incidental releases of facility wastewater, a few of which have resulted in wastewater released to Bat Cave Wash, as described in the RFI/RI Volume 1 Report (CH2M HILL, 2007a)."	Agree with RTC	DOI concurs with the response.	Comment resolved. Agencies approved PG&E response. Changes to Section 1.2 noted in the response have been made to the CMS/FS Report.
27	DOI-14	Section 1.2, Page 1-4, Paragraph 2, Sentence 1	U.S. Department of the Interior	AOC 1 consists of the floor of Bat Cave Wash and the area affected by the flow of wastewater from the former percolation bed. Portions of AOC 1 extend beyond the area "just west of the Topock Compressor Station". Revise the 1st sentence of the 2nd paragraph to read "SWMU 1 consists of the area that was formerly the site of wastewater percolation. AOC 1 includes that portion of the floor of Bat Cave Wash that surrounds SWMU 1 and has been affected by flow of wastewater from the percolation bed.	PG&E proposes to revise the first sentence of the second paragraph in Section 1.2 to the text below to be consistent with text from the RFI/RI Volume 1 Report: "SWMU 1 was formerly the site of wastewater percolation within Bat Cave Wash. AOC 1 is defined as areas affected by flow of wastewater from the percolation bed, including the floor of Bat Cave Wash in the area surrounding the location of the discharge area (SWMU 1) and the floor of Bat Cave Wash downstream from the discharge area towards the Colorado River."	Agree with RTC as revised	DOI continues to support defining the AOC based on the results of the soil sampling DOI concurs with the response.	Comment resolved. Agencies approved PG&E response. Changes to Section 1.2 noted in the response have been made to the CMS/FS Report.
28	CRIT-10	Section 1.3	Envirometrix (on behalf of the Colorado River Indian Tribe)	How and when will the potential threat to groundwater be evaluated and incorporated into this groundwater remedy as a result of any potential soil contamination that remain and may act as a continued source of contamination to the groundwater? Are there chemicals in soil at or near AOC 1 that may possibly impact groundwater in the future? Recently, significant elevated levels of Dioxin were reported at AOC-4. Is this a potential treat to groundwater? Are elevated levels of Dioxin present in groundwater?	As stated in Sections 1.0 and 2.0 of the CMS/FS Report, and as summarized in the RFI/RI Volume 2 report, the primary source of groundwater contamination at the site is the former discharge of wastewater to Bat Cave Wash between 1951 and 1964. While there may be some ongoing source(s) within the soils in the former percolation bed and/or other locations near the compressor station, these sources are likely to be minimal in comparison to the past wastewater discharge. The current soils investigations will provide more information on the nature and extent of soil contamination and the RFI/RI Volume 3 Report (and associated risk assessment), which encompasses the full RCRA/CERCLA evaluation including evaluation of soils as a potential source to groundwater, will provide conclusions about additional remedial action objectives (RAOs), if any, associated with the transport pathway of soil contamination migrating to groundwater. The groundwater characterization at the site is documented in the Final RFI/RI Volume 2 Report. While much of the data collection and evaluation for the groundwater focused on characterization of constituents most associated with blowdown water discharged to Bat Cave Wash, many groundwater samples from wells within the plume area and near the compressor station were analyzed for a wide list of analytical parameters including total petroleum hydrocarbons (TPHs), trace metals, volatile organic compounds (VOCs), semi-volatile organic compounds (SVOCs), polychlorinated biphenyls (PCBs), perchlorate, and radionuclides. Subsequent to the final RFI/RI Volume 2 Report, additional samples from wells near the compressor station and AOC 4 were also analyzed for dioxins and furans, polynuclear aromatic hydrocarbons (PAHs), pesticides, PCBs, SVOCs, and TPHs, and the results were all below reporting limits.	Agree with RTC. Will evaluate final language of CMS/FS.	DOI concurs with the response.	Comment addressed. Agencies approved PG&E response. No changes to the CMS/FS Report are required.

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28.5	CRIT-42	Section 1.3	Colorado River Indian Tribe via BLM	There is a need for a cumulative assessment as well.	See response to comment #28			Comment resolved as noted above in response to comment #28.
29	CRIT-11	Section 1.3	Envirometrix (on behalf of the Colorado River Indian Tribe)	For clarification purposes, did the Final Corrective Measures Workplan that was approved by DTSC and DOI as referenced in Section 1.3 indicate that only Chromium in groundwater was to be evaluated and only for AOC-1 for this CMS/FS? In response to our previous January 9, 2009 comment No. 13 regarding this question PG&E states that the remedial action objectives have been updated from what was presented in the workplan. Please provide clarification of what has actually changed from the approved workplan rather than simply stating that some items have been updated. It is further stated in Section 1.3 that "the purpose of this document is to identify and evaluate the remedial alternative that will ultimately lead to the selection of a final remedy". Since this CMS/FS only evaluates a remedial alternative for chromium in groundwater, it is important to stress this point consistently throughout all associated text in the document and not give the impression that this CMS/FS is anything more than that limited groundwater remedy.	A copy of the Final CMS/FS Work Plan is available on DTSC's Web site at: http://www.dtsc-topock.com/resources/CMS_FS/CMS_FSWorkPlan/CMFSWorkPlan_Final_3-6-08.pdf The Final CMS/FS Work Plan identified the SWMUs/AOCs and media to be addressed in both the RFI/RI Volume 2 Report and RFI/RI Volume 3 Report. The Final CMS/FS Work Plan states that separate CMS/FS reports would be prepared based on the conclusions of the RFI/RI reports. The Final CMS/FS Work Plan states that the principal contaminant in groundwater is hexavalent chromium associated with the historical operational practice of wastewater discharge to Bat Cave Wash, but that if additional sources of groundwater contamination and groundwater constituents of concern (COCs) are identified, the CMS/FS Report will be revised to incorporate that information. The CMS/FS Work Plan states that as the conclusions of the RFI/RI and risk assessments were not complete at the time of the work plan date, the RAOs as identified in the CMS/FS Work Plan are not final. In the Draft CMS/FS Report, two objectives pertaining to compliance with location-specific applicable or relevant and appropriate requirements (ARARs) were removed (although ARARs compliance remains a threshold remedial alternative evaluation criteria), and the objectives associated with reducing concentrations of COCs have been re-worded to focus more specifically on exposure routes and cleanup levels. The second sentence in Section 1.0 and the second sentence in the second paragraph in Section 1.3. will be revised to state: "The purpose of this document is to identify and evaluate remedial alternatives and to provide the basis for the selection of a recommended alternative to address the defined objectives for this remedial action." Due to the decision to incorporate data collected from the East Ravine into the target remediation area for chromium, no changes are proposed to the CMS/FS report title. In response to this comment, Section 3.0 of the CMS/FS Report will be revised to include the results of the groundwater risk assessment and to discuss molybdenum, selenium, and nitrate in the development of non-numerical remedial action objectives, consistent with DTSC's July 8, 2009 direction to PG&E.	Changes to the title of the report is required, see comment 4.	DOI concurs with the response pending review of the revised text for approval.	The report title was changed to "Groundwater Corrective Measures Study/Feasibility Study Report for SWMU 1/AOC 1 and AOC 10." Comment resolved following agency review and input during finalization of the CMS/FS Report text. Redline final submitted to agencies on November 13, 2009. Agencies approved the report revisions.

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30	CRIT-3	Section 1.3	Envirometrix (on behalf of the Colorado River Indian Tribe)	We are concerned that this CMS/FS is extremely limited in scope and is being conducted for only chromium in groundwater. From presentations and information provided in Consultative Work Group (CWG) meetings, it appears that this CMS/FS may be further limited to only hexavalent chromium in groundwater and only related to Solid Waste Management Unit (SWMU) 1/Area of Concern (AOC) 1. Our concern is that this is a piecemeal approach to a final remedy selection. One complete groundwater remedy should be considered that is protective of human health and the environment. If additional groundwater contamination was found (i.e. East Ravine) as a result of current investigations, this proposed groundwater remedy would need to be significantly altered or expanded. What will PG&E propose if additional Chromium groundwater contamination is found in other areas? What will PG&E propose if chemicals in addition to chromium are found in groundwater? What will DTSC and DOI require if additional contamination or chemicals are found in groundwater that required remediation? We are concerned that the CMS/FS is also being prepared out-of-sequence in advance of completing the RFI/RI for soil and groundwater and the Human and Ecological Risk Assessments. How can DTSC or DOI make any conclusions regarding the CMS/FS without first reviewing and evaluating the risk assessments? We find it extremely difficult to review and evaluate the CMS/FS without first reviewing the risk assessments. Further, this piecemeal approach will significantly impact evaluations being conducted under the California Environmental Quality Act (CEQA) for the Environmental Impact Report (EIR) related to the assessment of impacts and not adequately evaluate potential cumulative impacts, since a complete project description is not known. It appears that the project is being divided into smaller pieces that do not account for the projects overall impacts. How does DTSC intend to evaluate this action and the cumulative impacts including the potential contribution from contaminated soil? How does DTSC justify that this is not piecemealing? PG&E's response to our previous January 9,2009 comment No 4 states the following: • DTSC was responsible for and made a decision to accelerate the CMS/FS. • DTSC was responsible for and made the	In response to this comment and results of investigation activities in East Ravine in 2009, the CMS/FS Report will be revised to update the Cr(VI) target area and hydrogeologic characterization to include data from the East Ravine. The East Ravine data summary will be included in an appendix to the Final CMS/FS Report. Alternatives will be developed and evaluated to address the updated Cr(VI) target volume. It is recognized that additional data will be collected at the site during future characterization activities for completion of the RFI/RI Volume 3 Report; during future design activities for the remedial action, as well as during future monitoring activities both prior to and during implementation of the remedial action. PG&E does not believe it is prudent to delay addressing the Cr(VI) contamination in groundwater because of these future data collection activities. It is typical at remediation sites that changes to the remedial action are incorporated during the design and implementation phases in response to more recent data or changes in site conditions subsequent to the CMS/FS Report. A robust groundwater investigation has been performed that evaluated constituents most associated with blowdown water discharged to Bat Cave Wash, but also included many groundwater samples from wells within the plume area and near the compressor station analyzed for a wide list of analytical parameters including TPH, trace metals, VOCs, SVOCs, PCBs, perchlorate, and radionuclides. Subsequent to the Final RFI/RI Volume 2 Report, additional samples from wells near the compressor station and AOC 4 were also analyzed for dioxins and furans, PAHs, pesticides, PCBs, SVOCs, and TPHs, and the results were all below reporting limits. These additional constituents were not found in groundwater at levels that warrant remedial action. Additional characterization of the site is ongoing for completion of RFI/RI Volume 3 Report. These investigations will provide more information on the nature and extent of soil contamination. The RFI/RI Volume 3 Report (and associated risk assessment) which encompasses the full RCRA/CERCLA evaluation including evaluation of soils as a potential source to groundwater, will provide conclusions about additional RAOs, if any, associated with the transport pathway of soil contamination migrating to groundwater. Based on the conclusions of the RFI/RI Volume 3 Report there may be additional RAOs that may result in a separate remedial action or the modification of the current remedial action. The division of the site as currently proposed is not uncommon at remediation sites. Much emphasis has been placed in recent years on reforming USEPA policies for remediation sites to phase site remediation programs to focus resources on the areas or pathways of highest concern (e.g., Corrective Action Advance Notice of Proposed Rulemaking, USEPA Results-based Approaches and Tailored Oversight Guidance document (USEPA 530-R-03-	DTSC and DOI agree that PG&E should review the data set and evaluate all chemicals of concern for groundwater at the site instead of focusing solely on hexavalent chromium. Based on the review of the risk assessment, DTSC understands that the predominant risk driver for the groundwater is from the current concentration and mass of hexavalent chromium in groundwater. Therefore, DTSC is in support of a timely decision on the groundwater remedy to remove the toxic risks associated with hexavalent chromium. DTSC and DOI, however, are exploring the relationship between AOC1/SWMU1 release at the Bat Cave Wash and the East Ravine contamination. To the extent possible, DTSC agrees that a single remedial action should be selected as final remedy. However, it is undeniable that the majority of the contaminant mass resides in the upland and floodplain at the site and shares stakeholder desires to control and protect the Colorado River from the predominant risk as quickly as possible. It has been and continues to be DTSC objective to complete the investigation and remedy selection by following sound science and proper technical understanding. Without compromising this objective, DTSC was willing to look at the existing process and try all means possible to increase efficiency in reaching the final decision	(same as DTSC)	Comment resolved following agency review and input during finalization of the CMS/FS Report text. Redline final submitted to agencies on November 13, 2009. Agencies approved the report revisions. The results of the East Ravine Groundwater Investigation have been added as Appendix A to the Final CMS/FS Report, and the target volume for Cr(VI) has been revised based on the data collected in the East Ravine.

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				decision to conduct the RFI/RI and risk assessment out of sequence. • DTSC was responsible and made a decision directing PG&E to only focus on chromium in groundwater for this groundwater CMS/FS. For purposes of the administrative record, we would like additional clarification and verification from DTSC that these statements and the decisions made by DTSC are accurate. We would also like additional clarification if DOI has provided a similar decision and approval related to current process, since it significantly deviates from a normal corrective action process. We question why there is any actual need to be conducting this limited groundwater CMS/FS remedy at this time?	012 September 2003)).			
30.3	CRIT-36	Section 1.3	Colorado River Indian Tribe via BLM	What about the East Ravine? PG&E addresses carbon because it helps their case.	In response to this comment and results of investigation activities in East Ravine in 2009, the CMS/FS Report will be revised to update the Cr(VI) target area and hydrogeologic characterization to include data from the East Ravine. The East Ravine data summary will be included in an appendix to the Final CMS/FS Report.	Agree with RTC.	DOI concurs with the response pending review of the appendix and additional CMS/FS alternative text for approval	Comment resolved following agency review and input during finalization of the CMS/FS Report text. Redline final submitted to agencies on November 13, 2009. Agencies approved the report revisions. The results of the East Ravine Groundwater Investigation have been added as Appendix A to the Final CMS/FS Report, and the target volume for Cr(VI) has been revised based on the data collected in the East Ravine.
30.5	CRIT-38	Section 1.3	Colorado River Indian Tribe via BLM	He pointed out that PG&E is only treating for Cr, but what about dioxins, lead, arsenic, etc. in the water that is headed toward the river. T • BLM response: Yes PG&E has a narrow scope of contamination but as new information is brought forward it is sharing this information with the regulators to discuss and evaluate concerns about other Contaminants of Concern's (COC).	As discussed in RFI/RI Volume 2 Report, while the data collection and evaluation for the groundwater focused on characterization of constituents most associated with blowdown water discharged to Bat Cave Wash, many groundwater samples from wells within the plume area and near the compressor station were analyzed for a wide list of analytical parameters including TPH, trace metals, VOCs, SVOCs, PCBs, perchlorate, and radionuclides. The data were evaluated in the RFI/RI Volume 2 Report and the groundwater risk assessment. The data evaluation concluded that there is no complete groundwater-surface water pathway and that the primary risk driver for remediation- not associated with the river but associated with hypothetical future water supply wells - is from Cr(VI). Subsequent to the Final RFI/RI Volume 2 Report, additional samples from wells near the compressor station and AOC 4		It should be noted that the additional sampling for dioxins and furans was at the direction of DTSC and concurrence by DOI in response to the results of the AOC 4 investigation. DTSC agreed to the specific wells that were sample for this endeavor.	It is noted that the additional samples from wells near the compressor station and AOC 4 were collected and analyzed at the direction of DTSC and concurrence by DOI in response to the results of the AOC 4 investigation. Comment addressed. Agencies approved PG&E response. No changes to the CMS/FS

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					were also analyzed for dioxins and furans, PAHs, pesticides, PCBs, SVOCs, and TPH, and the results were all below reporting limits.			Report are required.
30.8	CRIT-41	Section 1.3	Colorado River Indian Tribe via BLM	He argues we should not separate Cr VI issue from East Ravine or the AOC 4; they are all related.	See responses to comments #28, 30, 30.3 and 30.5.		DOI concurs with the response pending review of the appendix and additional CMS/FS alternative text for approval	Comment resolved following agency review and input during finalization of the CMS/FS Report text. Redline final submitted to agencies on November 13, 2009. Agencies approved the report revisions.
Section 2 Comments - Description of Current Conditions								
31	SDCWA-3	Section 2.1 Page 2-1	San Diego County Water Authority	The fourth sentence states, “The compressor station is still active and is anticipated to remain an active facility into the foreseeable future.” It should also be stated for the unaware reader that the active facility no longer contributes to the Chromium VI concern, when it was ceased being used in the facility processes, and refer to the RFI/RI documents where this is fully discussed.	In response to this comment, the following text will be added to Section 2.1: “As discussed in Section 1.2, the station has not released untreated blowdown water containing Cr(VI) since 1964, and there have been no wastewater discharges to the percolation bed in Bat Cave Wash since 1971.” The following sentence will be added to the second-to- last paragraph in Section 1.2: “Since 1989, industrial wastewater from the compressor station has been disposed at the Class II (double-lined) evaporation ponds.”	Agree with RTC	DOI accepts the response.	Comment resolved. Agencies approved PG&E response. Changes to Section 2.1 and 1.2 noted in the response have been made to the CMS/FS Report.
32	HA-7	Section 2.1.1	Hargis & Associates, Inc. (on behalf of Fort Mojave Indian Tribe)	<u>4. Tribal Ownership of Property within the Site</u> PG&E is currently in the process of transferring the property on which the IM3 is located to the Tribe, in accordance with the Settlement Agreement between PG&E and the Tribe.[12] The land transfer is anticipated to be completed in March 2009. Therefore every reference to the land “owners” in the CMS/FS must include the Tribe.[13] [12] See *Fort Mojave Indian Tribe v. DTSC, et al.,* Sacramento Superior Court Case No. 05CS00437. [13] For further details regarding this land transfer, contact Steven P. McDonald, Esq., Tribal Counsel, at 858-551-1185.	Appropriate references to the FMIT as owner of the IM-3 property will be included in the final document, pending completion of the title transfer. It is anticipated that title to the property described in PG&E’s response as the IM-3 property will be transferred to the Ft. Mojave Tribe in 2009. An update on the status of the property transfer will be provided prior to completion of the Final CMS/FS.	PG&E should provide cut off date on information included in the document if the land transfer is still pending. State “as of preparation of the CMS/FS.	DOI concurs with the response	Comment resolved. Section 2.1.1 and Figure 2-2 have been modified to reflect the land transfer of parcel 650-151-06 in October 2009. DTSC and DOI reviewed and accepted these revisions.
33	CRIT-13	Section 2.1.1 Page 2-1	Envirometrix (on behalf of the Colorado River Indian Tribe)	PG&E's previous response to our January 9, 2009 comment No. 15 states, *The only property transfer within the boundaries of the APE that PG&E is aware of is the transfer of the parcel known as the IM No. 3 Site from PG&E to the*	It is anticipated that title to the property described in PG&E's response as the IM-3 property will be transferred to the Ft. Mojave Tribe (FMIT) in 2009. The transfer is part of a global settlement of litigation brought by the FMIT against DTSC, the Metropolitan Water District and PG&E. Immediately after		DOI concurs with the response.	Comment resolved. Section 2.1.1 and Figure 2-2 have been modified to reflect the land transfer of parcel 650-

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				FMIT. PG&E anticipates this will occur within the next 30 days. The property being transferred is subject to a site-wide easement that allows PG&E to install any remediation facilities required by state or federal regulatory agencies, conduct required remediation activities and other actions required to achieve final cleanup. The particulars of the easement are contained in the easement document which will be a recorded public document and copies will be provided to interested parties on request. The land transfer was not considered in the development of the discussion draft CMS/FS. We believe that a discussion of the land transfer and easement is significantly relevant in order to verify that PG&E has not agreed to any restrictions that could limit the operation of the current IM 3 facility, limit the expansion of the IM 3 facility or limit the construction of a new facility on this land. We would like to know if both DOI and DTSC were provided an opportunity to review the language contained in this easement document prior to being finalized. Why were stakeholders including CRIT not provided any opportunity to review this easement document? It appears that no meaningful input was desired early in the process, prior to any decisions being made. CRIT and other stakeholders were excluded from the process, and our input was not considered relevant or important. We are formally requesting that a copy of this document be provided to CRIT. Further, will this easement be brought before the California Public Utility Commission for approval? If so, when?	the settlement had been reached, PG&E briefed the Colorado River Indian Tribe (CRIT) leadership on its terms and provided a copy of the settlement agreement. The agreement, easement, and other relevant documents were filed with the Superior Court of Sacramento County and are of public record. A formal request for permission to transfer the IM-3 land was submitted to the California Public Utilities Commission (CPUC) under the provisions of Public Utilities Code Section 851 that sets out the standards and process for transfer of Utility properties. The settlement agreement and easement documents were filed with the CPUC along with briefing on the subject. A notice of the proceeding was sent to all interested parties including the CRIT and was published pursuant to required regulations. The CRIT filed an opposition to the transfer and then before the decision was issued withdrew the objection to the transfer. No other comments or objections were received by the CPUC, which then issued an order transferring the property. It is anticipated that title to the property described in PG&E's response as the IM-3 property will be transferred to the Ft. Mojave Tribe in 2009. An update on the status of the property transfer will be provided prior to completion of the Final CMS/FS.			151-06 in October 2009. DTSC and DOI reviewed and accepted these revisions.
34	DTSC-8	Page 2-1, Paragraph 5, Section 2.1.2	California Department of Toxic Substances Control	The section on land use should mention the presence of the surrounding wildlife refuge.	The following paragraph will be added to Section 2.1.2 (consistent with RFI/RI Volume 1 Report): "The HNWR encompasses approximately 37,515 acres along the Colorado River in Mohave and La Paz Counties, Arizona and in San Bernardino County, California (USFWS, 2006). Most of the refuge extends from the upper end of Topock Marsh southward to the head of Lake Havasu on the Arizona side of the river. A small portion of the refuge borders the compressor station. Recreational activities at the HNWR include sightseeing, bird watching, fishing, hunting, camping, and canoeing."	Agree with RTC	DOI concurs with the comment response	Comment resolved. Changes to Section 2.1.2 noted in the response have been made to the CMS/FS Report, as further modified by DTSC (see comment 458).
35	DTSC-9	Page 2-1, Paragraph 5, Line 4 Section 2.1.2	California Department of Toxic Substances Control	Minor edit to the following sentence*: "Open space near the uplands portion of the site is characterized primarily by sparse desert vegetation on elevated mesas and steep, rocky slopes."*	The sentence will be revised as requested.	Agree with RTC		Comment resolved. Agencies approved PG&E response. Changes to Section 2.1.2 noted in the response have been made to the CMS/FS Report.

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36	CRIT-14	Section 2.1.2 Page 2-1	Envirometrix (on behalf of the Colorado River Indian Tribe)	Section 2.1.2. PG&E's previous response to our January 9, 2009 comment No. 16 states, *PG&E is not aware of any disadvantaged communities in the area near the Topock Compressor Station. No environmental justice concerns have been identified to PG&E.* For PG&E to simply state that they are not aware of any disadvantage communities an environmental justice concern does not meet the basic standard of care to determine if such communities or concerns exist. This is the responsibility of PG&E and also DTSC to determine if these communities exist. We would like additional clarification and assurance from both PG&E and DTSC that no disadvantaged communities or environmental justice concerns exist in the area. We would also like to know what the definition of a "community" is.	PG&E is committed to working diligently to address all environmental justice issues, including any related to the ongoing investigation and cleanup at the Topock Compressor Station. To do so, PG&E and California state regulators have communicated with residents of nearby communities, including those communities at Moabi Regional Park and the Topock Marina, regarding ongoing investigative and proposed cleanup activities. Under California law, environmental justice is defined as "the fair treatment of people of all races, cultures and incomes with respect to the development, adoption, implementation, and enforcement of environmental laws, regulations and policies." It is similarly defined in guidance by the USEPA as "the fair treatment and meaningful involvement of all people regardless of race, color, national origin, or income with respect to the development, implementation, and enforcement of environmental laws, regulations, and policies." PG&E has worked to ensure the fair treatment and meaningful involvement of all nearby communities such that they all have the opportunity to participate in the decision-making process related to the investigation and cleanup at the Topock Compressor Station. The 2007 Public Participation Plan for the Topock Compressor Station discusses both the outreach conducted by PG&E in neighboring communities, including questionnaires and interviews, and the public participation opportunities for members of these communities, including options for briefings, presentations and meetings with DTSC; fact sheets; public notices; public meetings; public comment periods; site tours; mailing lists; information repositories; the Topock Web site; and contact persons. The interested public will also have an opportunity to provide input to final remedy selection as part of the public involvement process for DTSC's environmental review under the California Environmental Quality Act. Similarly, interested American Indian Tribes are participating in the remedy selection process through numerous vehicles, including but not limited, to government-to-government consultation and the Topock Leadership Partnership.	Agree with RTC.	DOI will continue to work with DTSC and PG&E to ensure neighboring communities, stakeholder, and interested Tribes are informed about the Topock Compressor Station activities and provided opportunities for input during the remedy selection process.	Comment resolved. Agencies approved PG&E response. No changes to the CMS/FS Report are required.
37	DTSC-10	Page 2-5, Paragraph 2, Line 1 Section 2.1.2	California Department of Toxic Substances Control	Minor edit to the following sentence as not all residences are located within mobile home parks*: "The nearest communities are mobile home parks and private residences at Topock, Arizona and Moabi Regional Park, California.*	The sentence will be revised as requested.	Agree with RTC	DOI concurs with the response.	Comment resolved. Agencies approved PG&E response. Changes to Section 2.1.2 noted in the response have been made to the CMS/FS Report.
38	SDCWA-4	Section 2.1.2 Page 2-5	San Diego County Water Authority	In the second paragraph to this section, third sentence, "1.5 mile" should be "1.5 miles".	The sentence will be revised as requested.	Agree with RTC	DOI concurs with the comment response.	Comment resolved. Agencies approved PG&E response. Changes to Section 2.1.2 noted in the response have been made to the CMS/FS

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								Report.
39	DOI-15	Section 2.2.3, Page 2-6, Paragraph 3	U.S. Department of the Interior	In the first of the paragraph, change "…upstream flow regulation" to "BOR power and water delivery schedule." Change the beginning of second sentence to read as follows, "The flow of the Colorado River at Topock is regulated by BOR by the controlled release of water from Davis Dam on Lake Mohave…"	The text will be altered slightly to maintain consistency with the RFI/RI Volume 2 Report. The maintenance of the water level at Lake Havasu also influences the flow, although to a lesser degree. The first two sentences of this paragraph are proposed as follows: "The flow of the Colorado River is dynamic and fluctuates daily and seasonally as a result of BOR power and water delivery schedule. The flow of the Colorado River at Topock is regulated by BOR, primarily by the controlled release of water from Davis Dam on Lake Mohave approximately 33 miles upstream."	Agree with RTC	DOI accepts the response and directs PG&E to make the changes to the document as proposed.	Comment resolved. Agencies approved PG&E response. Changes to Section 2.2.3 noted in the response have been made to the CMS/FS Report.
40	DOI-16	Section 2.2.5 Page 2-14 Paragraph 1	U.S. Department of the Interior	Rewrite this paragraph to read as follows: The hydrogeologic conditions of the site described below are summarized from the RFI/RI Volume 2 Report (CH2M HILL, 2009). The site is located at the southern downstream end of the Mohave Valley groundwater basin. Groundwater in the Mohave Basin occurs in the Tertiary and younger alluvial fan and fluvial deposits. The unconsolidated alluvial and fluvial deposits are underlain by the Miocene Conglomerate and pre-Tertiary metamorphic and igneous bedrock. The bedrock typically has very low permeability; therefore, groundwater movement occurs primarily in the overlying unconsolidated deposits. In the Colorado River Basin, water-bearing zones may occur locally where bedrock formations are weathered or fractured, although no areas have been identified in the Mohave groundwater basin where saturated bedrock formations are capable of yielding significant quantities of groundwater	The suggested changes will be incorporated.	Agree with RTC	Pending review of the final text, DOI accepts the response and directs PG&E to make the changes to the document as proposed.	Comment resolved. The suggested changes have been incorporated in Section 2.2.5 with slight revisions. to maintain consistency with the RFI/RI Volume 2 Report. Redline final CMS/FS Report was submitted to agencies on November 13, 2009. Agencies approved the report revisions.
41	DOI-17	Section 2.2.5 Page 2-14 Paragraph 2	U.S. Department of the Interior	Rewrite this paragraph to read as follows: Groundwater occurs under unconfined to semi-confined conditions within the alluvial fan and fluvial sediments beneath most of the site. The alluvial fan consists primarily of low permeability clayey/ silty sand and clayey gravel deposits interbedded with more permeable sand and gravel deposits. The alluvial deposits exhibit considerable variability in hydraulic conductivity within the individual layers. The fluvial sediments similarly consist of interbedded sand, sandy gravel, and silt/clay. The fluvial deposits at the site include the permeable Pleistocene to recent fluvial deposits associated with the Colorado River. The saturated portion of the alluvial fan and fluvial sediments are collectively referred to as the Alluvial Aquifer.	The text will be altered slightly to maintain consistency with the RFI/RI Volume 2 Report. The clay- and silt-containing sand and gravel deposits were not classified as low permeability. The second paragraph is proposed as follows: "Groundwater occurs under unconfined to semi-confined conditions within the alluvial fan and fluvial sediments beneath most of the site. The alluvial sediments consist primarily of clayey/ silty sand and clayey gravel deposits interfingered with more permeable sand and gravel deposits. The alluvial deposits exhibit considerable variability in hydraulic conductivity between fine- and coarse- grained sequences. The fluvial sediments similarly consist of interbedded sand, sandy gravel, and silt/clay. The fluvial deposits at the site include the permeable Pleistocene to recent fluvial deposits associated with the Colorado River. The saturated portion of the alluvial fan and fluvial sediments are collectively referred to as the Alluvial Aquifer."	Agree with RTC	DOI accepts the response and directs PG&E to make the changes to the document as proposed.	Comment resolved. Agencies approved PG&E response. Changes to Section 2.2.5 noted in the response have been made to the CMS/FS Report.

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42	DOI-18	Section 2.2.5 Page 2-14 Paragraph 4	U.S. Department of the Interior	Delete this paragraph after revising Paragraphs 1 and 2 as stated above.	The suggested changes will be incorporated.	Agree with RTC	Pending review of the final text, DOI accepts the response and directs PG&E to make the changes to the document as proposed.	Comment resolved. Agencies approved PG&E response. Changes to Section 2.2.5 noted in the response have been made to the CMS/FS Report.
43	DOI-19	Section 2.2.5 Page 2-18	U.S. Department of the Interior	The first bullet on this page discusses total dissolved solids (TDS). TDS maps need to be included with the document showing the areal and vertical distribution of TDS. The TDS is important because it can be used to indicate whether or not the alluvial aquifer at the site contains potable water. The document states that TDS in excess of 3,000 mg/L is not suitable for a drinking water supply. Indicate where the alluvial aquifer contains water with TDS concentrations in excess of 3,000 mg/L.	The RFI/RI Volume 2 Report Section 5.3.1.4 contains a detailed TDS distribution discussion with maps (Figures 5-18a, b, c) and cross section (Figure 5-19). In response to this comment, a reference to the TDS discussion in the RFI/RI Volume 2 Report will be added.	DTSC disagrees with the statement "broad description of natural TDS concentrations that make the groundwater generally unusable as a drinking water source." The groundwater at this basin is designated for beneficial uses and portions of the shallow aquifer contain potable water that exhibits TDS quality greater than that found in the Colorado River. Although at some depth, the groundwater has high TDS and is unlikely to be used for drinking water, the aquifer is currently being used by Park Moabi in California. See response below.	The reference to groundwater being "generally unusable" is incorrect. Groundwater in the area is currently being used by Park Moabi. Revise the response.	Comment resolved following agency review and input during finalization of Section 2.2.5 of the CMS/FS Report text. Redline final submitted to agencies on November 13, 2009. Agencies approved the report revisions.
44	DTSC-11	Page 2-18, Paragraph 3, Line 5 Section 2.2.5	California Department of Toxic Substances Control	Please delete the following sentence as was done for the RFI/RI. Please note that the majority of the shallow portion of the alluvial aquifer yields TDS values below 3,000 mg/L (See RFI/RI Figure 5-18a):	In response to this comment, suggested changes will be incorporated to describe TDS concentrations consistent with the RFI/RI Volume 2 Report, and the reader will be referred to the RFI/RI Volume 2 Report for TDS distribution maps. References to SWRCB Policy 88-63 will be removed as requested.	PG&E should not generally characterize a beneficial use aquifer as "unusable as a drinking water source…" DTSC conceptually agrees with proposed revision, however, a review of the final CMS/FS language for consistency with RFI/RI is needed.	DOI concurs with the response.	Comment resolved following agency review and input during finalization of Section 2.2.5 of the CMS/FS Report text. Redline final submitted to agencies on November 13, 2009. Agencies approved the report revisions.
45	DOI-20	Section 2.2.5 Page 2-18	U.S. Department of the Interior	Last sentence of 2.2.5 should be changed to "The majority of the alluvial aquifer does not exhibit reduced conditions."	The suggested changes will be incorporated.		DOI accepts the response and directs PG&E to make the changes to the document as proposed.	Comment resolved. Agencies approved PG&E response. Change to Section 2.2.5 noted in the response have been made to the CMS/FS Report.
46	DOI-21	Section 2.2.6, Page 2-19, Paragraph 2, Sentence 2	U.S. Department of the Interior	The following sentence seems to not make sense: "*Additionally, segments of the United States Route 66 (1926 -1947 and 1947-1966 alignments) associated features of segments of the pre-1926 alignment of United States Route 66 (National Old Trails Road) are historic properties listed on the NRHP. The right-of-way of the Atlantic and Pacific/Atchison, Topeka and Santa Fe Railroad has been determined to be eligible for listing on the NRHP. Route 66 and the railroad are located overlying the plume.*"	The subject sentence has been revised as follows: "Segments of the United States Route 66 (1926 -1947 and 1947-1966 alignments) and associated features of segments of the pre-1926 alignment of United States Route 66 (National Old Trails Road) are historic properties listed on the NRHP."	Please see DTSC replacement language for Section 2.2.6	DOI accepts the response and directs PG&E to make the changes to the document as proposed.	DTSC and DOI have re-written Section 2.2.6 and provided language to be published in this section, which deleted the subject sentence.

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47	HA-16	Section 2.2.6 Page 2-18	Hargis & Associates, Inc. (on behalf of Fort Mojave Indian Tribe)	This section is deficient in that it only addresses archeological sites.[25] Tribal heritage resources and sacred landscape concerns are not addressed. When and by whom were Maze Loci B and C determined eligible for the National Register of Historic Places? The Tribe was not invited to participate in that apparent determination. A key aspect of that determination for the Tribe would be the area and cultural components that were included. [25] See, for example, pp. 2-18 and 2-19.	The purpose of the section is to provide general background on cultural resources, and it appears that area tribes have differing perspectives on this issue, including with respect to the significance of the Maze and surrounding project vicinity. The report entitled Cultural Resources Investigation for Interim Measures No. 3: Topock Compressor Station Expanded Groundwater Extraction and Treatment System, San Bernardino County, California prepared by CH2M HILL in July 2004, recommended Loci B and C as eligible to the National Register. Subsequently, the IM No. 3 Cultural Resources Management Plan for the Topock Compressor Station Expanded Groundwater Extraction and Treatment System for San Bernardino County, California ("CRMP") provides for PG&E to prepare complete documentation of Loci B and C and to submit National Register of Historic Preservation nomination forms to the California Office of Historic Preservation. The BLM has requested that PG&E take into consideration the ethnographic study provided for in the CRMP (which will "focus on the Topock Maze and vicinity as a cultural landscape") in the development of the nomination forms. The BLM is in the process of developing a scope of work for the ethnographic study. Additionally, the nomination process for Loci B and C will provide an opportunity for additional input.	Please see DTSC replacement language for Section 2.2.6 Under California law, the EIR, not the CMS/FS, is the appropriate place to analyze the impacts of the project on cultural resources. DTSC will apply all of the CEQA criteria for historical resources, including the following per the CEQA guidelines: " Any object, building, structure, site, area, place, record, or manuscript which a lead agency determines to be historically significant or significant in the architectural, engineering, scientific, economic, agricultural, educational, social, political, military, or cultural annals of California may be considered to be an historical resource, provided the lead agency's determination is supported by substantial evidence in light of the whole record."	DOI accepts the response and recognizes that noting something as a cultural landscape does not mean that it is eligible for the National Register of Historic Places (NRHP). Once the National Register nomination process for Loci B and C are underway, the participating tribes will be given an opportunity to contribute their local knowledge of the importance of these areas based on oral history and other sources.	Comment resolved. DTSC and DOI have re-written Section 2.2.6 and provided language to be published in this section.
48	HA-1	Section 2.2.6	Hargis & Associates, Inc. (on behalf of Fort Mojave Indian Tribe)	<u>1. FMIT Cultural Considerations</u> As the Tribe has stressed from the very beginning and has communicated repeatedly since the first official engagement by the California Department of Toxic Substances Control (DTSC) and the U.S. Department of the Interior (DOI), the Topock Site, including the area of the Compressor Station, the nearby Maze, and the entire surrounding landscape (above, of or from, and below ground) are of paramount cultural and religious significance to the Tribe as well as to other Indian tribes in the area.[2] To date, significant desecration to this area has occurred as a result of the historic activities associated with PG&E's Topock Compressor Station, as well as highways and the railroad. Moreover, the desecration is continuing as a result of this investigation and the proposed remedial actions that will follow. [2] It is important to remember that known cultural artifacts are only physical evidence partially documenting the spiritual importance of the landscape to the Tribe. While such artifacts have importance in themselves, it is the cultural landscape within which the artifacts are located that has the deepest importance to the Tribe, and the desecration of this landscape, not simply the disturbance or destruction of artifacts that needs	The purpose of the section is to provide general background on cultural resources, and it appears that area tribes have differing perspectives on this issue, including with respect to the significance of the Maze and surrounding project vicinity. An ethnographic study "focusing on the Topock Maze and vicinity as a cultural landscape" is provided for by the IM No. 3 Cultural Resources Management Plan for the Topock Compressor Station Expanded Groundwater Extraction and Treatment System for San Bernardino County, California ("CRMP"). The BLM is in the process of developing a scope of work for the ethnographic study. The BLM has directed PG&E to work with all tribes in preparation of this study which may be used to evaluate these issues further, including whether the area meets National Register criteria for a cultural landscape.	DTSC understands that the FMIT has strong cultural concerns for the entire Topock area. Those concerns will be taken into account in the CEQA analysis as discussed in the response to Question 47.	DOI accepts the response and adds that as of July 8, 2009 a second draft of the Scope of Work for the Ethnographic Study is in preparation, and will be sent to all consulting parties for review and comment when available. As part of the ethnographic/ethno historic study, interested tribes will have an opportunity to discuss and document why existing cultural artifacts and archaeological sites in the APE comprise only the physical aspect while also discussing their views concerning the greater spiritual importance of the landscape and its need for protection. We recognize that the Fort Mojave Indian Tribe has a specific tribal history and story to share concerning the APE and BLM is interested in hearing the story of your cultural history.	Comment addressed. Agencies approved PG&E response. No changes to the CMS/FS Report are required.

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				to be, and must be, acknowledged. The slightest changes to the landscape can have great effects in spiritual dimensions that cannot be experienced or fully understood clearly in this time or life.				
49	HA-2	Section 2.2.6	Hargis & Associates, Inc. (on behalf of Fort Mojave Indian Tribe)	1a. Past Lack of Consideration of Tribal Cultural Values The ways in which the Tribe has suffered as a result of the actions directed by DTSC and DOI, and carried out by PG&E, cannot be fully or even adequately described in words. Since the Tribe began active participation in this project, it has become increasingly aware of the disruptive activities that have been carried out throughout the history of the Site. These discoveries reveal an appalling level of disrespect to the sacred landscape. The Tribe has suffered extreme sadness and anguish as a result of such disrespectful actions as, for example: the construction of the Interim Measures No. 3 (IM3) water treatment plant; installation of more than one hundred monitor and test wells and borings across the Area of Potential Effect (APE); constant, day-to-day intrusions by vehicles and personnel; and the presence and daily operations of the Compressor Station itself. Because of the Tribe's strong cultural ties to the area, the Tribe is suffering, and will continue to suffer from the remedy, no matter what remedy is selected. For the other stakeholders, the remedy is principally a discussion of measures to reduce hypothetical risks. But for the Tribe, the impacts are real and continuing. Every day there is an invasion and desecration of the Tribe's cultural area, resulting in further insult to the Tribe. DTSC and DOI must recognize and acknowledge that such desecration has happened and continues to occur. DTSC and DOI should have already and certainly now must proceed to consult directly with the Tribe to seek a remedy designed to avoid and minimize further continuing desecration, while continuing to protect the River. The Tribe has previously asked DTSC to expand the land use description section within the Groundwater Remedial Field Investigation/Remedial Investigation (RFI/RI) regarding the impacts to the landscape and to the Tribe. The Tribe understands that DTSC instead directed PG&E *not* to include any additional discussion on the basis that this document was a data presentation and that such information would be presented in the context of a California Environmental Quality Act (CEQA) analysis. Similarly, during the review of the	Implementation of the IM is expected to continue until a final corrective action/remedial action for the site is operating properly and successfully, and the regulatory agencies terminate the requirement for IM and allow PG&E to remove the facilities in place at the site. PG&E intends to continue with its consultation obligations as set out in the agreement settling the lawsuit brought by the FMIT within the context of responding to the directives of the DTSC and DOI. PG&E understands that the DOI is conducting government-to-government consultations with the Tribes (including during late April-early May 2009) on the Draft CMS/FS Report to ensure that the Tribe's views are taken into consideration. PG&E respects the various Tribal views and has and will continue to work diligently to consult with the Tribes on the completion of the CMS/FS Report.	DTSC understands that FMIT has expressed concerns that cultural impacts have occurred and continue to occur at Topock and that those impacts have been felt deeply by members of the Tribe. To the extent possible under the CEQA guidelines, those concerns will be taken into account in the CEQA analysis as discussed in the response to Question 47.	DOI accepts the response and adds that DOI will continue to expect IM #3 to be in place until a final remedy is put in place and functional, noting a final remedy may include continued use of the IM #3 facility. DOI understands that the tribe has expressed that they are suffering and commits to ensure that our representatives will be respectful while working and traveling through the area. BLM is providing formal consultation to all nine tribes on behalf of the federal agencies. This government-to-government consultation, which includes the NHPA Section 106 consultation, has taken place both in written and face-to-face oral form.	Comment addressed. Agencies approved PG&E response. No changes to the CMS/FS Report are required.

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				discussion draft of the CMS/FS, the Tribe offered additional, clarifying language regarding the description of cultural resources. This time, PG&E declined to incorporate the text revisions, again deferring resolution to a later point in the process. The Tribe strongly believes that presentation of this type of information is critical now because the CMS/FS will be used to support the remedial decision. Failure to include such a discussion and failure to directly consult with the Tribe on a government-to-government basis effectively precludes reasoned consideration of each remedy's potential compliance with threshold applicable or relevant and appropriate requirements (ARARs). These ARARs are designed to be protective of the Tribe's cultural and spiritual interests. Without meaningful and proper consultation with the Tribe to ascertain its input, DTSC and DOI will remain incapable of correctly evaluating ARAR compliance.				
50	HA-3	Section 2.2.6	Hargis & Associates, Inc. (on behalf of Fort Mojave Indian Tribe)	1b. Recognition of Tribal Values The above incident of DTSC's unwillingness to expand the section on cultural significance of the affected area is indicative of a much larger problem with the process. Tribal members often express frustration over the inadequacy of the English language to convey their true feelings of sadness and the nature of the impact to their holy grounds. So it is perhaps appropriate at this time to remind all of the stakeholders what is truly at stake here for the Tribe in the most poignant words available. These words have been passed down through Aha Makav elders via oral tradition: "The Mojave, whose true name is *Aha Makav*, means "people of the river," carry on life in the land given by our Creator, Mutavilya. We are one of seven river people whose origins begin from the high mountain called "Avi Kwa' Ame." In beginning time, as told through the oral traditions passed from one generation to the next, our ancestors' wisdom came from the understanding that all things created explain the meaning of our reality: the river, the mountains, the animal, the plants and the order of things above and below the earth and including the people. An unspoken spiritual relationship comprises the world as we see it. We are a living culture and have immense responsibility as caretakers of all living things in our domain. Before the arrival of Europeans, the Mojave thought of this land as its country and its countless places along and distant from the Colorado River. The song cycles sung of the various clans depict the journey of our people to	PG&E respects the Tribes views and intends to work with the FMIT and other Tribes under the direction of the BLM, as stated in the response to Comment Nos. 48 and 49.	DTSC's appreciates FMIT's ongoing efforts to express their cultural heritage and their concerns about how the project may affect cultural resources. To the extent possible under the CEQA guidelines, these concerns will be taken into account in the CEQA analysis as discussed in the response to Question 47.	DOI would like to thank you for providing your thoughts and perspective on this area. This information will be captured in the ethnographic/ethno historic study. Direct consultation with all the tribes will continue, including the Fort Mohave Indian Tribes.	Comment resolved. No changes to the CMS/FS Report are required.

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				places far and beyond. Our land base stretched as far north as Las Vegas to the south (Phoenix area), and east into Kingman and as far west to the Pacific Coast. This was our territory and traditional homeland and continues to be an integral part of our continued existence. Today, the Mojave live in separate patches of land within three states -- California, Arizona and Nevada. This diminished land base, a creation of the federal government and established though executive orders, is what is left of the vast territory that was once our area. *Our direct affiliation with the land, air, the earth’s plants and creatures, and most importantly the water, form the basis of our core belief. Nature and the universe are at the root of everything. It defines who we are as Mojave in a holistic spiritual way. We have many areas of cultural and spiritual connection all up and down the river valley. The connection is our way of life and represents our well-being as a people. The significance of our being is expressed through our strong language, clan, and oral history. We can never depart from the commandments by which we have been taught. We understand our true role and responsibility as caretakers in the scheme of the whole and work to maintain balance with nature. The land forever remains a critical and vital part of our existence. Holy places created hold reverence to our people.* *In reference to the place we know as the “shadow land,” “entrance into the next dimension,” we embrace it with high importance and protection. This place, known as the Topock Maze area, is a holistic, sacred ground. The word Topock itself is a Mojave word reference. Today, this place has been defiled with dishonor by those who do not understand our life ways. We ask that our spiritual area be honored with utmost respect as decisions are made to the cleanup project of hexavalent chromium contamination. The desecration must stop.”*[3] Tribal members maintain that, as creatures living in this world, no living people can fully understand the sacred area, nor be fully aware of the consequences of its desecration. In their belief, only at the time a person's spirit passes through the Maze and acquires a different level of spiritual knowledge, can that person understand the extent of the impact. To the FMIT, nothing can remedy the desecration of the area, but at the very least the CMS/FS must recognize the Tribe’s strong and continuing				

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				cultural affiliation to the area and recommend actions to accommodate this belief. [3] These words were prepared by the Aha Makav Cultural Society, and only tells a part of the story. A direct consultation with the Tribe and its elders is essential to a more complete understanding.				
51	CRIT-26	Section 2.2.6	Envirometrix (on behalf of the Colorado River Indian Tribe)	Our previous January 9, 2009 comment No. 35 stated that we also have serious concerns over the construction any new larger treatment system at the PG&E compressor station because it may not be respectful of the resources that are of special significance to CRIT in the area. We again support an ethnographic study for the site to be conducted early in the process. PG&E's response states, *Please see the response to Comment No.* 25 *for a discussion of PG&E's position with regard to the performance of an ethnographic study. That position notwithstanding, it would be helpful to PG&E (and, we believe, to the regulatory agencies) to understand whether the CRIT could provide meaningful information on the resources of special interest to the CRIT within the project area outside the context of an ethnographic study.* As previously stated by CRIT, it is our desire to provide information on Tribal cultural and sacred religious information related to resources of special interest to CRIT through the preparation of an Ethnographic Study. That is the method and process that CRIT wants to convey this information. To date, both PG&E and DTSC have chosen a path to not actually desire any concrete definition of what are the actual Tribal perspectives and issues on cultural and religious sacred concerns. Rather PG&E and DTSC continue to seek information from various individuals that may not actually represent the views of the Tribal government. We have repeatedly tried to explain the importance of obtaining concrete, verifiable, accurate, documented information that represent the position of the Tribal government so that progress on the project and the selection of the final remedy will not be delayed. The above-referenced response by PG&E continues to supports our concern and frustration that PG&E and DTSC just does not get the point and connection why obtaining a formal documented Tribal government position has always been fundamentally important to the project and the selection of a final remedy.	An ethnographic study "focusing on the Topock Maze and vicinity as a cultural landscape" is provided for by the IM No. 3 Cultural Resources Management Plan for the Topock Compressor Station Expanded Groundwater Extraction and Treatment System for San Bernardino County, California ("CRMP"). PG&E discussed with the CRIT and others how such a study would be prepared and by whom. On October 8, 2008, BLM advised PG&E that it would not accept an ethnographic study performed by the CRIT as satisfying the CRMP requirements, stating that the agency would instead conduct its own ethnographic study. The BLM distributed a draft Scope of Work for the ethnography study on December 23, 2008, seeking comments, including comments from area Tribes. PG&E provided comments on January 26, 2009, and is aware that certain Tribes have likewise provided comments on the draft Scope of Work. PG&E understands that the DOI is conducting government-to-government consultations with the Tribes (including during late April-early May 2009) on the Draft CMS/FS Report to ensure that the Tribe's views are taken into consideration.	DTSC cannot require an ethnographic study to be performed as part of this remediation project. However, DTSC has initiated a series of discussion with the tribes with respect to the cultural considerations for the EIR, which is the appropriate document for the discussion of cultural values with respect to the remedy evaluation. DTSC encourages the CRIT to provide your cultural viewpoints to us for EIR considerations.	DOI accepts the response and as called for in the Topock CRMP, all 9 tribes must be given an opportunity to contribute to the ethnographic/ethno historic study.	Comment addressed. Agencies approved PG&E response. No changes to the CMS/FS Report are required.

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52	CRIT-18	Section 2.2.6	Envirometrix (on behalf of the Colorado River Indian Tribe)	Cultural resources continue to play a key and significant role in this project. However, to date there appears to be a lack of interest by both PG&E and DTSC to solicit clarification and definition on specific cultural resource and religious sacred concerns. This approach has resulted in repeated delays on the project. This lack of clarity and definition on specific cultural resource and religious sacred concerns limits potential remedy alternatives. Please explain why this information is not relevant in the CMS/FS remedy decision making process. We believe that waiting for the EIR to address these issues is too late in the process.	Please see response to Comment Number 51.	DTSC is interested in the cultural viewpoints of all tribes as we proceed toward final remedy. DTSC encourages the Tribes to provide all cultural viewpoints to us for EIR considerations.	The CMS/FS is included under the CERCLA process which is relevant for the Federal portion of the project. The EIR is part of the RCRA process; thus, it is necessary to incorporate this comment under both sides of the process. Waiting for the EIR is not too late to address issues and concerns but is part of the process. As called for in the Topock CRMP, all 9 tribes must be given an opportunity to contribute to the ethnographic/ethno historic study.	Comment addressed. No changes to the CMS/FS Report are required.
53	CRIT-19	Section 2.2.6	Envirometrix (on behalf of the Colorado River Indian Tribe)	CRIT has previously stated and documented that they strongly desired to conduct an ethnographic study to provide factual verifiable information, clarity and definition on cultural resource and religious sacred concerns that could be used to understand, evaluate and implement investigations, work activities and proposed remedial alternatives in a manner that is respectful of, and causes minimal disturbance to, cultural resources including, in particular, resources that are of special interest to CRIT in the area. In order to address and facilitate the required activities under both the Environmental Impact Report (EIR) as well as this CMS/FS, CRIT prepared an ethnographic study work plan in September 2008. On October 20, 2008, CRIT prepared a letter to DTSC describing our concerns regarding the delays by PG&E in funding the preparation of an ethnographic study. At that time, we were well aware that the only way to implement remedial actions in a manner that is respectful of, and causes minimal disturbance to, cultural resources including, in particular, resources that are of special significance to CRIT was to have meaningful information in the form of an ethnographic study from any tribe who desired to prepare one. Since 2005, the DTSC administrative record has documented that DTSC had a long-standing commitment to support the preparation of an independent ethnographic study by any potentially impacted Tribe who desired to conduct such a study. However, to date, both PG&E and DTSC have ignored our request. Statements made by DTSC in the past indicating that cultural resources that are of special significance to tribes in the area will be	Please see response to Comment Number 51.	Although DTSC believes all cultural viewpoints on the project area will be beneficial for our decision making. DTSC can not require an ethnographic study to be performed and funded by PG&E as part of this remediation project. However, DTSC has initiated a series of discussion with the tribes with respect to the cultural considerations for the EIR, which is the appropriate document for the discussion of cultural values with respect to the remedy evaluation. DTSC encourages the CRIT to provide your cultural viewpoints to us for EIR considerations regardless of the format which the information is received.	BLM is extremely interested in obtaining the Colorado River Indian Tribes perspective as part of the ethnographic study. In other words, we recognize that the Colorado River Indian Tribes has an important story to share about their cultural and religious beliefs in the context of this sacred area, and the BLM wants to hear it. However, all tribal input will be encouraged and no tribal input will be given priority over any other tribe. We appreciate the Colorado River Indian Tribes continued effort to keep the ethnographic/ ethno historic study in the forefront. The Colorado River Indian Tribes do understand what is culturally and religiously significant and meaningful to their Tribes. BLM has taken over the administration of the ethnographic/ ethno historic study utilizing a third party contractor who will try to obtain tribal perspectives from all 9 tribes. The desired goal is to obtain a comprehensive, all inclusive and succinct ethnographic/ ethno historic study that will represent all 9 tribes' view points, including their concerns over cumulative impacts (actual or perceived) to cultural properties within the APE. BLM appreciates the Colorado River Indian Tribes' efforts to bring forth a Statement of Work for their ethnographic study. BLM is interested in obtaining the information that the Colorado River Indian Tribes have assembled to be included as part of the ethnographic/ ethno historic study.	Comment addressed. No changes to the CMS/FS Report are required.

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				interpreted and evaluated by the DTSC EIR contractor are not appropriate. CRIT understands what is culturally and religiously significant and meaningful to the Tribe and the method that CRIT wishes to present this information is through the preparation of an ethnographic study. Since DTSC and PG&E do not appear to want this meaningful information to be prepared by CRIT, how has DTSC and PG&E evaluated and determined what is culturally and religiously significance to the Tribal governments in the area? PG&E's response to our previous January 9, 2209 comment No 25 states, *it is not accurate to state that that PG&E has "ignored" the CRIT's request for funding to perform an ethnographic study of the Topock project area. PG&E is prepared to fund the reasonable and customary costs of performing such a study; however, the decision on whether, and how, to proceed with such a study rests with the primary regulatory agencies overseeing the cleanup.* It may be more accurate and correct to state that PG&E has not supported CRIT's request for funding to perform an ethnographic study as PG&E initially agreed. *Section 3.1.1 of the Cultural Resources Management Plan (CRMP) for PG&E's Interim Measures 3 Treatment Plant requires that PG&E fund the preparation of an ethnographic study. When the CRIT expressed interest in preparing an ethnographic study for use in DTSC's preparation of the Environmental Impact Report, PG&E believed that such an effort could also satisfy the CRMP requirement for preparation of an ethnographic study.* It was always the single intention of CRIT to prepare an ethnographic study for the EIR process. This information could be used during the preparation of the EIR to evaluate potential impacts related to cultural resources and religious sacred concerns associated with each remedy alternative. We recognized that this would assist regulatory agencies in the decision making process when evaluating potential remedy decisions. We always understood that cultural resources would play a significant role in the remedy decision. Therefore, CRIT desired to provide a level of factual verifiable and documented information related to traditional cultural beliefs so that decision makers could make informed decisions. However, it was				

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				PG&E's desire to try to link and combine the CRMP and EIR ethnographic study together. That was never the intention of CRIT. Each is considered a separate and distinct issue. *With this possibility in mind, PG&E advised the CRIT to provide both PG&E and the U. S. Bureau of Land Management (BLM) with a proposal for an ethnographic study.* At the request of PG&E, CRIT prepared and submitted a proposal to PG&E for preparation of an ethnographic study related to the EIR. It is incorrect to state that CRIT was also requested to provide a copy to BLM. It was PG&E's desire to try to make one document serve two purposes. *PG&E supported the CRIT ethnographic study proposal as satisfying the CRMP requirement. BLM's views regarding the CRIT proposal were provided in a letter dated October 8, 2008 to Mr. Daniel Eddy, Chairman of the Colorado River Indian Tribes from David Jaynes, BLM's Acting Field Manager. In that letter, BLM stated that "…given the sovereignty of individual federally recognized tribes, the BLM does not feel that a study produced by one tribe could be considered to be representative of the views and beliefs of other sovereign tribes without prior agreement by all concerned tribal nations. " The letter goes on to note that "... BLM finds no technical fault with the recently proposed study, but feels that any such study could only be considered representative of the tribe which produced it" and that "…BLM has determined that the interests of all concerned parties would be best served if an external contract entity such as university or research firm was used to complete an ethnographic study." BLM further notes in their letter their opinion that "... the completion of an ethnographic study of the Topock Remediation Project area by an outside party would address the concerns, beliefs, and values of all concerned tribes and stakeholders in an impartial manner. Each concerned tribe could participate in the study to the degree they feel appropriate. This would allow each participant to provide whatever materials and information deemed appropriate and necessary by each tribe." The BLM letter concludes with BLM's commitment to "... work with all concerned parties, including Pacific Gas and Electric, who will fund the study, to select an outside entity to perform the ethnographic study." Following the issuance of the BLM letter, DTSC on October 24, 2008, advised the CRIT and PG&E that it would not*				

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				require an ethnographic study as part of the EIR process. In light of the positions taken by the two regulatory agencies directing PG&E's remediation efforts at Topock, PG&E respectfully declined the CRIT's request to fund the ethnographic study as proposed in a letter from Robert Howard of PG&E to Chairman Eddy dated November 6, 2008. In that letter, PG&E stated its belief that the most promising path forward would be for the CRIT to work with the BLM to make sure the Tribe's views and concerns are taken into consideration, along with those of the other tribes, in BLM's development of its broad ethnographic study. Our understanding is that BLM has provided the stakeholder tribes with a statement of work to perform the ethnographic study, and has requested the tribe's review of and comment on that document. We have previously stated in correspondence to PG&E, that the ethnographic study, related to the CRMP, is a separate issue. Since 2005, the DTSC administrative record has been clear and documented that DTSC had a long-standing commitment to support the preparation of an independent ethnographic study by any potentially impacted Tribe who desired to conduct such a study. To date, CRIT has repeatedly requested that PG&E fund this ethnographic study. CRIT has prepared and submitted a proposal to PG&E as requested. CRIT understood from the administrative record that DTSC supported and understood the value of an ethnographic study in the decision making process. We also understood that since cultural resource and religious sacred concerns continued to play an important role in all aspects of the project and that in the past numerous delays were the result of cultural resource issues that PG&E, DTSC and DOI desired to have documented and verifiable information regarding cultural issues. While the lack of preparation of this ethnographic study may be beneficial to some entities in order to limit costs and limit potential remedial alternatives, CRIT does not share that same belief. The CMS/FS study states in a number of areas that the location of treatment facilities must also consider areas of the site that are culturally and religiously significant so that construction or other disturbance is minimized to the extent feasible. In addition to the information provided in the CRMP, what are the areas that PG&E and DTSC have determined to be culturally and religiously significant? What is the documentation that				

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				describes these areas? CRIT is requesting copies of documentation that PG&E and DTSC have created in order to answer this question. This information and documentation can be provided directly to CRIT if considered confidential. Since it does not appear that PG&E has any interest in taking the initiative to fund a CRIT ethnographic study without receiving specific instruction and direction from DTSC, we are again formally requesting that DTSC and/or DOI provide specific direction to PG&E to fund the CRIT ethnographic study related to the EIR and evaluation of potential remedy alternatives. PG&E has stated that they are waiting for direction from DTSC or DOI prior to funding this effort. We are requesting that DTSC or DOI provide this clear direction to PG&E.				
54	HA-27	Section 2.2.6	Hargis & Associates, Inc. (on behalf of Fort Mojave Indian Tribe)	Appendix F – PG&E Response to FMIT Specific Comment No. 1 The assertion that some tribes may lack sensitivity towards the Tribe's cultural area has no bearing on the FMIT's cultural view in general or specifically regarding the Topock area. Therefore, the Tribe's proposed language was factual when making a general statement and specific to the FMIT when discussing sacred values and should not be subject to substantive revision by other tribes who are free to submit their own viewpoints for consideration. The Tribe also disagrees with BLM's apparent view that a formal ethnographic study is needed to determine eligibility of Maze Loci B and C or the landscape as a whole and challenges BLM to explain the basis for this view, which seems to imply that BLM does not believe that the tribes are telling the truth about their cultural beliefs. The Tribe is concerned that the ethnographic study is being used as an excuse not to consider cultural ARARs within the CMS/FS and put them off until some undetermined time in the future. This will only result in avoidable, and unfortunate, program delays.	Please see response to Comment Number 50.	In preparing the CEQA analysis DTSC is consulting with all affected tribes. DTSC is aware that tribes may have different cultural traditions and different concerns. Potential impacts to cultural resources of concern to each tribe will be taken into account in the cultural resources analysis. It is possible that a resource may be important to one tribe but not another tribe. Even if a resource is important to only one tribe, it may be "significant under the CEQA criteria" as long as the significance is supported by substantial evidence.	In conjunction with the California SHPO and DOI, the basis of a cultural landscape designation needs to be evaluated by the SHPO with a supporting ethnographic/ ethno historic study. There are federal guidelines in place in order for BLM/DOI to determine a viable landscape approach for management of this area. The Hargis comment made on behalf of the Fort Mohave Indian Tribe asserts that "BLM does not believe that the tribes are telling the truth about their beliefs" is inaccurate. The BLM expects all tribes, stakeholders and others involved with this project to be honest and respectful of everyone involved with this project. It is difficult to understand why the Fort Mojave Indian Tribe suggests that BLM would treat any tribe with such disrespect—this has not and will never be our practice. The Cultural ARARs are being considered with respect to the final remedy and will be discussed on July 15, 2009 in an open forum with all tribes that are interested in representing their view point on the matter. DOI will provide language to PG&E concerning ARARs to be included in the CMS/ FS.	Comment addressed. No changes to the CMS/FS Report are required.
55	DOI-22	Section 2.2.7, Page 2-19	U.S. Department of the Interior	The tone of the Biological Resources section seems to be that areas within the APE are not important from an ecological standpoint. The refuge asserts that these areas are significant for	The subject paragraph will be clarified as follows: "Terrestrial wildlife found at the site is adapted to the interrelated stresses of drought, temperature extremes, and		DOI requests that PG&E remove the following statements from the CMS/FS: 1) "Terrestrial wildlife diversity and	Comment resolved following agency review and input during finalization of Section

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				the plants and animals found here, and that the refuge is charged with managing their lands to improve the habitats and promote native plant and animal species. Cite the information source and criteria being used to determine that abundance and diversity are low. Comparisons should not be made to nondesert regions. DOI disagrees that no wildlife corridor exists because of the mountains. Some animal species, even terrestrial ones, found in this area are not deterred by such mountains as the Chemehuevi—some terrestrial examples are the mountain lion, bighorn sheep, and various lizards; avian species also use this area. Mountains and deserts are not a barrier to the wildlife and plants adapted to this area. Also, although live tortoises and nesting southwestern willow flycatchers have not been detected in the APE recently, the APE contains some of the best habitat available in this area for these species.	the sparse or unpredictable food supply of the desert habitats found at the site.”		abundance are typically low in habitats found at the site." 2) "In addition, because of adjacent natural barriers such as the Chemehuevi Mountains and Colorado River, a continuous terrestrial wildlife corridor is not available for many species. This inhibits movement of some terrestrial wildlife species onto the site.” DOI accepts the final PG&E response.	2.2.7 of the CMS/FS Report text. Redline final submitted to agencies on November 13, 2009. Agencies approved the report revisions.
56	DOI-23	Section 2.2.7, Page 2-19, Paragraph 2	U.S. Department of the Interior	The following sentence is incorrect: *However, the occurrence of trees and patches of native vegetation near the Colorado River may provide limited habitat for avian species and other common wildlife species.* The native and nonnative vegetation near the Colorado River **does** provide habitat for avian and other wildlife species, and it is ecologically significant. This entire paragraph needs to be reevaluated.	The subject sentence will be clarified as follows: “However, trees and patches of native vegetation near the Colorado River provide habitat for avian and other wildlife species.”		Pending review of the final text, DOI accepts the response and directs PG&E to make the changes to the document as proposed.	Comment resolved following agency review and input during finalization of Section 2.2.7 of the CMS/FS Report text. Redline final submitted to agencies on November 13, 2009. Agencies approved the report revisions.
57	DOI-24	Section 2.2.7, Page 2-20, Paragraph 2	U.S. Department of the Interior	The third paragraph “These plant communities support a variety of wildlife species associated with the various habitat communities found on the project site.” seems to contradict the second paragraph “Terrestrial wildlife diversity and abundance are typically low in habitats found at the site.” DOI agrees with the third paragraph. The previous paragraph needs to be reworked.	The last two sentences in the third paragraph are proposed to be revised as follows: “These plant communities support a variety of common wildlife species and have, at least historically, provided habitat for several species that are currently designated as threatened or endangered by state and federal endangered species acts. These dominant plant communities, and associated threatened or endangered species, include:”		Pending review of the final text, DOI accepts the response and directs PG&E to make the changes to the document as proposed.	Comment resolved following agency review and input during finalization of Section 2.2.7 of the CMS/FS Report text. Redline final submitted to agencies on November 13, 2009. Agencies approved the report revisions.
58	DOI-25	Section 2.2.7, Page 2-20, Bullet 2	U.S. Department of the Interior	Under “Salt Cedar” section, although habitat may not be officially designated as critical for the southwestern willow flycatcher (SWFL) there is critical (very significant) habitat for SWFL all along the river within the APE, particularly in the NW section and the mouth of Bat Cave Wash.	See response to comments No. 55 and 56.		Pending review of the final text, DOI accepts the response and directs PG&E to make the changes to the document as proposed.	Comment resolved following agency review and input during finalization of Section 2.2.7 of the CMS/FS Report text. Redline final submitted to agencies on November 13, 2009. Agencies approved the report revisions.

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59	DOI-26	Section 2.2.7, Page 2-20, Bullet 2	U.S. Department of the Interior	Add a discussion that salt cedar is an invasive plant.	The following is proposed to be added to the second bullet in Section 2.2.7: "This plant community is characterized by dense thickets of Salt Cedar (*Tamarix* sp.), sometimes with an understory of arrowweed (*Pluchea sericea*). Salt Cedar is highly successful in arid climates with saline or alkaline soils and often occurs in monotypic stands in riparian areas. Considered a noxious weed, salt cedar is fire-, flood-, and drought-tolerant and resprouts readily after cutting or burning. It spreads through growth of adventitious roots and by dispersal of large amounts of seed. Salt Cedar also out-competes native plant species for water and can increase soil salinity as it sheds foliage where it accumulates excess salt, thereby making conditions less tolerable for other species."		DOI accepts the response and directs PG&E to make the changes to the document as proposed.	Comment resolved following agency review and input during finalization of Section 2.2.7 of the CMS/FS Report text. Redline final submitted to agencies on November 13, 2009. Agencies approved the report revisions.
60	CRIT-15	Section 2.3 Page 2-23	Envirometrix (on behalf of the Colorado River Indian Tribe)	Section 2.3 states, *The principal constituent of concern in groundwater at the site is Cr(VI), which is the result of past wastewater disposal practices, as described in Section 1.2. As described in the RFI/RI Vol. 2, molybdenum is carried forward as a COPC in groundwater based on its use at the facility and observed distribution in groundwater. Selenium (Se) is also carried forward as a COPC in groundwater based on DTSC direction. Based on the conclusions of RFI/RI Volume 2, the COPCs in groundwater from SWMU 1/AOC 1 are Cr(VI), Cr(T), molybdenum, and selenium (CH2M HILL, 2009). Of these COPCs, the extent of Cr(T) and Cr(VI) is clearly the most significant, and it is defined sufficiently well for the purpose of establishing remedial action objectives and for evaluating remedial alternatives.* We are confused with PG&E's attempt to introduce and discount additional COPCs that were directed by DTSC to be carried forward in the process. The RAOs (Section 3.0) state that this CMS/FS is for chromium in groundwater at AOC1. PG&E is now discussing molybdenum and selenium for AOC1. We are not clear on what this CMS/FS actually is intending to address. Is it chromium for AOC1? Or is it all chemicals related to AOC1? If it is for all chemicals, is Dioxin also a CPOC?	In response to this comment, Section 2.0 of the CMS/FS Report will discuss the site characterization results for COCs identified in the risk assessment, and will reiterate the conclusions of the RFI/RI for COPCs not carried forward. Section 3.0 of the CMS/FS Report will be revised to include the results of the groundwater risk assessment and to discuss molybdenum, selenium, and nitrate in the development of non-numerical remedial action objectives, consistent with DTSC's July 8, 2009 direction to PG&E.	Agree with RTC	DOI concurs with the response pending final review of the CMS/FS.	Comment resolved following agency review and input during finalization of Sections 2.-0 and 3.0 of the CMS/FS Report text. Redline final submitted to agencies on November 13, 2009. Agencies approved the report revisions.
60.5	Chemehuevi-3	Section 2.3	Chemehuevi via BLM	Vice-Chair Shirley Smith wanted to know how Cr VI moved about in the ecosystem, e.g., water, air, soil.	Chromium is a naturally occurring element found in rocks, animals, soil, and in volcanic dust and gases. It is present in the environment in several different forms, the most common forms are trivalent (Cr[III]), and hexavalent chromium (Cr[VI]). Most natural occurrence of chromium is in the trivalent chromium form and Cr(III) is also an essential nutrient for the human body. Chromium(VI)is found in several rocks and minerals, and is also present in the	Agree with RTC	DOI concurs with the response.	Comment resolved. Agencies approved PG&E response. No changes to the CMS/FS Report are required.

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					environment as a result of anthropogenic/industrial sources. (Source: Agency for Toxic Substances and Disease Registry: http://www.atsdr.cdc.gov) Both hexavalent and trivalent chromium do not usually remain in the atmosphere, but are deposited into soil and water through atmospheric deposition and precipitation. Hexavalent chromium may exist in water. Hexavalent chromium often reacts with organic matter or other reducing agents (such as certain naturally-occurring minerals in soil) to form Cr(III). The Cr(III) will eventually be precipitated and bound to the soil. Therefore, in environments rich in organic content, Cr(VI) will exhibit a much shorter lifetime. Any Cr(VI) in soil is expected to be reduced to Cr(III) by organic matter. (Source: USEPA *Toxicological Review of Hexavalent Chromium*, prepared by USEPA, August, 1998.)			
60.8	Chemehuevi-4	Section 2.3	Chemehuevi via BLM	Because Ken Hayes is new to this project, he wanted to know what Cr VI is and how it can be picked up by humans. o BLM response: The pathways that Cr VI can be completed with humans are …..	Please see response to comment #60.5 for a description of what chromium is and how it exists in the environment. Hexavalent chromium can exist in the air (attached to particles), soil, groundwater, and surface water. The potential pathways of exposure to humans are through inhalation of airborne particles, direct contact with soil and water, and ingestion of soil or water containing Cr(VI). PG&E is preparing human health risk assessments to evaluate the significance of potential exposure scenarios and pathways associated with Cr(VI) at the Topock site.	Agree with RTC	DOI concurs with the response.	Comment resolved. Agencies approved PG&E response. No changes to the CMS/FS Report are required.
61	DTSC-12	Page 2-23, Paragraph 4, Line 8 Section 2.3	California Department of Toxic Substances Control	Please delete the following sentence as it no longer applies:	The sentence will be deleted.	Agree with RTC	DOI concurs with the deletion.	Comment resolved. Agencies approved PG&E response. The subject sentence has been removed from Section 2.3 in the CMS/FS Report.
62	DOI-28	Section 2.3, Page 2-23, Paragraph 4	U.S. Department of the Interior	The extent of other COPCs should also be presented since they will need to be evaluated in the alternative selection process.	In response to this comment, Section 2.0 of the CMS/FS Report will discuss the site characterization results for COCs identified in the risk assessment, and will reiterate the conclusions of the RFI/RI for COPCs not carried forward. Section 3.0 of the CMS/FS Report will be revised to include the results of the groundwater risk assessment and to discuss molybdenum, selenium, and nitrate in the development of non-numerical remedial action objectives, consistent with DTSC's July 8, 2009 direction to PG&E.	Agree with RTC. Will await final CMS/FS language.	DOI concurs with the response pending final review of the CMS/FS.	Comment resolved following agency review and input during finalization of Section 3.0 of the CMS/FS Report text. Redline final submitted to agencies on November 13, 2009. Agencies approved the report revisions.
63	DOI-27	Section 2.3 Page 2-23 Paragraph 5	U.S. Department of the Interior	DOI disagrees with portions of the fifth statement. Delete the sentence starting "The chromium is confined…"	The sentence will be deleted.		DOI accepts the response and directs PG&E to make the changes to the document as proposed.	Comment resolved. Agencies approved PG&E response. The subject sentence has been deleted from Section 2.3 in the CMS/FS Report.

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64	DTSC-13	Page 2-23, Paragraph 5, Section 2.3	California Department of Toxic Substances Control	The CMS/FS for the Bat Cave Wash associated plume, can't be focused only on chromium, but on all chemicals that are considered a COC under the risk assessment. See comments 1 and 3 above.	In response to this comment, Section 3.0 of the CMS/FS Report will be revised to include the results of the groundwater risk assessment and to discuss molybdenum, selenium, and nitrate in the development of non-numerical remedial action objectives, consistent with DTSC's July 8, 2009 direction to PG&E.	Agree with RTC, Will await final CMS/FS language.	DOI concurs with the response pending final review of the CMS/FS.	Comment resolved following agency review and input during finalization of Section 3.0 the CMS/FS Report text. Redline final submitted to agencies on November 13, 2009. Agencies approved the report revisions.
65	DTSC-14	Page 2-23, Paragraph 6, Line 6 Section 2.3 and other similar references in the Report	California Department of Toxic Substances Control	After reviewing Figures 2-10 through to 2-12 of the Report, the chromium plume should be described as follows: *"Testing to characterize the extent of the chromium plume indicates that the plume extends from the former percolation bed in Bat Cave Wash approximately 3,000 feet north/northeast to the Colorado River floodplain, along the general direction of groundwater flow."*	The distance will be altered for accuracy. As discussed with DTSC, the plume boundaries will be revised in the Final CMS/FS Report based on data collected in July 2009 for the East Ravine wells and in October 2008 for remaining site wells.	DTSC conceptually agrees to RTC. Will await final CMS/FS language.	DOI defers to DTSC	Comment resolved following agency review and input during finalization o the CMS/FS Report text. Changes to Section 2.3 noted in the response have been made. Redline final submitted to agencies on November 13, 2009. Agencies approved the report revisions.
66	DTSC-15	Page 2-23, Paragraph 6, Last Sentence Section 2.3	California Department of Toxic Substances Control	The following edits are provide to more accurately describe site conditions, *"Chromium is present at all depth intervals of the alluvial portion of the aquifer but is generally_not present in shallow and middle-depth fluvial wells near the Colorado River where reducing conditions predominate."*	The sentence will be revised as requested	Agree with RTC	DOI concurs with the response.	Comment resolved. Agencies approved PG&E response. Changes noted in the response have been made to the CMS/FS Report.
67	CRIT-16	Section 2.3 Page 2-23	Envirometrix (on behalf of the Colorado River Indian Tribe)	Section 2.3 indicates that the sampling results from the October 2007 site-wide groundwater monitoring event were used to define the present distribution of chromium in groundwater at the site. Why were sampling results from October 2007 used? This event is more than a year old. We would assume that an additional site-wide sampling event has occurred since that time. When was the most recent site-wide sampling conducted?	When the draft report was written, the most recent sitewide monitoring event was October 2007. As discussed with DTSC, the plume boundaries will be revised in the Final CMS/FS Report based on data collected in July 2009 for the East Ravine wells and in October 2008 for remaining site wells. The report will be modified to include the updated plume maps, and will reference the report or appendix where the data supporting the plume maps are contained (GMP report for the October 2008 data and the East Ravine appendix for the July 2009 data).	DTSC conceptually agrees to RTC. Will await final CMS/FS language.	DOI concurs with the response pending final review of the CMS/FS.	Comment resolved following agency review and input during finalization of the CMS/FS Report text. Redline final submitted to agencies on November 13, 2009. Agencies approved the report revisions.
68	DOI-29	Section 2.3 Page 2-24	U.S. Department of the Interior	Discussion on the "calculated statistical UTL should be 31.8". Need to include the porosity used to make the volume calculation and reference the Cr concentration figures. Need to state assumption that the Cr concentrations on the figures represent the entire depth interval. The margins of the plume are probably over-predicted because the Cr probably is not uniformly distributed throughout the unit.	The sentence will be clarified to state that the calculated statistical UTL is 31.8 µg/L, which is rounded to 32 µg/L. The porosity (35 percent) and assumptions about chromium distribution used in the calculations will be stated. The following text will be added to Section 2.3: "This estimate was calculated by interpolating the Cr(VI) concentration contours, shown on Figures 2-10 through 2-12, over the model grid, integrating the concentration intervals over the depth of each zone (shallow, middle, and deep);, and applying a total porosity of 35 percent for the	DTSC conceptually agrees to RTC. Will await final CMS/FS language.	Pending review of the final text, DOI accepts the response and directs PG&E to make the changes to the document as proposed.	Comment resolved following agency review and input during finalization of Section 2.3.1 of the CMS/FS Report text. Redline final submitted to agencies on November 13, 2009. Agencies approved the report revisions.

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					alluvial / fluvial portion of the plume (from measurements of site materials presented in Ecology and Environment, Inc., 2004)."			
69	CRIT-17	Section 2.3 Page 2-24	Envirometrix (on behalf of the Colorado River Indian Tribe)	Section 2.3 states, *The chromium plume is defined as that part of the Alluvial Aquifer where Cr(VI) concentrations exceed natural background levels. The calculated statistical upper tolerance limit (UTL) of natural background levels for Cr(VI) in groundwater, obtained from sampling monitoring and water supply wells surrounding the Topock site, is 31.8 micrograms per liter (µg/L) (CH2M HILL, 2008d).The calculated statistical UTL for Cr(VI) of 32 µg/L is rounded to 32 µg/L for discussion of the extent of impacted groundwater below.* Previously, we commented that we do not agree that the natural background groundwater conditions should be equally applied from the upland area to the fluvial aquifer near the Colorado River. The background value for Cr(VI) in the fluvial aquifer would most likely be very low. However, considering that the ARAR for Surface Water is 11 ug/L, contouring the extent of groundwater contamination to at least this value would seem reasonable and appropriate. PG&Es response to our previous January 9, 2009 comment No. 19 states, *At the direction of OTSC (October 21, 2008 letter "Comments on the July 2008 RFI/RI Volume 2 Report"), PG&E has revised the Cr(VI) results distribution maps to show the chromium plume delineation to 32 µg/L which are under agencies' review. PG&E reiterates its belief, as stated in the July 23, 2008 cover letter to the Groundwater Background Study Steps 3 and 4: Final Report of Results, that having multiple (rather than a single) background concentrations at the Topock site would result in significant uncertainty, is not practical from a regulatory standpoint, and would hinder rather than advance progress toward selection and implementation of a groundwater remedy.* While PG&E may choose to respond by stating that they reiterate statements made in a July 23, 2008 cover letter, we do not agree with this response. To state that the technical and rationale basis for not having appropriate and separate groundwater background levels is that it would: • Result in significant uncertainty; • Is not practical from a regulatory standpoint;	The extent of Cr(VI) as described in Section 2.3 of the CMS/FS Report, including the contours in Figures 2-10, 2-11, and 2-12, to the calculated statistical UTL from the Groundwater Background Study Final Report, dated July 2008, is consistent with the preliminary cleanup goals described in Section 3.1.1, and the estimated mass of the groundwater to be remediated as discussed in Appendix D, Section D.2. As discussed in responses to comments #87, #88, #89, and #90, PG&E proposes no change to the preliminary cleanup goal in the floodplain area of the site. Modifications to Section 3.1.1 (preliminary cleanup goals) will be made to incorporate the results of the recent risk assessment and the risk-based concentration for Cr(VI) associated with a hypothetical future drinking water user, which is higher than the proposed preliminary remediation goal (32 parts per billion [ppb]Cr[VI]). In addition, the results of the RFI/RI Volume 2 Report and associated risk assessment show that no impairment of designated uses of the Colorado River has resulted from the Topock site. Establishment of a separate cleanup goal in groundwater in the floodplain area of the site to maintain concentrations in surface water lower than water quality standards, considering dilution and attenuation, would be orders of magnitude higher than the proposed cleanup goal of 32 ppb Cr(VI). Thus, the 32 ppb goal provides a significant factor of safety. With regard to the uncertainty associated with the development of multiple background concentrations in groundwater at the site, the uncertainty is associated with three points. First, uncertainty would stem from having only a few background study wells that are in the river-influenced fluvial category so that a reliable UTL cannot be calculated Second, applying the results of different background concentrations to different areas of the site would be arbitrary for wells with isotopic signatures intermediate to those of "pure" alluvial and fluvial sources. Third, the dynamic nature of groundwater conditions under the influence of current or future extraction/injection facilities could result in specific monitoring wells moving from one population to the other over time. PG&E agrees that the preliminary cleanup goal in the floodplain area of the site should be protective of the Colorado River, and as discussed above, a cleanup goal in groundwater in the floodplain area of the site to maintain concentrations in surface water lower than water quality standards, considering dilution and attenuation, would be orders or magnitude higher than the proposed cleanup goal of 32 ppb Cr(VI). As a regulated party, PG&E has a perspective on and experience with regulatory practicality – PG&E objects to the notion that such perspective is unique to those currently in the regulatory community. However, we acknowledge that	DTSC did not approve the background study number as presented by PG&E. DTSC recognize that there are true differences in the population between samples collected in the fluvial environment versus the alluvial conditions. DTSC, however, agrees with PG&E in that the background number is not an ARAR, but can be used to establish the cleanup objective. In evaluating the Remedial Action Objectives at the site, DTSC believes PG&E should not, ultimately, move significant concentrations of hexavalent chromium into areas where there have not been significant concentrations.	DOI defers to DTSC and the ongoing discussions and correspondence with respect to background concentrations in the floodplain.	Comment resolved following agency review and input during finalization of Section 2.3 of the CMS/FS Report text. Redline final submitted to agencies on November 13, 2009. Agencies approved the report revisions. Both DTSC and DOI approved the groundwater background study and those approvals are referenced in the Final CMS/FS report.

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				and • Would hinder rather than advance progress toward selection and implementation of a groundwater remedy is troublesome. First, we do not understand the intended meaning of "would result in significant uncertainty" PG&E must responsibly proceed to do what is appropriate and cleanup the contamination as a result of their past disposal activities and protect the Colorado River from any possible contamination. If establishing appropriate and relevant background concentrations near the Colorado River results or cause uncertainty, as stated by PG&E, then this may be an indication of a fatal flaw in the process. Second, we do not understand the statement or meaning of "is not practical from a regulatory standpoint". PG&E should not be making assumptions without regulatory agency input. Third, we do not understand the statement related to "and would hinder rather than advance progress toward a final remedy". PG&E should not limit appropriate activities or evaluations simply because they my hinder progress. We support activities that will identify a correct remedy and is protective of human health and the environment. We do not support the suggestion that any information, investigations, actions or tasks that may hinder rather than advance the process should be discounted, excluded or deferred. We also question the validity of the calculated groundwater background concentrations. PG&E response to our previous January 9, 2009 comment No. 20 states *DTSC, in response to CRIT comments on the RFI Volume 2 response summary, stated that PG&E utilized proper statistical methodologies in developing the background value of 32 µg/L for hexavalent chromium for the alluvial portions of the aquifer.* PG&E seems to suggest that we should interpret this statement as regulatory approval. We would like clarification if DTSC or DOI has actually approved any groundwater background concentrations for hexavalent chromium or chromium? It would be helpful to reference this specific approval action in the document. In the event that background concentrations were not approved, we do not see how PG&E can use the 32 ug/L for hexavalent chromium as a clean up goal since it would not be considered an ARAR at this time. Designing and considering any remedial alternatives must take into account the	the regulatory agencies will ultimately approve the final cleanup goals in the floodplain area of the site considering the results of the risk assessment and compliance with ARARs. Further, PG&E must respectfully disagree with the CRIT's perspective that "we (the CRIT) do not support the suggestion that tasks that may hinder rather than advance the process should be excluded or deferred." PG&E is committed to advancing progress toward the final remedy by focusing on those activities that support the development, evaluation, selection, and implementation of a robust, viable remedy for site contamination. PG&E believes part of this is a necessary and appropriate culling of tasks that do not add to this effort in a meaningful way. PG&E believes that if a separate, time-consuming background study to collect additional background data to have sufficient statistical populations to calculate multiple UTLs prior to completing the CMS/FS step in the cleanup process would result in an unnecessary delay to project and no commensurate increase in protectiveness of the selected remedy. PG&E notes that background concentrations are not a measure of protectiveness in terms of risk reduction or ARARs compliance. The DOI approved the Groundwater Background Study Final Report in August 2008, but the DTSC has not yet approved the background study. The DOI approval will be referenced in revisions to the CMS/FS Report, and if the DTSC approves the background study in the near term, that approval will also be referenced in revisions to the CMS/FS Report. Background concentrations are not ARAR, regardless of the conclusions of the background study report, and will not change the ARAR values identified in Table 3-1 of this report.			

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				possibility that a lower background number may be established in the future as a result of revised background calculations or information from the risk assessments. Therefore, the remedial goal of 32 ug/L as proposed by PG&E should include and appropriate factor of safety. We request that DTSC and DOI provide additional response to this comment in addition to PG&E.				
70	DTSC -16	Page 2-24, Paragraph 2, Line 5 Section 2.3	California Department of Toxic Substances Control	The following edits are suggested based on review of figures 2-10 through 2-12, *"For the shallow and mid-depth zones, the 32 µg/L concentration limit extends west of Bat Cave Wash and into the western portion of the floodplain. In the deep zone of the Alluvial Aquifer, the 32 µg/L concentration limit extends further west of Bat Cave Wash and further eastward into the floodplain in the area between monitoring wells MW-27 and MW-28.*	The suggested changes will be incorporated.	Agree with RTC	DOI concurs with the response.	Comment resolved. Agencies approved PG&E response. Changes noted in the response have been made to Section 2.3.1 in the CMS/FS Report.
71	DTSC-17	Page 2-24, Paragraph 2, Line 8 Section 2.3	California Department of Toxic Substances Control	The section discusses the variability in the vertical distribution of chromium within the aquifer and lists mechanisms for this mixing. Should historic pumping from long screened water productions wells PGE-1 and PGE-2 also be mentioned as potentially mixing contaminant zones?	The effect of pumping of former supply wells PGE-1 and PGE-2 likely had a strong effect on Cr(VI) distribution, but one that likely tended to homogenize concentration more than produce more variability, due to the long perforated intervals of these wells drawing water across all depths. The effects caused by these wells were largely limited to the groundwater area directly beneath Bat Cave Wash, according to model simulations. In response to this comment, the following sentence is proposed to be added: "Pumping at former facility supply wells PGE-1 and PGE-2, located adjacent to Bat Cave Wash at the present site of the Interstate-40 right-of-way, likely created downward gradients that acted to distribute Cr(VI) over multiple depth intervals beneath the wash."	Agree with RTC	DOI concurs with the response.	Comment resolved. Agencies approved PG&E response. Changes noted in the response have been made to Section 2.3.1 in the CMS/FS Report, as further modified by DTSC (see comment 466).
72	DOI-30	Section 2.3, Page 2-24, Paragraph 4, Sentence 3	U.S. Department of the Interior	Consider changing to "…nor does it adsorb strongly to mineral surfaces at the pH values of site groundwater". At low pH, Cr(VI) does adsorb to some extent.	The point is noted – anioic species such as chromate do adsorb more readily at low pH when mineral surfaces have greater positive charge. However, the strength of the adsorption was the point of this sentence, not the extent of adsorption. Chromate forms a relatively weak, outer-sphere surface complex with mineral surface, as opposed to a strong, inner-sphere complex formed by many cationic metals such as lead and cadmium. On the basis of these points, no changes will be made to the text.	Agree to RTC.	DOI accepts the response.	Comment resolved. Agencies approved PG&E response. No changes to the CMS/FS Report are required.
73	DTSC-18	Page 2-24, Paragraph 5, Last Sentence Section 2.3	California Department of Toxic Substances Control	The following statement is included in the Report, *"Strongly-reducing geochemical conditions are observed in groundwater in most of the fluvial deposits along the Colorado River floodplain and in bedrock. Reducing conditions in floodplain areas of the site are derived from organic carbon in the younger fluvial deposits."* For completeness, the origin of reducing	Pending decision on incorporation of East Ravine data, the text will be altered given the 2009 bedrock data. The "and in bedrock" portion of the sentence will be removed. In addition, the following clause is proposed to be added: "The high-TDS and low oxidation-reduction potential water found in several site bedrock wells (MW-24BR, PGE-7BR, PGE-8) is presumed to be very old water given the low permeability of the bedrock in these wells. As a	Agree with RTC.	DOI concurs with the response.	Comment resolved. Agencies approved PG&E response. Changes noted in the response have been made to Section 2.3.2 in the CMS/FS Report.

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				conditions in bedrock should be briefly discussed.	groundwater's residence time increases, the slow bacterial reactions that tend to lower the redox potential cause the water to become more reducing over time (Drever 1997). Groundwater in the shallow bedrock of the East Ravine area is notably less reducing, presumably due to stronger hydraulic communication with alluvial groundwater and/or surface runoff." Reference: Drever, J.I. 1997. The Geochemistry of Natural Waters, 3rd ed. Prentice Hall, 436 pp			
74	DOI-31	Section 2.3 Page 2-33 Paragraph 1	U.S. Department of the Interior	Delete "prevent" in second sentence of first paragraph.	The suggested change will be incorporated.	Agree with RTC	DOI accepts the response and directs PG&E to make the changes to the document as proposed.	Comment resolved. Agencies approved PG&E response. Changes noted in the response have been made to Section 2.3.2 of the CMS/FS Report.
75	MWD-2	Section 2.3 Page 2-33	The Metropolitan Water District of Southern California	In the top paragraph, it makes a very strong statement on the presence and capacity of the fluvial sediments to convert chromium VI to chromium III. The extent of the fluvial reducing layer is not known with certainty. This layer is heterogeneous and its ability to convert chromium VI to chromium III can vary. The Arcadis Report "In Situ Reactive Zone Treatment Design Elements" (Appendix E) states on page 21/29 that pockets of aerobic conditions can exist within the fluvial aquifer. This paragraph should be reworded to express the heterogeneity of the fluvial layer. The second sentence of the second paragraph states, "The capacity of the reducing material . . . "The third sentence in the second paragraph states, "Laboratory evidence confirms that the fluvial sediments in the anaerobic zone beneath the floodplain have the capacity to remove (Cr(VI) . . ." The word "capacity" in the second and third sentences should be replaced with "capability". The capacity of the fluvial layer to reduce chromium VI cannot be quantified.	The first sentence in the top paragraph is referring specifically to materials with reducing capacity not to all fluvial materials. The sentence was taken directly from the approved RFI/RI Volume 2 Report (Section ES.6.2). Hexavalent chromium is not stable under these conditions. Text will be added to the preceding paragraph as follows: "The reduction capacity and extent of the reducing zone are not precisely known, but the combinations of available core testing and groundwater data provide an approximate horizontal and vertical distribution of a predominantly reducing portion of the fluvial material, as described in the RFI/RI Volume 2 Report (CH2M HILL 2009)."	Agree with RTC	DOI concurs with the response.	Comment resolved. Agencies approved PG&E response. Changes noted in the response have been made to Section 2.3.2 in the CMS/FS Report.
76	DOI-32	Section 2.3 Page 2-33 Paragraph 2	U.S. Department of the Interior	The scientific and experimental basis must be cited for the statement that the chemical reduction of Cr(VI) to Cr(III) is effectively permanent and irreversible under site conditions.	The following sentence will be added in response to this comment: "The only naturally-occurring oxidant that can accomplish this is solid manganese dioxide, MnO_2 (Fendorf, 1995). If this solid is present, the Cr^{3+} ion can adsorb to the MnO_2 surface, where a redox reaction can occur which causes the chromium to be oxidized and the manganese to be reduced. However, under the reducing conditions present in the fluvial materials, MnO_2 is not stable, and manganese tends to exist as the dissolved cation Mn^{2+}, as shown by the detectable manganese concentrations in these wells		The response to the comment addresses the reducing conditions in the fluvial deposits not the alluvial deposits, which contain most of the plume. Cr (VI) reduction to Cr (III) will occur with the addition of reductant in both the fluvial and alluvial deposits at the Topock sites. Naturally occurring organic material in the fluvial deposits has created reducing conditions and is responsible for the absence of dissolved oxygen and the	Comment resolved following agency review and input during finalization of Section 2.3.2 of the CMS/FS Report text. The changes noted in the response have been made to Section 2.3.2 with slight revisions. Redline final submitted

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					(CH2M HILL, 2009a).” Section 2.0 of the CMS/FS Report describes existing physical site conditions, which includes the natural reducing conditions in the fluvial deposits. Information pertaining to induced reducing conditions in alluvial deposits is addressed in those parts of the report that discuss in situ treatment. Please see responses to comments #172, 176, 234, 311, 312, 318, 321, 369, 370, and 408 about the stability of the chemical reduction as an induced condition through *in-situ* treatment.		presence of manganese in groundwater in these deposits. These conditions will likely persist in the fluvial deposits after degradation of reductant added for in-situ removal of Cr (VI). This will likely prevent reoxidation of Cr(III) to Cr (VI). Organic material is largely absent in alluvial deposits at the Topock site and groundwater in these deposits is alkaline, oxic and contains naturally occurring Cr (VI) at concentrations as high as 35 ug/L. Oxidation of Cr (III) to Cr (VI) occurs naturally in oxic groundwater typical of the alluvial deposits at Topock. Once oxidized, Cr (VI) is mobilized from the solid phase to the dissolved phase by desorption in alkaline (pH > 7.5) groundwater. These processes account for the widespread occurrence of Cr (VI) in alluvial aquifers at Topock and in other aquifers typical of the Mojave Desert. Both manganese dioxide on the surfaces of mineral grains (Fendorf, 1995) and oxygen dissolved within the water (a stronger oxidant than manganese dioxide) can oxidize Cr (III) to Cr (VI). 1. After treatment of the plume in the alluvial deposits by added reductant, much of the manganese on the surface of mineral grains may be reduced and thus unable to oxidize Cr (III). The fraction of the manganese dioxide reduced during treatment and the speciation of manganese on the surfaces of mineral grains after treatment has not been determined, thus the potential for naturally occurring manganese dioxide remaining on the surfaces of mineral grains after treatment to reoxidize Cr (III) is not known. 2. As the reductant added to groundwater in the alluvial deposits is consumed by microorganisms, the reduced treated groundwater will ultimately be displaced by native oxidized groundwater. Oxidation of Cr (III) to Cr (VI) has been observed at environmentally significant rates in formerly reduced aquifers after exposure to oxygen (Izbicki and others 2008). After oxic conditions are restored to the treated plume environment reoxidation of	to agencies on November 13, 2009. Agencies approved the report revisions.

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							Cr (III) to Cr (VI) will occur. The rate of reoxidation will in part be determined by a) the total mass of chromium sorbed on the mineral grains and b) the manner in which Cr (III) is sorbed onto the mineral grains. The mass and concentrations of Cr (III) expected to be sorbed to exchange sites on the mineral grains has not been estimated nor has any measure of the potential saturation of the available exchange sites by reduced chromium. Weakly sorbed Cr (III) (present in the KCL extractable fraction defined by Chao and Sanzolone, 1989) is more likely to be reactive than Cr (III) that has been incorporated into organic phases or more crystalline phases (defined by the phosphoric and acid extractable fractions of Chao and Sanzolone, 1989).	
77	DTSC-19	Page 2-33, Paragraph 2, Section 2.3	California Department of Toxic Substances Control	The CMS/FS asserts that the conversion of Cr(VI) to Cr(III) is effectively permanent and irreversible under site conditions. Please provide reference(s) and/or studies that support this conclusion.	See response to comment #76. Section 2.0 of the CMS/FS Report describes existing physical site conditions, which includes the natural reducing conditions in the fluvial deposits. Information pertaining to induced reducing conditions in alluvial deposits is addressed in those parts of the report that discuss in situ treatment. Please see responses to comments #172, 176, 234, 311, 312, 318, 321, 369, 370, and 408 about the stability of the chemical reduction as an induced condition through *in situ* treatment.	DTSC awaits RTC to comments #172, 176, 234, 311, 312, 318, 321, 369, 370, and 408 when they are submitted	See the response to RTC 76.	Comment resolved following agency review and input during finalization of Section 2.3.2 of the CMS/FS Report text. Redline final submitted to agencies on November 13, 2009. Agencies approved the report revisions.
Section 3 Comments - Remedial Action Objectives								
78	DTSC-20	Page 3-1, Paragraph 1, Section 3.0	California Department of Toxic Substances Control	The Remedial Action Objectives must address all COCs.	Section 3.0 of the CMS/FS Report will be revised to include the results of the groundwater risk assessment and to discuss molybdenum, selenium, and nitrate in the development of non-numerical remedial action objectives, consistent with DTSC's July 8, 2009 direction to PG&E.	Agree with RTC	DOI concurs with the response pending final review of the CMS/FS.	Comment resolved following agency review and input during finalization of Section 3.0 of the CMS/FS Report text. Redline final submitted to agencies on November 13, 2009. Agencies approved the report revisions.
79	DOI-33	Section 3.0, Page 3-1, Paragraph 3	U.S. Department of the Interior	RAO number 4 states that groundwater cleanup should be accomplished within a "reasonable time frame". This goal can be subject to high scrutiny and variable interpretation. The alternatives provided within the CMS/FS achieve cleanup within a range of timeframes, as they should. It is recommended that the "reasonable time frame" phrase be deleted from the RAO. The issue of "reasonable time frame" for achieving RAOs is addressed in Section 5.2,	Consistent with the USEPA Guidance on Remedial Actions for Contaminated Groundwater at Superfund Sites (USEPA, 1988) the time frame for achieving the RAOs was included in the text. However, as noted by the commenter, this information is also included in Section 5.2, page 5-2. The text will be revised to remove reference to "reasonable time frame."	Agree with RTC	Pending review of the final text, DOI accepts the response and directs PG&E to make the changes to the document as proposed.	Comment resolved following agency review and input during finalization of Section 3.0 of the CMS/FS Report text. Redline final submitted to agencies on November 13, 2009. Agencies approved the report revisions.

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				page 5-2.				
80	DTSC-21	Page 3-1, Paragraph 3, Section 3.0	California Department of Toxic Substances Control	DTSC recommends PG&E to follow language and format for the RAOs as suggested in the USEPA Interim Final Guidance for Conducting Remedial Investigation and Feasibility Studies Under CERCLA, Oct 1988. (e.g. combine RAO 1 and 4 for human health: Prevent ingestion of groundwater having Cr(VI) in excess of 32 ug/L as a potable water supply/ drinking water source.) EPA guidance suggests RAOs be defined by media, and specifically for each receptor group. PG&E should also establish RAOs for all COCs and not just for chromium.	The RAO will be revised to incorporate the suggested text (ingestion rather than *exposure*), and RAOs #1 and #4 have been combined. Additionally, results of the final groundwater risk assessment will be incorporated into the text, and the numeric concentration, as concluded by the risk assessment for controlling risk via ingestion, will be revised to 46 ppb Cr(VI). Section 3.0 of the CMS/FS Report will be revised to include the results of the groundwater risk assessment and to discuss molybdenum, selenium, and nitrate in the development of non-numerical remedial action objectives, consistent with DTSC's July 8, 2009 direction to PG&E.	Need to see final text, but conditionally agree.	DOI concurs with response pending review of the final text.	Comment resolved following agency review and input during finalization of Section 3.0 of the CMS/FS Report text. Redline final submitted to agencies on November 13, 2009. Agencies approved the report revisions.
81	CRIT-9	Section 3.0 Page 3-1	Envirometrix (on behalf of the Colorado River Indian Tribe)	The Remedial Action Objectives (RAOs) listed in Section 3.0 have been significantly modified from the RAOs presented in the initial draft. Please describe the changes that have occurred and the basis used for modifying or deleting specific RAOs from the initial draft to this CMS/FS version. Were any additional significant modifications made by PG&E that were not related to and noted in the response to comments? If so, please describe.	As described in response to comment #29, two objectives pertaining to compliance with location-specific ARARs were removed between the work plan and the Draft CMS/FS Report (although ARARs compliance remains a threshold remedial alternative evaluation criteria), and the objectives associated with reducing concentrations of COCs were re-worded to focus more specifically on exposure routes and cleanup levels. In addition, RAOs #1 and #4 have been combined in response to comment #80.	Agree with RTC	DOI concurs with the response.	Comment resolved. Agencies approved PG&E response. Changes to Section 3.0 noted in the response have been made to the CMS/FS Report.
82	DTSC-22	Page 3-1, Paragraph 3, Section 3.0	California Department of Toxic Substances Control	Under the current proposed RAO format, please add a RAO as follows: *"5. The plume boundary shall not expand beyond current boundaries (see Figures 2-10, 11, and 12)."* DTSC does not want existing fluvial or alluvial monitoring wells that consistently yield Cr(VI) concentrations less than 32 ug/L to increase as a result of remedy implementation. This is especially true of fluvial wells near the Colorado River where background concentrations are demonstrated to be less than reporting limits (see Figure 5-22 of the RFI/RI Volume 2 Report).	The other RAOs developed for the CMS/FS are consistent with USEPA guidelines and specify the contaminant of concern, the exposure routes and receptors, and an acceptable contaminant concentration for each exposure pathway (USEPA, 1988a). The RAOs are based on risk assessment conclusions and ARARs compliance, and neither risk assessment conclusions nor ARARs compliance suggest that a remedial action objective as suggested is warranted. At remedy completion, the RAO will be met for all portions of the site, including the floodplain. Based on these considerations, an additional remedial action objective related to plume boundaries has not been added. Addressing the potential change in the plume boundary is already adequately addressed within the context of remedy implementation in the CMS/FS. As described in Section 5.2, PG&E established specific considerations for the development of alternatives, one of which is to protect the Colorado River through geochemical barriers or hydraulic gradients to prevent Cr(VI) from approaching the river, similar to DTSC's proposal. Also, as described in Section 5.3, optimization of all remedies would occur throughout the design, construction, and operational phases of remedy implementation. The optimization may occur to respond to site conditions and performance issues including contingency measures to prevent non-attainment of RAOs. Additionally, as discussed in Section 2.3, the natural reductive capacity in the floodplain area of the site is an	DTSC strongly disagrees and believes an additional RAO as suggested is in line with the spirit of the remedial action evaluation criteria to control toxicity and mobility. Although PG&E has discussed the natural reducing conditions at the site as a protection, PG&E also acknowledge that the final remedy may change the natural geochemistry of the site. PG&E cannot pick a clean up goal of 32 ug/l without considering that this concentration is not representatives of current values in many of the fluvial wells which are mainly non-detect for hexavalent chromium. See comment DTSC-24	Consistent with previous statements regarding other COCs, DOI concurs with DTSC in that, in the end, the remedy should not expand the plume boundaries or exacerbate the problem.	In response to this comment, the following RAO has been added: "Ensure that the geographic location of the target remediation area does not permanently expand following completion of the remedial action." Comment resolved following agency review and input during finalization of Section 3.0 of the CMS/FS Report text. Redline final submitted to agencies on November 13, 2009. Agencies approved the report revisions.

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					important aspect of the conceptual site model and remedial alternatives in Section 5 are evaluated with respect to potential long-term damage to this reductive zone. As discussed in responses to comments #69, #87, 88, 89, and 90, establishment of a separate cleanup goal in groundwater in the floodplain area of the site to maintain concentrations in surface water lower than water quality standards, considering dilution and attenuation, would be orders or magnitude higher than the proposed cleanup goal of 32 ppb Cr(VI). Thus, the 32 ppb goal provides a significant factor of safety, and additional RAOs are not warranted.			
83	DOI-35	Section 3.1.1, Page 3-2, Paragraph 2	U.S. Department of the Interior	Because the risk assessment is incomplete and all the COCs have not been identified significant uncertainties remain regarding the selection of an effective alternative.	At the time of publication of the Final CMS/FS, the groundwater risk assessment will be complete. Conclusions of the groundwater risk assessment will be incorporated into the Final CMS/FS Report.	DTSC conceptually agrees to RTC. Will await final CMS/FS language.	DOI concurs with the response pending final review of the CMS/FS.	Comment resolved following agency review and input during finalization of the CMS/FS Report text. The groundwater risk assessment conclusions are summarized in new Section 3.1.1. Redline final submitted to agencies on November 13, 2009. Agencies approved the report revisions.
84	DTSC-23	Page 3-2, Paragraph 2, Section 3.1.1	California Department of Toxic Substances Control	The following sentence should be deleted from the Report as the point of compliance described in section 3.1.2 will not change from current plume boundaries:	Section 3.0 of the CMS/FS Report will be revised to incorporate findings from the final groundwater risk assessment, and the subject sentence has been deleted as suggested. Additionally, suggested text changes described in comment #92 will be incorporated.	DTSC will await the review of revised language.	DOI concurs with the response, pending review of the final text.	Comment resolved following agency review and input during finalization of Section 3.0 of the CMS/FS Report text. Redline final submitted to agencies on November 13, 2009. Agencies approved the report revisions.
85	DOI-36	Section 3.1.1, Page 3-2, Paragraph 3 Sentence 2	U.S. Department of the Interior	Modify the end of sentence to read ". . . there is no existing use of groundwater within the Cr(VI) plume and, therefore, no *current* complete pathway."	The text will be revised as suggested. Additionally, Section 3.0 of the CMS/FS Report will be revised to incorporate findings from the final groundwater risk assessment. Changes to Section 3.0 of the CMS/FS Report to incorporate risk assessment results will be incorporated following completion of the risk assessment	DTSC conceptually agrees to RTC. Will await final CMS/FS language.	DOI accepts the response and directs PG&E to make the changes to the document as proposed, pending final review of the changes to Section 3.1.1.	Comment resolved following agency review and input during finalization of Section 3.0 of the CMS/FS Report text. Redline final submitted to agencies on November 13, 2009. Agencies approved the report revisions.
86	DOI-37	Section 3.1.1, Page 3-2, Paragraph 3	U.S. Department of the Interior	It should also be noted the Cr(VI) has been shown to be more toxic than the Cr(T).	Text will be added to Section 3.0 of the CMS/FS Report stating that in general, Cr(VI) is more toxic than Cr(III).	Agree with RTC	Dependent upon review of the final text, DOI accepts the response and directs PG&E to make the changes to the document as proposed.	Comment resolved following agency review and input during finalization of the CMS/FS Report text in Section 3.3.1 Redline

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								final submitted to agencies on November 13, 2009. Agencies approved the report revisions.
87	DTSC-24	Page 3-2, Paragraph 3, Section 3.1.1, Sentence 6	California Department of Toxic Substances Control	PG&E accurately states that “no existing use of groundwater within the Cr(VI) plume area and , therefore, no complete pathway.” However, DTSC would like the report to reflect that the same body of water is being used by Park Moabi beyond the plume. Also, private residences are utilizing private groundwater wells immediately across the river. Continued monitoring and hydraulic control over time must consider protection of the drinking water aquifer as well as the Colorado River. In addition, the groundwater is discharging to the Colorado River. The plume discharge is currently partially mitigated by natural reductive zones in the fluvial portion of the floodplain. However, throughout the rest of CMS, statement of the uncertainty of the reductive zone capacity and potential change of this geochemical zone and river channel has been made. Therefore, current compliance with California Toxic Rule (CTR, 40CFR 131.48) cannot be guaranteed for future site conditions. This would suggest a complete pathway to the Colorado River has to be considered. Considering the potential impact to surface water and uncertainties with the Cr(VI) background concentration, the more stringent criteria in CTR should be consider as the cleanup goal, at least along the floodplain. (This also applies to Section 5.5.1 and Table 5-5 regarding discussion on ARAR compliance with CTR.)	Groundwater and surface water uses at the site are discussed in Section 2.1.3. Section 2.1.3 discusses the nearest groundwater supply wells in California located approximately 1.3 miles west-northwest of the plume at the Park Moabi Marina and the nearest groundwater supply wells in Arizona, south of the Topock Marina on the eastern side of the Colorado River, approximately 0.3 mile east-southeast of the plume. In addition, the use of the surface water in the Colorado River is discussed in Section 2.1.3. It is agreed that protection of these groundwater and surface water supplies is of paramount importance. As discussed in Section 3.2.1 and Appendix A, the California Toxics Rule (40 CFR 131.38) is an identified ARAR. Compliance with the California Toxics Rule for each of the remedial alternatives is described in Table 5-5, and consideration for compliance over time is included in that evaluation. In consideration of this comment, as well as comments #88, 89, and 90, PG&E proposes no change to the preliminary cleanup goal in the floodplain area of the site. Modifications to Section 3.1.1 (preliminary cleanup goals) will be made to incorporate the results of the recent risk assessment and the risk-based concentration for Cr(VI) associated with a hypothetical future drinking water user, which is higher than the proposed preliminary remediation goal [32 ppb Cr(VI)]. In addition, the results of the RFI/RI Volume 2 Report and associated risk assessment show that no impairment of designated uses of the Colorado River has resulted from the Topock site. Establishment of a separate cleanup goal in groundwater in the floodplain area of the site to maintain concentrations in surface water lower than water quality standards, considering dilution and attenuation, would be orders or magnitude higher than the proposed cleanup goal of 32 ppb Cr(VI).	Agree with RTC	DOI concurs with the response.	Comment resolved. Agencies approved PG&E response. No changes to the CMS/FS Report are required.
87.5	DTSC-25	Page 3-2, Paragraph 4, Section 3.1.1	California Department of Toxic Substances Control	The CMS Report must accurately reflect background concentrations for COCs. The section must acknowledge limitations of the background study and indicate that fluvial formation waters exhibit Cr(VI) concentrations below detection limits and that Cr(VI) concentrations in alluvial waters are noted to significantly decrease with depth at the Topock site.	As noted in Section 3.0 and responses to comments in Section 3.1.1, the background UTL of 31.8 μg/L Cr(VI) site-wide is lower than the risk-based level for hypothetical future users of groundwater as a drinking water supply, and lower than needed for maintaining surface water quality standards in the Colorado River, Therefore, using 31.8 μg/L as a cleanup goal across the site will ensure protection, regardless of what the background values might be in different geochemical subzones at the site. In response to this comment, the following will be added to Section 2.3 as follows: “As described in the Final Background Study Report	Agree with RTC. However, although 32 ug/L is currently below the MCL standard, it may not be if health goal changes as currently under consideration by the California Department of Public Health.	DOI defers to DTSC.	Comment resolved. Agencies approved PG&E response. Changes noted in the response have been made to the CMS/FS Report in Section 2.3.3.

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					(CH2M HILL 2008c), depending on the interpretation criteria used, the background study data may be viewed as belonging to a single population or may be split into separate populations on the basis of multiple factors. General chemistry and oxygen/deuterium isotopic analysis indicate that many of the fluvial samples have different chemical characteristics compared to alluvial samples. This is due to the influence of the Colorado River for the shallow fluvial groundwater. In addition to the geographic/geologic criteria, separate populations may be defined on the basis of depth because the Topock Alluvial Aquifer is stratified. The highest mean concentrations of Cr(VI) and Cr(T) in the groundwater background study are found at the MW-18 well. This well is screened at or near the water table as some of the other shallow (non-background study) monitoring wells in the general vicinity such as OW-2S and OW-5S that have similar concentrations. Deeper wells in the area have much lower concentrations, suggesting the naturally elevated Cr(VI) concentrations are confined to shallow depth."			
88	MWD-3	Section 3.0 Page 3-1; Section 3.1.1 Page 3-2	The Metropolitan Water District of Southern California	Is the cleanup goal of 32 ug/L Cr(VI) only for the alluvial aquifer? Shouldn't the fluvial aquifer have a cleanup goal of non detect for Cr(VI) as this is the background level in these deposits? Also, the last sentence of the third paragraph states, "No MCLs exist for Cr(VI)." The following sentences should be added to this paragraph. "In 2001, a law was enacted that requires the California Department of Public Health (CDPH) to establish an MCL for chromium VI at a level as close as is technically and economically feasible to the contaminant's Public Health goal (PHG). A PHG is expected from the Office of Environmental Health Hazard Assessment."	In consideration of this comment, as well as comments #87, 89, and 90, PG&E proposes no change to the preliminary cleanup goal in the floodplain area of the site. As described in the background study report, the 32 ppb Cr(VI) is the calculated statistical UTL from the combined data set at six sampling events at approximately 25 wells representing a range of geologic and geochemical conditions of southern Mohave Valley groundwater. The calculated UTL for Cr(VI) is consistent with the concentrations reported in other published studies in the region. The background study was not designed, nor were appropriate data collected, for the calculation of multiple different UTLs for different groundwater sub-areas of the site. Modifications to Section 3.1.1 (preliminary cleanup goals) will be made to incorporate the results of the recent risk assessment and the risk-based concentration for Cr(VI) associated with a hypothetical future drinking water user, which is higher than the proposed preliminary remediation goal [32 ppb Cr(VI)]. In addition, the results of the RFI/RI Volume 2 Report and associated risk assessment show that no impairment of designated uses of the Colorado River has resulted from the Topock site. Establishment of a separate cleanup goal in groundwater in the floodplain area of the site to maintain concentrations in surface water lower than water quality standards, considering dilution and attenuation, would be orders or magnitude higher than the proposed cleanup goal of 32 ppb Cr(VI). PG&E notes that when a PHG is developed, it cannot be an ARAR because it is not a promulgated requirement. The maximum contaminant level (MCL) developed by CDPH will be an ARAR. The following footnote will be added to Table 3-1: "In 2001, a law was enacted that requires the California	DTSC did not approve the background study number as presented by PG&E. DTSC recognize that there are true differences in the population between samples collected in the fluvial environment versus the alluvial conditions. DTSC, however, agrees with PG&E in that the background number is not an ARAR, but can be used to establish the cleanup objective. In evaluating the Remedial Action Objectives at the site, DTSC believes PG&E should not, ultimately, move significant concentrations of hexavalent chromium into areas where there have not been significant concentrations.	DOI defers to DTSC.	Comment resolved following agency review and input during finalization of Section 3.0 of the CMS/FS Report text, including incorporation of risk assessment conclusions. Both DTSC and DOI approved the groundwater background study and those approvals are referenced in the Final CMS/FS report. The footnote added to Table 3-1 was modified slightly from that proposed in the response. Redline final submitted to agencies on November 13, 2009. Agencies approved the report revisions.

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					Department of Public Health (CDPH) to establish an MCL for chromium VI at a level as close as is technically and economically feasible to the contaminant's Public Health goal (PHG). A PHG is to be developed by the Office of Environmental Health Hazard Assessment. Although the will not be an ARAR because it is not a promulgated requirement, the MCL developed by CDPH will be an ARAR."			
89	HA-8	Section 3.1.1	Hargis & Associates, Inc. (on behalf of Fort Mojave Indian Tribe)	<u>5. Risk to the Colorado River and Natural Attenuation</u> The Tribe has heard that interim measures were required in the first place based solely on a perception of risk to the Colorado River. While the Tribe shares the concerns of other stakeholders regarding the need to protect the valuable resources of the Colorado River from chromium VI (Cr(VI)) mass influx via the groundwater pathway, it continues to challenge many of the previous statements made regarding the degree of risk. The challenge is based on an understanding of the science presented to date. Recent investigations have indicated that this risk to the River is minimal. This determination has been made based on the presence of the naturally-occurring reductive zone in the underlying fluvial sediments that effectively reduces and stabilizes the Cr(VI) in groundwater into harmless Cr(III) so that Cr(VI) cannot seep into the River. Additionally, studies have shown that even without this natural barrier, the rate of Cr(VI) mass loading into the River would be extremely low even under worst case scenarios. Indeed, the Tribe believes that this naturally-occurring protective feature of the River is owed to the wisdom of Providence. The Tribe believes that marginalizing the value of this naturally-occurring protective barrier as is done in the CMS/FS is itself a risky proposition. The Tribe believes that this is the earth's natural process of self-healing after an unnatural intrusion. In previous document reviews, the Tribe has noted and commented on the converging lines of evidence supporting the conceptual model of natural attenuation. In fact, even now, site assessments concerning the efficacy of the reductive zone as well as the low level of risk to the Colorado River continues to be produced. As recently as the February 2009 meeting of the project's Consultative Working Group (CWG), it was concluded on the basis of all water quality data collected in floodplain wells and in surface water collected from the River that:	In consideration of this comment, as well as comments #87, 88, and 90, PG&E proposes no change to the preliminary cleanup goal in the floodplain area of the site. Modifications to Section 3.1.1 (preliminary cleanup goals) will be made to incorporate the results of the recent risk assessment and the risk-based concentration for Cr(VI) associated with a hypothetical future drinking water user, which is higher than the proposed preliminary remediation goal [32 ppb Cr(VI)]. In addition, the results of the RFI/RI Volume 2 Report and associated risk assessment show that no impairment of designated uses of the Colorado River has resulted from the Topock site. Establishment of a separate cleanup goal in groundwater in the floodplain area of the site to maintain concentrations in surface water lower than water quality standards, considering dilution and attenuation, would be orders or magnitude higher than the proposed cleanup goal of 32 ppb Cr(VI). The cleanup goal of 32 ppb Cr(VI) site-wide (lower than the risk-based level for hypothetical future users of groundwater as a drinking water supply and lower than needed for maintaining surface water quality standards in the Colorado River) is proposed as a conservative measure for protectiveness. In response to this comment, and as requested by comment #23, the following will be added to Section 2.3: "The estimate of total plume Cr(VI) mass is approximately 34,000 pounds. Using this value and assuming a total porosity of 0.35 and soil particle density of 2.65 grams per cubic centimeter, the range of measured capacities (CH2M Hill 2007 - the Phase II Anaerobic Core Study) indicates that between 3.1 and 13.5 million cubic feet of anaerobic aquifer would be needed to reduce all of the Cr(VI) in the plume. The plume width along Park Moabi Road is approximately 2,300 feet, and the thickness of anaerobic fluvial material (based on groundwater data) ranges from 40 to 80 feet in the floodplain. Assuming 2,300 feet by 60 feet as the average cross-sectional area through which historical plume groundwater flowed, the measured capacities indicate that the west-to-east length of aquifer required to reduce all plume Cr(VI) is between 23 and 98 feet. This constitutes a relatively narrow strip of the known anaerobic zone of the floodplain, which stretches about 400 feet east to west. These calculations, although only approximate, suggest that there is capacity within the floodplain and beneath the river to reduce at least a significant portion of the Cr(VI) plume were the plume to reach the anaerobic portions of the	There is still uncertainty if the reducing conditions are through out the floodplain and if the reductive nature can completely manage the Cr(IV) at the site. Although PG&E asserts that current conditions preclude a complete pathway to surface water during the Feb 2009 CWG meeting, DTSC is approaching this issue with care and prefers to be more conservative on our assumptions. DTSC supports the conclusion that there is no risks to surface water in the risk assessment not just because of a site conceptual model of a reductive zone, but data to date did not indicate any reliable detections of Cr(VI) from the surface water sampling with IM3 operation. Thus, for calculation purposes there is no risk. Re the statement: "Establishment of a separate cleanup goal in groundwater in the floodplain area of the site to maintain concentrations in surface water lower than water quality standards, considering dilution and attenuation, would be orders or magnitude higher than the proposed cleanup goal of 32 ppb Cr(VI). " This depends on where the point of compliance is being measured. DTSC has at some sites required that the measurement be made at the edge of the plume, discounting any dilution or attenuation. In which case it will be at the wells closest to the river	DOI concurs with the response, noting to date that there is no indication of Cr(VI) entering the Colorado River.	Comment resolved following agency review and input during finalization of the CMS/FS Report. Proposed revisions to Section 2.3.2 were further modified in the redline final submitted to agencies on November 13, 2009, and modified again by DTSC (see comment 469). Change to Table 5-1 incorporated.

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				“The potential transport of floodplain COPCs [chemicals of potential concern] *in groundwater to the surface water represents an insignificant transport pathway: floodplain COPCs are not being transported to the Colorado River at concentrations that exceed screening-level surface water criteria.”* It was therefore concluded by the risk assessors that: *“Quantitative surface water human health and ecological assessments* [are] *not warranted.*”[14] [14] February 10, 2009, “Groundwater Human Health and Ecological Assessment Update” CWG Handout 4A, Slide Nos. 20 and 37.	floodplain and beneath the river.” In addition, Table 5-1 will be modified to acknowledge that natural attenuation is a component of all remedial alternatives, and remedial alternatives are evaluated in Section 5.4 and 5.5 in terms of their potential affect on the natural reductive features at the site.			
90	HA-9	Section 3.1.1	Hargis & Associates, Inc. (on behalf of Fort Mojave Indian Tribe)	6. Relevance of River Dilution Concepts Another recent analysis involved the assessment of a simple dilution calculation performed by PG&E based on the comparative rate of seepage of groundwater in the alluvial aquifer versus the average flow duration in the Colorado River. This preliminary analysis was performed in response to comments provided to the DTSC on PG&E’s July 2, 2008 Resource Conservation and Recovery Act (RCRA) Field Investigation/Remedial Investigation (RFI/RI) Volume 2 Groundwater report.[15] In response to this request, PG&E provided the following draft language to the Tribe: *“An additional bounding consideration of chromium fate and transport is provided below. The bounding consideration employs two hypothetical conditions aimed at providing a highly conservative (worst-case) scenario for potential chromium fate and transport. The first hypothetical condition is the evaluation of chromium fate and transport without consideration of the reducing zone that exists between the plume and the river. The second hypothetical condition is the discharge of the entire mass of Cr(VI) in the plume to the river over a 40-year period, the estimated time it took for the current plume to form. The first condition is hypothetical because a propensity of data has shown that Cr(VI) reduction occurs in reducing fluvial material near the river. The second condition is hypothetical because diffusion of contaminants out of a plume takes significantly longer than the time required for solute loading and advective transport. Given these*	In consideration of this comment, as well as comments #87, 88, and 89, PG&E proposes no change to the preliminary cleanup goal in the floodplain area of the site. Modifications to Section 3.1.1 (preliminary cleanup goals) will be made to incorporate the results of the recent risk assessment and the risk-based concentration for Cr(VI) associated with a hypothetical future drinking water user, which is higher than the proposed preliminary remediation goal [32 ppb Cr(VI)]. In addition, the results of the RFI/RI Volume 2 Report and associated risk assessment show that no impairment of designated uses of the Colorado River has resulted from the Topock site. Establishment of a separate cleanup goal in groundwater in the floodplain area of the site to maintain concentrations in surface water lower than water quality standards, considering dilution and attenuation, would be orders or magnitude higher than the proposed cleanup goal of 32 ppb Cr(VI). The cleanup goal of 32 ppb Cr(VI) site-wide is lower than the risk-based level for hypothetical future users of groundwater as a drinking water supply and lower than needed for maintaining surface water quality standards in the Colorado River, and is proposed as a conservative measure for protectiveness. The FMIT is correct that PG&E prepared an analysis of chromium fate and transport described in the comment. This analysis assumed hypothetical worst-case scenarios wherein there is a complete absence of a reducing zone between the plume and the river, and discharge to the river of the total estimated Cr(VI) mass in the plume over a 40 year period. The analysis concluded that the hypothetical river concentrations under this assumed scenario would be less than the federal water quality criteria. As described above, however, the RAOs and cleanup goal for Cr(VI) in groundwater ultimately are based on the risk assessment results assuming hypothetical future groundwater use.	Although dilution is a real life phenomenon, DTSC cannot rely on this process as an action to environmental protection. Dilution can not and should not be a solution to pollution. Since the beginning of this project, DTSC understood the position of all stakeholders, including FMIT, that the Colorado River is of significant importance culturally, spiritually and economically. If a viable remedial option is available, DTSC can not advocate the spreading of contamination per NCP guidelines or under remedy selection criteria.	DOI concurs with the response.	Comment resolved following agency review and input during finalization of Section 3.0 of the CMS/FS Report text. Results of the groundwater risk assessment have been included as a new Section 3.1.1. Redline final submitted to agencies on November 13, 2009. Agencies approved the report revisions.

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				hypothetical conditions, calculation of hypothetical average concentration of Cr(VI) in the river can be made, based on currently available information, specifically the the [sic] *concentration distribution of Cr(VI) in the plume and the quantity of river discharge flowing past the site. While both these factors may have changed over time, current conditions can provide a conservative estimate of the hypothetical, worst case plume impact to the river. The total plume mass of Cr(VI), estimated based on the concentration distribution and the geometry of the aquifer, may be divided by the total flow of the river over a 40-year period. The quotient of these estimates would provide a hypothetical average Cr(VI) contribution to concentration to the river over the 40-year period.* *Based on the Cr(VI) concentration contours for the upper, middle, and lower depth intervals shown on Figures 6-12a, 6-12b, and 612c and the thickness of model layers that represent these depth intervals, a total mass of 34,248 lbs is assigned for the Cr(VI) mass in the plume. This also requires an assumption of 35 percent porosity. As noted in Section 3.0, the flow in the Colorado River ranges from 4,000 to 25,000 cfs, with an average of about 12,500 cfs, based on monthly Davis Dam release data over the past several years. Using these numbers and the hypothetical condition that there is a complete absence of a reducing zone between the plume and the river, the total estimated Cr(VI) mass divided by 40 years of average river flow results in a hypothetical average concentration contribution of 0.035 µg/L Cr(VI) in river water. This value is well below the current analytical reporting limit of 0.2 µg/L. Any transport period greater than 40 years would result in a smaller hypothetical contribution to river Cr(VI) concentration.”*[16] Before this revision to the RFI/RI v. 2 could be implemented, DTSC advised the Tribe as follows: *“DTSC notes that PG&E and the Fort Mojave Indian Tribe have been working on specific language with respect to the subject section of the RFI/RI Volume 2 report. The main objective of the RFI/RI report is to describe the nature and extent of the chromium plume contamination at the Topock Compressor Station site. After much consideration, DTSC believes that the current language as proposed in the RFI/RI report is*				

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				based on an overly simplistic hypothetical scenario where the current mass of the plume would be flushed into the Colorado River within 40 years unabated. The technical premise of this scenario can easily be challenged…. DTSC believes, however, that the inclusion of this evaluation is not warranted within the RFI/RI Report.”[17] While the Tribe does not necessarily take issue with DTSC’s position on the relevance of this analysis to the context of the RFI/RI v. 2 report, it is interesting that DTSC apparently is summarily dismissing this important information considering its relevance to risk factors and remedy selection. Moreover, the perceived risk to water quality in the Colorado River was also the issue that initially prompted DTSC to impose requirements for interim measures. The analysis is criticized on the basis of its simplicity; however, the calculations are based on very conservative assumptions and, at the very least, provide a suitable basis for scoping. The assertion that the analysis can be “easily challenged” also does not offset the relevance of the analysis. The fact that an analysis can be challenged does not mean it is necessarily wrong; nor does it excuse a critic from actually conducting the allegedly “easy” challenge. Any technical analysis performed *should* be challenged and its worth determined from its ability to withstand reasonable challenges. Perhaps even more disturbing is DTSC’s complete disinterest in this dilution concept, regardless of how it is evaluated. Instead of either directing a more focused evaluation or presenting the analysis as it stands, DTSC has instead invited the Tribe itself to take the initiative of presenting this type of information to other stakeholders and to establish its relevance to specific remedial alternatives, as if the burden of proof for remedy selection were actually the responsibility of the Tribe or any other stakeholder. The Tribe understands from its February 19, 2009, meeting with DTSC Director Gorsen, that DTSC will place the dilution analysis on the next CWG agenda for presentation by PG&E. The CMS/FS should also reflect updated conclusions regarding risk. [15] See comment no. 16 of letter dated August 27, 2008 from H+A on behalf of the Tribe to DTSC and DOI.				

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				[16] Draft language provided to the Tribe by PG&E for review and potential inclusion in the RFI/RI v. 2, January 12, 2009. [17] E-mail communication from DTSC to the Tribe re "PG&E: Language for Section 6.6 in RFI/RI Volume 2," January 30, 2009.				
91	DOI-34	Section 3.1.1, Page 3-2, Paragraph 2 and Section 3.1.2	U.S. Department of the Interior	DOI does not concur with Section 3.1.2 in its entirety and believes additional discussions are required between DTSC, DOI, and PG&E.	In response to comment #92, Section 3.1.2 will be revised; however, PG&E welcomes additional discussion on revisions to this section. Text has also been revised to incorporate suggested revisions described in comment #26.		DOI has discussed the point of compliance with DTSC and PG&E. We agree with the decision that the point of compliance is the entire aquifer.	Comment resolved following agency review and input during finalization of Section 3.0 of the CMS/FS Report text. Redline final submitted to agencies on November 13, 2009. Agencies approved the report revisions. Point of compliance now discussed in Section 3.3.2 of the CMS/FS report.
92	DTSC-26	Page 3-3, Paragraph 2, Section 3.1.2	California Department of Toxic Substances Control	The following edits to the POC section are requested to remove unnecessary language. Furthermore, point of compliance is used to define attainment of RAO. It is unnecessary to assign priorities, therefore, please remove the third bullet. ***"3.1.2 Point of Compliance*** *The point of compliance for attainment of cleanup goals is throughout the area of contaminated groundwater, assuming that development of groundwater beneath the plume as a water supply may ultimately be pursued in the future. In establishing the point of compliance throughout the area of contaminated groundwater, the following are* *recognized:* *• Attaining the cleanup goals at the point of compliance may be through active remediation or through natural means.* *• Different areas of the plume may reach the media cleanup goal at different times.*	The suggested revisions will be incorporated, however, in response to comment #91 PG&E welcomes additional discussion on revisions to this section.	Agree with RTC	DOI concurs with the provided revisions.	Comment resolved. Agencies approved PG&E response. Changes noted in the response have been made to the CMS/FS Report. Point of compliance now discussed in Section 3.3.2 of the CMS/FS report.
93	DOI-38	Section 3.2, Page 3-3, Paragraph 2	U.S. Department of the Interior	The language regarding action-specific ARAR should be modified to state that "They are generally technology or activity-based requirements or limitations and apply . . ."	In response to this comment, the last sentence of paragraph 2 will be revised as follows: "They are generally technology- or activity-based requirements or limitations and apply to specific remedial approaches rather than to a site."		DOI accepts the response.	Comment resolved. Agencies approved PG&E response. Changes noted in the response have been made to the CMS/FS

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								Report.
94	HA-17	Section 3.2 Page 3-3	Hargis & Associates, Inc. (on behalf of Fort Mojave Indian Tribe)	This section presents a preliminary determination of ARARs that includes statutes that consider and protect cultural resources, including tribal heritage resources. Several of these are listed in the text within the summary of "most significant" ARARs. In fact, over half of the location-specific ARARs listed in the text would fall into this category. Still, this analysis is deficient because it is wholly missing analysis applying the preliminary cultural resource ARARs. See General Comment No. 3 above.	PG&E defers response to DOI		DOI agrees that the cultural resource ARARs compliance determinations in the January 2009 Draft CMF/FS are deficient. DOI will direct PG&E to revise the Draft CMS/FS with specific language for inclusion in the final CMS/FS regarding cultural resource ARARs attainment. This language will provide an analysis of whether or not each alternative can attain each ARAR considering potential impacts on culturally sensitive resources, potential mitigation measures, and other factors relevant to attainment of the ARAR. DOI has considered all comments received, including all input received during formal consultation with each of the tribes and will be providing language for insertion into the CMS/FS.	Comment resolved. The Final CMS/FS has been revised to include the language regarding ARARs compliance that DOI provided to PG&E.
95	DTSC-27	Table 3-1, Page 3-4	California Department of Toxic Substances Control	Footnote "a" indicates that the Cr(III) criteria is calculated based on water hardness concentrations of 142 mg/l. PG&E should cite the reference of the hardness value.	In response to this comment, the hardness values in Table 3-1 in the CMS/FS Report will be revised consistent with the RFI/RI Volume 2 Report and the risk assessment. Values that are hardness dependent will be shown as criteria @CaCO3 = 300 ppm (parts per million), consistent with data collected in the Colorado River during RFI/RI characterization. The 300 ppm value for hardness is based on measured values in the river, and was used in the RFI/RI Volume 2 Report, the RFI/RI Volume 2 Addendum, and the groundwater risk assessment for adjustment of surface water criteria for hardness. As DTSC notes, the actual measured hardness values in the river are typically above 300 ppm; the 300 ppm value was selected as a conservative value, noting that the surface water criteria for Cr(III) increases with increasing hardness. Using a hardness value of 300 ppm, the federal surface water criteria for Cr(III) is 438 ppb; using a hardness value of 400 ppm, the federal surface water criteria for Cr(III) is 554 ppb.	DTSC notes that surface water hardness values range from 300 ppm to 422 ppm circa 2005/2006. With the inclusion of the hardness selection rationale, DTSC agrees with RTC.	DOI concurs with the response.	Comment resolved. Agencies approved PG&E response. Changes to Table 3-1 noted in the responses (PG&E and DTSC) have been made to the CMS/FS Report.
96	DTSC-28	Page 3-4, Paragraph 1, Section 3.2.1	California Department of Toxic Substances Control	The ARARs must address all COCs.	Table 3-1 will include the chemical-specific ARARs for identified COCs.	Agree with RTC	DOI concurs with the response.	Comment resolved. Agencies approved PG&E response. Redline final CMS/FS submitted to agencies on November 13, 2009. Agencies approved the Table 3-1 report revisions.
97	ADEQ-2	Section 3.2.1 Page 3-4	Arizona Department of Environmental	The VRP contends that the Arizona Numeric Water Quality Criteria for total and hexavalent chromium in the Colorado River are relevant and	PG&E defers response to DOI		Pursuant to Section 121(d)(2)(A)(ii) of CERCLA, for a state standard to be an ARAR it must be "more stringent than	Comment addressed. No changes to the CMS/FS Report are required.

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			Quality	should be included in Table 3-1 of the CMS/FS.			any Federal standard" that has been promulgated to address the circumstances addressed by the state standard. This "more stringent than" requirement is reiterated in the National Oil and Hazardous Substances Pollution Contingency Plan ("NCP"), which states that: "Only those state standards that are promulgated, are identified by the state in a timely manner, and are more stringent than federal requirements may be applicable or relevant and appropriate." 40 CFR 300.400(g)(4). The VRP acknowledged in its comments that Arizona Numeric Water Quality Criteria for total and hexavalent chromium are not more stringent than their federal counterparts. Therefore, these Numeric Water Quality Criteria are not ARARs for this Site.	
98	ADEQ-4	Section 3.2.1 Page 3-4	Arizona Department of Environmental Quality	The VRP requests that the AWQS for total chromium is included in Table 3-1 of the CMS/FS where chemical-specific ARARs have been identified. A footnote may be added to indicate this ARAR is only relevant in reference to the Arizona portion of the Topock study area.	PG&E defers response to DOI		As with the Arizona Numeric Water Quality Criteria for chromium, the Arizona AWQS must be more stringent than any federal counterpart in order to be identified as an ARAR. The VRP acknowledged in its comments that the Arizona AWQS for total and hexavalent chromium are not more stringent than their federal counterparts. Therefore, these AWQS are not ARARs for this Site.	Comment addressed. No changes to the CMS/FS Report are required.
99	CRIT-20	Section 3.2.1 Page 3-4	Envirometrix (on behalf of the Colorado River Indian Tribe)	Does Arizona have any surface water protection standards for Cr(VI), CR(III) or Cr (T)? Does the California Regional Water Quality Control Board (RWQCB) have any surface water protection standards or basin plan water quality goals or objectives for these chemicals? Is the non-degradation policy of the RWQCB considered an ARAR? Are there any proposed or anticipated regulatory changes, standards, goals or water quality objectives for these chemical that may impact the ARARS in the future? If so, please list them.	PG&E defers response to DOI		Arizona's surface water protection regulations are not more stringent than their federal counterparts, therefore, they are not ARARs. The RWQCB does have surface water quality standards in its Water Quality Control Plan for the Colorado River Basin-Region 7. The RWQCB has proposed that these standards are ARARs and DOI is currently evaluating this proposal. If DOI concurs that these standards are ARARs they will be included in the revised Appendix A to the CMS/FS that DOI will provide PG&E for the final CMS/FS. DOI is not aware of any proposed regulatory changes at his time.	Comment addressed. DOI revised the ARARs list and provided the updated list to PG&E in October 2009. The updated ARARs list is included in the Final CMS/FS as Appendix B.
100	DTSC-29	Page 3-5, first bullet, Section	California Department of Toxic	The UIC permit requirement may not be applicable if the injection is within the plume	PG&E agrees that a UIC permit is not required for injection that occurs onsite, in accordance with the permit exemption in CERCLA Section 121(e)(1). Because the requirement that	Agree with RTC	DOI concurs with the response.	Comment resolved. Agencies approved PG&E response. No

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		3.2.3	Substances Control	associated with remediation.	ARARs be substantive and not administrative requirements is discussed in Appendix A, revisions to Section 3.2.3 have not been made in response to this comment.			changes to the CMS/FS Report are required.
101	DOI-39	Section 3.2.3, Page 3-6, Bullet 2	U.S. Department of the Interior	Delete last sentence: "A case-by-case determination . . ." Replace last sentence with: "This Act will apply if the proposed remedial actions will result in the take of, or adverse impacts to, threatened and endangered species."	The last sentence in Section 3.2.3, bullet 2 will be revised to read: "This Act will apply if the proposed remedial actions will result in the take of, or adverse impacts to, threatened and endangered species."	Agree with RTC	DOI accepts the response and directs PG&E to make the changes to the document as proposed.	Comment resolved. Agencies approved PG&E response. Changes noted in the response have been made to section 3.2.3 of the CMS/FS Report as further modified by DOI (see comment 476).
102	DOI-40	Section 3.2.3, Page 3-6, Bullet 4	U.S. Department of the Interior	Delete last sentence: "A case-by-case determination . . ." Replace last sentence with: "A determination regarding compliance with this Act will be made upon final guidance by the regulatory agencies and the results of consultation by those agencies with stakeholder tribes."	The last sentence in Section 3.2.3, bullet 4 will be replaced with the following: "A determination regarding compliance with this Act will be made upon final guidance by the regulatory agencies and the results of consultation by those agencies with stakeholder tribes."		DOI accepts the response and directs PG&E to make the changes to the document as proposed.	Comment resolved. The subject sentence has been deleted from the CMS/FS Report as directed by DOI (see comment 477).
103	DTSC-30	Page 3-6, first bullet, Section 3.2.3	California Department of Toxic Substances Control	Both construction and industrial SWPPP may be applicable depending on the remedy.	In response to this comment, the first bullet will be revised to read: "These regulations will apply if proposed remedial actions disturb more than 1 acre of soil and result in stormwater runoff that comes in contact with any construction activity from site remediation, or if proposed remedial actions involve specified industrial activities."	Agree with RTC	DOI concurs with the response.	Comment resolved. Agencies approved PG&E response. Changes noted in the response have been made to Section 3.2.3 of the CMS/FS Report.
104	DTSC-31	Page 3-6, Bullet 5, Section 3.2.3	California Department of Toxic Substances Control	The "Water Quality Protection Standard" bullet should be deleted from the Report as it does not apply to releases from SWMU/AOC 1.	Reference to compliance with the Water Quality Protection Standard as an ARAR for this remedial action will be removed from Section 3.2.3. PG&E agrees with DTSC that this requirement should not be ARAR for this remedial action. In order for a requirement to be considered relevant and appropriate it must be well suited to the circumstances at the site. The requirements in question are intended to apply to releases from permitted hazardous waste management units; neither SWMU 1/AOC 1 nor AOC 10 are or were permitted hazardous waste management units. The requirements specify a prescriptive groundwater corrective action strategy including establishing a list of COCs, specifying a point of compliance, and establishing a water quality protection standard based on background water quality. These prescriptive requirements, which were intended to address discreet disposal units, are not well suited to address the groundwater plume at this site, which originated from historic disposal practices. They do not take into account applicable water quality goals or beneficial uses of groundwater. The CERCLA program includes more flexible provisions for establishing groundwater monitoring programs and establishing risk-based cleanup levels that reflect site-specific circumstances. Applying a more prescriptive cleanup program as an overlay to the CERCLA	Agree with RTC	DOI defers to DTSC.	Comment resolved. Agencies approved PG&E response. Changes noted in the response have been made to Section 3.2.3 of the CMS/FS Report.

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					program requirements is not appropriate for the circumstances of this remedial action.			
105	DTSC-32	Page 3-6, Bullet 6, Section 3.2.3	California Department of Toxic Substances Control	“Closure and Post-Closure Care” bullet and all subsequent citations should be deleted from the Report since SWMU1/AOC 1 is not a “permitted” regulated unit. SWMU1/AOC 1 is subject to corrective action compliance only.	Reference to closure and post-closure care as an ARAR for this remedial action will be removed from Section 3.2.3. PG&E agrees with DTSC that this requirement should not be ARAR for this remedial action. As stated in the response to comment 104, in order for a requirement to be considered relevant and appropriate it must be well suited to the circumstances at the site. The cited requirements are the following portions of the closure and post-closure care requirements for permitted hazardous waste management facilities: • Meet the closure performance standard • Prepare a closure plan • Submit a certification of closure • Prepare a survey plat showing where waste has been left in place • Prepare a post-closure plan • Provide post-closure care of the property • Prepare post-closure notices • Prepare certification of completion of post-closure care. Neither SWMU 1/AOC 1 nor AOC 10 are or were permitted hazardous waste management units. Many of these requirements, such as preparing closure and post-closure plans, and submitting certification of closure and post-closure care, are administrative requirements and should not be considered as potential ARARs. The remaining substantive requirements are not well suited to the circumstances of the site for the following reasons: • Closure and post-closure requirements primarily address actions taken to remove or contain waste at a discreet waste management unit, such as removal of waste and contaminated soil and capping. This remedial action addresses a plume of dispersed groundwater contamination associated with historic disposal practices, not the specific location where the waste was originally released. • The post-closure requirements specify an arbitrary 30-year post closure care period and incorporate monitoring and maintenance requirements for discreet waste management units, that are not tailored to the circumstances of this remedial action. • The requirements to submit a post-closure notice and survey plat specifically address discreet waste	Agree with RTC	DOI defers to DTSC and acknowledges that additional information may be provided in the DTSC response to the DOI August 10, 2009 letter pertaining to “Interpretation of Certain California Requirements Designated as ARARs”.	Comment resolved. Agencies approved PG&E response. Changes noted in the response have been made to Section 3.2.3 of the CMS/FS Report.

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					management units. The requirement to implement institutional controls in 22 CCR 67391.1, which is cited as an applicable requirement, is intended to address remedial actions and is more well suited to the circumstances for this remedial action.			

Section 4 Comments - Identification and Screening of Remedial Action Technologies

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106	CRIT-21	Section 4	Envirometrix (on behalf of the Colorado River Indian Tribe)	In our previous January 9, 2009 comment No. 20, we requested that DTSC or DOI engineers conduct an additional review of these technologies and evaluate the basis PG&E uses for removing them from consideration. In the case of Permeable Reactive Barriers, PG&E states that Traditional Trenching methods have not been used at the required depth and trench stability becomes an issue at depths greater than 150 feet. CRIT stated that with our limited resources we were aware that effective Permeable Reactive Barriers have been installed to equivalent depths; not by trenching but by injection of reactive material. This procedure was successfully conducted at the California DuPont Oakley Facility. Therefore, we are not completely confident that an unbiased evaluation of remedies was provided. PG&E's response states that PG&E defers to DTSC and DOI for response to this comment. In order to assist PG&E, we conducted an internet search and found the following links that may be of assistance. http://oakley.dupont.com/publications/Phase%202%20PRB%20Construction%20Rpt%201ntro_Summary.pdf http://www.geosierra.com/deepprb.html We restate our request that DTSC and DOI engineers conduct a review and evaluation of all the technologies presented by PG&E.	Permeable reactive barriers (PRBs) may be installed using a variety of construction methods, and are functionally equivalent to the in-situ reactive zone (IRZ) lines included in several remedial alternatives in the Draft CMS/FS Report. One drawback with the PRBs installed using injection methods is that they require more wells to be drilled. One contractor estimated that to construct a PRB at the Topock site using pneumatic injection of iron filings, wells would need to be placed on 15 foot centers. The other drawback to PRB's constructed using solid phase materials such as zero valent iron is that they cannot be replenished once the reducing capacity is exhausted; they must be replaced. In response to this comment and comments #122 and 138, Tables 4-1 and 4-2 have also been modified to identify other construction techniques for PRBs, including trenches, fracturing, or boreholes, and to clarify that PRBs constructed using a line of wells that circulates reactive materials between each well is termed an IRZ. In addition, in response to comment #178, the text to Section 5.2.6 will be edited to include a discussion of semi-permanent well placement of reactive material.	DTSC agrees that there are other methods of installing both permeable reactive and impermeable barriers. DTSC has also made the same comment as the CRIT during the review of the draft CMS/FS document for PG&E's consideration.	DOI agrees that other methods are available for installation of permeable reactive barriers and impermeable barriers. We do, however, concur with the PG&E response pending review of the revised text.	Comment resolved following agency review and input during finalization of Tables 4-1 and 4-2 of the CMS/FS Report text. Redline final submitted to agencies on November 13, 2009. Agencies approved the report revisions.
107	DTSC-33	Section 4, general	California Department of Toxic Substances Control	This section should evaluate technologies for all COCs for the site and not just chromium.	No changes to Section 4.0 are proposed in response to this comment. The technologies appropriate for constituents other than chromium, namely institutional controls and monitoring, are currently included in the evaluation, and appropriately evaluated and retained.	DTSC agrees that monitoring might be the appropriate action for the extent of contamination known about the other COCs. However, PG&E should discuss the affect of the current remedial alternatives on these COCs.	DOI acknowledges that the focus of the CMS/FS is for Cr(VI) resulting from disposal at SWMU 1/AOC 1 and East Ravine. Additional COCs that may be identified during well installation at and near the station, during ongoing East Ravine investigations, and as a result of soils investigations will be evaluated independently. Source control may be considered during evaluation of alternatives in the soil investigation.	Comment resolved. The focus of the CMS/FS is Cr(VI) resulting from disposal at SWMU 1/AOC 1 and/or found in East Ravine. The rationale for not needing numerical RAOs for other constituents is discussed in Section 3.0. No further changes to Section 4.0 are required in response to this comment. Redline final

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								submitted to agencies on November 13, 2009. Agencies approved the report revisions.
108	DOI-41	Section 4.1, Page 4-1, Paragraph 1, Bullet 3	U.S. Department of the Interior	Monitored natural attenuation includes a monitoring component to ensure that the natural processes are reducing contaminant concentrations such that the RAOs will be achieved within the desired period of time. Although the other general response actions may also include monitoring, monitoring is an inherent and fundamental component of <u>monitored</u> natural attenuation.	This comment has been incorporated into the description of monitored natural attenuation (MNA), and in response to comment #109 (that MNA should be identified as a remedial technology instead of a general response action) the referenced bullet has been deleted, and the text has been moved to Table 4-1 where the description of MNA first appears. The description of MNA in Table 4-1 has been modified to read as follows: "Actions that rely on monitoring to show that natural subsurface processes such as dilution, volatilization, biodegradation, adsorption, dispersion, and chemical reactions with subsurface materials are reducing contaminant concentrations to acceptable levels within the desired period of time."	Agree with RTC	DOI accepts the modification to the text to be included in Table 4-1. It is recommended that dispersion be included in the list of processes.	Comment resolved. Agencies approved PG&E response. Changes to Table 4-1 noted in the response have been made to the CMS/FS Report.
109	DTSC-34	Page 4-1, Bullet 3, Section 4.1	California Department of Toxic Substances Control	Monitored Natural Attenuation (MNA) is a remedial technology type and not a general response action. MNA is a technology of two general response actions: monitoring and treatment by natural attenuation.	In response to this comment, MNA has been deleted from the list of general response actions. In addition, Tables 4-1 and 4-2 have been modified to show MNA under the category of treatment, rather than as a separate general response action.	Agree with RTC	DOI concurs with the response.	Comment resolved. Agencies approved PG&E response. Changes noted in the response have been made to the CMS/FS Report in Section 4.1, Table 4-1, Table 4-2, and Table 4-3.
110	DTSC-35	Table 4-1 and Table 4-2 MNA	California Department of Toxic Substances Control	See comment above on MNA as a general response action.	In response to this comment and comment #109, MNA has been moved as a remedial technology under the Treatment general response action in Tables 4-1 and 4-2.	Agree with RTC	DOI concurs with the response.	Comment resolved. Agencies approved PG&E response. Changes noted in the response have been made to the CMS/FS Report in Section 4.1, Table 4-1, Table 4-2, and Table 4-3.
111	DOI-42	Section 4.2.2, Page 4-4, Paragraph 1, last sentence	U.S. Department of the Interior	Change "was" to "were."	The sentence was revised as requested.	Ok	DOI accepts the response.	Comment resolved. Agencies approved PG&E response. Changes noted in the response have been made to the CMS/FS Report in Section 4.2.2.
112	DOI-43	Table 4-1, Page 4-5, Institutional Controls, Access and Use	U.S. Department of the Interior	The primary screening comments should not make judgments about whether a particular technology is reliable as a remedy or not. That is not the question being addressed here. At this point in the process, the only decision being made is whether or not the technology is implementable. In the case of institutional	In response to this comment, the phrase "not reliable as a stand alone option" has been removed from the text in the primary screening comments for permits.	Agree with RTC	DOI accepts the response.	Comment resolved. Agencies approved PG&E response. Changes noted in the response have been made to the CMS/FS Report in Table 4-1.

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		Restrictions		controls, the technology is implementable in conjunction with other technologies and is retained.				
113	DOI-44	Table 4-1, Page 4-5, Institutional Controls, Alternative Drinking Water Source	U.S. Department of the Interior	The rationale for the exclusion of this technology is inconsistent with the stated RAO #1 of reducing risk from exposure to contaminated potable water supply/drinking water source. Although the aquifer is not currently used, it is clearly being assessed in the risk assessment and CMS/FS as a potential future water supply. This technology could have application if the selected remedy requires decades or longer to achieve the RAOs, and development of alternative water supplies must occur to support future development in the interim. This technology should be retained.	The technology has been retained as suggested in the primary screening. The text under the primary screening comment for each of the process options in Table 4-1 has been modified as follows: "Groundwater beneath and immediately adjacent to the plume is not currently being used as a drinking water source. However future development of alternative water supplies may be necessary to support future development; therefore this technology is retained."	Agree with RTC	DOI accepts the response.	Comment resolved. Agencies approved PG&E response. Changes noted in the response have been made to Table 4-1 in the CMS/FS Report.
114	DTSC-36	Page 4-5 Table 4-1	California Department of Toxic Substances Control	Alternative Drinking Water Source - Modify the screening comment as follows to stress that water in the area is used for drinking water and that the groundwater within the entire area has designated beneficial uses: *Groundwater beneath and immediately adjacent to the plume is not currently being used as a drinking water source.*	The text has been modified as requested. See also response to comment #113.	Agree with RTC	DOI concurs with the response.	Comment resolved. Agencies approved PG&E response. Changes noted in the response have been made to Table 4-1 in the CMS/FS Report.
115	DTSC-37	Page 4-6, Table 4-1, Containment	California Department of Toxic Substances Control	Although remedial technology of capping has been identified as not passing primary screening, it is good to note that it may be an important technology type for groundwater protection if there is substantial source remaining in soil that may leach into groundwater. Currently there is not enough information to determine the necessity of capping. PG&E can modify the screening comment to indicate that a surface barrier might be used to mitigate localized infiltration and contaminant transport. This has not been assessed and may be used based on future evaluation of soils data.	In response to this comment, the following text has been added to the screening comment for the capping options in Table 4-1: "Capping might be used to mitigate localized infiltration and contaminant transport. This has not been assessed in the context of a technology for groundwater but may have application as a soils technology based on future evaluation of soils data."	Agree with RTC	DOI concurs with the response.	Comment resolved. Agencies approved PG&E response. Changes noted in the response have been made to Table 4-1 in the CMS/FS Report.
116	DOI-45	Table 4-1, Page 4-7, Containment, Vertical Barriers	U.S. Department of the Interior	Vertical barriers are not always excavated perpendicular to the groundwater flow direction. They may also be constructed at some other angle to flow to redirect groundwater flow in a preferred direction.	The text in Table 4-1 has been modified to remove the phrase "perpendicular to the groundwater flow direction."	Agree with RTC	DOI accepts the response.	Comment resolved. Agencies approved PG&E response. Changes noted in the response have been made to Table 4-1 in the CMS/FS Report.
117	DOI-46	Table 4-1, Page 4-8, Containment, Horizontal	U.S. Department of the Interior	Bedrock has not been demonstrated to be "relatively impermeable" throughout the site. Remove this statement. Contaminant migration appears to be primarily horizontal within the entire thickness of the alluvial aquifer, therefore vertical barriers do not appear to be an	The statement has been removed as requested.	Agree with RTC, will await review of final language	DOI accepts the response.	Comment resolved following agency review and input during finalization of the CMS/FS Report Table 4-1. Redline final submitted to agencies on

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		Barriers		appropriate technology for achieving RAOs.				November 13, 2009. Agencies approved the report revisions.
118	DTSC-38	Page 4-7 Table 4-1	California Department of Toxic Substances Control	Containment – This section must include hydraulic containment/ barriers as they are used in several of the proposed remedial alternatives.	Hydraulic containment has been added to Tables 4-1 and 4-2 as requested. Extraction wells were retained as the representative process option for this technology and were added to Table 4-3.	Agree with RTC, will await review of final language	DOI concurs with the response, pending review of the final text.	Comment resolved following agency review and input during finalization of the CMS/FS Report Table 4-1. Redline final submitted to agencies on November 13, 2009. Agencies approved the report revisions, as further modified by DTSC (see comment 485).
119	DTSC-39	Page 4-9 Table 4-1	California Department of Toxic Substances Control	Removal - Groundwater Collection. Include angled wells (vertical and horizontal are already included), as they may assist in minimizing disturbance to the land considered sacred by some tribes.	Angled wells have been included with horizontal wells in Tables 4-1 and 4-2. The following sentence has been added to the screening comment: "Angled wells may assist in minimizing disturbance to the land."	Angled and horizontal wells may be used in lieu of conventional vertical wells in specified areas where angled wells can reduce impacts to significant cultural resources.		Comment resolved following agency review and input during finalization of the CMS/FS Report Table 4-1. Redline final submitted to agencies on November 13, 2009 with Table 4-1 referring to both angled and horizontal wells in the added sentence noted in the response Agencies approved the report revisions.
120	DTSC-40	Page 4-9 Table 4-1	California Department of Toxic Substances Control	Removal - Enhanced Extraction through Injection. Modify item to allow injection of contaminated water as proposed for some remedial alternatives.	In response to this comment, the process option has been changed to "Injection of clean or contaminated water." The description text has been modified as follows: "Clean water from an outside source, or clean or contaminated water or water enhanced with carbon re-circulated from within the site, is injected into the aquifer to increase hydraulic gradients toward the extraction wells and to increase the flushing rate."	Agree with RTC	DOI concurs with the response, pending review of the final text.	Comment resolved. Agencies approved PG&E response. Changes to Table 4-1 noted in the response have been made to the CMS/FS Report.
121	DTSC-41	Page 4-10 Table 4-1	California Department of Toxic Substances Control	In-situ – Hydraulic Fracturing. Modify language and retain this alternative as it may supplement treatment of low permeability zones at the site. Also include the process for injecting reductants (e.g., filings) into groundwater via jetting or other injection mechanism.	The text was modified as requested and hydraulic fracturing was retained in Table 4-1 and was added to Table 4-2.	Agree with RTC, will await review of final language	DOI concurs with the response, pending review of the final text.	Comment resolved following agency review and input during finalization of Tables 4-1 and 4-2 of the CMS/FS Report text. Redline final submitted to agencies on November 13, 2009. Agencies approved the report revisions.
122	DTSC-42	Page 4-11 Table 4-1	California Department of	In-situ – Permeable Reactive Barriers. Mention that PRBs can be constructed without trenches.	The text was modified within Tables 4-1 and 4-2 to identify construction techniques for permeable treatment walls	Agree with RTC, will await review of final language	DOI concurs with the response, pending review of the final text.	Comment resolved following agency review

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			Toxic Substances Control	Elaborate on the techniques available.	without trenching, including fracturing or boreholes. Table 4-2 has been modified to clarify that PRBs constructed using a line of wells that circulates reactive materials between each well is termed an IRZ.			and input during finalization of Tables 4-1 and 4-2 of the CMS/FS Report text. Redline final submitted to agencies on November 13, 2009. Agencies approved the report revisions.
123	DTSC-43	Page 4-12, Table 4-1, Ex-situ Physical/ Chemical Treatment	California Department of Toxic Substances Control	Is “filtration” also considered a secondary treatment? If so, please add footnote “a”.	The footnote “a” was added to filtration as requested.	Agree with RTC	DOI concurs with the response, pending review of the final text.	Comment resolved. Agencies approved PG&E response. Changes to Table 4-1 noted in the response have been made to the CMS/FS Report.
124	DTSC-44	Page 4-14 Table 4-1	California Department of Toxic Substances Control	Disposal – Land Application. DTSC believes this option should be rejected because DTSC cannot envision a scenario in which aqueous waste would be discharged to the surface and degraded.	Tables 4-1 and 4-2 have been revised in response to this comment to screen out land disposal as a technology for the Topock site.	Agree with RTC	DOI concurs with the response, pending review of the final text.	Comment resolved. Agencies approved PG&E response. Changes to Tables 4-1 and 4-2 noted in the response have been made to the CMS/FS Report.
125	DTSC-45	Page 4-14 Table 4-1	California Department of Toxic Substances Control	Disposal – Untreated Groundwater Discharge. This option should be retained since it has been implemented on the site in the past under interim measures and may be a viable option for certain contingencies or limited action. Also, has rail haul been considered for the site?	In response to this comment, Table 4-1 will be revised to reflect that untreated groundwater discharge at an offsite permitted facility is retained as a possible contingency in the primary screening and will be added to Table 4-2. Rail haul has not been evaluated at a detailed level for management of untreated groundwater from the site.	Agree with RTC	DOI concurs with the response, pending review of the final text.	Comment resolved. Agencies approved PG&E response. Changes to Tables 4-1 and 4-2 noted in the response have been made to the CMS/FS Report.
126	HA-28	Table 4-1	Hargis & Associates, Inc. (on behalf of Fort Mojave Indian Tribe)	<u>Appendix F – PG&E Response to FMIT Specific Comment No. 3</u> The Tribe agrees that transportation of contaminated groundwater for offsite treatment is an appropriate addition for Table 4-1. With regard to PG&E’s position that it should not be retained for further evaluation, however, the Tribe suggests that this may need to be considered as a possible supplement or contingency in conjunction with other alternatives.	In response to this comment, Table 4-1 will be revised to reflect that untreated groundwater discharge at an offsite permitted facility is retained as a possible contingency in the primary screening and will be added to Table 4-2.	Agree with RTC	DOI concurs with the response.	Comment resolved. Agencies approved PG&E response. Changes to Tables 4-1 and 4-2 noted in the response have been made to the CMS/FS Report.
127	DTSC-46	Page 4-14, Table 4-1, Footnote a	California Department of Toxic Substances Control	Please explain what is a “secondary treatment”.	Footnote “a” to Table 4-1 has been changed to: “Retained for possible use as secondary component of a treatment train, but the option is not applicable as a primary treatment option for Cr(VI).”	Agree with RTC	DOI concurs with the response.	Comment resolved. Agencies approved PG&E response. Changes to Table 4-1 noted in the response have been made to the CMS/FS Report.
128	DTSC-47	Table 4-2	California Department of	Comments to Table 4-1 require modifications to	Changes to Tables 4-2 and 4-3 have been made as noted	Agree with RTC, await review of redline	DOI concurs with the response, pending	Comment resolved following agency review

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			Toxic Substances Control	Table 4-2 and 4-3.	above in the responses to comments on Table 4-1.	CMS/FS	review of the final text.	and input during finalization of the CMS/FS Report Tables 4-1, 4-2, and 4-3. Redline final submitted to agencies on November 13, 2009. Agencies approved the report revisions.
129	HA-18	Table 4-2 Page 4-15	Hargis & Associates, Inc. (on behalf of Fort Mojave Indian Tribe)	Over thirty different process options are evaluated on this table, of which approximately one-third were not retained for further evaluation, and seven were selected as the representative process option for developing the nine alternatives presented. As indicated earlier, if there is any further re-design or reformulation of remedial alternatives, the Tribe requests to be include in such discussions. In particular, the Tribe would be concerned if any of the rejected or non-selected process options are reconsidered. For example, the Tribe is strongly opposed to all of the General Response Actions under the Containment description.	In response to multiple comments, Table 4-1 has been revised to include additional process options as passing the primary screening in Table 4-1 and is evaluated further in Table 4-2. In response to comment #118, hydraulic containment has been added to Tables 4-1 (and 4-2), and extraction wells have been retained as the representative process option and added to Table 4-3. This does not, however, result in substantive revision to the approach to the remedial alternatives design since the extraction wells are primarily intended for Cr(VI) mass removal rather than long-term containment. In response to comment #113, alternative drinking water source has been retained in Table 4-1 and has been added to Table 4-2. This does not, however, result in substantive revision to the remedial alternatives design for the groundwater plume. In response to comment #121, *in-situ* hydraulic fracturing has been retained in Table 4-1 and has been added to Table 4-2. This does not, however, result in substantive revision to the remedial alternatives design since this option is only intended to supplement treatment of low permeability zone. In response to comment #125, untreated groundwater discharge at an offsite permitted facility has been retained in Table 4-1 and has been added to Table 4-2. This does not, however, result in substantive revision to the remedial alternatives design since this option is only intended as a contingency measure.	Agree with RTC	DOI concurs with the response, noting that the Tribes will have an opportunity to comment on the revised CMS/FS during the BLM lead formal consultation process on the proposed remedy.	Comment resolved. Agencies approved PG&E response. Changes to Tables 4-1 and 4-2 in response to other comments as noted in the response have been made to the CMS/FS Report.
130	DOI-47	Table 4-2, Page 4-15, No Action	U.S. Department of the Interior	Stakeholder acceptability has not been established at this point. It is not necessary to make this statement in this table. Remove the statement.	The phrase "but not acceptable to stakeholders" has been deleted from the sentence.	Agree with RTC	DOI accepts the response.	Comment resolved. Agencies approved PG&E response. Changes to Table 4-2 noted in the response have been made to the CMS/FS Report.
131	DTSC-48	Page 4-15, Table 4-2, IC	California Department of Toxic Substances Control	It is DTSC's understanding that actual permits will be required for non-NPL sites.	PG&E defers response to DOI	Agree with RTC	Section 121(e)(1) of CERCLA provides that "(n)o Federal, State, or local permit shall be required for the portion of any removal or remedial action conducted entirely on-site, where such remedial action is selected and carried out in compliance with this section." This	Comment addressed. No changes to the CMS/FS Report are required.

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							permit exemption applies to all onsite CERCLA response actions selected in compliance with Section121 of CERCLA, regardless of whether the site is listed on the National Priorities List (NPL). The CERCLA remedial action for the Topock site will be selected in compliance with Section 121 of CERCLA and, therefore, permits will not be required for on-site activities. Any substantive requirements that would be established by a permit, however, must still be attained.	
132	DOI-48	Table 4-2, Page 4-15, Monitored Natural Attenuation, Implement-ability	U.S. Department of the Interior	Revise 1st sentence of entry to read: "Typical monitoring networks for MNA include compliance wells to confirm that the constituents are being attenuated and that the plume is not expanding or migrating to undesirable locations."	The sentence has been revised as requested. Also note that MNA has been moved in Table 4-1 (see responses to comment #108 and comment #110).	Agree with RTC, will await review of final language	DOI accepts the response.	Comment resolved following agency review and input during finalization of Table 4-2 in the CMS/FS Report . Redline final submitted to agencies on November 13, 2009. Agencies approved the report revisions.
133	DOI-49	Table 4-2, Page 4-15 and 4-16, Containment, Screening	U.S. Department of the Interior	DOI does not agree with statement that containment technologies would not be effective as remediation technologies in combination with other technologies because they do not treat the contamination. Containment technologies are not intended to be treatment technologies. They are intended to contain contamination and are often applied in conjunction with other remediation technologies that treat contaminants. The basis for dismissal of the process option should focus on the unproven implementability at the site depths, the large surface disturbance, and site access limitations under the bridges and the risks to their structural integrity.	In response to this comment, the reference to treating constituents was deleted. The text now reads: "Not retained. Lack of a continuous aquitard at a depth that is within the vertical limits of traditional trenching equipment means that extensive disturbance of the biologically and culturally sensitive habitat at the surface would need to occur.	DTSC accepts the response Please replace with "extensive surface disturbance would be necessary to implement this technology."	DOI accepts the response.	Comment resolved following agency review and input during finalization of Table 4-2 in the CMS/FS Report. The text now reads: "Not retained. Lack of a continuous aquitard at a depth that is within the vertical limits of traditional trenching equipment means extensive surface disturbance would be necessary to implement this technology."
134	DOI-50	Table 4-2, Page 4-16, Removal, Groundwater Collection, Conventional Extraction Wells	U.S. Department of the Interior	The discussion of the effectiveness of conventional extraction wells and injection of clean water needs to be modified to indicate these techniques may not be effective if the contamination is contained in low permeability fine-grained layers. It should be also be noted here that depending on the array of the wells, there could be significant impact to the surface.	In response to this comment, the following text has been added under the effectiveness column in Table 4-2 for conventional extraction wells and injection of clean or contaminated water: "However, these techniques may not be effective if the contamination is contained in low-permeability, fine-grained layers and, depending on the array of the wells, there could be extensive surface disturbance."	Agree with 1st part of RTC, but the significance of surface impacts should not be concluded in this table. DTSC prefers evaluation of relative impacts be in comparative analysis or in EIR. Replace with "extensive surface disturbance" (as in #133). Avoid use of phrases "significant impact" in non-CEQA document.	DOI accepts the response.	Comment resolved following agency review and input during finalization of Table 4-2 in the CMS/FS Report. The text now reads: "However, these techniques may not be effective if the contamination is contained in low permeability, fine-grained layers"

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<table>
<tr><th></th><th>Comment Number</th><th>Section/ Page</th><th>Commenter</th><th>Comment</th><th>PG&E Response</th><th>DTSC Response</th><th>DOI Response</th><th>Final Comment Resolution</th></tr>
<tr><td></td><td></td><td></td><td></td><td></td><td></td><td></td><td></td><td>Redline final submitted to agencies on November 13, 2009. Agencies approved the report revisions.</td></tr>
<tr><td>135</td><td>DTSC-49</td><td>Page 4-16, Table 4-2, Removal, Horizontal Wells</td><td>California Department of Toxic Substances Control</td><td>Please provide additional discussion on the comment that “Horizontal wells are not as effective as vertical wells for this site.”</td><td>In response to this comment, the sentence has been modified and now reads:
“Depths of contamination and site hydrogeologic condition make horizontal or angled wells less effective than vertical wells for this site. Vertical wells are preferred at the site since they are easier to install develop and maintain than horizontal wells. The site hydrogeology does not necessitate the use of horizontal or angled wells. However, horizontal and angled wells are retained as they may have application in some portions of the site.”</td><td>Also reference conclusion of RTC 119.</td><td></td><td>Comment resolved following agency review and input during finalization of the CMS/FS Report Table 4-2. Redline final submitted to agencies on November 13, 2009 with Table 4-2 referring to both angled and horizontal wells in the added sentence noted in the response Agencies approved the report revisions.</td></tr>
<tr><td>136</td><td>DTSC-50</td><td>Page 4-16, Table 4-2, Removal, Injection of clean water</td><td>California Department of Toxic Substances Control</td><td>The CMS/FS should note that the sustainability of clean water supply would be a limitation for implementability of this process option. DTSC recommends, based on stakeholder input, adding a table that provides a conceptual view of water balance as part of the remedial alternatives evaluation. For each alternative, the table should provide information on amount of water that would be extracted from the ground or the Colorado River, amount of water that may be used as part of the remediation, and amount of water to be returned to the aquifer.</td><td>In response to this comment, a table such as the table below will be added to the CMS/FS Report in Section 5.0 or Appendix B.
<table>
<tr><th>Alternative</th><th>Description</th><th>Extraction, gpm</th><th>Injection, gpm</th><th>Net Consumptive Use, gpm</th></tr>
<tr><td>A</td><td>No Action</td><td>N/A</td><td>N/A</td><td>N/A [a]</td></tr>
<tr><td>B</td><td>Monitored Natural Attenuation</td><td>N/A</td><td>N/A</td><td>N/A</td></tr>
<tr><td>C</td><td>High Volume In-Situ Treatment</td><td>2,000</td><td>2,000</td><td>0 [b]</td></tr>
<tr><td>D</td><td>Sequential In-Situ Treatment</td><td>250-1,500</td><td>250-1,500</td><td>0 [b]</td></tr>
<tr><td>E</td><td>In-Situ Treatment with Freshwater Flushing</td><td>1,200</td><td>1,200</td><td>0 [b]</td></tr>
<tr><td>F</td><td>Pump and Treat</td><td>1,200</td><td>1,200</td><td>0 [b]</td></tr>
<tr><td>G</td><td>Combined Floodplain In Situ/Pump and Treat</td><td>1,200</td><td>1,200</td><td>0 [b]</td></tr>
<tr><td>H</td><td>Combined Upland In Situ/Pump and Treat</td><td>500</td><td>500</td><td>0 [b]</td></tr>
</table></td><td>DTSC agrees to the table, but requests that it be included in the main text instead of only evaluated in Appendix B. This helps with comparative evaluation and not only for cost estimates. Also, the revised Alt E will have different parameters.
Although PG&E estimates a zero net consumptive use for almost all alternatives, it is nearly impossible to have zero balance through treatment train. With carbon amendment, there may be a net gain in injection volume.</td><td>DOI concurs with the response and the addition of the table to Section 5.</td><td>Comment resolved. The requested information has been added to the CMS/FS Report in Table 5-6A, as adjusted to reflect the revised alternative configurations. Redline final submitted to agencies on November 13, 2009. Agencies approved the report revisions.</td></tr>
</table>

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					I Continued Operation of Interim Measure ^{c} 125-133 124-132 1-3 Notes: af-yr = acre-feet per year a. Not applicable as no pumping for extraction or injection is a part of the alternative. b. Approximate value. c. Rates are based on recent plant performance (December. 2008 to March 2009). Rates are adjusted to account for plant downtime. Note that the table above is reflective of the conceptual designs in the Draft CMS/FS Report and extraction and injection rates would be updated based on the revised alternative configurations in the Final CMS/FS Report. Allocation of water is based on net consumptive use. Net consumptive use is defined as the amount of extraction minus the amount of injection, as defined in "*Process and Procedures for Obtaining a Subcontract for Water under The Lower Colorado Water Supply Act of 1986*." As noted in the table, the only alternative with a net consumptive use is Alternative I because not all extracted groundwater is returned to the basin through reinjection. In Alternative I, approximately 5 percent of the extracted groundwater is trucked off-site as waste brine from the reverse osmosis system. The remaining active alternatives result in zero consumptive use because the amount of water extracted equals the amount of water injected. Alternatives A and B do not include extraction and injection (except for small amounts of purge water from monitoring wells in Alternative B). Based on minimal consumptive use, the sustainability of clean water supply is not anticipated to be a limitation for implementability of enhanced extraction through injection.			
137	DOI-51	Table 4-2, Page 4-16, Treatment, In-Situ Biological Treatment, Biochemical Reduction	U.S. Department of the Interior	Consider shading this process option blue. It is the representative process option listed in Table 4-3.	Table 4-2 has been modified to shade this process option blue.	Agree with RTC	DOI accepts the response.	Comment resolved. Agencies approved PG&E response. Changes noted in the response have been made to the CMS/FS Report.
138	DTSC-51	Page 4-16, Table 4-2, Treatment	California Department of Toxic Substances Control	The potential fracturing approach for installing deep Permeable Reactive Barrier should be discussed. DTSC notes that this process option may have limited application for the site and retention should be considered.	Fracturing was added to the text as a possible PRB construction method. Constructing a continuous barrier without gaps is difficult to achieve with fracturing. In addition, the reducing capacity of PRB's constructed through pneumatic fracturing cannot be replenished without reconstructing the PRB. The IRZ's included in several	Fracturing approach can be considered for East Ravine and bedrock remediation	DOI concurs that this technology be retained but not carried forward as a representative technology.	Comment resolved following agency review and input during finalization of the CMS/FS Report Table 4-2. Redline final

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					remedial alternatives are functionally equivalent to a PRB but can be constructed with a much smaller footprint and can be replenished with relative ease.			submitted to agencies on November 13, 2009 with PRBs retained as a technology in Table 4-2. Agencies approved the report revisions.
139	DTSC-52	Page 4-17, Table 4-2, Treatment, Phyto-remediation	California Department of Toxic Substances Control	The only discussion on effectiveness of this process option is that it takes a large surface area for an extended period of time. Please discuss how this process option is implementable at the PG&E Topock site.	In response to this comment, the implementability column in Table 4-2 for phytoremediation will be revised to state: "Implementable; water applied to phytoremediation field via subsurface drip irrigation. Irrigation equipment vendors readily available. Requires large surface area with fertile soil and active management for pest control and plant sustenance."	Agree with RTC	DOI concurs with the response.	Comment resolved following agency review and input during finalization of the CMS/FS Report. The implementability column in Table 4-2 has been modified to state: "Implementable, however would require large surface area and would require extended period of time to establish the phytoremediation system." Redline final submitted to agencies on November 13, 2009. Agencies approved the report revisions.
140	DTSC-53	Page 4-17, Table 4-2, Ex-situ Physical/ Chemical Treatment	California Department of Toxic Substances Control	It is not clear why chemical reduction and filtration are considered processes with high capital costs.	The text was revised to indicate moderate capital cost for chemical reduction and filtration.	Agree with RTC	DOI concurs with the response.	Comment resolved. Agencies approved PG&E response. Changes to Table 4-2 noted in the response have been made to the CMS/FS Report.
140.5	Chemehuevi-1	Table 4-2, In-situ Treatment	Chemehuevi Tribe via BLM	Kara McCoy questioned the feasibility of in-situ treatment and wanted to know the nature of the in situ process.	The feasibility of *in-situ* treatment at the PG&E Topock site has been studied through the conduct of two separate pilot studies, the results of which are contained in the *Floodplain Reductive Zone In-Situ Pilot Test Final Completion Report*, dated March 5, 2008, and the *Upland Reductive Zone In-Situ Pilot Test Final Completion Report,* dated May 3, 2009.	Although the pilot tests suggests that Cr(VI) reduction does take place, the delivery system and the IRZ created for the pilot test is far more simple and at tighter spacing than proposed remedial alternatives. These uncertainties should be evaluated carefully during the remedial design if In-situ treatment is a component of the final remedy.	DOI concurs with the response.	Comment addressed. No changes to the CMS/FS Report are required.
141	DTSC-54	page 4-18, Table 4-2, Disposal	California Department of Toxic Substances Control	Deep well injection usually has moderate to high costs.	The text was changed to indicate deep well injection has moderate to high capital and operation and maintenance costs.	Agree with RTC	DOI concurs with the response.	Comment resolved. Agencies approved PG&E response. Changes to Table 4-2 noted in the response have been made to the CMS/FS Report.

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142	DTSC-55	Page 4-18, Table 4-2, Disposal, Agricultural	California Department of Toxic Substances Control	Agricultural use of treated water should appear less favorable than the rejected options of POTW and surface water disposal since there is limited agriculture surrounding the PG&E site.	In response to this comment, agriculture use has been screened out based on the limited agriculture surrounding the site.	Agree with RTC. Will review final Table for consistency.	DOI concurs with the response, pending review of the final text.	Comment resolved following agency review and input during finalization of the CMS/FS Report text. Redline final submitted to agencies on November 13, 2009, with agricultural use not retained as a disposal option in Table 4-2. Agencies approved the report revisions.
143	DTSC-56	Table 4-2, Disposal	California Department of Toxic Substances Control	PG&E should include “off-site” treatment and disposal by trucking (see comment 45).	This option has been added to Table 4-2. Please see responses to comments #125 and #126.	Agree with RTC	DOI concurs with the response.	Comment resolved. Agencies approved PG&E response. Changes to Table 4-2 noted in the response have been made to the CMS/FS Report.
Section 5 Comments - Development and Analysis of Remedial Action Alternatives								
144	DOI-52	Section 5, Page 5-1, General Comments	U.S. Department of the Interior	All alternatives should include a short description of the restoration activities required to recreate physical conditions necessary to sustain the natural habitat in the area. It is noted that PG&E has included restoration and remedy deconstruction activities in the cost estimates. Due to the lack of detail provided for the alternatives, it is not clear how these costs were developed.	In response to this comment, additional information has been added to the cost estimates in Appendix D. The cost estimate tables for each of the alternatives have been revised from one lump sum item for restoration and facility deconstruction to multiple line items under “Miscellaneous” for deconstruction of facilities and equipment, with additional notes providing the cost estimate basis. For each of the alternatives, a short description of restoration activities is included in Section 5.3. The site restoration activities are described to include deconstruction or decommissioning of treatment and monitoring facilities, including roads, extraction wells, IRZ wells, injection wells, monitoring wells, pipelines, tanks, instrumentation, foundations, and other equipment associated with the remedial facilities. After deconstruction and decommissioning of the facilities, the areas would be restored using decompaction and grading techniques designed to decrease erosion and accelerate revegetation of native species or other as directed by the land manager.	Agree with RTC. Will review revised cost estimate for consistency.	Pending review of the final text in Section 5.3 and tables in Appendix B, DOI accepts the response.	Comment resolved following agency review and input during finalization of the CMS/FS Report Section 5.3 and Appendix D. Redline final submitted to agencies on November 13, 2009, with modifications to cost estimate tables modifications noted in the response incorporated. Agencies approved the report revisions.
145	MWD-1	Section 5	The Metropolitan Water District of Southern California	There are seven alternatives (C, D, E, F, G, H, and I) that involve active treatment of the plume. Each of these alternatives has limitations and uncertainties in the effectiveness of achieving the goals of the cleanup. Any alternative that is chosen should address contingencies that would adjust treatment to achieve the cleanup goals. Metropolitan recognizes that the discussion of contingencies is not appropriate for the CMS/FS because this is a conceptual document. We recommend that a detailed contingency plan be	PG&E agrees that the selected alternative would address contingencies to adjust treatment to achieve cleanup goals. As stated in Section 5.3 for Alternatives C, D, E, F, and G, optimization of the remedy would occur throughout the design, construction, and operational phases of remedy implementation to enhance performance of the remedy to attain the cleanup goals and respond to site conditions and performance issues. Also, as required by the Corrective Action Consent Agreement (CACA), a contingency plan/plans will be included in the Operations and Maintenance Plan and the Construction Work Plan for the	Agree with RTC. DTSC agrees that the Interim Measure was not designed to be a final remedy; however, since the IM3 pump and treat has been deemed successful in protecting the Colorado River and that it is accelerating the removal of Cr mass from the plume in comparison to MNA or No Action, it warrants a review of its effectiveness as a long term remedy either as a standalone alternative or as a	DOI concurs with the response.	Comment resolved. Agencies approved PG&E response. Changes noted in the response have been made to the CMS/FS Report, including addition of Table 5-3 : Example Contingency Actions During Remedial Alternative

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				included with the selected alternative. All of the alternatives require monitoring to evaluate the status and effectiveness of the treatment process. As stated above, details of the monitoring program are not appropriate for this document but should be included with the selected alternative. Monitoring should be frequent enough and spatially dispersed to effectively evaluate the treatment effectiveness. Alternative I involves the continued operation of the interim measures. The interim measures were implemented to provide a hydraulic gradient to protect the river. The system was not designed to treat the plume. Alternative I should not be included as an alternative in the CMS. It is important to protect the river during implementation of the final remedy as well as during the treatment period. An effective hydraulic gradient has been maintained with Interim Measures 3. This hydraulic gradient protection should be maintained during the construction of the selected treatment alternative and until the time the treatment alternative has proven to be in place and working as planned.	selected remedy. In response to this comment, PG&E proposes to add a table to the Final CMS/FS Report identifying contingencies for example scenarios under which the alternatives would not meet the stated objectives of the remedial action. The table would also note that a contingency plan would be prepared for the selected alternative. PG&E agrees that a monitoring program would be established for the selected alternative. With the exception of Alternative A, all of the alternatives assume that the corrective action monitoring program would occur until the cleanup goals are attained, including long-term monitoring following completion of active treatment. As required by the CACA, a monitoring plan will be prepared and included in the Operation and Maintenance Plan for the selected alternative. The monitoring plan would include a description and purpose of monitoring, monitoring schedule, and field and laboratory quality control. It is expected that the corrective action monitoring program would be dynamic and would be adjusted as needed to promote optimization of the alternative to attain the remedial action goals. PG&E agrees that Alternative I was not designed to attain the remedial action objectives (RAOs). As stated in Section 5.3, Alternative I (Continued Operation of the Interim Measure) has been incorporated into this CMS/FS Report per DTSC's request (DTSC letters to PG&E dated November 6, 2008 and December 5, 2008); the configuration of Alternative I has not been modified to adjust to the goals of the remedial action (Section 3.0), but instead focuses on the goals of the Interim Measure (hydraulic control of the plume only). With regard to transition from the IM to the remedial action, please see responses to comments #19, 20, and 21; Section 1.1.2 will be revised to state: "Implementation of the IM is expected to continue until a final corrective action/remedial action for the site is operating properly and successfully, and the regulatory agencies terminate the requirement for IM."	component of a final remedy. PG&E estimated a total mass of 34,248 pounds of Cr within the plume based on the thickness and concentrations in the deep, middle and shallow layers contoured for the model. The IM3 has already removed (as of July 2009) over 5,400 lbs of the Cr . Further optimization of extraction has potential of further increasing its effectiveness. At a minimum, the existing IM3 will not require any additional infrastructure to implement.		Implementation. Redline final submitted to agencies on November 13, 2009. Agencies approved the report revisions.
146	SDCWA-1	Section 5	San Diego County Water Authority	We agree with the Metropolitan Water District of Southern California on their comments regarding the limitations and uncertainties in the effectiveness to achieving the goals of the cleanup for each of the alternatives C through I. That any alternative chosen should address contingencies that would adjust treatment to achieve the cleanup goals. While the discussion of contingencies may not be appropriate for the	PG&E agrees. Please see response to comment #145.	Agree with RTC.	DOI concurs with the response.	Comment resolved. Agencies approved PG&E response.

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				CMS/FS, we concur that a detailed contingency plan be included with the selected alternative. Further, we support Metropolitan in their comments requiring monitoring to evaluate the status and effectiveness of the treatment process. While Section 5.2.8, Monitoring states ". . . monitoring is a component of all of the assembled alternatives for measuring the performance of the remedy, compliance with standards, and progress of the remedial action," a comprehensive discussion of monitoring should be included with the selected alternative that includes a monitoring program that is frequent enough and spatially dispersed to effectively evaluate the treatment effectiveness.				
147	CRIT-5	Section 5	Envirometrix (on behalf of the Colorado River Indian Tribe)	We previously inquired if any specific actions, requirements or other obligations as a result of the DTSC or PG&E settlement agreements were incorporated into this CMS/FS Report and if so, did any of the provisions in either of these settlement agreements identify any preferred or otherwise predetermined location related to any of the described remedial alternatives or the location of any proposed remedial equipment or systems. PG&E response to our previous January 9, 2009 comment No. 6 attempts to frame the response in terms of ARARs. This response also appears to be inconsistent with information presented by PG&E in a CMS/FS presentation with CRIT and DTSC. In that meeting, CRIT asked specifically if the proposed groundwater treatment system location at the PG&E compressor station was selected based on terms in any of the settlement agreements. PG&E stated that the location of the groundwater treatment system at the PG&E compressor station was selected and based on the terms in the PG&E settlement agreement. The question of whether the terms of the settlement agreement were treated as ARARs was not the question we asked. The question was if any specific actions, requirements or other obligations, as a result of the DTSC or PG&E settlement agreements, were incorporated into this CMS/FS or predetermined as a result of any negotiations related to any settlement agreement by PG&E or DTSC. The response provided by PG&E does not address this point. The questions remain and a response is requested by both PG&E and DTSC.	The settlement agreement between PG&E and the Fort Mojave Indian Tribe, and the negotiations related to that agreement, did not preclude the consideration of any remedial alternatives. However, by the terms of that settlement agreement, if a treatment facility is deemed necessary as part of the final remedy, PG&E is required to propose as the preferred alternative that the IM No. 3 treatment plant be decommissioned, removed, and relocated to the Topock Compressor Station property. In conformance with this settlement obligation, and because the only property that will be owned by PG&E at the time of implementation of the final remedy will be the Topock Compressor Station property, PG&E proposed that any treatment plant required be sited at the compressor station. In response to a DTSC directive, PG&E also included the IM No. 3 property as an alternative potential site for any required treatment plant. At the time of final remedy implementation, PG&E will maintain a sitewide easement over the IM No. 3 property for the siting of any facilities required by DTSC or DOI.	Since the terms of the settlement differs between PG&E and DTSC, and DTSC was not present at the CRIT's meeting with PG&E, DTSC cannot comment on PG&E's response and if the draft CMS/FS incorporated the intent of their agreement. DTSC settlement agreement did not preclude the consideration of any remedial alternatives. DTSC's direction to PG&E is to develop a CMS/FS report that is first and foremost technically sound. If any consideration of the PG&E settlement was incorporated into the CMS/FS, it should not impact the elimination of alternatives and/or implementability of the proposed alternatives. Wisdom dictates, however, that the remedial design should attempt to avoid actual or implied impacts to the site to the extent possible.	No response requested from DOI.	Comment addressed. Agencies approved PG&E response. No changes to the CMS/FS Report are required.

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148	HA-24	Section 5	Hargis & Associates, Inc. (on behalf of Fort Mojave Indian Tribe)	Appendix F – PG&E Response to FMIT General Comment No. 1 See General Comment No. 5 above. The Tribe understands natural attenuation processes would not be the primary component of these other alternatives (Alternatives C through I); however, as even acknowledged by PG&E, natural attenuation remains a potential secondary component remedy if allowed to operate. In fact, by concept and inference, it was operative during the, perhaps, forty years prior to the implementation of interim measures at the Site. The Tribe believes that it is important to at least acknowledge and evaluate the potential effectiveness of natural attenuation in the floodplain area. As discussed above in General Comment No. 7d, it is reasonable to assess the performance of so-called “Alternative E2,” which, by eliminating perhaps 15 wells in the two IRZs east of Park Moabi, allows for a greater degree of reliance on the naturally-occurring reductive zone in the fluvial sediments. It is argued in the new material in Section 5.2.5 of the CMS/FS that certain active remedies may alter the reductive properties of these sediments if pumping were to cause River water to enter the fluvial sediments. If true, would this not be a risk only for Alternatives F, H, and I? As speculated in the respective discussions of limitations of these alternatives, the potential for such damage to the natural system is acknowledged. The Tribe would therefore suggest that by virtue of consideration of these alternatives and moreover operation of the IM3, the natural protective barrier of the Colorado River fluvium is being marginalized (as suggested earlier), if not potentially physically compromised.	As stated in Section 2.3 “The reducing conditions in the fluvial sediments provide a natural geochemical barrier that would, at the very least, greatly limit or prevent the movement of Cr(VI) in groundwater through the fluvial sediments adjacent to and beneath the Colorado River.” Also, as stated in Section 5.2.5: “As it is recognized that natural attenuation occurs at the Topock site, natural attenuation may be considered a feature of the site that augments those active remedial alternatives that allow chromium in groundwater to contact the fluvial materials.” Although reducing conditions are prevalent in the fluvial aquifer near and below the Colorado River today, the capacity of the reducing zone to attenuate Cr(VI) over the long periods of time during which the remedial alternatives will likely be in operation is subject to uncertainty. The flow regime of the river changed greatly following the closure of Hoover and Davis dams. Spring floods that previously deposited organic detritus in the floodplain sediments no longer occur. It is not clear how the change in flow regime will affect the reducing conditions in the floodplain in the coming decades and centuries. Given the prevalence of the reducing conditions near and below the Colorado River today, it is not possible to conclusively prove the absence of discontinuities in the blanket of reducing materials in the floodplain and beneath the river. Accordingly, other than Alternative B (monitored natural attenuation [MNA]), none of the alternative remedies has been designed to rely on natural attenuation as a component of the remedy. PG&E recognizes the value of the natural reducing conditions in the floodplain as a buffer between the Cr(VI) plume and the river, but has chosen not to rely upon MNA as a component of the active remedies for the purposes of conceptual design. PG&E does recognize, however, that MNA could play a role in the remediation of recalcitrant zones at the end of the active phase of remediation, as discussed in responses to comments #378, 379, 381, 382, and 383. Active remedies (using pumping to induce landward gradients from the river) have the potential to alter the reductive properties of the fluvial sediments by drawing oxygen-containing river water through the fluvial sediments. Over time, the aerobic river water could diminish or, in some areas, even exhaust the reductive capacity of the fluvial sediments. Alternatives F, H, and I would result in the most river water being drawn through the floodplain. The pumping associated with Alternative G may also alter the reductive properties of the fluvial sediments directly beneath the river, but the injection of carbon substrates in the floodplain included in this alternative would help preserve the reducing capacity throughout most of the floodplain. The potential for damage to the natural protective barrier of	DTSC will review the proposed evaluation of the alternatives without IRZ lines east of the National Trails Highway. However, DTSC is concerned with any remedy that may potentially accelerate and/or cause migration of the plume or its equally toxic secondary products from reduction towards the Colorado River without proper monitoring.	DOI is currently evaluating the response provided by PG&E during the technical call on 9/10, addressing the alternatives utilizing the IRZ along the National Old Trails Highway. PG&E has provided a technical memorandum for the AR. Our approval of the Technical Memorandum will constitute acceptance of the response.	Comment resolved. PG&E prepared a separate technical memorandum titled “Conceptual Floodplain Design Options, Pacific Gas and Electric Company Topock Compressor Station” dated October 5, 2009 that summarized conceptual options for the design of in-situ treatment systems in the floodplain, including the option of no floodplain infrastructure.

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					the Colorado River fluvium with continued operation of IM No. 3 pumping or other alternatives using pumping to induce landward gradients is addressed in the response to comments #175 and 278. In response to this comment, as well as comments #192, 243, and 284, PG&E will prepare an evaluation of Alternatives C, D, E, and G without IRZ lines or infrastructure east of National Trails Highway. Additional remedial alternatives have not been added to the report.			
149	SDCWA-5	Section 5.2 Page 5-1	San Diego County Water Authority	The second paragraph seems to lead the reader into a level of concern that the CMS/FS does not consider all viable alternatives. It is not until the third paragraph that it becomes evident that the assembly of alternatives was guided by the National Contingency Plan requirements. Therefore, it may be beneficial to expand the fourth sentence in the second paragraph to include at the end of the sentence, ". . . to determine a preferred alternative, while meeting the requirements of the National Contingency Plan for Alternatives".	The suggested change has been made.	Agree with RTC.	DOI concurs with the response.	Comment resolved. Agencies approved PG&E response. Changes to Section 5.2 noted in the response have been made to the CMS/FS Report.
150	DOI-53	Section 5.2 General	U.S. Department of the Interior	PG&E has established that 25 to 30 years is the reasonable time frame for the removal of 95 percent of the Cr(VI) contaminant mass. Provide the basis for selection of this timeframe. Setting the "reasonable" time frame at 25-30 years may eliminate some alternatives that otherwise might be suitable. Specify the method by which 95 percent mass removal will be determined. Currently the total Cr(VI) mass at the site is not known. The estimate of mass is made from a limited number of wells that are perforated within coarse-grained units. Inspection of the contour maps shows that there is much uncertainty in the contouring of the plume and data are not available to determine if there is variability in the Cr concentrations within coarse-grained and fine-grained units in the same depth intervals.	Please note that the specific considerations listed in the second set of bullets in Section 5.2 are not RAOs; these considerations were used to help focus the assembly of alternatives for purposes of the CMS/FS evaluation. As noted in Section 5.3, all of the active remedial alternatives can be modified to adjust the number and locations of wells, modify the flow rates, and/or adjust operational strategies to increase or decrease the time to attain RAOs. The consideration to target 95 percent mass reduction in approximately 25 to 30 years in the Draft CMS/FS Report was meant to focus the conceptual design of alternatives and provide a basis for comparison between alternatives for the purpose of the CMS/FS that does not arbitrarily bias the evaluation for or against any particular technology due to cleanup time. The 25 to 30 year target reflects PG&E's preference and commitment to perform the cleanup and is considered practical based on experience at other sites. None of the technologies evaluated in Section 4.0 is eliminated from consideration based on this time frame. The 95 percent mass removal assumption only applies to mass simulated in the groundwater model, not mass actually in the plume. To maximize efficiency in the simulation process, the flow rates in the simulated remedial alternatives were not adjusted through time as the plume size decreased. The last 5 percent of the mass in these simulations is often in small stagnation zones that persist because simulated flow rates are unchanging. During the actual operation of the	DOI to decide on response.	The Department of Interior Solicitors' Office provided revised final language for Section 5 on 10/16/2009. This language resolves the comment and reflects the modifications made based on the response received from DTSC and the Regional Water Quality Control Board on 10/06/09 regarding the interpretation of California ARAR Comment Resolved. Please see the file transmittal "Sec 5 DOI edits 8-4-09" for modifications to the text in response to the RTC.	Comment resolved. Text provided by the Department of the Interior with specific revisions to Section 5.0 have been incorporated in the report. The change to the second bullet in Section 5.2 has been modified as noted in the response, as further modified by DTSC (see comment 491).

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					remedy, changes in flow rates will be common to optimize performance. The stagnation zones that persist in the model will not persist in the real-world operation of the system. Rather than go through the tedious process of simulating changes in flow rates in each remedial alternative as the plume changes over time, we chose to consider the last 5 percent of mass remaining in the model as insignificant for the purposes of estimating cleanup times. We do not intend to suggest that the remedial alternatives are designed to only remove 95 percent of the mass. The target mass reduction noted in Section 5.2 is an assumption that allowed efficiency in the conceptual-level evaluation of remedial alternatives appropriate for a CMS/FS and a consideration for developing the alternatives for comparison and is not intended to be an RAO or ARAR. In response to this comment, the phrase “achieve the RAOs in a reasonable time frame” was removed from the second bullet. In addition, as a result of other changes to the alternative evaluations that have affected the target mass removal and time frames, the bullet now reads: “Target cleanup (estimated as the time at which 98 percent mass reduction occurs in the groundwater model simulations) in 40 years or less for those remedies that use active remediation.”			
151	DTSC-57	Page 5-1, Paragraph 2, First Sentence Section 5.2	California Department of Toxic Substances Control	The remedial alternatives assembled must address all COCs.	In conformance with DTSC’s direction to PG&E dated July 8, 2009, the RAOs in Section 3.0 have been revised to address additional constituents; however, remedial action alternatives are not to be developed and evaluated to attain a numerical cleanup standard for constituents other than Cr(VI).	Agree with RTC. Will review final language in Section 3 when available.	DOI acknowledges that the focus of the CMS/FS is for Cr(VI) resulting from disposal at SWMU 1/AOC 1 and East Ravine. Additional COCs that may be identified during well installation at and near the station, during ongoing East Ravine investigations, and as a result of soils investigations will be evaluated independently. Source control may be considered during evaluation of alternatives in the soil investigation.	Comment resolved following agency review and input during finalization of Section 3.0 of the CMS/FS Report text. Redline final submitted to agencies on November 13, 2009. Agencies approved the report revisions.
152	DOI-54	Section 5.2, Page 5-1	U.S. Department of the Interior	A brief discussion on the potential effects, if any, of reactive barriers on the permeability of the formation should be provided.	Remedial technologies that promote mineral precipitation in natural aquifers can have an effect on permeability through reductions in porosity if the mass of precipitates being formed is significant. This relationship is depicted below in a chart excerpted and adapted from Payne et al., 2008 (Figure 1).		DOI accepts the response.	Comment addressed. Agencies approved PG&E response. No changes to the CMS/FS Report are required.

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					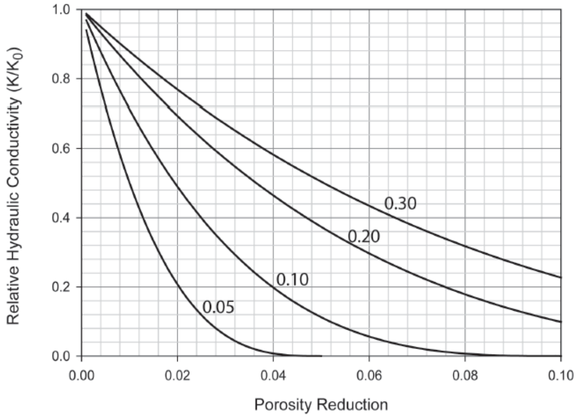 Figure 1: Reduction in hydraulic conductivity/permeability that results from a reduction of porosity due to mineral precipitation. Calculations shown for initial mobile porosities range from 5% to 30%. The calculations are based on the Kozeny-Carmen equation and conservatively assume that the mobile porosity is the dominant contributor to observed hydraulic conductivity. Porosity reductions are in absolute units, so a 10% total reduction represents a 100% reduction for the 10% initial mobile porosity case. At Topock, the background concentration of Cr(T) in soil is 22.3 ± 8.8 milligrams per kilogram (mg/kg). The amount of additional Cr(T) that will be added by the *in-situ* treatment is very small compared to the naturally occurring concentration of Cr(T) in the soil and will be at or much below the standard deviation of the background data set. The resulting chromium precipitates will predominately take the form of hydroxides, with amorphous $Cr(OH)_3$ the least dense/occupying the most volume relative to the spectrum of chromium oxy-hydroxide minerals (published density of 2.4 g/cm^3 (Bell and Matijević, 1974)). Thus, 9 mg/kg of chromium would result in a porosity reduction of 1.3E-5 (absolute), a level that will have a negligible effect on aquifer permeability for any of the mobile porosities noted above in Figure 1. A consideration is that changes in permeability will be a net effect. In addition to the creation of chromium precipitate mass that was not there initially, other precipitates may also be created such as carbonates of calcium, iron, manganese, and iron sulfides. However, this will be balanced against the reductive dissolution of natural iron and manganese (and other) minerals. Based on ARCADIS' experience, the overall net effect of simply maintaining an anaerobic environment is neutral, even after years of operation. Ref: Bell, A., and Matijević, E. 1974. Growth mechanism of			

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					hydrous chromium(III) oxide spherical particles of narrow size distribution. *Journal of Physical Chemistry* 78(25): 2621-2625. Payne, Fred C, Joseph A. Quinnan, Scott T. Potter. 2008. *Remediation Hydraulics*. CRC Press, Boca Raton, FL.			
153	CRIT-22	Section 5.2 Page 5-1	Envirometrix (on behalf of the Colorado River Indian Tribe)	Section 5.2 states, *To meet the RAOs identified in Section 3.0, PG&E has established the following specific considerations for the development of alternatives. These considerations are consistent with the NCP requirements listed above and help to further focus the assembly of alternatives. These considerations are to: Protect the Colorado River through geochemical barriers or hydraulic gradients to prevent Cr(VI) from approaching the river. Achieve the RAOs in a reasonable time frame (target 95 percent mass reduction in groundwater in approximately 25 to 30 years) for those remedies which use active remediation. Provide sustainable treatment alternatives that minimize energy use and minimize the amount of residual treatment byproducts that require handling and offsite disposal. Develop alternatives that maximize the environmental benefit, ecological, and human use associated with implementation, such as minimizing disturbance to sensitive cultural and biological resources by citing most remedial facilities in previously disturbed areas.* We believe that the above referenced "specific considerations" may have been designed to limit and direct the selection of a desired pre-determined remedy by including limitations such as "minimize energy use and minimize the amount of residual treatment byproducts". We do not agree with how PG&E is further limiting and focusing the analysis of treatment alternatives. Is this process of providing further limitations and "specific considerations", consistent with the CERCLA and RCRA process and guidelines? If not, we believe that this section should be removed from the CMS/FS.	While current remedy-selection regulations do not explicitly require consideration of sustainability in the remedial process, neither do they prohibit it. In fact, there are growing movements within USEPA, DTSC, and other entities to ensure that remediation projects evaluate and minimize energy use, raw material consumption, and humankind's carbon footprint. Green remediation or sustainable remediation initiatives are becoming increasingly important in recent years, as evidenced by DTSC's Green Remediation Initiative in 2008 and 2009, publication of USEPA's *Green Remediation: Incorporating Sustainable Environmental Practices into Remediation of Contaminated Sites* in 2008, and publication of the Sustainable Remediation Forum's white paper in 2009. DTSC's Green Remediation Initiative promotes the use of green technologies in site remediation work that are the least disruptive to the environment, generate less waste, are recyclable, and emit fewer pollutants and greenhouse gases to the atmosphere. In addition, recent federal guidance including USEPA's *Smart Energy Resources Guide and Executive Order 13123 - Greening the Government through Efficient Energy Management* encourage the use of sustainability principles in the design and operation of remediation systems. These are also important factors for PG&E. As a provider of electricity and natural gas to approximately 40 percent of Californians, PG&E is committed to operating in a manner that is consistent with its principles of energy efficiency, safety, and promotion of a healthy environment. No changes to Section 5.2 have been made in response to this comment.	Agree with RTC.	The nine evaluation criteria discussed in Section 5.5 encompass the statutory requirements utilized to thoroughly evaluate the alternatives in the CERCLA process. These criteria will be used by the federal agencies in determining the preferred alternative. However, utilization of sustainable practices and opportunities in the remedial process are encouraged. DOI concurs with the response.	Comment resolved. Agencies approved PG&E response. No changes to the CMS/FS Report are required.
154	DTSC-58	Page 5-1, Paragraph 3, Last Sentence Section 5.2	California Department of Toxic Substances Control	The sentence below appears to incorporate an important concept that significant flexibility is permissible during remedial design. Please note that Significant changes from the selected remedial alternative and process may require additional public notice under CEQA. Based on stakeholder input, DTSC considers it necessary for PG&E to describe the remedial alternatives in greater detail in the CMS so that meaningful input can be provided by stakeholders as well as allowing the DTSC EIR team to evaluate any	The statement in the CMS/FS in question is consistent with USEPA guidance as described below. Consistent with the USEPA's *Guidance for Conducting Remedial Investigations and Feasibility Studies Under CERCLA* (Section 4.2.5), the referenced section of text is intended to justify the omission of each and every possible combination of retained process options, which would make the number of assembled alternatives unnecessarily large. This section is not intended to provide any increased flexibility during remedial design beyond what is typically afforded as the standard in any FS and remedy selection process.	Agree with RTC that additional public involvement might be necessary if significant change is to occur during design which may not have been specified during the CEQA evaluation. Depending on the scope and nature of the expansion or modification of a previously-evaluated project, additional CEQA documentation may be necessary	DOI concurs in part with the response. After a ROD is signed, new information may be received or generated during the design (or in the case of the Topock Groundwater Remedy, the initial implementation) of the remedy that could affect the remedy selected in the ROD. DOI must consider the following as provided in the NCP §300.435©(2)(i) as to whether the remedial action	Comment resolved. Agencies approved PG&E response. No changes to the CMS/FS Report are required.

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				potential affects. *"Once a preferred alternative is selected, other process options can be implemented, or changes to the specific alternative components can be made during remedial design without compromising the remedy selection process in the CMS/FS."*	Section 4.2.5 of the RI/FS guidance states "The representative process provides a basis for developing performance specifications during preliminary design; however, the specific process actually used to implement the remedial action at a site may not be selected until the remedial design phase. In some cases more than one process option may be selected for a technology type. This may be done if two or more processes are sufficiently different in their performance that one would not adequately represent the other." Further, the remedial alternatives in the CMS/FS were developed to a level of detail consistent with the approved *Final Corrective Measures/Feasibility Study Work Plan for the PG&E Topock Compressor Station, Needles, California.* The approved Work Plan states that "each alternative will be defined to a sufficient level of detail to develop a remedial cost estimate, in accordance with USEPA's *A Guide to Developing and Documenting Cost Estimates During the Feasibility Study*." As stated in the cost estimating guidance, at the FS stage, the design for the remedial action project is still conceptual, not detailed, and the cost estimate is considered to be "order-of-magnitude." As the project progresses through remedy selection, remedial design, remedial action, and operation and maintenance, the design becomes more complete, and the cost estimate becomes more definitive. PG&E recognizes that a significant change to the remedy following the RCRA or CERCLA remedy selection may include additional opportunity for public involvement.		"differs significantly from the remedy selected in the ROD with respect to scope, performance, or cost, the lead agency shall consult with the support agency, as appropriate, and shall either: (i) Publish an explanation of significant differences when the differences in the remedial or enforcement action, settlement, or consent decree significantly change but do not fundamentally alter the remedy selected in the ROD with respect to scope, performance, or cost.", or as provided in the NCP §300.435©(2)(ii) (ii) Propose an amendment to the ROD if the differences in the remedial or enforcement action, settlement, or consent decree fundamentally alter the basic features of the selected remedy with respect to scope, performance, or cost. To amend the ROD, the lead agency, in conjunction with the support agency, as provided in Sec. 300.515(e),	
155	DTSC-59	Page 5-1, Paragraph 4, Section 5.2	California Department of Toxic Substances Control	The CMS Report should cite and discuss 40 CFR Section 300.430(a)(1)(iii)(F) which states that groundwater is to be returned to beneficial uses where practicable within a reasonable timeframe. Additionally, it states that if return to beneficial uses is not practicable, then plume migration and exposure should be prevented. Following these lines of reason, the CMS Report should indicate that further migration of the plume (including adverse remedial plume byproducts) towards the river will be prevented.	In response to this comment, the first sentence in the third paragraph of Section 5.2 is proposed to be modified: "To assemble an appropriate range of alternatives, several factors are considered, including the factors identified in 40 CFR Section 300.430(a)(1)(iii)." Please note that in response to comment #79, the RAO to achieve a cleanup goal in groundwater within a reasonable time frame was removed from Section 3.0, and in response to comment #150, the phrase "achieve the RAOs in a reasonable time frame" was removed from the second bullet in the site-specific considerations in Section 5.2. In response to this comment, as well as comment #82, PG&E will add an RAO in Section 3.0 that states the 32 parts per billion plume line will not 'permanently' expand.	Agree with RTC. Please note, however, that the RWQCB Basin Plan has been identified as an ARAR by DOI.	DOI concurs with the response.	Comment resolved. Agencies approved PG&E response. Changes to the RAOs in Section 3.0 as well as the change to section 5.2 noted in the response have been made to the CMS/FS Report.
156	DTSC-60	Page 5-2, Paragraphs 1 & 2, Section 5.2	California Department of Toxic Substances Control	The CMS Report should also cite and further discuss 40 CFR Section 300.430(e)(4) which states that a limited number of remedial alternatives shall be developed with different restoration time periods. The CMS Report does not seem to address this issue as most alternatives are intentionally normalized to 25 to	Section 5.2 includes a list of six National Contingency Plan (NCP) requirements that are used to assemble the appropriate range of alternatives in accordance with 40 CFR Section 300.430(e). The fifth bullet in the list addresses the different time frames for restoration specified in 40 CFR Section 300.430(e)(4) for groundwater response actions. Consistent with these NCP requirements, the alternatives	DTSC will review the proposed sensitivity analysis when available.		Comment resolved. The sensitivity analysis noted in the response is included in the Final CMS/FS Report as Table 5-2. Redline final submitted to agencies on

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				30 year timeframes. To address this issue, identified alternatives could be optimized with respect to time (within reason). Conversely, each alternative could also be optimized to minimize overall footprint to address tribal concerns regarding sacred lands which may equate to a time issue. This would lead to three modified versions for most alternatives: a time optimized, a time normalized, and a minimized footprint option. The time periods could then be evaluated to see if they differ significantly. This type of sensitivity analysis will provide significant insight into the viability of alternatives to address a host of concerns from cost to tribal landscape impacts.	presented in the CMS/FS represent a range in cleanup times (ranging from decades to centuries). In response to this comment, PG&E will prepare a sensitivity analysis for Alternatives C, E, F, G, and H in a table format for inclusion in the Final CMS/FS Report discussing relationship between cleanup time and footprint. PG&E will discuss the flexibility to decrease cleanup time and/or decrease footprint, discuss the constraints/boundaries, and provide insight into the limiting factors.			November 13, 2009. Agencies approved the report revisions.
157	DOI-55	Section 5.2, Page 5-2, Paragraph 1, Bullet 1	U.S. Department of the Interior	The bullet should be revised to read: “Protect the Colorado River through geochemical barriers or hydraulic gradients to prevent Cr (VI) from *entering* the river.”	In response to this comment (and comment #158), the first bullet has been revised to state: “Protect the Colorado River through geochemical barriers or hydraulic gradients to prevent Cr(VI) from entering the river.”	DTSC does not believe that the wording “actively induced” should be part of the consideration. This is not necessarily required.	DOI accepts the response.	Comment resolved. The first bullet in Section 5.2 reads: “Protect the Colorado River through geochemical barriers or hydraulic gradients to prevent Cr(VI) from entering the river.”
158	MWD-4	Section 5.2 Page 5-2	The Metropolitan Water District of Southern California	Suggest inserting “actively induced” as follows for the first bulleted item: “Protect the Colorado River through ‘actively induced’ geochemical barriers or hydraulic gradients.”	In response to this comment (and comment #157), the first bullet has been revised to state: “Protect the Colorado River through geochemical barriers or hydraulic gradients to prevent Cr(VI) from entering the river.” .	DTSC does not believe that the wording “actively induced” should be part of the consideration. This is not necessarily required.	DOI accepts the response.	Comment resolved. Per DTSC, the term actively induced was not added. The first bullet in Section 5.2 reads: “Protect the Colorado River through geochemical barriers or hydraulic gradients to prevent Cr(VI) from entering the river.”
159	DOI-56	Section 5.2, Page 5-2, Paragraph 1, Bullet 2	U.S. Department of the Interior	Provide the basis for selection of 25 to 30 year period as the reasonable timeframe for achieving the RAOs.	Please see response to comment #150.	See DTSC direction to 150.	Please see the file transmittal “Sec 5 DOI edits 8-4-09” for modifications to the text in response to the RTC.	Comment resolved. Text provided by the Department of the Interior with specific revisions to Section 5.0 have been incorporated in the report. The second bullet in Section 5.2 has been further modified by DTSC (see comment 491).
160	CRIT-25	Section 5.2	Envirometrix (on behalf of the Colorado	We previously stated on our January 9, 2009 comment No. 15 that the following remedial action alternatives should have been included in	Please note that the purpose of the CMS/FS is to develop and evaluate a set of alternatives that represents a range of performance and cost options. It is not necessary for the	Agree with RTC. DTSC will not require PG&E to identify additional treatment plant location if PG&E has already identified	DOI agrees that other methods are available for installation of permeable reactive barriers and impermeable	Comment resolved. Agencies accept PG&E response. No changes to

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			River Indian Tribe)	the report. (1) Leaving the existing groundwater treatment system as is. (2) Not limit the location of any new groundwater treatment system to only the PG&E compressor station. (3) Constructing a barrier wall or permeable reactive barrier in conjunction with the existing groundwater treatment system. (4) *In-situ* treatment in conjunction with the existing groundwater treatment system. (5) Expanding the existing groundwater treatment system. (6) Constructing a new or supplemental groundwater treatment system in a different location; such as Park Moabi, along Park Moabi Road, near the Sewage disposal ponds or in Arizona. PG&E's response states. *Alternative H has been added to the CMSIFS report. Alternative H combines in-situ treatment with ex-situ treatment. The ex-situ treatment component of Alternative H (300 gpm) may be accommodated by a retrofitting the existing Interim Measure treatment plant or by construction of a new above ground treatment plant.* *Alternative I has been added to the CMS/FS report. Alternative I is the continued operation of the Interim Measure, including the above-ground treatment plant. Alternatives F, G, and H each include an above-ground treatment plant as a component of the alternative, and each of these alternatives identify two possible locations for the treatment plant: the Topock Compressor Station and the existing Interim Measure treatment plant location. The size of the treatment plant for Alternatives F and G is considerably larger than the existing treatment plant and would require substantively replacing the existing Interim Measure treatment system. The size of the treatment plant under Alternative H, in contrast, may be accommodated by a retrofit to the existing Interim Measure treatment plant or by construction of a new above ground treatment plant.* Other locations in addition to the Topock Compressor Station and the existing IM3 Treatment plant location should be considered such as constructing a new or supplemental groundwater treatment system at Park Moabi, along Park Moabi Road, near the Park Moabi Sewage disposal ponds, near the existing injection wells, or in Arizona. *Vertical barrier technologies and permeable reactive barrier technologies are addressed in Section 4.0 of the CMSIFS report.*	alternatives to include every possible configuration and combination of technologies. Rather, representative technologies are selected to assemble conceptual alternatives that support the evaluation and comparison of alternatives used as the basis for selecting a remedy for the site. As stated in Section 5.3, numbers and locations if remedial facilities and described operational elements are largely assumptions at this point in the definition of the alternative and are used as a means to compare alternatives against each other. It is fully expected that changes to the numbers, locations, methods, configuration, and other assumptions made in developing the remedial costs will change for the selected alternative as it moves through the design, construction, and operational phases. As presented in Section 5.2.7 of the CMS/FS Report, the location of a future *ex-situ* treatment plant has many constraints. Those constraints include placement close to extraction and injection facilities to minimize the amount of pipeline and pump stations required for transporting groundwater, proximity to a power source, available space for construction, and accessibility for construction and operation. In addition, location of the treatment plant must also take into account landowner and leaseholder requirements, cultural and religious significance of the land, sensitive habitats, historical sites, topographical constraints, and existing infrastructure. Considering all these factors there are two locations identified for an *ex-situ* treatment plant in the conceptual design for those alternatives that include pump-and-treat technology; these two location are the Topock Compressor Station property and the current IM No. 3 treatment plant location. The IM No. 3 treatment plant location was added as an alternative as required by DTSC's November 6, 2008 letter. The configuration of these alternatives was selected for evaluation in the CMS/FS. If the selected alternative includes pump-and-treat technology, the additional locations for constructing an *ex-situ* treatment plant (at Park Moabi, along Park Moabi Road, near the Park Moabi Sewage disposal ponds, near the existing injection wells or in Arizona) can be evaluated during remedial design. Please also see response to comment #106 regarding DTSC and DOI review of the technology screening.	suitable locations. If a treatment system is required as part of the final remedy and PG&E determines that additional treatment plant locations would be necessary due to design constrains. DTSC may have to conduct additional CEQA analysis in accordance with the law.	barriers. We do, however, concur with the PG&E response pending review of the revised text.	the CMS/FS report are required.

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				Both vertical barriers and permeable reactive barrier technologies should have been considered as alternatives but were not. As previously stated, we request that DOI and DTSC review the applicability of these technologies and provide direction to PG&E, as necessary.				
161	HA-11	Section 5.2	Hargis & Associates, Inc. (on behalf of Fort Mojave Indian Tribe)	7a. Cultural Constraints in the Conceptual Designs of Selected Remedies The proposed conceptual designs of selected groundwater remedies do not account for exclusions of new facilities from areas of archaeological and other significance. For example, Alternatives D and H show the placement of lines of IRZs directly through Locus B of the Maze, even as narrowly defined by archeologists, and Alternatives F, G, H, and I all show an alternative location for a water treatment facility in the middle of the Maze loci and on Tribal land. In the former example, the analysis of cleanup times, possibly the number of wells and configuration of other infrastructure, and cost projections would be different if such cultural constraints were properly honored. The latter example includes the retention or expansion of a facility in a location that the Tribe has strongly objected to since its very construction due to its adverse cultural impacts.	PG&E defers response to DOI	DOI DTSC acknowledges the Tribe's concerns. The technical merit of a proposed alternative is the key consideration in whether it is included as one of the alternatives to be further evaluated in the CEQA-based environmental review process. The CEQA process (which includes detailed consideration of cultural resources) can provide a rationale for the Lead Agency to eliminate or modify a technically feasible alternative. Federal processes under DOI include the identification of ARARs, any of which may result in the elimination of an alternative for (federal) consideration on the basis of legal infeasibility. Narrowing down of potential alternatives by the California and federal lead agencies may not occur simultaneously; however the agencies are coordinating their review of alternatives as closely as possible and the remedy selection will reflect input from both.	DOI would like to thank the FMIT for providing their thoughts and perspective on this area. The FMIT and other Tribes will be provided an opportunity to provide this information in the development of the ethnographic/ethno historic study. The Bureau of Land Management will continue to conduct formal Section 106 consultation with the nine federally recognized Tribes including consultation with the Fort Mohave Indian Tribe. DOI has consulted with the tribes to solicit tribal input on the draft Corrective Measures Study/ Feasibility Study (CMS/FS) Report including face-to-face meetings with four tribes. This consultation on the draft study that first identifies and evaluates remedial alternatives is early in the CERCLA remedy selection process. This consultation has informed DOI's perspective in its' direction to PG&E on revisions to be made in the final CMF/FS Report (including revisions related to attainment of applicable or relevant and appropriate requirements (ARARs)), . In addition, the Department of Interior Solicitors' Office provided revised final language for Section 5 on 10/16/2009. The consultation will also allow DOI to make an informed decision as it proposes and then selects a remedy from among the alternatives now being evaluated.	Comment addressed. No changes to the CMS/FS Report are required.
162	HA-26	Section 5.2	Hargis & Associates, Inc. (on behalf of Fort Mojave Indian Tribe)	Appendix F – PG&E Response to FMIT General Comment No. 7 The Tribe disagrees with the implication of the response that protection of culturally sensitive areas is only a factor to be considered upon the selection of alternatives and not a criterion to be considered when developing the range of the alternative measures themselves. See discussion above in Comment No. 3.	Because compliance with ARARs is a threshold criterion for remedial alternative evaluation, compliance with cultural resources ARARs will be evaluated by DOI prior to remedy selection. The alternative analysis in the Final CMS/FS will be revised to evaluate compliance with ARARs, including compliance with cultural resources ARARs.	Please see response to #162.	DOI concurs with the response, pending incorporation of text provided by the DOI solicitors' office and review of the final text.	Comment resolved. DOI's ARARs compliance evaluation has been added to the CMS/FS Report. DOI's preliminary analysis has indicated that as a threshold matter, none of the alternatives under consideration can be eliminated based on the alternative's inability to

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								satisfy cultural resource ARARs
163	DOI-57	Section 5.2.3, Page 5-3, 1st paragraph	U.S. Department of the Interior	The statement regarding the rate-limited diffusion from low permeability units is a critical consideration at the Topock site given the heterogeneous nature of the aquifer materials. The statement regarding “Properly place injection wells …” should be rephrased to state that these wells can enhance groundwater capture. Whether this results in significant enhancement of cleanup depends on many factors, including the cleanup goals and the rate limitations imposed by the aquifer materials.	The sentence has been deleted. Please see comment #165 (DTSC-62) and response	Agree with RTC.	DOI accepts the response.	Comment resolved. Agencies approved PG&E response. The subject sentence has been removed from Section 5.2.3.
164	SDCWA-6	Section 5.2.3 Page 5-3	San Diego County Water Authority	In the first paragraph, fifth sentence, “compliment” should be changed to “complement”.	The change has been made.	Agree with RTC.	DOI concurs with the response.	Comment resolved. Agencies approved PG&E response. Changes to Section 5.2.3 noted in the response have been made to the CMS/FS Report.
165	DTSC-62	Page 5-3, Paragraph 4, Section 5.2.3	California Department of Toxic Substances Control	The discussion on the benefit and utility of injection wells is inappropriate in this section. Please remove sentence.	The following sentence has been deleted from the paragraph: “Properly-placed injection wells can greatly increase cleanup efficiency by creating larger hydraulic gradients that control groundwater flow and can help push the contaminants toward the extraction wells.”	Agree with RTC.	DOI concurs with the response.	Comment resolved. Agencies approved PG&E response. The subject sentence has been removed from Section 5.2.3.
166	DOI-58	Section 5.2.3, Page 5-4, 1st full paragraph	U.S. Department of the Interior	The first sentence should be revised to state “In addition to the siting issues associated with *groundwater capture* efficiency, ...”	The suggested revision has been made.		DOI accepts the response.	Comment resolved. Agencies approved PG&E response. Changes to Section 5.2.3 noted in the response have been made to the CMS/FS Report.
167	DOI-59	Section 5.2.4, Page 5-4, last sentence of the page	U.S. Department of the Interior	Revise the sentence to read ““Properly place injection wells can increase *groundwater capture efficiency …*”	Per DOI’s August 4, 2009 correspondence, the sentence has been revised as follows: “Properly-placed injection wells can enhance cleanup efficiency by creating larger hydraulic gradients that control groundwater flow and can help push the contaminants toward the extraction wells.”		DOI accepts the response.	Comment resolved. Agencies approved PG&E response. Changes provided by DOI to Section 5.2.4 noted in the response have been made to the CMS/FS Report.
168	DOI-60	Section 5.2.4, Page 5-5, first full paragraph on page	U.S. Department of the Interior	The heterogeneous nature of the aquifer materials will influence flow patterns, and hence appropriate well placement. Revise the sentence to read: “Number, size, and locations of injection wells are also affected by design flow rates and aquifer *characteristics and* capacity.”	The sentence was revised as requested.	Agree with RTC	DOI accepts the response.	Comment resolved. Agencies approved PG&E response. Changes to Section 5.2.4 noted in the response have been made to the CMS/FS Report.

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169	DTSC-63	Page 5-5, Paragraph 1, Section 5.2.4	California Department of Toxic Substances Control	With the discussion on the benefit of creating a hydraulic gradient by injection wells, it is equally important to provide a caution on the potential to spread contamination and the importance of proper monitoring and hydraulic controls.	The following sentence has been added to Section 5.2.4: "Proper monitoring and careful design of the well locations are necessary to avoid the potential spread of contamination through uncontrolled movement of groundwater."	Recommend changing "groundwater " to "contaminated groundwater."	DOI concurs with DTSC's request.	Comment resolved. The following sentence has been added to Section 5.2.4: "Proper monitoring and careful design of the well locations are necessary to avoid the potential spread of contamination through uncontrolled movement of contaminated groundwater.""
170	HA-31	Section 5.2.3/5.2.4	Hargis & Associates, Inc. (on behalf of Fort Mojave Indian Tribe)	<u>Appendix F – PG&E Response to FMIT Specific Comment No. 10d</u> In general, the Tribe would prefer above-ground piping wherever possible as it is believed to represent a lesser degree of intrusion.	As stated in Sections 5.2.3 and 5.2.4, piping can be either aboveground or belowground. In response to this comment, the following modification is proposed to Sections 5.2.3 and 5.2.4: "Construction of wells and associated facilities, such as pipelines, at the site must also consider areas of the site that are of cultural or religious significance so that construction or other disturbance is minimized to the extent feasible."	In the technical feasibility review of the CMS/FS, DTSC has no preference between above ground and below ground infrastructures if they are equally functional and protective of human health and the environment. Avoidance, Minimization and/or Mitigation Measures in the EIR may specify technical and/or spatial restrictions that are protective of sensitive natural and cultural resources.	This point will be considered during the design phase for the final remedy. The Bureau of Land Management will continue to conduct formal Section 106 consultation with the nine federally recognized Tribes including consultation with the Fort Mohave Indian Tribe. The perspective of the Tribes will be considered during design of the final remedy.	Comment resolved following agency review and input during finalization of Sections 5.2.3 and 5.2.4 of the CMS/FS Report. Redline final submitted to agencies on November 13, 2009. Agencies approved the report revisions.
171	DOI-61	Section 5.2.5, Page 5-5	U.S. Department of the Interior	The use of the term "treatment" in association with natural attenuation is potentially misleading and can be confused with active treatment. Natural attenuation is comprised of a variety of processes, including dilution as well as chemical degradation. DOI prefers to distinguish natural attenuation processes, including natural chemical reduction processes that occur at the Topock site, from active treatment. Revise the first sentence to read: "Natural attenuation (also known as intrinsic remediation) relies on natural processes to reduce chemical concentrations."	The first sentence in Section 5.2.5 has been modified as requested. Please note that in response to comments #109 and #110, Section 4.0 has been modified to categorize MNA under the category of treatment, rather than as a separate general response action, per DTSC's request.	Agree with RTC	DOI accepts the response, pending final review of the text. For consistency, PG&E may choose to utilize the slightly modified description of MNA provided in response to comment 108 (DOI 41) i.e., "natural subsurface processes such as dilution, dispersion, biodegradation, adsorption, and chemical reactions with subsurface materials."	Comment resolved following agency review and input during finalization of Section 5.2.5 of the CMS/FS Report. Redline final submitted to agencies on November 13, 2009. Agencies approved the report revisions.
172	DTSC-64	Page 5-5, Last Paragraph Section 5.2.5	California Department of Toxic Substances Control	Cite and summarize appropriate references regarding the conversion and permanence of Cr(VI) to Cr(III).	In response to this comment, the sentence added to Section 2.3 in response to comment #76 will also be added to Section 5.2.5. The sentence reads: "The only naturally occurring oxidant that can accomplish this is solid manganese dioxide, MnO_2 (Fendorf, 1995). If this solid is present, the Cr^{3+} ion can adsorb to the MnO_2 surface, where a redox reaction can occur with chromium oxidized and manganese reduced. However, under the reducing conditions present in the fluvial materials, MnO_2 is not stable, and manganese tends to exist as the dissolved cation $Mn^{2+,}$ as shown by the detectable manganese concentrations in these wells (CH2M HILL 2009a)."	DTSC accepts this response provided agency comments to item 176/DOI-63 are appropriately addressed.		Comment resolved following agency review and input during finalization of Section 5.2.5 of the CMS/FS Report. Redline final submitted to agencies on November 13, 2009. Agencies approved the report revisions.

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173	DOI-62	Section 5.2.5, Page 5-6, 1st full paragraph	U.S. Department of the Interior	Characterizing natural attenuation as a technology and treatment method is potentially misleading and confusing. Revise sentence to read: “While natural attenuation is recognized as a viable remediation approach, it is often accompanied by active treatment methods.”	The sentence was revised as requested.	Agree with RTC	DOI accepts the response.	Comment resolved. Agencies approved PG&E response. Changes to Section 5.2.5 noted in the response have been made to the CMS/FS Report.
174	MWD-5	Section 5.2.5 Page 5-5; Section 5.3.2.1 Page 5-15	The Metropolitan Water District of Southern California	These sections state that the reducing conditions have been observed in the floodplain and beneath the river at every location where a well has been installed. There are some areas in the fluvial layer that are not or were not originally reducing (e.g., the 80-foot and deep zone at monitoring well 34). This section should be reworded to reflect the heterogeneity of the fluvial reducing zone.	In response to this comment the sentence added to Section 2.3 in response to comment #75 will also be added to Section 5.2.5. In response to this comment, and comment #214, Section 5.3.3.1 is proposed to be revised as follows: “Although the reducing conditions in the shallow fluvial deposits within the floodplain and beneath the river have been present at every location where a well has been installed or a pore water sample has been collected, there is no way to prove that these conditions exist everywhere. Further, reducing conditions in fluvial deposits do not extend to deeper zones in some parts of the aquifer near the Colorado River, and non-reducing conditions are prevalent in the Alluvial Aquifer where the majority of the Cr(VI) plume exists. Over the centuries that would be required for MNA to reach cleanup goals, it is possible that the geochemistry or groundwater flow directions, or even the location of the Colorado River channel, could change significantly.”	Refer to Response to comment 75.		Comment resolved. Agencies approved PG&E response. Changes to Section 5.0 noted in the response have been made to the CMS/FS Report.
175	DTSC-65	Page 5-6, Paragraph 3, Section 5.2.5	California Department of Toxic Substances Control	The cited paragraph below introduces the new concept (not mentioned in RFI) of oxic waters adversely affecting reducing conditions in fluvial materials. The basis for this statement must be included as it seems to contradict statements in the RFI Volume 2 regarding the significant capacity of fluvial materials to quickly reduce Cr(VI) contamination. The section should discuss at what point will reducing conditions be adversely impacted and if the impact will be permanent. The section must cite IM-3 extraction data and indicate if that data set does or does not support the newly introduced concept. If the concept is speculative in nature it must be clearly stated as such and deleted from the report if unsubstantiated. If oxic waters actually do impact fluvial materials at Topock, the cited paragraph may need to modified as follows: *“Conversely, active remedial alternatives that rely on groundwater flushing or extraction ~~near the river~~ may alter these beneficial natural reducing conditions, as groundwater flushing/extraction causes an influx of oxic ~~river~~ water and thus*	In response to this comment, the subject sentence in Section 5.2.5 will be revised as requested. The potential impacts of IM activities were considered to be outside of the scope of the RFI/RI Volume 2 Report, the purpose of which was to characterize natural site conditions. Statements in the RFI/RI Volume 2 Report regarding the apparent significant capacity of the fluvial materials to quickly reduce Cr(VI) contamination are valid; however, the pervasiveness of this barrier will always be subject to some uncertainty. The flow regime of the river changed greatly following the closure of Hoover and Davis dams. Spring floods that previously deposited organic detritus in the floodplain sediments no longer occur. It is not clear how the change in flow regime will affect the reducing conditions in the floodplain in the coming decades and centuries. It is not possible to accurately quantify the capacity of the fluvial sediments to retain their capability to reduce Cr(VI) contamination with sustained IM pumping or during pumping at potentially greater extraction rates. Based on measurements of the dissolved oxygen and oxidized species present, the oxidizing capacity of the Colorado River water is much greater than that of the chromium plume. It would be imprudent to assume that the reducing capacity of the fluvial materials is inexhaustible if subjected to long-term flushing by oxic Colorado River water. If the fluvial materials are	Based on PG&E’s response, the concern regarding exhausting the reductive capacity of fluvial materials with oxic river water is quite subjective and marked with uncertainty. Therefore, as requested, PG&E needs to clearly state the speculative nature of this concept. DTSC still awaits revised language regarding this issue.		Comment resolved following agency review and input during finalization of Section 5.2.5 of the CMS/FS Report. Additional text noted in the response about the information gathered concerning the reducing floodplain conditions during operation of the IM has been added to Section 5.2.5. Redline final submitted to agencies on November 13, 2009. Agencies approved the report revisions.

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				more oxidizing conditions can develop in the shallow floodplain aquifer." Additionally, conclusions regarding the ability of MNA to accomplish clean up may need to be revised. Finally, alternatives should add dosing the fluvial materials with reductant should it become necessary to enhance the reductive capacity of those soils.	flushed with enough oxic river water, it could result in a loss of their reductive capacity. Regular monitoring of floodplain geochemistry has occurred since IM pumping began in 2004. To date, data collected do not strongly indicate that the reductive capacity of the fluvial materials has been compromised. However, the relatively short period of IM pumping (approximately 5 years) at relatively modest flow rates does not provide a sufficient dataset to make conclusions about the potential effects of much longer-term and generally higher volume pumping associated with Alternatives F and H or the very long-term pumping associated with Alternative I (estimated between 150 and 1,500 years). As presented in the 2006 through 2009 combined Fourth Quarter and Annual Performance Evaluation Reports (CH2M HILL March 15, 2006; April 6, 2007; March 14, 2008; and March 13, 2009), there are multiple lines of evidence that IM pumping has induced strong landward and downward hydraulic gradients from shallow floodplain wells and the river towards the IM pumping wells, and that previously oxic river water has been drawn in towards pumping wells. These lines of evidence (as documented in the reports) include: • Changing deuterium isotope concentrations. • Increasing oxidation-reduction potential (ORP) data for MW-33-40 and MW-33-90. • Decreasing total dissolved solids concentrations. Injection of soluble carbon substrates can provide a short-term replenishment or enhancement of the reducing capacity that could last for months to years.			
175 .5	Chemehuevi-5	Section 5.2.5	Chemehuevi via BLM	Kara McCoy pointed out that natural attenuation alt. is supported by Ft. Mojave Tribe is not scientifically based	Natural attenuation of Cr(VI) has been shown to be a potential viable remedial method at the Topock site. Data presented in the RFI/RI and laboratory core testing indicate that subsurface conditions in fluvial deposits near the Colorado River floodplain are such that Cr(VI) is reduced to the less toxic Cr(III). In addition, abundant scientific research is available that indicates natural attenuation of Cr(VI) readily occurs under common subsurface conditions and is recognized by USEPA. Some references include: USEPA. 1994. Groundwater Issue, *Natural Attenuation of Hexavalent Chromium in Ground Water and Soils*. USEPA. 2007. *Monitored Natural Attenuation of Inorganic Contaminants in Ground Water, Volume 2, Assessment for Non-Radionuclides Including Arsenic, Cadmium, Chromium, Copper, Lead, Nickel, Nitrate, Perchlorate, and Selenium*.	DTSC acknowledges and agrees that natural attenuation does occur in natural environment. DTSC, however, reserves its opinion-as to whether these conditions are sufficiently extensive and able to fully attenuate this plume to meet the Remedial Action Objectives.	DOI concurs with the response.	Comment addressed. Agencies approved PG&E response. No changes to the CMS/FS Report are required.
176	DOI-63	Section	U.S.	Appendix E infers that Cr(VI) that has been	**This issue is resolved – the original response shown**	**Cr(VI) Generated from Reductively**	Comment resolved with PG&E	Comment resolved. The

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		5.2.6 General-- *In-situ* Treatment	Department of the Interior	reductively precipitated *in-situ* will be stable over the long-term under ambient geochemical conditions at the site. The authors postulate because Cr(III) concentrations are effectively controlled by low solubility Cr(III) hydroxides and mixed iron-Cr(III) hydroxides, the amount of aqueous Cr(III) available for adsorption onto manganese oxide surfaces and subsequent oxidation will be limited. Using this logic, Cr(VI) would never occur in Alluvial Aquifers naturally; however, as has been documented by Izbicki and others (2008) Cr(VI) can occur in natural environments at concentrations as high as 60 µg/L. The manganese oxides are on the surface coatings of the mineral grains and will be reactive with the precipitated Cr(III). Recent data collected by the USGS in El Mirage, CA (Izbicki, 2009, in review) demonstrates that Cr(III) can undergo oxidation reactions to Cr(VI) under natural conditions, at timescales relevant to this project. Before any of the *in-situ* treatments are considered, studies need to be completed to determine if the reduced chromium will remain on the solid phase becoming increasingly refractory and less mobile with time, or will the chromium be reoxidized and become mobile once added reductant is consumed and geochemical or hydrologic conditions change. If reductant will need to be added in the future, the time and costs of cleanup should reflect this additional treatment. The report states that *in-situ* treatment can result in the generation of transient byproducts such as arsenic and manganese at concentration in the range of those found in the naturally occurring fluvial deposits. The report or Appendix E does not demonstrate that the arsenic and manganese will be 'transient" in the oxic/alkaline water present naturally in the Alluvial Aquifer. The sorptive capacity of the aquifer sediments will be reduced at alkaline pH's. The reported ranges of arsenic and manganese concentrations are above the MCL's. If the *in-situ* treatment resulted in concentrations in these ranges, the water would not be suitable for drinking, so the chromium problem would be removed but the water would still be nonpotable. Appendix E infers that if the arsenic and manganese concentrations did not naturally attenuate in the Alluvial Aquifer, they would be removed in the hyporheic zone at the Colorado River. This is probably true but then one is looking at timeframes approaching natural attenuation to totally cleanup the site.	**here for completeness. The changes to Section 5.2.6 provided by DOI on August 4**, 2009, as revised during meetings October 13 and October 23, 2009 **have been incorporated.** The cited reference (Izbicki 2009, in review) deals with vadose-zone chemistry and mineralogy that is much different from conditions in the saturated zone at Topock. The paper acknowledges that the soil mineralogy was naturally enriched in chromite and manganese minerals from the geologic deposition of eroded mafics, which is different from Topock where the background study did not show elevated chromium in soils. This—coupled with the very long residence time of porewater in the vadose zone (retained as the non-drainable fraction that represents the natural soil moisture) and the strongly alkaline pH—have allowed chromium concentrations to build up in the porewater evaluated in Izbicki's work. This scenario cannot be directly translated to the post-remedial setting at Topock. As pointed out by Oze et al., 2007, the potential for chromium oxidation is controlled by the solubility/dissolution rate of the Cr(III) minerals, pH, and the availability of reactive manganese oxide surfaces. In an aquifer, flushing via the continued movement of groundwater is also a factor. The low solubility of the mixed iron/chromium precipitate that will be formed by the *in-situ* treatment, the alkaline pH of the groundwater at Topock further limiting the solubility of the Cr(III) minerals formed by *in-situ* treatment, and the movement of groundwater preventing accumulation of chromium in any particular location after treatment, are all factors that will minimize chromium dissolution in a post-remedial setting. These are substantially different conditions than the vadose setting of the Izbicki work. While the natural potential for Cr(III) oxidation in the underlying aquifer is evident in background areas proximal to the Topock site, the addition of the anthropogenic chromium from the compressor station to the aquifer solids through *in-situ* treatment will not significantly increase the aquifer solid phase chromium concentration over natural background. The following factors play a role preventing Cr(III) reoxidation in an *in-situ* treated groundwater setting: 1. Initially, reaction of manganese with Cr(III) will be inhibited by reduced iron minerals such as iron sulfide/FeS (Deng and Wu, 2006), a mineral that will be formed within IRZs in the same area where chromium is precipitated. FeS essentially inactivates manganese oxides and precludes them from reacting with Cr(III). 2. Oxidation of Cr(III) by manganese oxides is inhibited at moderately alkaline pH such as is found at Topock. This is due to the fact that Cr(III) must be present in the dissolved form for the reaction to proceed, and this range of pH is where chromite minerals are most stable (Oze et	**Precipitated *in-situ* Processes**: Please add text and clarify in the CMS/FS report how significantly elevated hexavalent chromium [Cr(VI)] background concentrations are generated in the geochemical environment present at the Topock site. This will assist in differentiating between processes that generate Cr(VI) from reductively precipitated chromium via *in-situ* mechanisms and help answer the following question: How do you get 32 ug/L of hexavalent chromium for a naturally occurring background concentration at the site, yet are limited to only 1 to 2 ug/L Cr(VI) concentrations from reductively precipitated chromium? **In-situ Byproduct Generation**: PG&E's response indicates that Figure E4 illustrates temporary mobilization of arsenic and manganese. DTSC's evaluation of Figure E4 suggests that both arsenic and manganese were generated well above baseline conditions during IRZ operations and reduced in concentrations (arsenic) or remained elevated (manganese) only after IRZ shutdown. Figure E4 suggests that a slug of manganese and arsenic contamination was created in the aquifer and moved toward extraction wells. DTSC is less certain how the arsenic and manganese would behave/persist within fluvial/anaerobic portions of the aquifer adjacent to the Colorado River where PG&E postulates that an environment exists that favors elevated arsenic and manganese. DTSC has provided one edit to DOI language to Section 5.2.6 of the CMS/FS. See page 1-9 in the accompanying attachment. DTSC directs PG&E to delete the identified statement (redline/strikeout) regarding groundwater potability in its response as it is not accurate or necessary. As indicated in other DTSC comments, the state has identified the groundwater basin around the Topock station as containing potential beneficial uses including drinking water. PG&E has also been previously notified that portions of the shallow Alluvial Aquifer exhibit water quality that even exceeds that	incorporation of language provided by DOI in the file transmittal entitled "Sec 5 DOI edits 8-4-09", pending review of final text. Although the response uses the Izbicki reference to highlight differences at Topock, there are similarities: a) Precipitation of Cr(III) during in situ treatment could create localized high concentrations of Cr(III) minerals on grain surfaces; b) Aqueous Mn released from reductive dissolution of dispersed manganese minerals could re-precipitate in a relatively narrow zone of changing geochemistry resulting in higher localized concentrations of new manganese minerals; c) Pore water in stagnant zones of the aquifer will also have long residence times; d) Topock groundwater has alkaline pH values that are high enough to allow build up of Cr. FeS will inhibit the reaction of manganese with Cr(III) is true as long as FeS persists. Eventually FeS will reoxidize. It is conceivable that locally high concentrations of reduced Cr(III) and re-oxidized Mn minerals could be created if the appropriate geochemical environment exists. There is no direct evidence from the aquifer to make the statement that 1-2 ppb would be the worst case scenario, especially in smaller localized areas of the aquifer. In summary, both the comments and responses present sound geochemical arguments for their respective points of view. It is not possible to conclusively answer the question of remobilization of Cr using only laboratory experiments because of the difficulty in re-creating aquifer geochemistry and simulating residence times in the lab in sufficient detail to simulate potential aquifer reactions.	paragraph in Section 5.2.6 about the stability of the Cr(VI) reduction reaction has been re-written by DOI in collaboration with DTSC and PG&E, and made consistent with revisions to Appendix G. Redline final submitted to agencies on November 13, 2009. Agencies approved the report revisions.

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					al., 2007). As shown in ARCADIS 2009,the oxidation rate, measured in nanomoles per hour (nM/hr), decreases two orders of magnitude from pH 3 to 7. The resulting steady-state concentration of Cr(VI) is dependent upon the surface area of the Cr(III). For Topock, a preliminary calculation indicates that concentrations should not exceed ~1 µg/L. Details of this calculation are provided in ARCADIS 2009. Note that this is the predicted concentration of Cr(VI) that may be generated only due to the reaction between chromium and manganese oxides. The prediction is conservative in that it assumes ideal contact between chromium and manganese oxides and optimum reactivity of the manganese oxide surface (in the aquifer, contact and reactivity will be limited). In addition, this concentration of Cr(VI) is not a prediction of the future total background concentration of Cr(VI) in groundwater. 3. Oxidation of Cr(III) by manganese oxides has been shown to be inhibited by chromium hydroxide precipitates, essentially passivating the reactive surfaces (Fendorf et al., 1992; Fendorf, 1995). The hydroxide precipitate is one of the forms of Cr(III) that will be created through reductive precipitation of Cr(VI). In the areas where Cr(III) hydroxides are precipitated, these hydroxides (and other minerals) can form on the surfaces of manganese minerals that are not reductively dissolved, thereby limiting their reactivity. 4 The overall mass of chromium being immobilized in the soil matrix is a small fraction of the naturally occurring chromium and will not be concentrated in any one location with manganese oxides, as opposed to some natural environments where chromium and manganese minerals are concentrated (such as in the Izbicki paper). Over time frames relevant to this project, the worst case “rebound” (1-2 ppb) should not be distinguishable from the natural background. Regarding the temporary mobilization of arsenic and manganese, Figure G9 in Appendix G shows that both arsenic and manganese were transient in the floodplain IRZ. While natural attenuation of Cr(VI) relies on the reducing conditions found in the floodplain, the attenuation of manganese and arsenic can occur by a longer list of mechanisms that are active both in the reducing zones and the oxidizing zones. These mechanisms are discussed in Appendix G, Section G.8. Furthermore, as pointed out in Appendix G, the process of recovery can be accelerated if warranted. Discussion will be added to Appendix G to provide this information. Additional information on the hyporheic zone will be included in the edits made to Appendix G. References: ARCADIS. 2009. Response to comments on Draft	of the adjacent Colorado River. DTSC awaits edits to Appendix E that are proposed by PG&E in its response.		

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					CMS/FS for PG&E Topock Site. Submitted to DTSC and DOI June 15, Izbicki, J. 2009, in review. Letter dated December 24, 2008 from Peter Martin, USGS San Diego Project Office to Christy Hunter, Lahontan Regional Water Quality Control Board; including attached summary of El Mirage, CA. Oze, C., Bird, D.K., and Fendorf, S. 2007. Genesis of hexavalent chromium from natural sources in soil and groundwater. Proceedings of the National Academy of Sciences, 104 (16): 6544-6549. Wu, Y., Deng, B., 2006, Inhibition of FeS on Chromium(III) Oxidation by Biogenic Manganese Oxides, Environmental Engineering Science, Volume 23, Number 3, 2006, p. 552-560. Fendorf, S.E. 1995. Surface reactions of chromium in soils and waters. Geoderma 67: 55-71. Fendorf, S.E., Fendorf, M., Sparks, D.L., and Gronsky, R. 1992. Inhibition mechanisms of Cr(III) oxidation by manganese oxides. Journal of Colloid and Interface Science 148: 37-54.			
177	DTSC-66	Page 5-6, Last Paragraph Section 5.2.6	California Department of Toxic Substances Control	Main considerations for active *in-situ* treatment systems should include the hydrogeology affecting distribution of reagent to all appropriate (contaminated) areas of the aquifer.	In response to this comment, the subject sentence will be revised to state: "The main considerations for active *in-situ* treatment at the site are the type of reagent (which affects treatment residuals, contaminant half lives), the hydrogeology affecting distribution of reagent to all appropriate (contaminated) areas of the aquifer, and the methodology to deliver the reagent to the contaminated groundwater or move the contaminated groundwater toward an *in-situ* treatment zone."	Agree with RTC.	DOI concurs with the response.	Comment resolved. Agencies approved PG&E response. Changes to Section 5.2.6 noted in the response have been made to the CMS/FS Report.
178	DTSC-67	Page 5-7, Paragraph 3 Section 5.2.6	California Department of Toxic Substances Control	The paragraph compares IRZ wells to a highly impractical permeable reactive barrier (PRB) constructed using trenching. IRZ should be compared to a realistic alternative such as a PRB created using semi-permanent wells to inject reactive materials into the subsurface.	The text to Section 5.2.6 will be edited to include a discussion of semi-permanent well placement of reactive material; the conclusions would remain the same: Constructing a reactive barrier could be accomplished by excavating a trench and backfilling the trench with reactive materials to create a subsurface wall that allows groundwater to pass through while prohibiting the movement of constituents. Other options include fracturing or the use of boreholes to inject reactive materials (such as zero valent iron) that the groundwater will pass through. Another option for creating a reactive barrier is to establish an IRZ using a line of wells that circulates reactive materials between each well. In any case, the barrier is installed across the flow path of the constituent plume, thereby allowing groundwater to move through the barrier below grade to reduce Cr(VI) to low solubility and less toxic Cr(III).	DTSC directs PG&E to revise the CMS/FS language as proposed in this response. Additionally, change "insoluble" to "low solubility" in the last sentence in accordance with other comments (see highlighted text).	DOI concurs with the response noting the DTSC request to modify the proposed text to change referring to the insolubility of Cr(III).	Comment resolved. Agencies approved PG&E response. Changes to Section 5.2.6 noted in the responses (PG&E and DTSC) have been made to the CMS/FS Report.
179	DOI-64	Section	U.S.	The term "attain treatment" is not clear. Revise	The sentences were revised as requested.	Agree with RTC. Will review final language	DOI accepts the response.	Comment resolved.

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		5.2.6 Page 5-8, 1st paragraph after Figure 5-3	Department of the Interior	the last two sentences of the paragraph to read: “Greater numbers of wells and IRZ lines would distribute the substrate more quickly than fewer wells and IRZ lines. Combining IRZ lines with extraction and injection technologies would allow manipulation of groundwater flow to enhance distribution of reactant material.”		for consistency.		Agencies approved PG&E response. Changes to Section 5.2.6 noted in the responses (PG&E and DTSC) have been made to the CMS/FS Report.
180	DOI-65	Section 5.2.6, Page 5-8, Paragraph 2	U.S. Department of the Interior	The second sentence in this paragraph states that establishing more wells would “attain treatment more quickly”. It would be more accurate to state that additional wells would “establish the treatment zone more quickly”.	The sentence was modified to eliminate the phrase “attain treatment” per response to comment #179.	Agree with RTC. Will review final language for consistency.	DOI accepts the response.	Comment resolved. Agencies approved PG&E response. Changes to Section 5.2.6 noted in the responses have been made to the CMS/FS Report.
181	DOI-66	Section 5.2.6 Page 5-8, last paragraph	U.S. Department of the Interior	DOI remains concerned about the potential creation of new contaminant plumes (e.g., As and Mn) as a result of in situ treatment of the upland areas. The dismissal of concerns about As and Mn as having short-lived adverse effects must be better supported by analysis that demonstrates the processes by which these constituents disappear from groundwater. DOI also remains concerned that precipitation of Mn as the aquifer re-oxidizes could adversely affect the permanence of the CR reduction reaction.	**This issue is resolved – the original response shown here for completeness. The changes to Section 5.2.6 provided by DOI on August 4**, 2009, as revised during meetings October 13 and October 23, 2009 **have been incorporated.** Once released, the reduced forms of manganese and arsenic will be attenuated through precipitation, sorption, diffusion and co-precipitation. Arsenic and manganese do not need to be transported to an oxidized zone to precipitate as a carbonate (for manganese) or sulfide (for arsenic), both of which happen in reducing zones of an IRZ. Adsorption of these elements also occurs in the reducing zone to minerals that are stable in the reducing zone, including iron sulfides, mixed-valence iron oxides such as magnetite or green rust, and some aluminum hydroxides and silicates. Thus, transport of these elements from the reducing zone to an oxidizing zone is not required for them to return to low-solubility forms. If transported into the oxidized zone, arsenic and manganese will also be attenuated by sorption and co-precipitation to metal oxides and by the oxidation of manganese to form an oxide precipitate. Any manganese and arsenic that are transported out of the reducing zone will eventually be immobilized as they enter the more oxidizing environment. Several examples of byproduct attenuation with time and distance were presented in Appendix G, and additional examples are presented here. In the floodplain pilot tests (Appendix G), the rate of attenuation varied depending on carbon loading, with PT-3D in the floodplain pilot test returning to baseline arsenic concentrations rapidly after organic carbon injections ceased. PT-1D, where more carbon was delivered was slower to attenuate, has returned to close to baseline arsenic concentrations after a year following the last injection.	The PG&E response indicates that Mn and As attenuation will occur via geochemical processes other than oxidation. However, Appendix E (e.g., Figures E1, E3 and E4) reinforce the idea that oxidation is the only process. Therefore, it is recommended that Appendix E be revised if PG&E desires this concept be captured in the CMS/FS. Please see response to comment 176/DOI-63 above regarding Figure E4. DTSC is less certain regarding the fate of arsenic and manganese within fluvial/anaerobic portions of the aquifer adjacent to the Colorado River and where great amounts of reductant would be added to large portions of the Alluvial Aquifer.	Comment resolved with PG&E incorporation of language provided by DOI in the file transmittal entitled “Sec 5 DOI edits 8-4-09”, pending review of final text. The response is generally accurate but assumes that all of the potential problems are contained within the existing area of the Cr plume. The potential for contaminant transport along preferential flow paths not accounted for in the groundwater model could result in greater As and Mn transport than anticipated. This is of greater concern if in-situ application occurs in the fluvial sediments. Residence times are significantly shorter and the potential for flow to the river is greater.	Comment resolved. The paragraph in Section 5.2.6 about the potential for transient byproducts has been re-written by DOI, in collaboration with DTSC and PG&E, and made consistent with revisions to Appendix G. Redline final submitted to agencies on November 13, 2009. Agencies approved the report revisions

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					Manganese attenuation within the reducing zone has been slower but reflects the same trends as arsenic, with attenuation more rapid where carbon loading was lower. In the upland pilot test (ARCADIS 2009), carbon was distributed and a reactive zone was created along the flow path in the shallow zone from PTR-2 through MW-24A and PT-8S. Within this reactive zone, manganese concentrations up to 17,200 µg/L and arsenic concentrations up to 82.8 µg/L were generated. By the time treated water, as evidence by decreased Cr(VI) and nitrate concentrations and the presence of groundwater tracers fluorescein and eosine, reached PT-7S located less than 100 feet outside of the reactive zone, manganese concentrations decreased to 2,300 µg/L and arsenic concentrations decreased to 12.1 µg/L. It is expected that concentrations would have decreased further, if given more distance. Data from another site, presented in Appendix G, also demonstrated the attenuation of manganese, iron and arsenic within the IRZ to baseline concentrations along a flowpath from the injection locations. Note, arsenic and manganese concentrations attenuated to baseline concentrations within the reduced IRZ before reaching the oxic downgradient recovery zone. As described in the response to DOI-63 (above) the precipitation of manganese as the aquifer re-oxidizes will not affect the permanence of the chromium that is precipitated within the IRZ. Reference: ARCADIS 2009. Upland Reductive Zone In-Situ Pilot Test. Final Completion Report. Waste Discharge Requirements Order No R7-2007-0015. PG&E Topock Compressor Station. March 3.			
182	DOI-67	Section 5.2.6, Page 5-8, Paragraph 1 and Figure 5-3	U.S. Department of the Interior	Consider discussing the advantages and disadvantages of vertical versus horizontal circulation. For example, horizontal circulation would likely result in a greater spacing between fewer wells, but would have the problem of preferential flow in zones of high permeability and the chance of incomplete distribution of the carbon source. Vertical circulation would have a better chance to distribute organic carbon vertically through zones of low and high permeability, but would likely require more wells spaced closer together.	While vertical and horizontal circulation systems are both possible, the engineered system is determined by site characteristics. Multiple recirculation configurations were considered in the design of the upland pilot, with each evaluated using the model developed to analyze the pilot data. These analyses established that sufficient data were collected from the pilot to define the relevant parameters for design. This will allow for design of a flexible and optimal recirculation system during the engineering of the selected alternative. During the remedial design phase, the well configuration will be considered in detail for the particular IRZ location; it is possible that the same wells could be operated in both configurations. This issue will be reviewed in greater detail during remedial design.	DTSC agrees the issue can be flushed out in greater detail during design.	DOI accepts the response and agrees that further review is appropriate should IRZ be selected as a remedy.	Comment resolved. Agencies approved PG&E response. No changes to the CMS/FS Report are required. PG&E prepared a separate technical memorandum titled “Conceptual Floodplain Design Options, Pacific Gas and Electric Company Topock Compressor Station” dated October 5, 2009 that summarized conceptual options for the design of in-situ treatment systems in the

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								floodplain.
183	DTSC-68	Page 5-8, Last Paragraph Section 5.2.6	California Department of Toxic Substances Control	More discussion is needed in the body and appendix of the CMS Report supporting the statement that byproducts (As, Mn, Fe) are naturally attenuated over time or distance and are not expected to have a long-term negative impact on water quality.	The topic of *in-situ* byproduct generation and attenuation was raised in comments 176 (DOI-63), 181 (DOI-66), and several subsequent comments. The text in Section 5.2.6 and text and figures in Appendix G will be edited to add clarity with respect to the attenuation mechanisms of precipitation, sorption, and coprecipitation for arsenic, manganese, and iron, as presented in response to the comments noted above.”	Deferral to a later date for clarification language is not helpful in meeting the aggressive schedule. DTSC believes that this information is pertinent in the remedial alternatives comparison. DTSC will await final language for evaluation.		Comment resolved. The paragraph in Section 5.2.6 about the potential for transient byproducts has been re-written by DOI, in collaboration with DTSC and PG&E, and made consistent with revisions to Appendix G. Redline final submitted to agencies on November 13, 2009. Agencies approved the report revisions
184	DOI-68	Section 5.2.6, Page 5-9, Paragraph 1	U.S. Department of the Interior	This discussion is somewhat vague. There should be some discussion of the number of wells that may be necessary beyond what is stated about clean up time, etc. The reader should be able to get an idea of the surface impact of this technology from this discussion.	The referenced section of the report (Section 5.2) is intended to provide a more general discussion of the considerations for each of the retained general response actions (GRAs). Section 5.3 (and the appendices referenced in Section 5.3) provides more details on the number of wells associated with each of the alternatives developed for evaluation. In response to this comment, a sentence has been added to Section 5.2.3 describing that the number, size, and location of wells affects the extent of piping and surface impacts (see also response to comment #188).	DTSC believes that additional details on the design will provide greater differentiation and assessment of each remedial alternative. However, DTSC agrees that this can be flushed out during the design phase.	Pending final review of the text, DOI accepts the response.	Comment resolved following agency review and input during finalization of Section 5.2 of the CMS/FS Report, including the sentence added to Section 5.2.3 noted in the response. Redline final submitted to agencies on November 13, 2009. Agencies approved the report revisions.
185	DTSC-69	Page 5-9, Paragraph 1 Section 5.2.6	California Department of Toxic Substances Control	The section states, *“Different reactant materials may be applied to different areas of the site (e.g., floodplain vs. upland) to reflect different natural geochemical conditions.”* Additional discussion and detail is requested regarding this statement.	The text to Section 5.2.6 will be edited: *“”Different reactive materials may be applied to different areas of the site (e.g., floodplain vs. upland) to reflect different natural or ambient geochemical conditions. The selection of the appropriate reactant for a specific area depends on the balance between the mode of delivery and the reactant properties, and the rate of reactant utilization and the ability to overcome the consumption of the reactant due to ambient conditions. For example, during the remedial design loading rates and specific carbon sources will be finalized for specific areas of the site. Ethanol might be utilized at lower concentrations where a smaller reductive footprint is desired, and whey might be utilized where a larger reductive footprint is desired. Section 4.3 of Appendix E provides additional detail on the topic of alternate carbon sources.*	DTSC directs PG&E to revise the CMS/FS language as proposed in this response. However, DTSC agrees to defer additional discussion until design.	DOI concurs with the response.	Comment resolved. Section 5.2.6 modified as follows: “There is a wide spectrum of organic carbon substrates available for anaerobic IRZ applications, including fermentable soluble substrates such as molasses, lactate, and whey; alcohols such as ethanol and methanol; semi-soluble substrates such as emulsified vegetable oil; and solids such as chitin and bark mulch. The selection of the appropriate substrate for a site depends on

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								the balance between the mode of delivery and the substrate properties, and the rate of carbon utilization and the ability to overcome the ambient electron acceptor recharge (to establish a sufficiently reducing environment). More details on the various donor types as they relate to IRZ activities at Topock are discussed in Appendix G." Redline final submitted to agencies on November 13, 2009. Agencies approved the report revisions
186	DTSC-70	Page 5-9, Paragraph 1 Section 5.2.6	California Department of Toxic Substances Control	Similar to last paragraph of page 5-9 on Ex-Situ Treatment, an In-Situ Treatment system will also require, although at a lesser degree, operation and maintenance on a continued basis.	The comment is correct that both types of actions require ongoing operation and maintenance. The referenced sentence is specifically describing the need for *continuous* operation and maintenance of a treatment plant associated with *ex-situ* treatment. Section 5.2.6 does state that considerations for siting a reactive treatment zone include ensuring that facilities are located in areas that are accessible for construction, operation and maintenance, and management of the substrate storage and injection equipment. The differences in the level of O&M requirements for the actions are discussed during the alternative comparisons.	DTSC concurs with RTC.	DOI concurs with the response.	Comment resolved. Agencies approved PG&E response. No changes to the CMS/FS Report are required.
187	DTSC-71	Page 5-9, Paragraph 4 Section 5.2.7	California Department of Toxic Substances Control	The statement is made that possible locations for an *ex-situ* treatment plant are on the Topock Compressor Station property and at the current IM No. 3 treatment plant location. List other locations that PG&E considered and provide rationale for rejection.	Considerations for location of a future *ex-situ* treatment plant are discussed in Section 5.2.7 of the CMS/FS Report. Considering all the listed factors, there are currently two locations identified in the CMS/FS Report for the treatment plant: the Topock Compressor Station property and the current IM No. 3 treatment plant location. The location of the Topock Compressor Station property was selected for purposes of cost estimating. The location at the current IM No. 3 treatment plant location was included in the CMS/FS Report alternative description, as required by DTSC. Please note that at the CMS/FS Report stage, the design for the remedial alternatives is still conceptual. In accordance with applicable guidance, viable remedial technologies are identified and then assembled into a range of alternatives that can satisfy the RAOs in the CMS/FS. The location of an *ex-situ* treatment plant for purposes of alternative evaluation, as shown in the CMS/FS, is not intended to mean that other locations are not viable and could not be evaluated during remedial design.	See response to comment 160.		Comment resolved. Agencies approved PG&E response. No changes to the CMS/FS Report are required.

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188	DOI-69	Section 5.2.7, Page 5-9, Paragraph 6	U.S. Department of the Interior	This should mention the impact to surface depending on the number and size of wells installed.	In response to this comment, The following sentence has been added to Section 5.2.3: "The number, size, and location of wells installed will affect the extent of piping and disturbances at the surface." Note that the referenced section of the report (Section 5.2) is intended to provide a general discussion of the considerations for each of the retained GRAs; the number and size of wells are associated with the removal GRA (Section 5.2.3) rather than the *ex-situ* treatment GRA (Section 5.2.7).	DTSC accepts the response.	DOI accepts the response.	Comment resolved. Agencies approved PG&E response. Changes to Section 5.2.3 noted in the responses have been made to the CMS/FS Report.
189	HA-12	Section 5.2.7	Hargis & Associates, Inc. (on behalf of Fort Mojave Indian Tribe)	<u>7b. Current IM3 Location</u> As far as the siting of a water treatment plant at or near the present location of the IM3 facility, not only would this continue to pose an intrusion on the Tribe's sacred landscape, but the Tribe understands that this location may not even offer sufficient space for the anticipated size of an enlarged facility to handle a 1,200 gallons per minute (gpm) inflow as conceptualized in the CMS/FS. Thus, the CMS/FS is flawed and needs to be revised to properly account for cultural constraints in the conceptual design. The Tribe understands that the reason that PG&E included the IM3 location as an option in Alternatives F, G, H, and I within this draft of the CMS/FS was because this was directed by DTSC in letters dated November 6, 2008, and December 5, 2008.[18] Regardless of the rationale for retaining this location, the Tribe regards any consideration of retaining or expanding the IM3 treatment plant as offensive, unacceptable, and inconsistent with the spirit of the existing Settlement Agreement with the State of California.[19] The Tribe would strongly object to (1) a taller building in this area; (2) additional grading in this area; and/or (3) the use of the former IM3 staging area for an expanded facility. Additionally, the Tribe would also have concerns about introducing more power poles and lines in this area. The Tribe also notes that DTSC previously ordered PG&E to restore the staging area and does not understand how this area could even be considered for development.[20] Finally, as pointed out earlier, the acceptability of this site has been challenged by the engineers responsible for remedy design. Moreover, it is not necessarily true that	As presented in Section 5.2.7 of the CMS/FS Report, the location of a future *ex-situ* treatment plant has many constraints. Those constraints include placement close to extraction and injection facilities to minimize the amount of pipeline and pump stations required for transporting groundwater, proximity to a power source, available space for construction, and accessibility for construction and operation. In addition, location of the treatment plant must also consider cultural and religious significance of the land, sensitive habitats, historical sites, topographical constraints, and existing infrastructure. Considering all these factors, there are currently two locations identified in the CMS/FS Report for the treatment plant, including the Topock Compressor Station property and the current IM No. 3 Treatment Plant location. Because compliance with ARARs is a threshold criterion for remedial alternative evaluation, compliance with cultural resources ARARs will be evaluated prior to remedy selection. The alternative analysis in the Final CMS/FS Report will be revised to evaluate compliance with ARARs, including compliance with cultural resources ARARs. DOI's preliminary analysis has indicated that, as a threshold matter, alternatives with a treatment plant located at the compressor station cannot be eliminated for an inability to attain the various cultural resource ARARs. Additionally, tribal comments on cultural resources and viewpoints are currently being evaluated by DTSC for inclusion in the draft Environmental Impact Report and by the DOI in a manner consistent with federal law. Lastly, PG&E intends to comply with the requirements of the settlement agreement with the Fort Mojave Indian Tribe.	DTSC will await final language for evaluation.	Compliance with ARAR is a threshold criterion under CERCLA. Evaluation of the alternatives for compliance with cultural ARARs will be conducted before a final remedy selection is made. DOI is not a party to the settlement agreement between FMIT and the CA state agencies. The terms and conditions of the agreement are not ARAR's and may not be considered prior to the final remedy selection. DOI would like to thank the FMIT for providing their thoughts and perspective on this area. The FMIT and other Tribes will be provided an opportunity to provide this information in the development of the ethnographic/ethno historic study. The Bureau of Land Management will continue to conduct formal Section 106 consultation with the nine federally recognized Tribes including consultation with the Fort Mohave Indian Tribe.	Comment addressed. DOI's evaluation of ARARs compliance is included in the Final CMS/FS Report.

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				constructing a new treatment plant at the station results in greater disturbance than leaving in place or expanding the existing IM3 plant. The Tribe has repeatedly told the agencies that the IM3 facility must be removed at the earliest practicable date and that leaving it in place would itself be a great, continuing disturbance and desecration of this sacred place. In addition, for CEQA and CMS/FS ranking purposes, Alternative I should consider the IM3 as a new facility and NOT as an existing facility.[21] Therefore, it cannot be accurately stated that Alternative I has the "next lowest impact,"[22] or that it should be considered as an existing, and therefore less impactful facility in ranking.[23] [18] See CMS/FS Table F1, No. 5. response. [19] This Settlement Agreement was also reached in the case styled, *Fort Mojave Indian Tribe v. DTSC, et al.,* Sacramento Superior Court Case No. 05CS00437. [20] See, for example, direction from Karen Baker for IM-3 Staging Area Site Restoration Plan, dated November 22, 2005. [21] The parties to the settlement agreements committed to remove the IM3 treatment plant from its current location on the IM-3 Site either as a component of or prior to the final remedy. (See Agreement with PG&E at Section VI.A, Agreement with DTSC at Section III.A.). In addition, the IM3 should be considered a new facility because of the special circumstances giving rise to it pursuant to CEQA Guidelines section 15125 (the baseline for assessing impacts will *normally* be the environmental setting for the project at the time of the CEQA Notice of Preparation therefore allowing for other than the NOP timing as the environmental baseline under special circumstances, such as here). [22] As asserted on p. 5-47. [23] See pp. 5-55 and 5-57.				
190	DOI-70	Section 5.2.8, Page 5-10, 1st paragraph of section	U.S. Department of the Interior	The discussion of monitoring not achieving long term cleanup goals is potentially misleading. Delete the 2nd and third sentences of the first paragraph.	Per DOI's August 4, 2009 correspondence, the second sentence in Section 5.2.8 has been revised to state: "Monitoring alone does nothing to reduce chromium concentrations."	Agrees with RTC.	DOI accepts the response.	Comment resolved. Agencies approved PG&E response. Changes to section 5.2.8 as noted in the response

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								have been made to the CMS/FS Report, as further modified by DTSC (see comment #500).
191	DTSC-72	Page 5-10, Paragraph 2 Section 5.2.8	California Department of Toxic Substances Control	Citing monitoring wells is discussed, but fails to include the obvious factor that wells are needed at specific locations to monitor groundwater hydraulics and chemistry. The section should be revised to incorporate this issue.	The following sentence has been added to the beginning of the paragraph: “Monitoring wells need to be located in areas that provide relevant data on groundwater hydraulics and chemistry.”	Agrees with RTC.	DOI concurs with the response.	Comment resolved. Agencies approved PG&E response. Changes to Section 5.2.8 noted in the response have been made to the CMS/FS Report.
192	HA-10	Section 5.2.9	Hargis & Associates, Inc. (on behalf of Fort Mojave Indian Tribe)	7. The Tribe’s Position Regarding the Proposed Alternatives Natural attenuation processes are inherently a component of each of the alternatives proposed as well as any other groundwater remedial alternative that might be conceived for the Site, regardless of whether or not PG&E accounts for natural attenuation in the design. The Tribe believes that, if the process of natural attenuation were properly acknowledged as a component of alternatives other than a stand-alone A and B, significant simplifications over the currently proposed designs could be made. For example, Alternatives C, D, E, and G all call for the establishment of *in situ* reductive zones (IRZ) within the floodplain area, east of Park Moabi Road. The Tribe believes that these facilities may be unnecessary considering the demonstrated effectiveness of the naturally-occurring reductive zone combined with the conclusions of the risk assessment studies that acknowledge insignificant risk to the River from floodplain groundwater COPCs.	Please see response to comment #148. As stated in Section 2.3 “The reducing conditions in the fluvial sediments provide a natural geochemical barrier that would, at the very least, greatly limit or prevent the movement of Cr(VI) in groundwater through the fluvial sediments adjacent to and beneath the Colorado River.” Also, as stated in Section 5.2.5 “As it is recognized that natural attenuation occurs at the Topock site, natural attenuation may be considered a feature of the site that augments those active remedial alternative that allow chromium in groundwater to contact the fluvial materials.” Although reducing conditions are prevalent in the fluvial aquifer near and below the Colorado River today, the capacity of the reducing zone to attenuate Cr(VI) over the long periods of time during which the remedial alternatives will likely be in operation is subject to uncertainty. Accordingly, other than Alternative B (MNA), none of the alternative remedies has been designed to rely on natural attenuation as a component of the remedy. PG&E recognizes the value of the natural reducing conditions in the floodplain as a buffer between the Cr(VI) plume and the river but has chosen not to rely upon MNA as a component of the active remedies for the purposes of the conceptual remedial design. In response to this comment, as well as comments #148, 243, and 284, PG&E will prepare an evaluation of Alternatives C, D, E, and G without infrastructure east of National Trails Highway. Additional remedial alternatives have not been added to the report.	Please note that restoring the groundwater basin to a beneficial use is also an important objective and an ARAR. Currently, elevated concentration of Cr(VI) is still detected above the bedrock at the flood plain area. It is clear that there is little reductive capacity at depth.	Natural attenuation is inherently part of and augments all the alternatives. The capacity of the reducing zone to attenuate Cr(VI) for lengthy periods of time remains unknown, especially when considering the potential timeframes for the proposed remedial alternatives. DOI would like to thank you for providing your perspective on the alternatives. The Bureau of Land Management will continue to conduct formal Section 106 consultation with the nine federally recognized Tribes including consultation with the Fort Mohave Indian Tribe.	Comment resolved. PG&E prepared a separate technical memorandum titled “Conceptual Floodplain Design Options, Pacific Gas and Electric Company Topock Compressor Station” dated October 5, 2009 that summarized conceptual options for the design of in-situ treatment systems in the floodplain, including the option of no floodplain infrastructure.
193	HA-29	Section 5	Hargis & Associates, Inc. (on behalf of Fort Mojave Indian Tribe)	Appendix F – PG&E Response to FMIT Specific Comments Nos. 4 & 6 The responses to these respective comments are identical and refer back to the discussion provided for General Comment No. 1. Accordingly, please see FMIT’s further discussion of the significance of the Tribe’s position on natural attenuation as discussed	See response to comment #148.	See response to comment 148.		Comment resolved. PG&E prepared a separate technical memorandum titled “Conceptual Floodplain Design Options, Pacific Gas and Electric Company Topock Compressor Station”

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				under comments for General Comment No. 1.				dated October 5, 2009 that summarized conceptual options for the design of in-situ treatment systems in the floodplain, including the option of no floodplain infrastructure.
194	CRIT-23	Section 5.2.9 Page 5-10	Envirometrix (on behalf of the Colorado River Indian Tribe)	When considering a possible pump and treat system, This CMS/FS focuses on the desire to have one large system at a single location. Alternatives such as expanding the current system as much as possible and the construction of a smaller additional pump and treat system or systems in another location does not seem to be a consideration or option. Why is this approach consistently not being considered? Are there any cost advantages in considering this approach?	Please see response to comment #160. As stated, the purpose of a CMS/FS is to develop and evaluate a set of alternatives that represents a range of performance and cost options. It is not necessary for the alternatives to include every possible configuration and combination of technologies. The CMS/FS Report identifies considerations for location of a future ex-situ treatment plant and selects a representative configuration for purposes of alternative evaluation. For purposes of alternative development and evaluation in the CMS/FS Report, a single treatment plant is considered due to the site constraint factors discussed in Section 5.2.7, storage of chemicals and waste, and cost. A single location is likely to be less costly and takes less space. This is due to the need for power and control distribution equipment, chemical storage, and waste storage equipment at each location. In addition, the treatment equipment is not appreciably smaller. Implementing multiple small systems is more difficult because of the land use access requirements, multiple operational systems, and personnel requirements. The configuration of an ex-situ treatment plant for purposes of alternative evaluation, as shown in the CMS/FS Report is not intended to mean that other configurations are not viable and could not be evaluated during remedial design. Such a change in remedial design would not invalidate the analysis in the CMS/FS because the performance of multiple treatment systems is adequately represented in the alternative evaluation by the single larger treatment system.	See response to comment 160.	DOI concurs with the response. The Bureau of Land Management will continue to conduct formal Section 106 consultation with the nine federally recognized Tribes. The perspective of the Tribes will be considered during design to altogether avoid or mitigate adverse effects to cultural properties.	Comment resolved. Agencies accept PG&E response. No changes to the CMS/FS report are required.
194 .3	CRIT-44	Section 5.2.9	Colorado River Indian Tribe via BLM	He pointed out that we are in a drought situation with less water now than before and that Lake Mead is at a low point; therefore, the water is more concentrated.	As discussed in the response to comment #136, with the exception of Alternative I, the remedial alternatives in the CMS/FS Report result in little or no consumptive use of water since essentially all the water that is extracted from the ground is reinjected back into the aquifer. The operation of the remedial alternatives has no effect on the volume of groundwater available in the basin or the flow in the river and the extent of concentration does not impact any of the proposed alternations. All the remedial alternatives are able to accommodate fluctuations in groundwater levels associated with changes in river stage. During drought, it is likely that the river would remain at fairly low levels, and changes in groundwater levels would be less than in times of normal river flow. Thus, the remedial alternatives that are designed to work at times of normal river flow should work just as well in times of	Agree with RTC. See response to comment 136.	DOI concurs with the response.	Comment resolved. Agencies approved PG&E response. No changes to the CMS/FS Report are required.

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					drought.			
194 .5	CRIT-45	Section 5.2.9	Colorado River Indian Tribe via BLM	Therefore, dispersal or dilution is not viable	None of the remedial alternatives proposed in the CMS/FS Report is designed to achieve the RAOs through dilution or dispersion.	Agree with RTC.	PG&E should consider the definition of natural attenuation when responding to this comment.	Comment resolved. Agencies accept PG&E response. No changes to the CMS/FS report are required. The definition of natural attenuation in Table 4-1 is as follows: "Actions that rely on monitoring to show that natural subsurface processes such as dilution, volatilization, biodegradation, adsorption, dispersion, and chemical reactions with subsurface materials are reducing contaminant concentrations to acceptable levels within the desired period of time."
194 .8	CRIT-46	Section 5.2.9	Colorado River Indian Tribe via BLM	PG&E does not seem to have a concern that the drought is affecting the water level now in the Colorado River; they are not addressing unnatural water conditions in their studies	As discussed in the response to comment #136, with the exception of Alternative I, the remedial alternatives in the CMS/FS Report result in little or no consumptive use of water since essentially all the water that is extracted from the ground is reinjected back into the aquifer. The operation of the remedial alternatives has no effect on the volume of groundwater available in the basin or the flow in the river. All the remedial alternatives are able to accommodate fluctuations in groundwater levels associated with changes in river stage. During drought, it is likely that the river would remain at fairly low levels, and changes in groundwater levels would be less than in times of normal river flow. Thus, the remedial alternatives that are designed to work at times of normal river flow should work just as well in times of drought.	Agree with RTC.	DOI concurs with the response.	Comment resolved. Agencies approved PG&E response. No changes to the CMS/FS Report are required.
195	DOI-71	Section 5.3 General	U.S. Department of the Interior	A five-layer ground-water flow model was used to estimate well locations, flow rates, and time to cleanup for the CMS/FS. As stated in the CMS/FS report, there is a large degree of uncertainty in the projections of time to cleanup because of the assumptions and limitations of the ground-water flow model. One of the limitations is the simplification of the complex lithology of the site into 5 model layers with averaged hydraulic properties. The USGS completed a modeling exercise to evaluate how variations in lithology affect the projections of time to cleanup. Lithologic variation was evaluated by utilizing a radial ground-water flow	**Issue resolved. Original response shown below for completeness. The changes to Section 5.3 provided by DOI on August 4 have been incorporated, in lieu of the proposed changes to Section 5.3 below.** The groundwater flow model used in the CMS/FS Report was developed and calibrated on the basis of available groundwater hydraulic data. The four alluvial layers represent the four depth intervals into which well screen intervals fell at the time of model development in 2005. It is agreed that within the depth interval of each model layer there is likely a variety of hydraulic conductivity variation, based on geologic and geophysical logs. The potential effects of these variations on flushing time were	DTSC concurs with the DOI response.	Comment resolved with PG&E incorporation of language provided by DOI in the file transmittal entitled "Sec 5 DOI edits 8-4-09", pending review of final text. It is possible that injection of reductants could create reducing zones surrounding fine-grained Cr(VI) containing sediments. These reductants could reduce Cr(VI) as it diffuses out of these sediments. The reductants could also penetrate the fine-grained sediments to varying extent and reduce Cr(VI). This type of scenario is	Comment resolved. Several paragraphs in Section 5.3 describing the groundwater model and assumptions for consideration during remedial alternative development and evaluation have been re-written by DOI for inclusion in Section 5.3. Redline final submitted to agencies on

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				model with particle tracking. The modeling exercise involved comparing two modeling approaches. The first modeling approach assumes that the aquifer system can be simplified into 5 layers with average hydraulic properties (aquifer model) and the second modeling approach assigns discrete hydraulic properties to individual lithologic zones (lithologic model). Both models have the same total transmissivity per aquifer layer. The aquifer layers were based on the model used for the CMS/FS report. The results of the modeling exercise (01_TW-2D_LithComparison.pdf) indicated that the aquifer model (averaged hydraulic conductivity values) would underestimate cleanup time if low-permeability lithologic units contain high concentrations of Cr. In addition, 3-D variations in lithology will increase the estimated cleanup time even more than estimated with the radial flow model and inefficiencies in cleanup design "dead zones" would be exacerbated by lithologic variations. Because the CMS/FS model utilizes average hydraulic properties, the time for cleanup estimates are highly uncertain. If all of the contamination is in water within coarse-grained deposits, the CMS/FS model may reasonably estimate the time to cleanup. However, if a substantial amount of the chromium mass is contained within fine-grained deposits the model will severely underestimate the cleanup time. In the central part of the plume, it is high probability that a substantial mass of chromium is retained in the fine-grained layers of the Alluvial Aquifer because there has been a long time for the chromium to migrate into the fine-grained deposits. However, on the margins of the plume, it is likely that the chromium is largely contained within the coarse-grained layers. Core squeezing by the USGS at site MW-31D supports this statement. The CMS/FS states that the alternatives were designed to achieve cleanup in 30 years or less. As stated above, because the aquifer system has variations in lithology that are not simulated in the model, the estimated cleanup times will be significantly greater than estimated.	demonstrated by the USGS modeling exercise (01_TW-2D_LithComparison.pdf). However, water level changes caused by these variations are not measurable using the hydraulic head data and aquifer test responses of the site monitoring wells – the screened intervals are too long and the number of wells too few to determine with great detail whether the aquifer is finely layered as USGS postulates or more randomly heterogeneous. Rather than include hypothetical low-permeability layers that would explicitly create longer flushing times, PG&E chose to make the level of detail in the model consistent with the level of detail in its site data and account for the uncertainty in flushing efficiency by quoting a wide range of cleanup times equivalent to between 2 and 20 pore volume flushes. The USGS file provided one possible distribution of hydraulic conductivities out of a virtually infinite set of combinations. It clearly demonstrated why some portions of the aquifer will flush much more slowly than other portions. The effect that this variability in flushing rate will have on cleanup time is unknown. It will depend on the fraction of fine-grained materials present, how the fine-grained materials are distributed throughout the aquifer, the concentration of Cr(VI) in the fine-grained materials at the start of remediation, and the diffusion rate of the Cr(VI) out of the fine-grained materials after remediation is complete or nearly complete. It is impossible at this point to estimate with precision what effect poor flushing of fine grained layers would have on cleanup time. For this reason, PG&E has shown a wide range of possible cleanup times equivalent to between 2 and 20 pore volume flushing times. PG&E agrees that the cleanup time estimates are uncertain, and this uncertainty is discussed in multiple places within the CMS/FS Report (e.g., Section 5.3, Section 5.4, Appendix F). The cleanup times are based on average parameters assigned to the model layers based on aquifer testing and other calibration targets. The emphasis is on five pore volume flushing. There are several lines of site specific data (ISPT tracer tests, stable isotope movement through the floodplain, breakthrough of injected water from IM No. 3 in the uplands) that support the assumption that five pore volume flushes would be sufficient to remove most of the contaminant mass. The use of five pore volumes is designed to incorporate the variations in hydraulic properties and transport processes (diffusion, dispersion, retardation) that are known to affect contaminant transport rates. Because these are not measurable to a high degree of accuracy and comprehensiveness, the five pore volume estimate is considered appropriate for the scope of a CMS-level evaluation. In recognition of the uncertainty in the time to cleanup calculations, PG&E has bracketed the uncertainty by showing 2 to 20 pore volume cleanup curves in Appendix F. The long-term pore flushing *efficiency* is what is not known, given all the heterogeneity that is described in this comment. The heterogeneity will likely result in areas that will be slow to clean up with any remedy. This specific		different than uncertainties in physical flushing. The different alternatives use in situ treatment to varying degrees and estimates of cleanup times may not be equally weighted because of uncertainties in how alteration of aquifer geochemistry affects removal Cr(VI) from groundwater. Given the uncertainty in hydraulic properties inherent in the 5-layer model, along with the geochemical uncertainties stated above, errors in the model simulations cannot be equally weighted for each alternative under consideration. Each alternative contains different pumping and in situ scenarios, and it seems likely that the groundwater flow model may provide more realistic cleanup times for some alternatives than others.	November 13, 2009. Agencies approved the report revisions.

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					efficiency cannot be precisely known at present, and all remedies being considered in the CMS/FS contain this unknown, so this method is appropriate and adequate for comparing alternatives at this level of detail, even with the uncertainty in cleanup time. The imperfect flushing processes over which DOI is concerned would occur during all remedial actions at all sites. Contaminants that are not completely flushed from low-permeability layers can continue to diffuse outward after active remediation is complete. However, it is not possible to predict neither the mass of Cr(VI) present in fine-grained material nor the net effect of this slow diffusion on the water quality in the aquifer as measured by monitor wells. Compared to organic solvents like trichloroethene, chromium is not strongly sorbed to aquifer solids. Therefore, it is more amenable to flushing and less likely to exhibit “rebound” than organic solvents. In addition, the chromium discharged to AOC 1 at the Topock site was diluted in cooling tower blowdown water. Therefore, the maximum concentrations that could be present in the fine-grained layers are significantly less, in comparison to the RAO, than at sites were concentrated plating tank solutions were discharged. This tends to limit the mass that could be present in the fine-grained layers and therefore limit the rate of diffusion out of those fine-grained layers. Based on what is known about the source and the geology of the site, the anticipated imperfect flushing should not be any more of a concern at this site than at many other similar sites around the country. The approaches PG&E has used to evaluate remedial alternatives are commonly used at other sites. In response to this comment, the following sentence is proposed to be added to the second paragraph in Section 5.3: “For example, if a large portion of the target mass of contamination is contained in low-permeability zones, the time to cleanup estimates may be underestimated.” In addition, the sixth sentence in the second paragraph in Section 5.3 is proposed to be revised as follows: “Appendix D provides a more detailed description of how the model was used in development of the remedial alternatives and to estimate time to cleanup. The emphasis is on five-pore volume flushing; as explained in Appendix D the estimate of five pore path volumes is a reasonably good comparison tool between alternatives and may not be an accurate measure of cleanup time for any given alternative. Therefore, in order to provide a more reasonable range of cleanup time estimates, a range of cleanup times based on between two and 20 flow path volumes is used to describe the time to cleanup estimates;” In addition, the second sentence in the third paragraph in			

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					Section 5.3 is proposed to be revised as follows: "To facilitate meaningful comparison of the relative footprint and effectiveness of the active alternatives, the active alternatives were designed to achieve a target simulated cleanup time based on assumptions described in Appendix D (i.e., five flow path volumes) of about 30 years or less. As discussed above, the actual cleanup times are uncertain – the principal objective of this modeling is for comparison of alternatives."			
196	DOI-72	Section 5.3, Page 5-11, General Comment	U.S. Department of the Interior	PG&E should consider proposing a monitoring network for each alternative to address concerns about point of compliance, environmental impacts from well installation (if required), and cost. The "Limitation" sections should provide options for consideration if RAOs are not achieved by the remedy. Such contingencies could include, but are not limited to, continued maintenance of the IRZ, continued operation of IM-3, or long-term institutional controls.	In response to this comment, PG&E proposes to add a table to the Final CMS/FS Report identifying contingencies for example scenarios under which the alternatives would not meet the stated RAOs. The table would also note that a contingency plan would be prepared for the selected alternative. As required by the CACA, a detailed monitoring plan will be included in the O&M Plan for the selected alternative. The monitoring plan would include a description and purpose of monitoring, monitoring schedule, and field and laboratory quality control. It is expected that the corrective action monitoring program would be dynamic and would be adjusted as needed to promote optimization of the alternative to attain the RAOs. All of the remedial alternatives except Alternative A include a corrective action monitoring program of routine sampling, analysis, and reporting. Assumptions for the monitoring program, including numbers of sampling points, frequency of sampling, length of monitoring program, and analytical parameters for purposes of the cost estimates, are included in Appendix D. The corrective action monitoring program is assumed to rely on the existing network of approximately 100 monitoring wells, potentially supplemented by additional monitoring wells. Exact locations of additional monitoring facilities will depend on final alternative configuration and data collected during construction. As noted in Section 5.2.8, final locations of monitoring wells depend on accessibility, landowner and leaseholder requirements, cultural resources, sensitive habitats, historical sites, topographic constraints, and locations of existing infrastructure.	Agree with RTC. DTSC awaits review of final contingency table.	DOI accepts the response regarding the monitoring network. DOI accepts the response regarding contingencies, pending review of the final format and content of contingency table.	Comment resolved following agency review and input during finalization of the CMS/FS Report. Table 5-3 has been added that includes example contingency actions during remedial alternative implementation to respond to failure to attain RAOs. Redline final submitted to agencies on November 13, 2009. Agencies approved the report revisions.
197	DTSC-73	Page 5-11, Section 5.3, Remedial Action Alternative Descriptions	California Department of Toxic Substances Control	General Comment: In general, there are insufficient details provided for the remedial action alternative descriptions. Please note that under Section 6.2 of the EPA Guidance for Conducting Remedial investigation and Feasibility Studies, "the information developed to define alternatives at this stage in the RI/FS process may consist of preliminary design calculations, process flow diagrams, sizing of key process components, preliminary site layouts, and a discussion of limitations, assumptions, and uncertainties concerning each alternative."	In response to this comment, the cost estimates for each of the alternatives in Appendix D have been revised to provide additional detail. Rather than a one-page-per-alternative cost spreadsheet, the cost spreadsheets will be expanded to two pages per alternative, and additional tables and text will also be added to Appendix D to provide basis for the cost estimates. In addition, the third sentence in Section 5.3 is proposed to be revised to state: "Appendix D provides the cost estimates, including alternative components, assumptions, and cost estimating factors." This information—combined with the remedial alternative	DTSC will review the revised cost estimates and the additional detail as described in RTC.	DOI concurs with the response, pending review of the final text and Appendix B.	Comment resolved following agency review and input during finalization of Appendix D to the CMS/FS Report. Redline final submitted to agencies on November 13, 2009. Agencies approved the report revisions.

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				In the current CMS/FS, there are simple statements on number of anticipated monitoring wells, extraction wells, IRZ wells, pipe sizes and anticipated pipe lengths in the cost estimates, but the basis of these statements, preliminary design calculations, assumptions, and uncertainties are severely inadequate or not provided. Please note the level of details presented in Appendix F, case study example, in the EPA guidance.	descriptions and layout figures in Section 5.0, the groundwater modeling assumptions, and the supporting information on in-situ treatment design, and proof of concept studies—provide the level of detail consistent with the referenced USEPA guidance. The elements listed in the cited USEPA guidance are included in the CMS/FS Report, including preliminary design calculations, process flow descriptions, sizing of key process options, preliminary site layouts, and discussion of limitations, assumptions, and uncertainties. In addition, the level of detail in Section 5.3 is consistent with the noted case study example in the USEPA guidance. Though not specifically required by USEPA guidance, PG&E proposes to add additional information to the remedial alternative descriptions to quantify conceptual design assumptions on sustainability factors such as energy use, waste generation, and vehicle traffic.			
198	HA-19	Section 5.3 Page 5-11	Hargis & Associates, Inc. (on behalf of Fort Mojave Indian Tribe)	The document is internally inconsistent in regard to the consideration of sensitive resources and constraints. On one hand, it states that there would be minimal disturbance to cultural resources, yet conceptual well field designs proposed for some alternatives show wells and/or facilities located in the Maze itself and adjacent areas.[26] As discussed earlier, it is not proper to defer consideration of cultural/tribal resources as ARARs to a future time because these have a direct bearing on the remedy-selection decision on which this document focuses. The Tribe also requests that the Community Acceptance criterion for the CERCLA ROD or the RCRA Statement of Basis for this project be addressed at this time and not defer its consideration to some later, unspecified time or document. [26] Cf. the last paragraph on p. 5-12 with Figure 5-6, 5-9, 5-10, and 5-11, for example.	In response to this comment the paragraph will be revised as follows: "PG&E acknowledges that there are sensitive resources in the vicinity of the remedial action alternatives. At this early stage of analysis, the conceptual design of the remedial alternatives considered sensitive resources by re-positioning some infrastructure into previously disturbed areas. Important parameters throughout the design and implementation phases of the selected remedy will include: (1) implementing a remedial action in a manner that is respective of, and causes minimal disturbance to, cultural resources including, in particular, resources that are of special significance to tribes in the area; implementing a remedial action in a manner that limits disturbance to wildlife and their habitats; and implementing a remedial action in a manner that complies with sensitive resource protection ARARs" In addition, the alternative analysis in the Final CMS/FS Report will be revised to evaluate compliance with ARARs, including compliance with cultural resources ARARs. Stakeholders, including state agencies and tribes, have provided input and feedback during the development of the CMS/FS, which have directly influenced the alternatives presented in the Draft CMS/FS Report. Additional stakeholder comments received during review of the Draft CMS/FS Report have been addressed and incorporated into the Final CMS/FS Report. The paragraph is referencing the standard process under CERCLA where the lead agency prepares a Proposed Plan that summarizes the final FS, which is then released for public comment. Following receipt of all public comments, the lead agency will then prepare a Responsiveness Summary, which is included in the Record of Decision and is used to evaluate the state and community acceptance in the	Agree with RTC. However, DTSC will review augmented RTC. ~~after DOI issues response on ARARs.~~ DTSC acknowledges the Tribe's concerns. The technical merit of a proposed alternative is the key consideration in whether it is included as one of the alternatives to be further evaluated in the CEQA-based environmental review process. The CEQA process (which includes detailed consideration of cultural resources) can provide a rationale for the Lead Agency to eliminate or modify a technically feasible alternative. Federal processes under DOI include the identification of ARARs, any of which may result in the elimination of an alternative for (federal) consideration on the basis of legal infeasibility. Narrowing down of potential alternatives by the California and federal lead agencies may not occur simultaneously; however the agencies are coordinating their review of alternatives as closely as possible and the remedy selection will reflect input from both.	The Department of Interior Solicitors' Office provided revised final language for Section 5 on 10/16/2009. This language addresses consideration of cultural resources and compliance with ARAR. The Bureau of Land Management will continue to conduct formal Section 106 consultation with the nine federally recognized Tribes. Community acceptance will be considered during the public comment period and in the preparation of the Record of Decision (ROD). After public comments have been received, DOI will prepare a Responsiveness Summary to be included in the ROD. Additional input from the Tribes will also be requested during the design an implementation of the selected remedy.	DOI's evaluation of ARARs compliance has been added to the Final CMS/FS Report. DOI's preliminary analysis has indicated that, as a threshold matter, alternatives with a treatment plant located at the compressor station cannot be eliminated for an inability to attain the various cultural resource ARARs. The revision to the last paragraph in Section 5.3 has been modified as noted in the response.

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					Record of Decision. DOI has commented (see comment #384) that the CMS/FS Report should more explicitly reflect that the recommended remedial alternative in the CMS/FS Report does not take into consideration state and community acceptance criteria. In addition, DTSC has commented (see comment #282) that the agencies will formally address the modifying criteria of "State Acceptance and Community Acceptance" at the time of the Record of Decision. The assessment will consider input beyond the comments on the CMS/FS Report, up to and including comments received during the public comment period for the Statement of Basis and the Proposed Plan. These modifying criteria will be fully addressed during the final remedy selection under the Record of Decision and DTSC's final remedy adoption.			
199	CRIT-24	Section 5.3 Page 5-11	Envirometrix (on behalf of the Colorado River Indian Tribe)	Section 5.3 states, *Alternative I (Continued* Operation *of the Interim Measure) has been incorporated into this CMSIFS report per DTSC's request (DTSC, 2008b, 2008c); the configuration* of *Alternative I has not been modified to adjust to the goals* of *the remedial action (Section 3.0), but instead focuses on the goals of the Interim Measure (hydraulic control* of *the plume only)*. We request additional clarification regarding the reason that PG&E did not include Alternative I initially in this CMS/FS. We also do not understand why PG&E is making the specific point that inclusion was per DTSC request. We believe that Alternative I was a reasonable, practical and appropriate alternative that PG&E should have included initially, without having to receive direction form DTSC.	As stated, Alternative I is designed to focus on the goals of the IM (hydraulic control of the plume only), rather than the goals of the remedial action to reduce Cr(VI) concentrations. Most specifically, the extraction wells in Alternative I are not optimally located for Cr(VI) mass removal. As noted in Appendix F, the estimated cleanup time for Alternative I based on the range of 2- to 20-flowpath flushing times is significantly longer in comparison to the other active alternatives.	See response to comments 145.	DOI concurs with the response.	Comment resolved. Agencies approved PG&E response. No changes to the CMS/FS Report are required.
200	DOI-73	Section 5.3, Page 5-12, 1st full paragraph	U.S. Department of the Interior	The groundwater model is a flow model that does not simulate contaminant behavior. While the model reasonably simulates large-scale flow patterns and responses to aquifer stresses, it does not attempt to simulate the detailed flow patterns associated with the heterogeneous aquifer materials, nor does it address contaminant/substrate distribution within or migration between the various coarse and fine grained layers. As noted in the paragraph, in order to estimate timeframes for achieving the RAOs, PG&E has relied on assumptions about flushing efficiency and substrate distribution. The statement that these assumptions are consistent with data at the site is potentially misleading. Data are extremely limited on which to estimate the rate at which contaminants will flush from the groundwater system, particularly when considering cleanup to background levels, or on the degree to which substrates will penetrate contaminated fine grained materials. Therefore,	**Issue resolved. Original response shown below for completeness. The changes to Section 5.3.2 provided by DOI on August 4, 2009 have been incorporated, in lieu of the proposed changes to Section 5.3.2 below.** PG&E agrees that the cleanup times listed in the CMS/FS Report are rough estimates based on limited data, which require generalized aquifer parameters and assumptions relating to transport/cleanup. Cleanup time uncertainty is discussed in multiple places within the CMS/FS Report (e.g., Section 5.3, Section 5.4, Appendix D). As discussed in the response to comment #195, there are several sets of site-specific data (ISPT tracer tests, stable isotope movement through the floodplain, breakthrough of injected water from IM No. 3 in the uplands) that were used to develop the estimate that five pore volume flushes would be sufficient to remove most of the contaminant mass. It is typical in large-scale plume cleanups that some areas of the plume reach RAOs much faster than others. While it is true that there may be recalcitrant zones at the Topock site	DTSC does concur with PG&E's response statement that, "…attainment of RAOs throughout most of the aquifer would be greatly accelerated by active remedies in comparison with natural flushing."	Comment resolved with PG&E incorporation of language provided by DOI in the file transmittal entitled "Sec 5 DOI edits 8-4-09", pending review of final text.	Comment resolved. The discussion of cleanup time for Alternative B has been re-written by DOI for inclusion in Section 5.3.3. Redline final submitted to agencies on November 13, 2009. Agencies approved the report revisions.

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				assumptions about the number of pore volumes needed to flush the contamination or distribute substrate to all contaminated intervals in the aquifer are speculation not founded on a reliable data set. The degree to which the speculative timeframe estimates are presented as time to reach cleanup goals, and the degree to which those estimates affect alternative rankings is a concern to DOI, particularly where timeframe estimates are used as a primary basis for distinguishing between alternatives that are assumed to require a few decades versus those that are estimated to require centuries (i.e., as is done when comparing the active remedies in Alternatives C,D,E,F,G,H, and I with No Action and MNA in Alternatives A and B). DOI believes that site hydrogeologic factors could drive longer than expected cleanup times regardless of system sizing, and that these factors could affect some alternatives to a greater degree than others. Therefore, the conclusion that the relative rankings would remain unchanged if different timeframe assumptions are used may be flawed. DOI understands and appreciates PG&E's attempt to establish a time-based design criterion on which to develop comparably-scaled remediation systems, but this should not be misconstrued as a basis for concluding that RAOs can actually be achieved in the assumed timeframes. PG&E must rephrase the timeframe discussions to reflect that the designs are based on flushing a certain number of pore volumes of water or substrate through the aquifer system over a given time. Any statements or inferences that these time frames represent actual cleanup times should be removed from the discussion.	where RAOs will be difficult to meet, attainment of RAOs throughout most of the aquifer would be greatly accelerated by active remedies in comparison with natural flushing. Even with significant model uncertainty, the effects of the active remedies (Alternatives C, D, E, F, G, H, and I) will greatly increase flushing and/or natural reduction processes compared to natural attenuation (Alternatives A and B). Further, it is typical in large-scale plume cleanups that ongoing optimization or augmentation of the remedy is required to meet RAOs everywhere across the site. With normal remedial process optimization throughout the life of the remedial action, PG&E believes that the active remedies would require much less time than the passive (no-action or MNA) remedies to reach RAOs across the vast majority of the plume. As discussed in Section 5.3, with the exception of Alternatives A, B, and I, all alternatives are assumed to include optimization of the remedy throughout the design, construction, and operational phases that may include changes to the number, location, and configuration of the extraction, treatment, and injection systems and/or changes to the type, method, and configuration of the treatment delivery system to enhance performance of the remedy to attain the cleanup goals and to respond to site conditions and performance issues. In response to this comment, the text will be revised throughout the document to indicate that remedies that rely on flushing are being evaluated based on estimates of five pore volume flushing times. For example, the fifth through seventh sentences in the first paragraph in Section 5.3.2, the time to cleanup for Alternative B will be revised to state: "The best ~~engineering~~ estimate of the time ~~to cleanup required~~ for five pore volumes to be flushed with this alternative is 1,000 years. This estimate of pore volume flushing time is considered appropriate for the purpose of comparing relative duration of alternatives. The actual cleanup time will be dependent on the flushing efficiency of the aquifer and is subject to considerable uncertainty. The length of time needed to attain cleanup goals in the Alluvial Aquifer would be longer if the flushing efficiency of the Alluvial Aquifer is less than indicated by the available site specific data. The likely range of cleanup time is estimated to be from 700 years (based on 2 pore volumes) to 3,000 years (based on 20 pore volumes)." The discussion of cleanup times for the other alternatives will be modified similarly.			
201	DOI-74	Section 5.3, Page 5-12, 2nd full paragraph	U.S. Department of the Interior	Revise the 2nd sentence to read: "To facilitate meaningful comparison of the relative footprint and effectiveness of the active alternatives, all were designed to either move five pore volumes through the desired area or distribute substrate throughout the desired area in a roughly similar period of time (~30 years or less)."	Per DOI's August 4, 2009 correspondence, the sentence has been revised to state: "To facilitate meaningful comparison of the relative footprint and effectiveness of the active alternatives, all were designed to achieve certain goals (e.g., distribution of organic carbon substrate in a one pore volume flush, or movement of five pore volumes of water through aquifer		DOI accepts the response.	Comment resolved. Agencies approved PG&E response. Changes to Section 5.3 noted in the response have been made to the CMS/FS Report.

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					materials) in a roughly similar period of time (~40 years or less).”			
202	DOI-75	Section 5.3, Page 5-12, 3rd full paragraph	U.S. Department of the Interior	The effect of the timeframe estimates on the estimated costs should be re-evaluated. DOI believes some of the alternatives that rely on groundwater extraction or flushing, or distributing substrate across large distances have a relatively higher degree of uncertainty in the timeframe to reach cleanup goals. These cleanup approaches could require many decades or centuries to complete. Assuming a cleanup period of a few decades artificially constrains the costs.	**Issue resolved. Original response shown below for completeness.** We agree that it is possible that cleanup times may exceed the estimates in the CMS/FS Report, as noted by the range of uncertainty in Figures D4-1 through D4-8. The cleanup time estimates are mainly for remedy comparison purposes only. There are many factors that could influence cleanup times up or down that cannot be measured with accuracy or sufficient areal extent. The CMS/FS assumes that all of the alternatives (with the exception of Alternatives A, B, and I) will include some degree of optimization/augmentation to meet RAOs across the entire plume. Like the other criteria used for remedy evaluation, the cost comparison in the CMS/FS is meant only to provide relative rankings for the alternatives. Ongoing costs out beyond a few decades do not have a large bearing on the net present value. If DOI would like PG&E to use a longer time period for calculating costs than outlined in Table B-16, it can be done; however, it likely would not make a large difference in the relative cost rankings.		Comment resolved with PG&E incorporation of language provided by DOI in the file transmittal entitled “Sec 5 DOI edits 8-4-09”, pending review of final text.	Comment resolved. Text provided by DOI for discussion of estimated times for the remedial alternatives has been included in the Final CMS/FS Report. Redline final submitted to agencies on November 13, 2009. Agencies approved the report revisions.
202 .5	RWQCB-1	Section 5.3, page 5-12, 3rd paragraph	Water Quality Control Board - Colorado River Basin Region	While Regional Board staff does not endorse any particular alternative, Regional Board staff is concerned that the remedial action alternatives presented in the subject report (including the recommended Alternative E) do not specify any contingency plans to address any failure in or suboptimal performance of the alternative. The selected alternative must include consideration of the Water quality Objectives which protect the beneficial uses of waters within the Colorado River. To provide some level of assurance that Water Quality Objectives would continue to be protected, Regional Board staff recommends that either the IM-3 facilities remain intact and available, or alternate facilities with approximately 135 gpm extraction and treatment capacity be available, as necessary, to supplement the selected corrective measure(s), at least until such time as it becomes clear, based on operating history and risk analysis, that the need for the facilities no longer exist. Having the facilities available as a back-up would ensure that hydraulic control and treatment of the hexavalent chromium contamination plume would be maintained in the event that future surface and/or groundwater monitoring indicated that there was an imminent threat to the beneficial uses of waters within the Colorado River. In the event that adjustments to the current processes within the IM-3 facilities are	In response to this comment, PG&E proposes to add a table to the Final CMS/FS Report identifying contingencies for scenarios under which the alternatives would not meet the stated objectives of the remedial action. The table would also address failure to comply with ARARs during implementation of the remedial action, noting that Water Board requirements have been identified as ARARs. The table would also note that a contingency plan would be prepared for the selected alternative. Please also see responses to comments #19, #20, and #21. Section 1.1.2 of the CMS/FS is proposed to be revised to state: “Implementation of the IM is expected to continue until a final corrective action/remedial action for the site is operating properly and successfully, and the regulatory agencies terminate the requirement for the IM.”	DTSC will review the final contingency table proposed.	DOI concurs with the response regarding contingencies, pending review of the final format and content of contingency table.	Comment resolved. Table 5-3 has been added to the Final CMS/FS Report to address example contingency actions during remedial alternative implementation. Redline final submitted to agencies on November 13, 2009. Agencies approved the report revisions.

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				determined to be needed for the facilities to be fully effective as a supplement to the selected corrective measure(s), such adjustments should be considered and, as appropriate, should be allowed.				
203	DTSC-74	Page 5-12, last paragraph, Section 5.3	California Department of Toxic Substances Control	This paragraph states that consideration has been given to the sensitive resources and constraints in the development of alternatives. It may be helpful to stakeholders if PG&E provided a decision logic progression on how these were considered. DTSC's understanding is that the CMS/FS alternatives were first developed based on technical feasibility to attain RAOs. Then the alternatives were modified to reduce impact to sensitive resources, where possible. Transparency in decision logic may help reviewers.	PG&E used several concepts to guide the development of the alternatives. For most alternatives, there was a general preference for placement of infrastructure in previously disturbed areas. PG&E developed two different approaches to in-situ treatment in the uplands area (Alternatives C and D) for comparison, one with infrastructure primarily in previously disturbed areas (Alternative C) to contrast with placement of infrastructure solely focused on treatment efficiency (Alternative D). The in-situ floodplain cleanup strategy for Alternatives C, E, and G only considered placement of infrastructure focused on treatment effectiveness and efficiency. Extraction wells, injection wells and associated piping in the uplands area were primarily located in previously disturbed areas for Alternatives E, F, and G. In response to this comment, and comment #198, the paragraph will be revised as follows: "PG&E acknowledges that there are sensitive resources in the vicinity of the remedial action alternatives. At this early stage of analysis, the conceptual design of the remedial alternatives considered sensitive resources by positioning infrastructure in previously disturbed areas where feasible. Important parameters throughout the design and implementation phases of the selected remedy will be: (1) implementing a remedial action in a manner that is respectful of, and causes minimal disturbance to, cultural resources, particularly resources that are of special significance to tribes in the area; (2) implementing a remedial action in a manner that limits disturbance to wildlife and their habitats; and (3) implementing a remedial action in a manner that complies with sensitive resource protection ARARs."	DTSC agrees with RTC.	DOI concurs with the response.	Comment resolved. Agencies approved PG&E response. Changes to Section 5.3 noted in the response have been made to the CMS/FS Report.
204	DOI-76	Section 5.3.1, Page 5-13	U.S. Department of the Interior	PG&E should acknowledge that land ownership and current restrictions would also remain the same.	In response to this comment, the sentence has been modified as follows: " . . .there would be no land ownership changes initiated as part of the remedy and no institutional controls imposed to restrict use of groundwater . . ."	PG&E response is acceptable Institutional controls for use of groundwater may be required until PG&E attains RAOs for chromium. However, DTSC understands that federal landowners are not in favor of institutional controls over actual clean-up options.	DOI accepts the response.	Comment resolved. Agencies approved PG&E response. Changes noted in the response have been made to Section 5.3.2 of the CMS/FS Report.
205	DTSC-75	Page 5-13, Paragraph 2 Section 5.3.1 Alternative A	California Department of Toxic Substances Control	The sentence should be modified as follows as some fluvial sediments are contaminated or have been contaminated in the past, *"While natural attenuation would occur within <u>most of</u> the fluvial sediments near the Colorado River,…"* A similar acknowledgement of this issue shall be	The sentence in Section 5.3.1 was revised as suggested. Please see response to comments #174 and #214 for revisions to Section 5.3.3.1.	Agree with RTC, please see response to comment 174.	DOI concurs with the response.	Comment resolved. Agencies approved PG&E response. Changes noted in the response have been made to Section 5.3.2 of the CMS/FS Report.

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				included in the following section (5.3.2/5.3.2.1) on MNA.				
206	DTSC-76	Page 5-13, Paragraph 2 Section 5.3.1 Alternative A	California Department of Toxic Substances Control	No action alternative should be clarified that IM3 operation will cease also (different from Alternative I).	The description of no action has been revised to clarify that operation of the existing interim measure would not continue.	Agrees with RTC.	DOI concurs with the response.	Comment resolved. Agencies approved PG&E response. Changes noted in the response have been made to Section 5.3.2 in the CMS/FS Report.
207	SDCWA-7	Section 5.3.1 Page 5-13	San Diego County Water Authority	Does, as written “No active construction or operational activities would occur under this alternative” mean that the IM would not continue? Or rather, does, as written, “This alternative does not include decommissioning of the existing wells” mean that the wells would remain but not be operational? In any case, it would be useful to clarify this in this section and refer to section 5.3.9 Alternative I – Continued Operation of Interim Measures.	The description of no action has been revised to clarify that operation of the existing interim measure would not continue and that existing wells and facilities would not be decommissioned.	Agree with RTC.	DOI concurs with the response.	Comment resolved. Agencies approved PG&E response. Changes noted in the response have been made to Section 5.3.2 in the CMS/FS Report.
208	DOI-77	Section 5.3.2 Page 5-13 Alternative B	U.S. Department of the Interior	See “General” comments for Section 5.2.5.	No changes to Section 5.3.2 are proposed in response to this comments, consistent with comment #171. The first sentence in Section 5.3.2 states that no *active* treatment to reduce Cr(VI) concentrations in groundwater would occur under this alternative. PG&E believes this statement meets the spirit and intent of DOI’s concerns on this issue.		DOI accepts the response.	No changes to the CMS/FS are required in response to this comment.
209	DOI-78	Section 5.3.2, Page 5-13, Paragraph 1	U.S. Department of the Interior	It should be noted that the Cr(III) is less toxic than the Cr(VI).	The text in Section 5.3.3 has been revised to state Cr(VI) is converted to its stable *and less toxic* form of Cr(III), which is essentially immobile (the phrase “and less toxic” is the added text).	Agree with RTC.	DOI accepts the response.	Comment resolved. Agencies approved PG&E response. Changes noted in the response have been made to the CMS/FS Report in Section 5.3.3
210	DOI-79	Section 5.3.2, Page 5-13, Alternative B, MNA	U.S. Department of the Interior	Please clarify that the evaluation timeframe is based on the estimated time to move five pore volumes through the floodplain under natural hydraulic gradients and summarize the key assumptions and limitations used in computing this timeframe. Replace sentences 6 through 9 of the 1st paragraph with: “It is estimated that it would take more than 1,000 years for five pore volumes of contaminated Alluvial Aquifer groundwater to pass through the reducing zone at the floodplain under the current natural hydraulic gradients at the site. The length of time needed to attain cleanup goals in the Alluvial Aquifer would likely be longer given the heterogeneity of the Alluvial Aquifer.”	**Issue resolved. Original response shown below for completeness. The changes to Section 5.3.2 provided by DOI on August 4, 2009 have been incorporated, in lieu of the proposed changes to Section 5.3.2 below.** The calibrated groundwater flow model, which is the best available tool for estimating groundwater flow rates, projects that five pore volumes would pass through the floodplain in 1,000 years. It is not clear what basis DOI has for concluding that a longer time frame would be required to flush five pore volumes. PG&E agrees that the degree of heterogeneity in the Alluvial Aquifer would affect the flushing efficiency and therefore the time to cleanup. PG&E has therefore suggested a range of cleanup times from 700 to 3,000 years. There is considerably less uncertainty, however, in the time required to flush five pore volumes through the aquifer. In response to this comment, PG&E proposes the sentences in question in Section 5.3.3 be revised as shown below:		Comment resolved with PG&E incorporation of language provided by DOI in the file transmittal entitled “Sec 5 DOI edits 8-4-09”, pending review of final text.	Comment resolved. The discussion of cleanup time for Alternative B has been re-written by DOI for inclusion in Section 5.3.3. Redline final submitted to agencies on November 13, 2009. Agencies approved the report revisions.

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					"The best ~~engineering~~ estimate of the time ~~to cleanup required~~ for five pore volumes to be flushed with this alternative is 1,000 years. This estimate of pore volume flushing time is considered appropriate for the purpose of comparing relative duration of alternatives. The actual cleanup time will be dependent on the flushing efficiency of the aquifer and is subject to considerable uncertainty. The length of time needed to attain cleanup goals in the Alluvial Aquifer would be longer if the flushing efficiency of the Alluvial Aquifer is less than indicated by the available site specific data. The likely range of cleanup time is estimated to be from 700 years (based on 2 pore volumes) to 3,000 years (based on 20 pore volumes). This length of time for this method to attain cleanup goals is dependent on transport of Cr(VI) from all parts of the plume under natural hydraulic gradients to the natural reductive conditions in the floodplain."			
211	DTSC-77	Page 5-13, Last Paragraph Section 5.3.2 Alternative B	California Department of Toxic Substances Control	The paragraph below has been modified to stress long term monitoring that would be required for the plume. *"Under this alternative, the existing groundwater monitoring network would potentially be enhanced with additional groundwater monitoring wells, and ~~the~~ a long term corrective action monitoring program of routine sampling, analysis, and reporting would occur until the cleanup goals are attained."* The CMS report indicates additional wells may be added to the existing monitoring network. The number of wells proposed (See Table 5-3), while stated by PG&E to be conceptual, must have some basis that should be indicated in the Report for this and all other alternatives. Along with discussion in the report, the proposed wells, while conceptual, for this and all other alternatives should be plotted on a map to allow assessment by all stakeholders. Also, please ensure that the proposed monitoring system is compliant with the USEPA MNA guidance documents.	The sentence has been revised as requested. As required by the CACA, a detailed monitoring plan will be included in the O&M Plan for the selected alternative. The monitoring plan would include a description and purpose of monitoring, monitoring schedule, and field and laboratory quality control. It is expected that the corrective action monitoring program would be dynamic and adjusted as needed to promote optimization of the alternative to attain the remedial action goals. In the CMS/FS Report, all of the remedial alternatives, except Alternative A, include a corrective action monitoring program of routine sampling, analysis, and reporting. Assumptions for the monitoring program, including numbers of sampling points, frequency of sampling, length of monitoring program, and analytical parameters for purposes of the cost estimates, are included in Appendix D. The corrective action monitoring program is assumed to rely extensively on the existing network of approximately 100 monitoring wells, supplemented by additional monitoring wells. Please note that exact locations of additional monitoring facilities cannot be known at this time and will depend on final alternative configuration and data collected during construction. In addition, final locations of monitoring wells depend on accessibility, landowner and leaseholder requirements, cultural resources, sensitive habitats, historical sites, topographic constraints, and locations of existing infrastructure. In response to this comment, PG&E proposes to modify the cost estimate tables to describe the basis for assumption for number of additional monitoring wells. However, figures in Section 5.0 will not be modified to show conceptual well locations.	DTSC agrees that a monitoring plan will be fully developed during design and implementation for the final remedy. DTSC will agree to deferral of monitoring plans development until remedy design.	DOI concurs with the response.	Comment resolved. Agencies approved PG&E response. Changes noted in the response have been made to the CMS/FS Report. The suggested revision has been incorporated in section 5.3.3, and the cost estimates in Appendix D provide additional information for the basis for the monitoring program cost estimates.
212	CRIT-27	Section	Envirometrix	How would PG&E maintain and enforce	As discussed in Section 2.1.1 of the CMS/FS Report, there	Agree with RTC. DTSC will require the	DOI concurs with the response. Federal	Comment resolved.

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		5.3.2 Page 5-13	(on behalf of the Colorado River Indian Tribe)	institutional controls? What would be the proposed limit of the buffer area? Why are surface water monitoring points not included in this alternative? The same questions apply to other alternatives as appropriate.	are different property owners in the plume area, including PG&E, BOR, BNSF, and USFWS. There are also several entities that have easements and/or rights of way in the plume area. Maintenance and enforcement of institutional controls would vary depending on the property owners involved. For PG&E property, PG&E likely would record a deed restriction on the property. A similar mechanism may be appropriate for some other property owners. PG&E would work with each property owner and the regulatory agencies to identify and implement the appropriate institutional control measure for each property. The initial limit of the buffer area for establishment of an institutional control restricting development of a water supply well would likely be the Colorado River to the east, Park Moabi Slough to the north, Park Moabi Road to the west, and the mountains to the south. Future water supply development proposed within this area would be assessed on a case-by-case basis to determine whether the water supply would affect groundwater flow directions within the plume. As noted in Appendix D, operation and maintenance costs for Alternatives B through I assume that the corrective action monitoring program is to include periodic sampling and analysis of groundwater and surface water, both during the active remediation period and following the active remediation period.	development of a land use covenant with private land owners and will work with Federal Agencies on the appropriate mechanism for enforcement of the necessary institutional controls.	agencies can limit or prohibit certain uses of federal property managed by the agency as part of a CERCLA remedy. These limitations must be consistent with and/or incorporated by the management plans of the affected Bureaus.	Agencies approved PG&E response. No changes to the CMS/FS Report are required.
212 .5	Hualapai - 1	Section 5.3.2	Hualapai Tribe via BLM	Alt B: What is the assumption based on that the fluvial sediments are consistent enough through the plume area to make the conclusion that all migrating groundwater and Cr(VI) will be immobilized?	Evaluation of the fluvial sediments at the site has been through well installation and sampling, a pore water study, and laboratory core studies. Data presented in the RFI/RI and laboratory core testing studies indicate that subsurface conditions in fluvial deposits near the Colorado River floodplain are such that Cr(VI) in the floodplain would be reduced to the less toxic Cr(III). As stated in Section 2.3, laboratory evidence confirms that the fluvial sediments in the anaerobic zone beneath the floodplain have the capacity to remove Cr(VI) from groundwater via a chemical reductive process, and calculations suggest that there is sufficient capacity with the floodplain and beneath the river to reduce at least a significant portion of the Cr(VI) plume were the plume to come in contact with these sediments. However as noted in Section 5.3.3.1, although the reducing conditions in the shallow floodplain and beneath the river have been present at every location where a well has been installed or a pore water sample has been collected, there is no way to prove that these conditions exist everywhere. Please also see response to comment #148.	PG&E response is acceptable. Please note that DTSC also commented on the extent of the reductive zone in comment 214. PG&E should be consistent in describing the reductive zone and its limitations.	DOI concurs with the response.	Comment resolved. Agencies approved PG&E response. No changes to the CMS/FS Report are required.
213	DOI-80	Section 5.3.2.1, Page 5-15, Paragraph 1	U.S. Department of the Interior	These are important unknowns about the reducing zone and they should be mentioned throughout the discussion where appropriate.	The uncertainties about the extent or persistence of these natural reducing conditions at the site are reflected in the evaluation of Alternative B in Table 5-7.	Agree with RTC.	DOI accepts the response.	Comment resolved. Agencies approved PG&E response. No changes to the CMS/FS Report are required.

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214	DTSC-78	Page 5-15, Paragraph 2 Section 5.3.2.1	California Department of Toxic Substances Control	Revise the section according to the Page 5-13, Paragraph 2, Section 5.3.1 comment above regarding the extent of reductive conditions in fluvial sediments. The section should acknowledge that data clearly indicate that reducing conditions do not "occur everywhere" adjacent to the river. The section must comment on contaminated fluvial groundwater wells in the middle and deeper zones that would possibly be increasing in concentrations today if it were not for IM No. 3 measures and that the middle and deep zone are assumed to discharge into the Colorado River. The section should also note that some wells along the perimeter of the plume are increasing in Cr(VI) concentrations and that MNA is not operating or operating sufficiently in these areas. Finally, it must be stated that a major limitation with MNA is that it does not operate throughout the majority of the Cr(VI) plume.	In response to this comment and comment #174, Section 5.3.3.1 is proposed to be revised as follows: "Although the reducing conditions in the shallow fluvial deposits within the floodplain and beneath the river have been present at every location where a well has been installed or a pore water sample has been collected, there is no way to prove that these conditions exist everywhere. Further, reducing conditions in fluvial deposits do not extend to deeper zones in some parts of the aquifer near the Colorado River, and non-reducing conditions are prevalent in the Alluvial Aquifer where the majority of the Cr(VI) plume exists. Over the centuries that would be required for MNA to reach cleanup goals, it is possible that the geochemistry or groundwater flow directions, or even the location of the Colorado River channel, could change significantly." The DTSC is correct that natural reducing conditions do not occur everywhere at the site. Alternatives A and B rely on *movement* of the plume under natural hydraulic gradients to the natural reductive conditions in the floodplain.	Agree with RTC.	DOI concurs with the response.	Comment resolved. Agencies approved PG&E response. Changes noted in the response have been made to the CMS/FS Report in Section 5.3.3.1.
215	DOI-81	Section 5.3.3 Page 5-15 Alternative C	U.S. Department of the Interior	See "General" comments for 5.2.6. If a substantial quantity of the chromium mass is in the fine-grained units, there will have to be substantially more wells and/or a more time than estimated to attain the cleanup goals.	The exact distribution of chromium in fine-grained layers is not known. PG&E agrees that cleanup time could be extended if a large mass of chromium is present in fine-grained layers AND if the rate of mass diffusing from these fine-grained layers is sufficient to prevent achieving RAOs.	Agree with RTC.	DOI accepts the response.	Comment resolved. Agencies approved PG&E response. No changes to the CMS/FS Report are required.
216	DOI-82	Section 5.3.3, Page 5-15	U.S. Department of the Interior	Figure 5-5 shows all wells in Bat Cave Wash as injection wells. Why are there no 190 day halos apparent in Figures D3-1-4 for wells in Bat Cave Wash? The 190 day halos are obvious in the southern and eastern injection wells.	There are 190-day haloes from all injection wells shown on these four figures. The haloes were drawn by generating 36 flowlines emanating from each injection well, regardless of the injection rate. The haloes from the southern and eastern injection wells appear darker and more pronounced because they represent much smaller flow rates than the wells in Bat Cave Wash. In the more transmissive areas where the injection rates are higher, the flowlines spread farther so do not appear as dark.		DOI accepts the response.	Comment resolved. Agencies approved PG&E response. No changes to the CMS/FS Report are required.
216 .5	Hualapai - 2	Section 5.3.3	Hualapai Tribe via BLM	Alt C: Has this technological approach been attempted at this scale before? What is the volume of Carbon that will need to be added?	As stated in Section 5.3.4.3, *In-situ* technology has not often been applied to treat an entire plume of this size and depth. *In-situ* groundwater treatment is a robust remedial approach with a history of over 15 years of successfully treating impacts in the subsurface. Two large-scale examples of this approach for Cr(VI) treatment are discussed in Appendix G. The Central Area IRZ and the Source Area IRZ at the PG&E Hinkley Compressor Station are both currently treating groundwater impacted by Cr(VI). A third example of a large-scale IRZ is located in Lubbock, Texas. Trichloroethene leaked from a former military base forming a plume 3 miles long by 0.5 mile wide. The focus of the in-situ system is an area approximately 0.5 square mile where the bulk of the contaminant mass is located.	Since PG&E Hinkley has not selected a final remedy to date, it should not be used as an example. Otherwise, DTSC agrees with RTC.	DOI concurs with the response	Comment resolved. Agencies approved PG&E response. No changes to the CMS/FS Report are required.

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					Groundwater is extracted from 12 wells on the northern and southern edges of the plume, is amended with organic ,carbon and is reinjected into 36 wells distributed throughout the plume. Data demonstrate that there has been a 50% reduction in the mass of trichloroethene in the first year of operation; the projected date for remedy completion is 2012 (Suthersan, Divine, and Potter, 2009). The volume of carbon that will be added for the *in-situ* approach will be estimated as part of the design process. Based on site conditions at Topock, the projected carbon substrate concentration will be 1,000 mg/L or less. Preliminary estimates used for the CMS/FS call for approximately 14,560,000 gallons of ethanol in the Alternative C cost estimates over 20 years. Reference: Suthersan, S.S., C.E. Divine, and S.T. Potter. 2009. Remediating Large Plumes: Overcoming the Scale Challenge. *Ground Water Monitoring & Remediation* 29, no. 1.			
217	DOI-83	Section 5.3.3.1, Page 5-15, Alternative C, High Volume In Situ Treatment	U.S. Department of the Interior	Please clarify that the evaluation timeframe is based on the estimated time to move the substrate through the contaminated area and summarize the key assumptions and limitations used in computing this timeframe.	In response to this comment, an additional section will be provided in Appendix F to clarify the assumptions used in estimating cleanup times. The same basic assumptions were used in all alternatives in an effort to provide a common basis for comparison.	DTSC awaits final section for review.	DOI accepts the response, pending review of the final text.	Comment resolved following agency review and input during finalization of Appendix F to the CMS/FS Report. A table has been added to Section F.2.1 that provides a summary of the major assumptions upon which the evaluation of remedial alternatives and the limitations inherent in the methods and the data sets used. Redline final submitted to agencies on November 13, 2009. Agencies approved the report revisions.
218	DTSC-79	Page 5-15, Paragraph 4 Section 5.3.3.1 Alternative C	California Department of Toxic Substances Control	The CMS Report includes the following statement: *"The floodplain IRZs could be constructed using arrays of injection and extraction wells or they could be constructed with injection wells only."* The preferred design alternative should be stated including advantages/limitations of each design. More importantly, additional discussion, detail, and clarification of how the actual floodplain cleanup would be sequenced is desired (This applies to all Alternatives with an *in-situ* floodplain cleanup component). Minimizing	The alternatives are described in a conceptual manner that includes various types of wells that could be used to achieve remedial goals. Figure 5-5 presents a two phase approach for Alternative C that employs three types of remedial wells. The well arrays will be constructed and operated to allow for maximum flexibility, with design performed following remedy selection. The floodplain itself is currently undergoing remediation as a result of the beneficial effects of the IM No. 3 interim measure pumping and the floodplain in-situ pilot test. As such, it is possible that the scope or areal extent of the floodplain remedy may be reduced by the time the final design is undertaken. The text in section 5.3.4.1 will be edited:	The response does not address the two part comment. The DTSC comment focuses on IRZ floodplain remediation (Phase 1) only. A response is requested, even if only conceptual. DTSC desires a better understanding as to how PG&E envisions the floodplain cleanup postulated.		Comment resolved. Changes noted to Section 5.3.4.1 in the response have been made to the CMS/FS Report. In addition, PG&E prepared a separate technical memorandum titled "Conceptual Floodplain Design Options, Pacific Gas and Electric Company

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				byproduct flux towards the river is a desired outcome.	“The floodplain IRZs could be constructed using arrays of injection and extraction wells or they could be constructed with injection wells only. The final design may be adjusted based on stakeholder and engineering considerations and the exact conditions present in the floodplain at the time of final remedy design. IRZ systems are operated in a flexible manner guided by real time monitoring data as discussed in Appendix G, Section G.5.”			Topock Compressor Station” dated October 5, 2009 that summarized conceptual options for the design of in-situ treatment systems in the floodplain.
219	DTSC-80	Page 5-15/16, Paragraph 4, Last Sentence Section 5.3.3.1	California Department of Toxic Substances Control	The CMS Report includes the following statement: *“The current monitoring well network in the floodplain and the additional Phase 1 wells would provide an extensive monitoring network to measure chromium concentrations and adjust the active interior plume cleanup following completion of Phase 1.”* It must clearly be stated that additional Phase 1 monitoring wells are being proposed. Injection/extraction wells will not suffice as monitoring wells. Most additional monitoring wells should be located at points away from injection/extraction wells to monitor the effectiveness of distal cleanup and presence of any byproduct constituents. As requested in a previous comment, anticipated monitoring wells should be plotted on figures and included in the CMS Report.	In response to this comment, the sentence (now Section 5.3.4.1) will be modified as follows: “The current monitoring well network in the floodplain and the additional Phase 1 monitoring wells would provide an extensive monitoring network to measure chromium concentrations and adjust the active interior plume cleanup following completion of Phase 1.”	Agree with RTC.	It is not clear how the sentence was modified.	Comment resolved. Agencies approved PG&E response. Changes to Section 5.3.4.1 noted in the response have been made to the CMS/FS Report.
220	CRIT-28	Section 5.3.3.1 Page 5-15	Envirometrix (on behalf of the Colorado River Indian Tribe)	Will the portion of the plume that is located under the Colorado River be completely remediated under this alternative? The same question applies to other alternatives as appropriate.	Each of the active remedial alternatives was designed to remediate the entire target Cr(VI) volume which is defined as the area within the 32 ppb plume lines in Figures 2-10, 2-11, and 2-12. These figures have been updated since the Draft CMS/FS to include data from more recent sampling events; a small portion of the target volume is located in the deeper zone approximately 80 feet below the elevation of the bottom of the Colorado River. It is noted that monitoring will continue after the CMS/FS through remedy design, implementation and construction, and the target volume will be adjusted based on the results of future sampling events.	PG&E should acknowledge that the leading edge of the plume beneath the river has not been characterized and that the extent of the plume contour in figure 2-12 is assumed. Unless the remedial technology includes hydraulic capture beyond the edge of the river, any chromium beneath the river is unlikely to be remediated.	DOI concurs with the response.	In response to this comment, the note on Figure 2-12 (deep well map) was changed to: "The estimated extent of Cr(VI) in the deep zone (80-90 feet below the Colorado River) is based upon data from nearby wells, hydraulic gradients, and flow lines predicted by the groundwater flow model. There are no wells or samples confirming the presence or extent of Cr(VI) under the Colorado River." Redline final submitted to agencies on November 13, 2009. Agencies approved the report revisions.
220	Hualapai -	Section	Hualapai Tribe	Alt C: How will they determine if the reducing	The carbon substrate used is a soluble compound such as	Agree with RTC.	DOI concurs with the response.	Comment resolved.

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.5	3	5.3.3.1	via BLN	environment is not "filling up" and reducing the potential treatment area?	ethanol or molasses. It dissolves in the water and does not occupy any of the interstitial space or "fill up" the aquifer. There was no observable decrease in permeability during the pilot test of *in-situ* technology at the site, and none is expected during the full-scale implementation. Please also see response to comment #152.			Agencies approved PG&E response. No changes to the CMS/FS Report are required.
221	DOI-84	Section 5.3.3.2, Page 5-16	U.S. Department of the Interior	This discussion should mention that the 190 day halos are based on injection of whey, which has a longer half-life than the ethanol used in the upland pilot study. A statement of assurance should also be included that whey has been used at other sites and can be used at Topock without the need for additional pilot tests. The result of this alternative (and also alternative D) is reduction of Cr(VI) to Cr(III) by injection of organic carbon, thereby creating reducing conditions in much of the aquifer. In spite of the pilot experiments, calculations, and experience of the operators, there is a chance that the Cr(VI) plume will be replaced by a plume containing arsenic. Eventually the arsenic concentrations will decrease as the aquifer returns to a more oxic state.	Descriptions of the various types of substrates considered will be provided in Section 5.2.6. See also response to comment #185. Additional information about whey is provided in the response to DOI-157 (below). Whey has been used at a site in Colorado and the estimate of the concentration of whey at 190 days travel time is based upon this experience, with scaling factors used to adjust for the temperature difference between Colorado and Topock. The details of this analysis will be updated and provided in Appendix G Whey has also been applied on sites in California, Kansas, Wisconsin, Florida, and elsewhere. It is important to note that ethanol remained at reactive concentrations more than 200 days transport from the injection well in the upland pilot test, so 190 day halos are not dependent on whey usage. As stated by the commenter: "arsenic concentrations will decrease as the aquifer returns to a more oxic state." This is in fact demonstrated by the data set from pilot experiments that show arsenic concentrations declining to background once carbon injections are stopped (see Appendix G) and by the relationship of arsenic concentrations in the IRZ to the concentration of organic carbon (see Appendix G). The IRZ will be operated to optimize Cr(VI) reduction and to minimize byproduct production.	DTSC awaits updates to Appendix E that are proposed by PG&E in its response. Please see response to comment 176/DOI-63 and 181/DOI-66 regarding byproduct formation.	Comment resolved with PG&E incorporation of language provided by DOI in the file transmittal entitled "Sec 5 DOI edits 8-4-09", pending review of final text. Response accepted, pending review of final text.	Comment resolved following agency review and input during finalization of the CMS/FS Report. Section 5.2.6 has been modified to provide additional information on the various types of substrates considered, and text provided by DOI has been incorporated. Redline final submitted to agencies on November 13, 2009. Agencies approved the report revisions.
222	DOI-85	Section 5.3.3.2, Page 5-16, Paragraph 1, Sentence 10	U.S. Department of the Interior	The statement that the "carbon would continue to be injected to treat the water being injected" causes some confusion. It may be better to state that carbon injection would continue until levels were sufficient to treat the water being injected as part of aquifer flushing.	In response to this comment and comment #225, the text in section 5.3.4.2 will be edited: "During this flushing period, carbon would continue to be added only at levels sufficient to treat the water being injected as part of aquifer flushing. After the initial distribution of carbon has been achieved, there is no need to continue to distribute the carbon across large areas of the aquifer since the water drawn from the perimeter will be treated and injected, while the water from the central portion of the plume will also be treated as it flows through the reduced zone generated from the initial high concentration injection of carbon around the injection wells."	DTSC requests that this additional detail be inserted into the CMS/FS provided there is no objection from DOI. This would be inserted within DOI's modified text.	Comment resolved with PG&E incorporation of language provided by DOI in the file transmittal entitled "Sec 5 DOI edits 8-4-09", pending review of final text.	Comment resolved following agency review and input during finalization of the CMS/FS Report Section 5.3.4.2. Changes noted in the response were made to Section 5.3.4.2. Redline final submitted to agencies on November 13, 2009. Agencies approved the report revisions**.**
223	DOI-86	Section 5.3.3.2, Page 5-16, Alternative C, High Volume In Situ	U.S. Department of the Interior	The basis for the time to cleanup estimate is not explained. It appears that the model estimates a timeframe of five years to distribute the substrate across the plume area, but acknowledges that the distribution may not reach all portions of the contaminated aquifer. The basis for the 20 year estimate is not clear. Please summarize the key	**Issue resolved. Original response shown below for completeness. The changes to Section 5.3.3 provided by DOI on August 4, 2009 have been incorporated, in lieu of the proposed changes to Section 5.3.3 below.** PG&E agrees that there is uncertainty in projecting actual time to cleanup. Because this remedy does not rely on five	DTSC awaits any of PG&E's proposed revised CMS/FS language, if any, regarding more detail on assumptions that will be provided in Section 5.3.3.3 and in Appendix E (see PG&E response to the left).	Comment resolved with PG&E incorporation of language provided by DOI in the file transmittal entitled "Sec 5 DOI edits 8-4-09", pending review of final text.	Comment resolved. The discussion of cleanup time for Alternative C has been re-written by DOI for inclusion in Section 5.3.4.2.

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		Treatment		assumptions and limitations used in computing this timeframe. DOI agrees that there is uncertainty in the ability to distribute the substrate across the area, and to achieve contact between contaminated groundwater and the substrate, particularly in low permeability intervals. As noted earlier, the groundwater model simulates the broad flow patterns and responses to pumping and injection, but does not attempt to simulate the detailed flow patterns that the injected substrate would follow. Data on such flow patterns is not available. Therefore, the actual time to clean up the aquifer is simply not predictable. In order to achieve cleanup in a few years, or even 20 years by injection at the proposed sites, the groundwater flow system would have to behave on a detailed scale as predicted by the model, which is not likely. More likely is that low permeability recalcitrant contaminated zones will persist for long periods of time, perhaps hundreds of years despite continued injection of amended water at the planned locations.	pore volume flushing, PG&E will attempt to rephrase the discussion of cleanup time in terms of distribution of reductant. More detail on the assumptions will be provided in Section 5.3.3.3 and in Appendix G. In estimating the 20-year cleanup time, PG&E assumed that most of the reductant would be distributed in the first 7 years of operation and that years 8 through 20 would involve optimization of the remedy to address recalcitrant zones. However, as DOI points out, there is no solid basis to determine whether recalcitrant zones will be problematic and, if so, how long it might take to achieve complete cleanup. In response to this comment, Section 5.3.3.3 will be altered as follows: "*In-situ* technology has not often been applied to treat an entire plume of this size and depth. Alternative C would result in a plume-wide IRZ being established at the Topock site. There is uncertainty regarding the ability to obtain complete distribution of substrates across this large an area. The calculation of reductant substrate delivery time throughout each targeted area is based on an assumption of a modeled single pore volume flush and an assumed half-life of reductant in the aquifer (explained in more detail in Appendix G). The uncertainty associated with these assumptions is applied equally to all alternatives that include in situ as part of the remedy."			Redline final submitted to agencies on November 13, 2009. Agencies approved the report revisions
224	DTSC-81	Page 5-16, Paragraph 2, Section 5.3.3.2 Alternative C	California Department of Toxic Substances Control	The term "*core of the plume*" is used inappropriately/too loosely in this section and should be replaced with "interior of the plume" or just "the plume". Injection is proposed in locations other than the core of the plume.	In response to this comment, the word "core" will be replaced with "interior" in the first sentence in Section 5.3.4.2.	Agree to RTC, will await final document review for consistency.	DOI concurs with the response.	Comment resolved. Agencies approved PG&E response. Changes to Section 5.3.4.2 noted in the response have been made to the CMS/FS Report.
225	DTSC-82	Page 5-16, Paragraph 2, Line 17, Section 5.3.3.2 Alternative C	California Department of Toxic Substances Control	Clarify why there would be no need to distribute the carbon across large areas of the aquifer.	In response to this comment and comment #222, the text in Section 5.3.4.2 will be edited: "During this flushing period, carbon would continue to be added only at levels sufficient to treat the water being injected as part of aquifer flushing After the initial distribution of carbon has been achieved, there is no need to continue to distribute the carbon across large areas of the aquifer since the water drawn from the perimeter will be treated and injected, while the water from the central portion of the plume will also be treated as it flows through the reduced zone generated from the initial high concentration injection of carbon around the injection wells."	DTSC requests that this additional detail be inserted into the CMS/FS provided there is no objection from DOI.	DOI concurs with the response.	Comment resolved. Text deleted by DOI in Section 5.3.4.2 has been added as noted in the response. Redline final submitted to agencies on November 13, 2009. Agencies approved the report revisions.
226	DTSC-83	Page 5-16, Last Sentence /Paragraph Section	California Department of Toxic Substances Control	The CMS Report includes the following statement: *"…this alternative would include installation of approximately 22 extraction wells, approximately*	The report will be modified to reconcile quantities expressed for the conceptual design in various locations in the report. Please note that there are stated reasons for discrepancies between cost estimates and figures. For example, monitoring wells were included in cost estimates but are not shown on	Although DTSC agrees that the details of these items can be flushed out during the remedy design, PG&E should remain consistent with information. If multiple injection wells are envisioned but not shown,		Comment resolved. Changes noted in the response have been made to the CMS/FS Report.

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		5.3.3.2 Alternative C		*33 injection wells, 29 IRZ wells…"* This does not correlate with Figure 5-5 of the CMS Report or PG&E's February 18, 2009 email which responded to CWG stakeholder concerns and lists estimates for the number of wells for each alternative in the Upland and Floodplain areas. This needs to be reconciled in the revised Report. Similarly, all Remedial Action Alternative Descriptions should be reconciled with figure, Table 5-3, and the cost estimates in Appendix B.	figures, and locations requiring multiple injection wells to accept required flow are shown as a single point on the Section 5.0 figures.	PG&E should clarify that information.		
227	DTSC-84	Page 5-16, Paragraph 2, Line 17, Section 5.3.3.2 Alternative C	California Department of Toxic Substances Control	The CMS Report includes the following statement: *"The floodplain would be treated in the initial phase by pumping from wells near the river and injecting into wells near National Trails Highway."* The CMS Report should compare the configuration proposed to clean up the floodplain with *in-situ* using the Alternative D approach (see Figure 5-6) with the other floodplain *in-situ* approach (Alternatives C, E, and G). The superior approach should be identified. If they are similar, should flexibility be allowed for these differing approaches to be interchanged during remedy implementation?	This sentence is in Section 5.3.5 under Alternative D. The CMS/FS Report text does compare the various alternatives in Section 5.5. Flexibility in design, construction, and implementation of an IRZ is a primary component of a successful *in-situ* remedy. The configuration of the IRZ in the floodplain can be modified in any one alternative to match that of another alternative. The alternatives were conceived to cover a range options and can be interchanged as site factors dictate. The text in Section 5.3.4 will be edited: "The floodplain would be treated in the initial phase by pumping from wells near the river and injecting into wells near National Trails Highway. The final design may be adjusted based on stakeholder and engineering considerations. IRZ systems are operated in a flexible manner guided by real time monitoring data as discussed in Appendix G, Section G.5."	The stated response is not responsive to the comment. As stated in the comment, it is requested that only the floodplain component of the different alternatives be compared. Specifically, Alternative G illustrates a different well configuration and pumping approach than in Alternatives C, G, and E. The Alternative G approach may offer an advantage in controlling unwanted *in-situ* byproducts (e.g., arsenic, manganese) that may migrate towards the river. DTSC desires a better understanding as to how PG&E envisions to clean up the floodplain (see comment 218/DTSC-79).		Comment resolved following agency review and input during finalization of the CMS/FS Report Section 5.3.5 Redline final submitted to agencies on November 13, 2009. Agencies approved the report revisions. In addition, PG&E prepared a separate technical memorandum titled "Conceptual Floodplain Design Options, Pacific Gas and Electric Company Topock Compressor Station" dated October 5, 2009 that summarized conceptual options for the design of in-situ treatment systems in the floodplain.
228	DOI-87	Section 5.3.3.2, Page 5-19, Paragraph 1	U.S. Department of the Interior	It is important to note that the appropriate agencies and stakeholders would be contacted and approval gained for any changes to the original design.	In response to this comment, the sentence will be modified as follows: "Changes to the number, location, and configuration of the extraction, treatment, and injection systems, and/or changes to the type, method, and configuration of the treatment delivery systems, as approved by appropriate agencies and stakeholders, may occur to enhance performance of the remedy to attain the cleanup goals, and to respond to site conditions and performance issues."	Agree to RTC; however, PG&E must recognize the possibility of additional stakeholders review and approval.	DOI accepts the response.	Comment resolved. Agencies approved PG&E response. Changes noted in the response have been made to the CMS/FS Report, as modified by DOI (see comment #515).
229	DTSC-85	Page 5-19, Paragraph 2, Section 5.3.3.2	California Department of Toxic Substances Control	PG&E proposes contingency measures to be put in place to address system failures and/or operational issues. However, no specifics on the contingency measures are provided. This is necessary for the evaluation and acceptance of all alternatives.	In response to this comment, PG&E proposes to add a table to the Final CMS/FS Report identifying contingencies for example scenarios under which the alternatives would not meet the stated objectives of the remedial action. The table would also note that a contingency plan would be prepared for the selected alternative, as required by the CACA.	DTSC awaits the final contingency table.	DOI concurs with the response, pending review of the final text and format of the contingency table.	Comment resolved following agency review and input during finalization of the CMS/FS Report. Table 5-3 has been added that includes example

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								contingency actions during remedial alternative implementation to respond to failure to attain RAOs. Redline final submitted to agencies on November 13, 2009. Agencies approved the report revisions.
230	DTSC-86	Page 5-19, Paragraph 3, Section 5.3.3.2	California Department of Toxic Substances Control	As stated earlier, PG&E will need to provide conceptual designs and basis for monitoring programs. PG&E should be able to plot these monitoring points/ wells on a map.	Please see response to comment #211.	DTSC agrees that a monitoring plan will be fully developed during design and implementation for the final remedy. DTSC will agree to deferral of monitoring plans development until remedy design.	DOI concurs with the response.	Comment resolved. Agencies approved PG&E response. No changes to the CMS/FS Report are required.
231	DOI-88	Section 5.3.3.3, Page 5-19, Alternative C Limitations	U.S. Department of the Interior	The report states that Mn and As are likely to temporarily increase. An estimate of the maximum expected concentrations should be presented. See “General” comments for 5.2.6.	The expected range of concentrations of arsenic and manganese will be provided in Appendix G. Maximum concentrations of manganese and arsenic in the floodplain pilot are summarized in Appendix G. The expected range of iron, manganese, and arsenic is within the range observed in natural reducing zones at the site, or approximately 0 to 30,000 µg/L iron, 0 to 10,000 µg/L manganese, and 0 to 50 µg/L arsenic. This range is consistent with the range observed in the floodplain IRZ pilot test. Higher concentrations were temporarily observed in a few upland pilot test monitoring wells; however, this test had far higher carbon loading concentrations than planned for future IRZs. Close to injection wells, where organic carbon is being injected, the high range will likely be observed. A short time after cessation of injection, these concentrations will drop off. With further distance from the injection wells, substantially attenuated concentrations of these constituents will be observed which, in time, will return to baseline conditions associated with the natural aquifer conditions. Discussion will be added to Appendix G to provide this information.	DTSC concurs with DOI’s response. It appears PG&E is citing maximum concentrations detected in standard floodplain wells, not wells exhibiting byproduct formation. Please see response to comment 176/DOI-63 and 181/DOI-66 regarding byproduct formation. DTSC awaits updates to Appendix E that are proposed by PG&E in its response.	Comment resolved with PG&E incorporation of language provided by DOI in the file transmittal entitled “Sec 5 DOI edits 8-4-09”, pending review of final text. Although the response uses the Izbicki reference to highlight differences at Topock, there are similarities: a) Precipitation of Cr(III) during in situ treatment could create localized high concentrations of Cr(III) minerals on grain surfaces; b) Aqueous Mn released from reductive dissolution of dispersed manganese minerals could re-precipitate in a relatively narrow zone of changing geochemistry resulting in higher localized concentrations of new manganese minerals; c) Pore water in stagnant zones of the aquifer will also have long residence times; d) Topock groundwater has alkaline pH values that are high enough to allow build up of Cr. FeS will inhibit the reaction of manganese with Cr(III) is true as long as FeS persists. Eventually FeS will reoxidize. It is conceivable that locally high concentrations of reduced Cr(III) and re-oxidized Mn minerals could be created if the appropriate geochemical environment exists. There is no direct evidence from the aquifer to make the statement that 1-2 ppb would be the worst case scenario, especially in smaller localized areas of	Comment resolved following agency review and input during finalization of the Appendix G to the CMS/FS Report. Redline final submitted to agencies on November 13, 2009. Agencies approved the report revisions.

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							the aquifer. In summary, both the comments and responses present sound geochemical arguments for their respective points of view. It is not possible to conclusively answer the question of remobilization of Cr using only laboratory experiments because of the difficulty in re-creating aquifer geochemistry and simulating residence times in the lab in sufficient detail to simulate potential aquifer reactions.	
232	DOI-89	Section 5.3.3.3, Page 5-19, Alternative C, High Volume In Situ Treatment, Limitations	U.S. Department of the Interior	DOI remains concerned about the potential creation of new contaminant plumes (e.g., As and Mn) as a result of in situ treatment of the upland areas. The conclusion that these contaminants will not be a significant issue must be better supported by analysis that demonstrates the maximum expected concentrations, the timeframes for which these elevated concentrations will persist, and the processes by which these constituents disappear from groundwater in a short timeframe. DOI also remains concerned that precipitation of Mn as the aquifer re-oxidizes could adversely affect the permanence of the Cr reduction reaction.	Discussion will be added to Appendix G as per the suggested revised text detailed in the response to comment 181 (DOI-66). Maximum expected concentrations are shown in Appendix G, and the timeframe that these concentrations persist beyond the operational period of the IRZ is also depicted on this figure. A detailed discussion of the mechanisms responsible for the removal of manganese and arsenic from groundwater is provided Appendix G, Section G.8. The reaction between precipitated manganese and reduced chromium will be limited because of (1) self-limiting nature of this reaction because of passivation reactions, (2) reduced iron compounds such as FeS passivating manganese oxides from reacting with Cr(III), and (3) low rate of reoxidation at the ambient pH at Topock. This discussion is detailed in the response to DOI comment #63. Any reaction between manganese and chromium is expected to result in very low concentration of Cr(VI) because of (1-3) as well as the fact that Cr(III) will not be present at a high concentration at any one location (as opposed to Cr(III) in serpentine minerals enriched in chromite present at some locations in the Mojave River valley). Discussion will be added to Appendix G to provide this information.	DTSC concurs with DOI's response. DTSC awaits PG&E's proposed revised CMS language regarding Appendix E. Please see response to comment 231/DOI-88 regarding byproduct formation.	Comment resolved, pending review of final text. A reference only to Appendix E in this section is not acceptable and the statement that "byproducts are not expected to be a significant issue" provides little assurance that steps will be in place to respond to upset conditions. Acknowledgement of the uncertainty should be stated and a statement that monitoring will occur and contingencies will be in place should be provided.	Comment resolved following agency review and input during finalization of the Appendix G to the CMS/FS Report. Redline final submitted to agencies on November 13, 2009. Agencies approved the report revisions.
233	DTSC-87	Page 5-19, Section 5.3.3.3	California Department of Toxic Substances Control	As stated earlier in the general comment, reviewers will need to understand PG&E's assumptions to the design. How many flushes of the 1.6 billion gallon plume is anticipated for the clean-up? Are there any performance constraints to the design (e.g., feasible extraction/ injection rates, maximum spacing between recirculation wells, fresh water infiltration on floodplain, etc.)? What about potential cultural sensitivity to infrastructures? These performance and design constraints should be elaborated in the limitations section to allow deliberation of pros and cons with the alternative.	Please see response to comment #156 pertaining to a sensitivity analysis to be included in the Final CMS/FS Report. The performance and design constraints associated with the alternatives are included in the sensitivity analysis. As stated in Section 5.3, the groundwater model was used for conceptual design of the alternatives, and was used to estimate well locations, flow rates, and time to cleanup for each alternative (based on assumed number of pore volume flushes and distribution of carbon). Appendix F provides detailed descriptions of how the model was used in the development of the remedial alternatives. Appendix D provides assumptions used in development of the cost estimate for wells, treatment facilities, pipelines, utilities, roads, and other components. Appendix G provides	See response to comment 156.		Comment resolved. The sensitivity analysis noted in the response is included in the Final CMS/FS Report as Table 5-2. Redline final submitted to agencies on November 13, 2009. Agencies approved the report revisions.

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					information supporting the assumption of the persistence of in-situ substrate used in the development of the alternative configurations. PG&E acknowledges there are potential cultural sensitivities to infrastructure. All of the remedial alternatives (except Alternative A) include installation of new infrastructure. In addition to new infrastructure, PG&E acknowledges that there are cultural sensitivities to operation and maintenance activities, as well as cultural sensitivities to the No Action alternative.			
234	DOI-90	Section 5.3.4, Page 5-19 Alternative D	U.S. Department of the Interior	Similar to Alternative C, the effectiveness and long-term sustainability of the *in-situ* treatment needs to be demonstrated. The lithologic variations will increase the cleanup time.	The effectiveness and sustainability of *in-situ* treatment has been discussed in comment #176 (DOI-63) and other subsequent comments. In addition, Appendix G includes detailed information on IRZ performance. As described in responses to comments #195 and #200, PG&E agrees that the cleanup time estimates are uncertain. DOI is correct that if mass flux out of the fine-grained layers is sufficient to prevent achieving RAOs in the monitoring wells, cleanup time could be longer than projected.		DOI accepts the response.	Comment resolved. Agencies approved PG&E response. No changes to the CMS/FS Report are required.
235	DOI-91	Section 5.3.4, Page 5-19 through 5-20, Alternative D, Sequential In Situ Treatment	U.S. Department of the Interior	This alternative poses some of the same concerns to DOI as does Alternative C; particularly with respect to the creation of new contaminants and the possibility of reversal of the Cr reduction reaction in the upland area, and the estimated timeframes for clean up. This alternative appears to have a greater potential for shorter term success in temporarily reaching cleanup goals because the injection is much more densely spaced and can be modified to address recalcitrant zones as they are identified during remediation. The down side is that substantial surface and subsurface disruption would be required to install the injection wells throughout previously undisturbed upland areas.	Comment noted. This comment expresses DOI judgment of the merits and tradeoffs of this alternative in comparison with others. Evaluation of the alternatives against criteria and in comparison with each other is addressed in Section 5.5.		Response noted.	Comment resolved. No changes to the CMS/FS Report are required.
236	DTSC-88	Page 5-20, Paragraph 3, Line 2 Section 5.3.4 Alternative D	California Department of Toxic Substances Control	The CMS Report includes the following statement: *"…construction activities for this alternative would include installation of approximately 100 IRZ wells…"* This does not correlate with Figure 5-6 of the CMS Report or PG&E's February 18, 2009 email which responded to CWG stakeholder concerns and lists estimates for the number of wells for each alternative in the Upland and Floodplain areas. This needs to be reconciled in the revised Report.	The report will be modified to reconcile quantities expressed for the conceptual design in various locations in the report. Please note that there are stated reasons for discrepancies between cost estimates and figures. For example, monitoring wells were included in cost estimates but not shown on figures, and locations requiring multiple injection wells to accept required flow are shown as a single point on the Section 5.0 figure.	DTSC agrees with RTC. PG&E should remain consistent with information. If multiple injection wells are envisioned but not shown, PG&E should clarify that information.	DOI concurs with the response.	Comment resolved. Agencies approved PG&E response. Changes noted in the response have been made to the CMS/FS Report.
237	DOI-92	Section 5.3.4, Page 5-20,	U.S. Department of the Interior	Typographical error. Delete the second "as well as changes to the type, method, and configuration of the delivery systems."	The sentence has been revised.	Agree with RTC.	DOI accepts the response.	Comment resolved. Agencies approved PG&E response. Changes noted in the

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		Paragraph 4, Sentence 2						response have been made to the CMS/FS Report in Section 5.3.5.
237.5	Hualapai - 4	Section 5.3.4	Hualapai Tribe via BLM	Alt D: Can multiple wells be drilled from one site to reduce the overall impact of drilling multiple wells?	Directional drilling methods have been developed in the oil industry that allow wells to be curved from vertical into horizontal orientation. This can allow for multiple wells to be installed from a single drilling location. The radius of the curves has to be gentle enough to allow the hardened steel drilling rods to bend around the curve during well construction. Oil wells are typically many hundreds to thousands of feet deep. The relatively shallow (200 feet) depth of the aquifer at the Topock site would dictate too sharp a curvature in the borehole and precludes the use of oil-industry directional drilling techniques. Horizontal wells can be installed using directional drilling techniques. These wells start at a shallow angle, extend down to a specific depth within the aquifer, and then run horizontally. *In-situ* injection wells require frequent cleaning to control plugging due to growth of microbes. Conventional well cleaning techniques are very difficult or impossible to apply in horizontal wells. Therefore, horizontal wells are not desirable for use as *in-situ* injection wells. In addition, multiple horizontal wells installed at different depths in the aquifer would likely be required to achieve adequate distribution of the carbon substrate across the entire thickness of the aquifer.	Agree with RTC.	DOI concurs with the response.	Comment resolved. Agencies approved PG&E response. No changes to the CMS/FS Report are required.
238	DOI-93	Section 5.3.4.1, Page 5-22, Alternative D, Limitations	U.S. Department of the Interior	The report states that Mn and As are likely to temporarily increase. An estimate of the maximum expected concentrations should be presented. See “General” comments for 5.2.6.	The expected range of concentrations of arsenic and manganese will be provided in Appendix G. Responses to DOI comment #88 provides the range of concentrations of manganese and arsenic that were measured in the pilot tests. Discussion will be added to Appendix G to provide this information.	DTSC awaits PG&E’s proposed revised CMS/FS language regarding Appendix E (see PG&E response to the left). Please see response to comment 231/DOI-88 regarding byproduct formation.	DOI accepts the response, pending review of final text.	Comment resolved following agency review and input during finalization of the Appendix G to the CMS/FS Report. Redline final submitted to agencies on November 13, 2009. Agencies approved the report revisions.
239	DOI-94	Section 5.3.4.1, Page 5-22, Alternative D, Sequential In Situ Treatment, Limitations	U.S. Department of the Interior	DOI remains concerned about the potential creation of new contaminant plumes (e.g., As and Mn) as a result of in situ treatment of the upland areas. The conclusion that these contaminants will not be a significant issue must be better supported by analysis that demonstrates the maximum expected concentrations, the timeframes for which these elevated concentrations will persist, and processes by which these constituents disappear from groundwater in a short timeframe. DOI also remains concerned that precipitation of Mn as the aquifer re-oxidizes could adversely affect the permanence of the Cr reduction reaction.	Response to comment DOI-88 discusses the maximum concentrations, time frames, and processes by which manganese and arsenic are removed from groundwater. Response to comment DOI-63 discusses the permanence of the Cr(III) precipitated within the IRZ. Discussion will be added to Appendix G to provide this information.	DTSC concurs with DOI’s response. DTSC awaits PG&E’s proposed revised CMS/FS language regarding Appendix E (see PG&E response to the left). Please see response to comment 231/DOI-88 regarding byproduct formation.	Comment resolved with PG&E incorporation of language provided by DOI in the file transmittal entitled “Sec 5 DOI edits 8-4-09”, pending review of final text. A reference only to Appendix E in this section is not acceptable and the statement that “byproducts are not expected to be a significant issue” provides little assurance that steps will be in place to respond to upset conditions. Acknowledgement of the uncertainty should be stated and a statement that monitoring will occur and contingencies will be in place should be provided.	Comment resolved following agency review and input during finalization of the Appendix G to the CMS/FS Report. Redline final submitted to agencies on November 13, 2009. Agencies approved the report revisions.

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239 .5	Hualapai - 5	Section 5.3.4.1	Hualapai Tribe via BLM	Alt D: Has this ever been applied at this level before?	As stated in Section 5.3.5.1, *in-situ* technology has not often been applied to treat an entire plume of this size and depth. Three examples of similar sized plume are provided in response to comment #216.5. In addition, two pilot-scale tests have been conducted at the Topock site using *in-situ* technology—one in the floodplain and one in the upland. A summary of these tests is provided in Appendix G.	See response to 216.5.	DOI accepts the response.	Comment resolved. No changes to the CMS/FS Report are required.
240	DOI-95	Section 5.3.5 General— Alternative E In-Situ Treatment with Fresh Water Flushing	U.S. Department of the Interior	Due to the anisotropy of the system, determining the location and injection rates for the injection wells will be difficult. Stream deposits dominate the hydraulic conductivity matrix of the aquifer. The streams flowed from south to north with finer grained sediments being deposited to the east and west from the active stream channel. The location of the active stream channel has changed through geologic time; therefore, the alluvial aquifer consists of a series of coarse-grained and fine-grained zones both areally and vertically. The continuity of coarse-grained units is more likely to be in a north-south direction at a particular point in the alluvial aquifer than in an east-west direction. Later in geologic time the Colorado River dissected the alluvial deposits and deposited the fluvial deposits. The Colorado River is now the low point in the hydrologic system, so groundwater flow is currently from west to east in the project area. Therefore, groundwater is flowing perpendicular to the directional permeability in the alluvial aquifer. The groundwater flow model handles this directional permeability by assigning a principal direction of the permeability for an individual model cell and the ratio between the permeability of the aquifer in the principal direction and the permeability of the aquifer in the direction perpendicular to the principal direction (anisotropy). The anisotropy simulated in the model cannot adequately simulate the "true" aquifer system unless the model utilizes a very fine model grid. The current model simulates the alluvial aquifer with 4 layers; therefore, the variability of the system can only be approximated. Because of the directional permeability of the aquifer system, the flushing process could result in the plume being spread to the north following the directional permeability formed by the ancient stream channels. Monitoring will be imperative to ensure that the location of the injection wells and the injection rates are moving the plume in the correct direction. The flushing will be most effective in connected coarse-grained zones and relatively ineffective in isolated fine-grained zones. If a significant mass	**Issue resolved. Original response shown below for completeness.** Although anisotropy as described almost certainly exists at the site, it has not been observed to be extreme based on the relatively uniform water level response from the IM No. 3 injection wells. Based on experience with the IM No. 3 injection system, it seems unlikely that anisotropy will be a major limitation for Alternative E (or other alternatives that rely on injection to control groundwater movement). The model contains built-in anisotropy for the alluvial materials (SW-NE) and for fluvial deposits (approximately following river direction). These are, by necessity, generalized estimates of principal directions of anisotropy based on the dominant geologic features of the site. PG&E agrees that monitoring will be required to ensure that injection wells produce the designed effect on the aquifer, and PG&E will be prepared to alter the injection system as necessary as part of normal remedial process optimization. The assumption that this alternative would include monitoring is included in Section 5.3.6. In addition, Section 5.3.6 describes that optimization of the remedy would occur throughout the design, construction, and operational phases of remedy implementation including changes to the number, location and configuration of the injection system. Please see responses to comment #195 and #200 pertaining to the use of the groundwater model as the best available tool for predicting groundwater flow.	The DOI comment states, "Monitoring will be imperative to ensure that the location of the injection wells and the injection rates are moving the plume in the correct direction." DTSC wishes to highlight concurrence with this issue and notes that the eight monitoring wells PG&E has reported as part of the preliminary design estimates is probably insufficient to adequately conduct the additional monitoring. Resolution of this issue should be deferred to remedy design, but the actual number of wells eventually needed should not be inappropriately limited by "preliminary estimates."	Comment resolved with PG&E incorporation of language provided by DOI in the file transmittal entitled "Sec 5 DOI edits 8-4-09", pending review of final text.	Comment resolved. The discussion of cleanup time for Alternative E has been re-written by DOI for inclusion in Section 5.3.6. Redline final submitted to agencies on November 13, 2009. Agencies approved the report revisions.

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				of chromium is in the fine-grained zones, more injection wells may need to be installed.				
241	DOI-96	Section 5.3.5, Pages 5-22 through 5-26, Alternative E, In Situ Treatment with Freshwater Flushing	U.S. Department of the Interior	This alternative poses some of the same concerns to DOI as do Alternatives C and D; particularly with respect to the substantial disturbance of the floodplain and the estimated timeframes for clean up. This alternative does not pose the same upland area new contaminant and Cr reaction reversibility concerns because in situ treatment is not proposed in the uplands. The timeframe for attaining the cleanup goals in the upland area could be substantially longer than estimated by PG&E. Timeframe estimates based on numbers of pore volumes moved through the uplands are based on a simplified hydrogeologic model and a limited data set. DOI believes this approach could require in excess of a hundred years to attain the cleanup goals in the upland area.	Comment noted. This comment expresses DOI judgment of the merits and tradeoffs of this alternative in comparison with others. Evaluation of the alternatives against criteria and in comparison with each other is addressed in Section 5.5. **Issue resolved. Original response shown below for completeness. The changes to Section 5.3.5.2 (now Section 5.3.6) provided by DOI on August 4, 2009 have been incorporated, in lieu of the proposed changes to Section 5.3.5.2 below.** As discussed in responses to comments #195 and #200, PG&E agrees that the cleanup time estimates are uncertain. This uncertainty is repeated in the second paragraph in Section 5.3.5.2. In response to this comment about timeframe for attaining cleanup goals, PG&E proposes to rephrase the second paragraph in Section 5.3.5.2 in terms of pore volume flushes, rather than time to cleanup as follows: "The best ~~engineering~~ estimate of the time ~~to cleanup required~~ for five pore volumes to be flushed with this alternative is 20 years. This estimate of pore volume flushing time is considered appropriate for the purpose of comparing relative duration of alternatives. The actual cleanup time will be dependent on the flushing efficiency of the aquifer and is subject to considerable uncertainty. The length of time needed to attain cleanup goals in the Alluvial Aquifer would be longer if the flushing efficiency of the Alluvial Aquifer is less than indicated by the available site-specific data. The likely range of cleanup time is estimated to be from 8 years (based on two pore volumes) to 70 years (based on 20 pore volumes). The estimated time for five pore volumes to be flushed from the aquifer for this alternative is derived based on the assumed configuration as described above. The estimate time for this alternative could be adjusted by modifying the number and location of wells and/or by modifying the flow rates." It should be pointed out that Figure D4-4 shows a potential time to cleanup of up to 70 years. PG&E does not disagree with DOI that, under unfavorable conditions and without optimization during implementation, it could take 100 years or even longer.	PG&E originally stated in its response, "*Response to the portions of this comment not pertaining to the estimated cleanup times for this alternative is deferred at this time.*" Therefore, DTSC awaits PG&E's deferred response to portions of this comment.	Response noted. Comment resolved with PG&E incorporation of language provided by DOI in the file transmittal entitled "Sec 5 DOI edits 8-4-09", pending review of final text.	Comment resolved. The discussion of cleanup time for Alternative E has been re-written by DOI for inclusion in Section 5.3.6. Redline final submitted to agencies on November 13, 2009. Agencies approved the report revisions.
242	DTSC-61	Page 5-2, Paragraph 3, Section 5.3.5 Alternative E	California Department of Toxic Substances Control	The Report should consider contingencies for Alternative E that includes partial pumping at the core of plume. Objectives of this pumping would be to; cut off contaminant migration towards the East Ravine area where reductive capacity is assumed negligible; efficient mass removal from the core of the plume; and, if necessary, creation of landward gradients by the floodplain to control	In response to this comment, PG&E proposes to add a table to the Final CMS/FS Report identifying contingencies for example scenarios under which the alternatives would not meet the stated objectives of the remedial action or comply with ARARs. Example actions for Alternative E may include adding injection, extraction, or IRZ wells; modifying amendment delivery type; modifying amendment delivery rates; and increasing or decreasing pumping rates. The table would also note that a contingency plan would be prepared	Revision of Alternative E will need to be further developed for the purpose of the CMS/FS. DTSC awaits submission of the revisions for review.	DOI concurs with the response and anticipates continued discussion regarding East Ravine and Alternative E.	Comment resolved. Changes noted in the response have been made to the CMS/FS Report, including addition of Table 5-3 : Example Contingency Actions During Remedial Alternative

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				IRZ byproduct formation.	for the selected alternative, as required by the CACA. In response to this comment and results of the investigation activities in the East Ravine in 2009, the CMS/FS Report will be revised to update the Cr(VI) target area and hydrogeologic characterization to include data from the East Ravine, and the remedial alternatives will be revised to address the revised target area. In response to this comment, PG&E will revise the configuration of Alternative E to replace the floodplain IRZ lines with a line of extraction wells near the river, The extraction wells would provide capture of groundwater emanating from the plume and pull carbon across the floodplain from the IRZ near National Trails Highway, negating the need for the IRZ lines in the floodplain. Water pumped from the line of extraction wells near the river would be amended with a carbon reagent and injected into a new set of injection wells near the western edge of the plume. Freshwater injection at wells further to the west of the plume would still be used to control gradients, but freshwater injection flow rates would be reduced from those proposed in the original Alternative E.			Implementation, update of the Cr(VI) target area considering East Ravine investigation data, and revision to the Alternative E configuration. Redline final submitted to agencies on November 13, 2009. Agencies approved the report revisions.
243	HA-32	Section 5.3.5	Hargis & Associates, Inc. (on behalf of Fort Mojave Indian Tribe)	<u>Appendix F – PG&E Response to FMIT Specific Comment No. 14</u> PG&E's response indicated a clarification of the Tribe's earlier comment. Specifically, the previously-described "Alternative E2" would represent one potential configuration involving Alternatives B and E. The Tribe expects that for this scenario, the cleanup time might increase slightly (or not), but that the cost of the alternative would be less than the original Alternative E.	In response to this comment, as well as comments #148, 192, and 284, PG&E will prepare an evaluation of Alternatives C, D, E, and G without infrastructure east of National Trails Highway.	See response to comment 148.	DOI anticipates further clarification on eliminating the IRZ in the floodplain.	Comment resolved. PG&E prepared a separate technical memorandum titled "Conceptual Floodplain Design Options, Pacific Gas and Electric Company Topock Compressor Station" dated October 5, 2009 that summarized conceptual options for the design of in-situ treatment systems in the floodplain, including the option of no floodplain infrastructure.
244	DTSC-89	Page 5-22, Paragraph 4, Section 5.3.5.1 Alternative E	California Department of Toxic Substances Control	See previous comments (e.g., Alternative C/D floodplain cleanup). Also, similar issues on lack of information for this alternative.	Please refer to responses to comments. Clarification is requested as to whether any specific changes are suggested to Section 5.3.5.1 (now Section 5.3.6).	DTSC agrees that details of the monitoring plan can be flushed out during the design.		Comment resolved. Agencies approved PG&E response. No changes to the CMS/FS Report are required.
244 .5	Hualapai - 7	Section 5.3.5.1	Hualapai Tribe via BLM	Alt E: It is unclear from the information presented if the injected carbon substrate will fill up the interstitial spaces and/or if the ability to reduce Cr VI to Cr V III will decrease due to the filling of the aquifer spaces with deposited materials.	The carbon substrate used is a soluble compound such as ethanol or molasses. It dissolves in the water and does not occupy any of the interstitial space or "fill up" the aquifer. There was no observable decrease in permeability during the pilot test of *in-situ* technology at the site, and none is expected during the full-scale implementation.	Agree with RTC.	DOI concurs with the response	Comment resolved. Agencies approved PG&E response. No changes to the CMS/FS Report are required.

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					Please also see response to comment #152.			
245	DTSC-90	Page 5-22, Paragraph 5, Section 5.3.5.2 Alternative E	California Department of Toxic Substances Control	Consideration should be given to contingencies for particular Alternatives such as E. These contingencies would supplement cleanup if short or longer term objectives are not being met. Just like pump and treat, flushing is not likely to be effective in cleaning up the entire interior plume. An *in-situ* contingency should be included to treat recalcitrant or unaffected zones of the aquifer. Additional contingencies should include moving injection wells in closer towards the plume as the plume contracts. Adding reductant to a Bat Cave Wash injector pictured in Figure 5-7 should also be considered. The alternatives proposed for the CMS Report should also consider the recent detections of hexavalent chromium found at the East Ravine. Flushing may exacerbate the unbounded chromium issue at the East Ravine.	In response to this comment, PG&E proposes to add a table to the Final CMS/FS Report identifying contingencies for example scenarios under which the alternatives would not meet the stated objectives of the remedial action or comply with ARARs. Example actions for Alternative E may include adding injection, extraction, or IRZ wells; modifying amendment delivery type; modifying amendment delivery rates; and increasing or decreasing pumping rates. The table would also note that a contingency plan would be prepared for the selected alternative, as required by the CACA. In response to this comment and results of the investigation activities in the East Ravine in 2009, the CMS/FS Report will be revised to update the Cr(VI) target area and hydrogeologic characterization to include data from the East Ravine, and the remedial alternatives will be revised to address the revised target area. In response to this comment, PG&E will revise the configuration of Alternative E, as noted in response to comment #242.	DTSC will review all revised sections when submitted.	DOI concurs with the response, pending review of the contingency table. DOI expects continued dialogue on the revision to Alternative E and East Ravine and awaits review of the submitted text.	Comment resolved. Changes noted in the response have been made to the CMS/FS Report, including addition of Table 5-3 : Example Contingency Actions During Remedial Alternative Implementation, update of the Cr(VI) target area considering East Ravine investigation data, and revision to the Alternative E configuration. Redline final submitted to agencies on November 13, 2009. Agencies approved the report revisions.
246	CRIT-29	Section 5.3.5.2 Page 5-22	Envirometrix (on behalf of the Colorado River Indian Tribe)	Could the imported injected water require treatment prior to injection in order to not alter the balance of the subsurface chemistry?	The following text has been added to the description of Alternative E (the discussion referred to in the comment is now Section 5.3.6): Depending on the source of water, some minor pH adjustment might be required to make the water chemically compatible with the aquifer where it is injected and to prevent scaling in the injection wells. If needed, this pH adjustment would require a small system with equipment such as chemical storage tank(s), secondary containment, feed pump, and security enclosure such as a building or fence. If surface water source is used, filtration may be needed for sediment and bacteria removal (for injection well maintenance). In addition, a discussion of the potential types of treatment that might be needed for injected water will be added to Appendix D.	Agree with RTC. However, PG&E should not add types of fresh water treatment in Appendix B (cost estimate), This discussion should be placed in text describing the alternative. DTSC will review additional language when provided.	DOI concurs with the response and inclusion of the information in Section 5, pending review of the final text.	Comment resolved. Changes noted in the response have been made to the CMS/FS Report in Section 5.3.6 and Appendix D. Redline final submitted to agencies on November 13, 2009. Agencies approved the report revisions.
247	DOI-97	Section 5.3.5.2, Page 5-25	U.S. Department of the Interior	Potential water sources for flushing should be tested to determine 1) the presence of any constituents that may become byproducts of the IRZ, 2) if any additional constituents should be included in the monitoring program, or 3) if there is a potential for introduction of new contaminants or potential changing levels of contaminants by the introduction of an outside water source.	The following sentence has been added to the description of Alternative E (the discussion referred to in the comment is now Section 5.3.6): "Potential sources of injection water would be tested for contaminants and to ensure compatibility with the aquifer where the water would be injected." Please note that data are available for the Topock 2/3 wells and Park Moabi wells and that the general water quality in these wells is similar to shallow site groundwater. In addition, a discussion of the potential types of treatment that might be needed for injected water will be added to Appendix D.	Agree with RTC. However, PG&E should not add types of fresh water treatment in Appendix B (cost estimate), This discussion should be placed in text describing the alternative. DTSC will review additional language when provided.	DOI accepts the response, pending review of the final text. Should an off-site source of water be required in the final remedy, further discussion would be anticipated during design.	Comment resolved. Changes noted in the response have been made to the CMS/FS Report in Section 5.3.6 and Appendix D. Redline final submitted to agencies on November 13, 2009. Agencies approved the report revisions.

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248	DTSC-91	Page 5-25, Paragraph 4, Section 5.3.5.2 Alternative E	California Department of Toxic Substances Control	The CMS Report should include discussion on the types of treatment that may be needed for the imported water including where the treatment would take place and if a treatment plant would be needed.	The following text has been added to the description of Alternative E (the discussion referred to in the comment is now a new Section 5.3.6): "Depending on the source of water, some minor pH adjustment might be required to make the water chemically compatible with the aquifer where it is injected and to prevent scaling in the injection wells. If needed, this pH adjustment would require a small system with equipment such as chemical storage tank(s), secondary containment, feed pump, and security enclosure such as a building or fence. If surface water source is used, filtration may be needed for sediment and bacteria removal (for injection well maintenance)." In addition, a discussion of the potential types of treatment that might be needed for injected water will be added to Appendix D.	Agree with RTC. However, PG&E should not add types of fresh water treatment in Appendix B (cost estimate), This discussion should be placed in text describing the alternative. DTSC will review additional language when provided.	DOI concurs with the response, pending review of the final text.	Comment resolved. Changes noted in the response have been made to the CMS/FS Report in Section 5.3.6 and Appendix D. Redline final submitted to agencies on November 13, 2009. Agencies approved the report revisions.
248 .5	CRIT-37	Section 5.3.5.2	Colorado River Indian Tribe via BLM	He is questioning how we can push contaminated water towards the river.	The assumption for Alternative E Phase 2, is that a groundwater gradient is used to enhance cleanup time (faster cleanup than would occur under natural conditions). Groundwater flow throughout the basin is naturally in the direction of the river. Phase 2 of Alternative E would only begin upon successful completion of Phase 1. Phase 1 includes cleanup of the floodplain and establishment of a larger geochemical barrier than represented by the existing fluvial sediments. In response to this comment, PG&E will revise the configuration of Alternative E, as noted in response to comment #242.	See response to comment 242.	DOI expects further clarification to proposed revision to Alternative E during the September Technical Working Group meeting.	Comment resolved. PG&E revised the configuration of Alternative E in response to this and other comments on the CMS/FS report. The revised alternative configuration was outlined in a Technical Work Group meeting September 28 (see comments #443 - #448).
249	SDCWA-8	Section 5.3.5 Page 5-25	San Diego County Water Authority	The fourth paragraph on this page "assumes" that a potable water source would be "available over the implementation period." Since this alternative considers the offsite water source of potable water could be the same as for the Topock Compressor Station, which is "from wells in the Arizona", and that "future water supply may be from the Colorado River or from wells on the California side of the river," it should be required to prepare a Water Supply Assessment (WSA) in a manner consistent with requirements contained in California Senate Bill 610. SB 610 requires assessment of water supplies to a project if groundwater is identified as source of water, as well as projects subject to the California Environmental Quality Act (CEQA). SB 221 also defines criteria for determining "sufficient water supply" such as using normal, single-dry, and multiple-dry year hydrology and identifying the amount of water that can reasonably be relied on to meet existing and future planned uses. Rights to extract additional groundwater, if used for the project, must also be substantiated. While the Topock Compressor Station groundwater	PG&E is committed to complying with the substantive requirements of federal, state, and local environmental laws during implementation of the remedial action. While the requirement cited in the comment is not currently identified in Appendix B, it is presumed that it would be included in a future ARARs listing if it is determined to be ARAR for this action. If determined to be ARAR, PG&E would comply with substantive requirement of the cited requirement during implementation of the action. In response to this comment, as well as comment #136, an additional table will be added to the CMS/FS Report that outlines water use for each of the remedial alternatives. As noted in response to comment #136, the only alternative with a net consumptive use is Alternative I because not all extracted groundwater is returned to the basin through reinjection. The remaining active alternatives result in zero consumptive use because the amount of water extracted equals the amount of water injected. PG&E has allocated water rights for remediation of 322 acre-feet per year (200 gallons per minute). The operation of all the remedial alternatives within the existing water rights is discussed under implementability for all of the remedial alternatives in	Has DOI considered the requirements provided in this comment as ARARs? Also, please see response to comment 136 on net consumption.	Upon review, DOI has determined that California Senate Bills 610 and 221 are not CERCLA ARARs for the Topock site.	Comment addressed. Agencies approved PG&E response. No changes to the CMS/FS Report are required.

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				cleanup may not specifically meet SB 610/SB 221 requirements to prepare a WSA, but approvals from landowners and associated water agencies would be required, it would be prudent and should be considered to prepare a WSA using these criteria, particularly considering the current drought conditions in the Colorado River Basin and the entire West. If this is referenced in this section, it should also be referenced in section 5.5.6 Implementability for Alternative E, in Table 5-5 under Alternative E, and in section 6.0 Recommended Remedial Action Alternative since Alternative E is being recommended.	the alternative analysis.			
250	HA-30	Section 5.3.5.2	Hargis & Associates, Inc. (on behalf of Fort Mojave Indian Tribe)	Appendix F – PG&E Response to FMIT Specific Comment No. 10c Note that the Tribe regards the injection of waters from a different source as an unnatural intrusion. Accordingly, further consideration and discussion of this component of Alternative E will be required.	PG&E understands that the federal government continues to consult with the Tribes regarding the CMS/FS, and that tribal views on the injection of water under Alternative E will be considered by the federal government during that consultation and by DTSC through comments submitted by the Tribe to DTSC for consideration in the Environmental Impact Report. As described in Section 5.3.6, the offsite potable water is assumed to be the same as the water source for the Topock Compressor Station. The Topock Compressor Station is currently purchasing its water from wells in Arizona from Southwest Water, Inc. Future water supply may be from the Colorado River or from wells on the California side of the river. These sources are within an approximately 2-mile radius of the proposed injection locations. As stated in the RFI/RI, the site and surrounding area (both sides of the Colorado River) are within the southern end of the Mohave Valley groundwater basin, and groundwater discharge in this part of Mohave Valley is primarily into the river (except where IM is presently operating), so the proposed source of injected water is part of the same hydrologic system as the site groundwater.	DTSC appreciates the comment and will consider the FMIT perspective as the EIR analysis is prepared.	The Bureau of Land Management will continue to conduct formal Section 106 consultation with the nine federally recognized Tribes including consultation with the Fort Mohave Indian Tribe. The Tribes will have an opportunity to comment on the revised CMS/FS and proposed plan in the future.	Comment addressed. Agencies approved PG&E response. No changes to the CMS/FS Report are required.
250 .5	Hualapai - 6	Section 5.3.5.2	Hualapai Tribe via BLM	• What would be the source of the potable injection water? o BLM response: The potable water source is being analyzed as coming from Arizona. • It is now coming from fresh wells in Arizona via a contract with the city of Needles?	As described in Section 5.3.6, the offsite potable water would be the same as the water source for the Topock Compressor Station. The Topock Compressor Station is currently purchasing its water from wells in Arizona from Southwest Water, Inc. Future water supply may be from the Colorado River or from wells on the California side of the river. Pipelines would be constructed to convey potable water from the source to the injection wells. For purposes of the cost estimate for Alternative E, the freshwater supply was assumed to be provided by new extraction wells drilled in Arizona.	Agree with RTC.	DOI concurs with the response.	Comment addressed. Agencies approved PG&E response. No changes to the CMS/FS Report are required.
251	DTSC-92	Page 5-25, Paragraph 5, Line 2, Section 5.3.5.2	California Department of Toxic Substances Control	The CMS Report includes the following statement: *"…construction activities for this alternative would include installation of approximately eight*	The report will be modified to reconcile quantities expressed for the conceptual design in various locations in the report. Please note that there are stated reasons for discrepancies between cost estimates and figures. For example, monitoring wells were included in cost estimates but not shown on	DTSC agrees with RTC. PG&E should remain consistent with information. If multiple injection wells are envisioned but not shown, PG&E should clarify that information.	DOI concurs with the response.	Comment resolved. Agencies approved PG&E response. Changes noted in the response have been

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		Alternative E		*injection wells, 29 IRZ wells …"* This does not correlate with Figure 5-7 or Table 5-3 of the CMS Report or PG&E's February 18, 2009 email which responded to CWG stakeholder concerns and lists estimates for the number of wells for each alternative in the Upland and Floodplain areas. This needs to be reconciled in the revised Report.	figures, and locations requiring multiple injection wells to accept required flow are shown as a single point on the Section 5.0 figures.			made to the CMS/FS Report.
252	DTSC-93	Page 5-26, Paragraph 3, Section 5.3.5.3 Alternative E	California Department of Toxic Substances Control	The main limitation that concerns DTSC that should be documented in the report is that the entire contaminant mass is being pushed towards the Colorado River and remedy failure would, therefore, be unacceptable. Long term leaching of treated chromium within the floodplain has recently been introduced as a potential concern and limitation. The issue regarding oxic water adversely affecting reducing conditions in fluvial materials should be included as a potential limitation for this alternative and Alternative C (see Comment on Page 5-6, Paragraph 3, Section 5.2.5). The CMS Report discussion on limitations of Alternative E should include nearly identical language as used for Alternative F regarding "flushing to remove contaminants" (see page 5-29 of the CMS Report). The limitations section should also discuss utilizing an imported potable water resource during times of drought. For fresh water flushing, it is assumed that fresh water is available. However, the fresh water assessment has not been done, and the compatibility of fresh water quality has not been evaluated. These uncertainties have not been reflected in the cost estimate (Table B-6), nor properly discussed in Table 5-5.	In response to this comment, PG&E will revise the configuration of Alternative E as noted in response to comment #242. As documented in the Final RFI/RI Volume 2 Report, chemical reduction of Cr(VI) to Cr(III) is effectively permanent and irreversible under site conditions, as described in Section 5.5.4. Chemical oxidation of treated Cr(III) back to Cr(VI) is discussed in Appendix G. As discussed in response to comment #148, active remedies that extract groundwater near the floodplain have the potential to alter the reductive properties of the fluvial sediments by drawing oxic river water through the fluvial sediments. Over time, the aerobic river water could diminish or, in some areas, even exhaust the reductive capacity of the fluvial sediments. Alternatives F, H, and I would result in the most river water being drawn through the floodplain. The pumping or flushing associated with Alternatives C, E, and G may also alter the reductive properties of the fluvial sediments directly beneath the river, but the injection of carbon substrates in the floodplain included in these alternatives would help preserve the reducing capacity throughout most of the floodplain. PG&E agrees that the limitations of flushing effectiveness for Alternative E are similar than for Alternative F. In response to this comment, Section 5.3.6.1 has been modified to add language from Section 5.3.7.1 about the limitations of flushing technology and reference to papers that document experience at other sites. No changes are proposed to the limitations section due to availability of freshwater. As noted in response to comment #136, this alternative (similar to the other active alternatives except Alternative I) results in essentially zero net consumptive use of groundwater since the groundwater extracted would be injected into the same basin. The cost estimate has included the costs for the freshwater flushing (see response to comment #396).	See response to 242. DTSC will await review of revised document for consistency between Alt E and Alt F limitations.	There was agreement on 9/22 that the language would be "softened" regarding oxic river water effects.	Comment resolved. PG&E revised the configuration of Alternative E in response to this and other comments on the CMS/FS report. The revised alternative configuration was outlined in a Technical Work Group meeting September 28 (see comments #443 - #448).
253	DOI-98	Section 5.3.6 General— Pump and Treat	U.S. Department of the Interior	As stated in the document the limitation of this alternative is the difficulty of removing the chromium from low permeability fine-grained layers. If a large mass of the chromium is in fine-grained layers, more extraction wells will be required and the clean-up time will be extended.	**Issue resolved. Original response shown below for completeness. The changes to Section 5.3.6 now 5.3.7) provided by DOI on August 4, 2009 have been incorporated, in lieu of the proposed changes to Section 5.3.6 below.** The exact distribution of chromium in fine-grained layers is	PG&E's response states, "PG&E would also point out that adding more extraction wells has questionable benefit in a system where mass flux is dominated by diffusion from fine grained layers." DTSC would like to point out that arriving at	Comment resolved with PG&E incorporation of language provided by DOI in the file transmittal entitled "Sec 5 DOI edits 8-4-09", pending review of final text.	Comment resolved. The discussion of cleanup time for Alternative F has been re-written by DOI for inclusion in Section 5.3.7.

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					not known. PG&E agrees that cleanup time could be extended if a large mass of chromium is present in fine-grained layers AND if the rate of mass diffusing from these fine-grained layers is sufficient to prevent achieving RAOs in the monitoring well network. PG&E would also point out that adding more extraction wells has questionable benefit in a system where mass flux is dominated by diffusion from fine-grained layers. In response to this comment, PG&E proposes to rephrase the second paragraph in Section 5.3.7 in terms of pore volume flushes, rather than time to cleanup as follows: "The estimate of the time ~~to cleanup required~~ for five pore volumes to be flushed with this alternative is 30 years. This estimate of pore volume flushing time is considered appropriate for the purpose of comparing relative duration of alternatives. The actual cleanup time will be dependent on the flushing efficiency of the aquifer and is subject to considerable uncertainty. The length of time needed to attain cleanup goals in the Alluvial Aquifer would be longer if the flushing efficiency of the Alluvial Aquifer is less than indicated by the available site specific data. The likely range of cleanup time is estimated to be from 10 years (based on two pore volumes) to 100 years (based on 20 pore volumes). The estimated time for five pore volumes to be flushed from the aquifer for this alternative is derived based on the assumed configuration described above. The estimate time for this alternative could be adjusted by modifying the number and location of wells and/or by modifying the flow rates."	this conclusion would likely require installing additional extraction wells at Topock as PG&E has documented in other responses (e.g., Comment Number 264, 269) that, "The exact distribution of chromium in fine grained layers is not known."		Redline final submitted to agencies on November 13, 2009. Agencies approved the report revisions.
254	DOI-99	Section 5.3.6, Page 5-26, Paragraph 2, Sentence 3	U.S. Department of the Interior	Typographical error. There is a redundancy in the sentence.	Per DOI correspondence dated August 4, 2009 this sentence has been revised.		Comment resolved.	Comment resolved. Language provided by DOI for inclusion in Section 5.3.7 fixed the noted redundancy.
255	DOI-100	Section 5.3.6, Page 5-26, Alternative F, Pump and Treat	U.S. Department of the Interior	The timeframe for this alternative to attain cleanup goals in the upland area is highly uncertain and could be substantially longer than estimated by PG&E. DOI believes this approach could require in excess of a hundred years.	**Issue resolved. Original response shown below for completeness.** As described in responses to comments #195 and #200, PG&E agrees that the cleanup time estimates are uncertain. This uncertainty is repeated in the second paragraph in Section 5.3.7 (see proposed revision to 2nd paragraph in Section 5.3.6 in response to comment #253). As shown in Figure D4-5, projected cleanup time for Alternative F is up to 100 years. DOI is correct that under unfavorable conditions, and without optimization during implementation, it could be even longer.	DOI's comment regarding upland cleanup for the pump and treat alternative states, "DOI believes this approach could require in excess of a hundred years." DTSC believes it is important to note that this statement should also apply to the upland area for Alternative E due to potential similar hydraulic responses. In fact, Alternative E should take longer due to less ability to adjust hydraulics nearer the core of the contaminant plume.	Comment resolved with PG&E incorporation of language provided by DOI in the file transmittal entitled "Sec 5 DOI edits 8-4-09", pending review of final text.	Comment resolved. The discussion of cleanup time for Alternative F has been re-written by DOI for inclusion in Section 5.3.7. Redline final submitted to agencies on November 13, 2009. Agencies approved the report revisions.
256	DTSC-94	Page 5-26, Section 5.3.6 Alternative	California Department of Toxic Substances	See the comments above (Page 5-19, Paragraph 2, Section 5.3.3.2 and Page 5-22, Paragraph 5, Section5.3.5.2) regarding contingencies.	Please see responses to comments #229 and #245. PG&E proposes to add a table to the Final CMS/FS Report identifying contingencies for example scenarios under which the alternatives (including Alternative F) would not meet the stated objectives of the remedial action. The table would also	See response to comments 229 and 245.		Comment resolved. Table 5-3, Example Contingency Actions During Remedial Alternative

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		F	Control		note that a contingency plan would be prepared for the selected alternative, as required under the CACA.			Implementation has been added to the CMS/FS Report. Redline final submitted to agencies on November 13, 2009. Agencies approved the report revisions.
257	DTSC-95	Page 5-26, Section 5.3.6 Alternative F	California Department of Toxic Substances Control	It would seem that the current IM-3 extraction centers should be retained (and possibly enhanced) in the proposed Alternative F due to the proximity of the plume to the river. The basis for not including these extraction centers for extra protection of the River should be explained.	The extraction well locations shown for Alternative F were optimized for attainment of the RAOs to reduce chromium concentrations to the stated cleanup goals. Use of the existing IM extraction wells would not provide additional mass removal or gradient control if used in addition to the extraction wells identified for Alternative F and could potentially create stagnation zones between the pumping centers.	DTSC will defer this issue to remedial design.	DOI concurs with deferring this issue until a remedy is selected.	Comment addressed. No changes to the CMS/FS Report are required.
258	DTSC-96	Page 5-26, Section 5.3.6 Alternative F	California Department of Toxic Substances Control	The conceptual design of the CMS/FS report specifies extraction and injection of over 1200 gallons per minute of water from the site. Based on past well installations, DTSC questions if PG&E can achieve these extractions and injection rates. If so, what are the design parameters?	Past well installations at the site provide evidence of the capacity of wells to produce water. For the CMS/FS, extraction wells were assumed to have a maximum design flow rate of 620 gpm for a 12-inch well (although the maximum identified in the conceptual designs, not including the freshwater supply wells, was 450 gpm). Injection well design capacity was assumed to be 150 gpm, except wells only receiving freshwater, which had an assumed design capacity of 250 gpm. These rates are based on operational experience and testing at the IM No. 3 injection wells and the former PGE-1 and -2 production wells. In response to this comment, these assumptions will be reiterated in Appendix D and in Appendix F. Step drawdown tests conducted at IM injection wells IW-2 and IW-3 confirmed that each well had an injection capacity much greater than the target IM design capacity of 200 gpm (see *Groundwater and Hydrogeologic Investigation Report for Interim Measures No. 3 Injection Area*, prepared by CH2M HILL dated June 2005). IW-2 and IW-3 are 6-inch diameter wells with 160-foot screens. Pump tests were performed at PGE-1 and PGE-2 for 48 hours in separate tests. PGE-1 produced between 400 and 500 gpm from 78 feet of perforated casing, and PGE-2 produced approximately 330 gpm from only 54 feet of perforated casing. There was no observable drawdown in the other non-pumped well during either of these tests, indicating that the limitation in pumping rate was likely due to low well efficiency rather than dewatering of the aquifer. The PGE-1 and PGE-2 pump test results are contained in Appendix B-2 of the *Revised Final RCRA Facility Investigation and Remedial Investigation Report*, Volume 2 prepared by CH2M HILL, dated February 2009. Please note that all well numbers and extraction and injection rates are approximate for purposes of the CMS/FS evaluation. It is anticipated that hydraulic testing of newly	DTSC will defer design issues to design and implementation.	DOI concurs with deferring this issue until a remedy is selected.	Comment resolved. Changes noted to Appendix D and Appendix F to reiterate the design assumptions have been incorporated in the CMS/FS Report.

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					drilled wells would be conducted during the implementation of the remedial action, and adjustments to well numbers, well spacing, and projected flow rates would be made as the remedy was installed or during the initial phases of operation.			
259	DTSC-97	Page 5-26, Paragraph 4, Line 8, Section 5.3.6 Alternative F	California Department of Toxic Substances Control	The CMS Report indicates it is assumed that extracted groundwater will not require salinity removal. The basis for this statement should be included in the Report including if the RWQCB has/is willing to approve this approach. Note that salinity removal was required for IM No.3 treatment. If salinity reduction is needed, can it be reduced by importing low TDS water prior to reinjection (This question also applies to the other pump and treat alternatives)? Additionally, potential concerns exist for elevated salinity to discharge, via injected groundwater, into the Colorado River or migrate towards Park Moabi water supply wells despite PG&E's assertion that the movement of TDS is net balanced. The CMS Report should indicate if Alternatives F, G, and H might adversely impact TDS water quality beyond the limits of the contaminant plume due to perimeter injection. Finally, the anticipated mean and range of TDS concentrations for Alternatives F, G, and H should be stated in the Report.	PG&E met with the Water Board on two occasions to discuss this topic. The Water Board has stated verbally that salinity removal would not be required as part of any of the proposed remedial alternatives. Alternatives F, G, and H will not add TDS to the aquifer. The distribution of TDS in the aquifer is primarily correlated with the depth above bedrock where wells are screened not horizontally inside the plume and outside the plume. There will be significant vertical mixing of water during the operation of Alternatives F, G, and H that will result in homogenization of TDS across the depth of the aquifer. TDS will increase in shallow aquifer zones and decrease in deep zones, but there will be no net increase in TDS as a result of operating these alternatives. The salinity of water produced from any well will depend on the depth of the well and the relative contribution of water and salt across the screened interval. Because of the vertical stratification of TDS in the aquifer and the heterogeneous distribution of transmissivity, it is not possible to provide an accurate range of TDS in the effluent water until all the extraction wells have been drilled and tested and the mixing ratio of water from multiple extraction wells with screened intervals extending through varying water quality zones within the Alluvial Aquifer has been determined.	Response noted.		Comment addressed. No changes to the CMS/FS Report are required.
260	CRIT-30	Section 5.3.6 Page 5-26	Envirometrix (on behalf of the Colorado River Indian Tribe)	It is stated that the location of treatment facilities must also consider areas of the site that are of cultural or religious significance so that construction or other disturbance is minimized to the extent feasible. Based on these factors, the location of the *ex-situ* treatment facilities is assumed to be within the lower yard of the Topock Compressor Station. Please explain and provide the documented verifiable information that PG&E used to make the determination and evaluation that the location of the proposed treatment system met the above-referenced criteria that PG&E indicated they considered in evaluating and prior to selecting this location for the treatment system. For reference, input and meaningful discussion from CRIT was never requested or initiated by PG&E in order to obtain any information prior to PG&E making this decision. Since PG&E states that it was important to understand and determine what areas of the site that are both culturally and religiously significant, we request that PG&E provide the exact boundary areas of the site and any verifiable source information that PG&E used	As presented in Sections 5.2.7 and 5.3.7 of the CMS/FS Report, the location of a future *ex-situ* treatment plant has many constraints. Those constraints include placement close to extraction and injection facilities to minimize the amount of pipeline and pump stations required for transporting groundwater, proximity to a power source, available space for construction, and accessibility for construction and operation. In addition, location of the treatment plant must also consider landowner and leaseholder requirements, cultural and religious significance of the land, sensitive habitats, historical sites, topographical constraints, and existing infrastructure. Also, by the terms of the settlement agreement between PG&E and the Fort Mojave Indian Tribe, if a treatment facility is deemed necessary as part of the final remedy, PG&E is required to propose as the preferred alternative that the IM No. 3 treatment plant be decommissioned, removed, and relocated to the Topock Compressor Station property. In conformance with this settlement obligation, because the only property that will be owned by PG&E at the time of implementation of the final remedy will be the Topock compressor station property, and based on the above discussed and currently understood constraints, PG&E proposed that any treatment plant required be sited at the	DTSC will defer to DOI for response however, DTSC acknowledges the Tribe's concerns. The technical merit of a proposed alternative is the key consideration in whether it is included as one of the alternatives to be further evaluated in the CEQA-based environmental review process. The CEQA process (which includes detailed consideration of cultural resources) can provide a rationale for the Lead Agency to eliminate or modify a technically feasible alternative. Federal processes under DOI include the identification of ARARs, any of which may result in the elimination of an alternative for (federal) consideration on the basis of legal infeasibility. Narrowing down of potential alternatives by the California and federal lead agencies may not occur simultaneously; however the agencies are coordinating their review of alternatives as closely as possible and the remedy selection will reflect input from both.	DOI would like to thank CRIT for providing their thoughts and perspective on this area. The nine federally recognized Tribes will be provided an opportunity to supply additional information during the development of the ethnographic/ethno historic study. Additionally, the Bureau of Land Management will continue to conduct formal Section 106 consultation with the nine federally recognized Tribes including consultation.	Comment addressed. No changes to the CMS/FS Report are required.

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				to document the cultural and religious significance to the Tribes. If considered confidential this information can be directly submitted to CRIT.	Compressor Station. In response to a DTSC directive, and taking into account the above described constraints, PG&E also included the IM No. 3 property as an alternative potential site for any required treatment plant. The Topock Compressor Station location for the ex-situ treatment plant in the CMS/FS Report is within PG&E-owned property in an area that has been operated as an industrial facility for over 50 years. DOI's preliminary analysis has indicated that, as a threshold matter, alternatives with a treatment plant located at the compressor station cannot be eliminated for an inability to attain the various cultural resource ARARs. Please note, however, that at the CMS/FS stage, the design for the remedial alternatives is still conceptual. In accordance with applicable guidance, viable remedial technologies are identified and then assembled into a range of alternatives that can satisfy the RAOs in the CMS/FS. The location of an ex-situ treatment plant for purposes of alternative evaluation, as shown in the CMS/FS Report, is not intended to mean that other potential locations are not viable and could not be evaluated during remedial design, consistent with the requirements of the identified ARARs. As the remedy selection process continues through the issuance of a Proposed Plan and the Record of Decision and as a remedy is designed and implemented, the federal agencies have and will continue to engage in consultation with Tribes, State Historic Preservation Officers, and others to identify potential effects on cultural resources, including areas of the site that may be both culturally and spiritually important, and will seek ways to avoid, minimize, or mitigate any adverse effects, thereby ensuring that the selected remedy attains these ARARs. The federal agencies will also solicit input and information from the nine federally recognized Tribes during the development of an ethnographic and ethnohistoric study, and through government-to-government consultations with the Tribes.			
261	DTSC-98	Figure 5-8	California Department of Toxic Substances Control	This Figure only depicted three injection well locations. Is it PG&E's intent to not site an injection well at the southern tip of the chromium plume similar to alternatives E, G, and H?	The conceptual design for this alternative is as shown in Figure 5-8. This design is intended for purposes of the CMS/FS evaluation and, based on the procedure described in Appendix F, to adjust the well configuration and flow rates to achieve capture of the target volume. Please note that there are other possible configurations of this alternative, and the configuration selected for evaluation in the CMS/FS Report does not mean that other injection locations are not feasible and will not be evaluated during design and implementation to optimize the alternative based on field conditions, cleanup efficiency, accessibility, sensitive habitats, historical sites, topographic constraints, existing infrastructure, ARARs compliance, and/or landowner and leaseholder requirements.	DTSC understands the proposal in CMS/FS is conceptual and will flush out this issue in design phase.	DOI concurs with deferring this issue until a remedy is selected.	Comment resolved. Agencies approved PG&E response. No changes to the CMS/FS Report are required.
262	DTSC-99	Page 5-28, Paragraph	California Department of	The CMS Report should include clarification regarding Figure 5-8 and text indicating that	For the CMS/FS Report, extraction wells were assumed to have a maximum design flow rate of 620 gpm for a 12-inch	Agree with RTC.	DOI concurs with the response.	Comment resolved. Agencies approved

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		5, Line 2, Section 5.3.6 Alternative F	Toxic Substances Control	Alternative F would require installation of approximately five extraction and ten injection wells. Also, since alternative E and F are both managing approximately 1200 gpm, please explain why Alternative F will require 10 injection wells when alternative E will only require 8.	well. Injection well design capacity was assumed to be 150 gpm, except wells only receiving freshwater without carbon which had an assumed design capacity of 250 gpm. In response to this comment, these assumptions will be reiterated in Appendix D and in Appendix F. The difference between the number of injection wells between Alternative E and Alternative F is stated in Appendix D. It was assumed that the maximum design injection rate is 150 gpm per well. The groundwater model used to design the alternatives is based on the amount of water that actually enters the aquifer; it does not account for inefficiencies in a single injection well. Therefore, additional wells were added in this cost estimate to the numbers projected by the groundwater model to ensure that there is sufficient redundant injection capacity at a given location. This would result in multiple wells being constructed at those locations where the model projected flow rate exceeds 150 gpm. For freshwater injection as in Alternative E, the 150 gpm limit was not considered since the wells are less likely to foul as quickly, and a single standby well at each injection location was included in the cost estimate for Alternative E.			PG&E response. Changes to Appendices D and F noted in the response have been made to the CMS/FS Report.
263	DTSC-100	Page 5-29, Paragraph 4, Section 5.3.6.1 Alternative F	California Department of Toxic Substances Control	The CMS Report discusses general limitations of pump and treat. The Report must also site specific limitations, if any, that have been observed through operation of the IM No. 3 treatment plant. Since Alternatives E, F, G, H and I all rely on “flushing” to mobilize the hexavalent chromium in subsurface for treatment, they all share similar limitations. However, Alternative E should include additional discussion on the uncertainties associated with control of secondary product which are not inherently as great of an issue with existing pump and treat systems. Also, the issue regarding oxic water adversely affecting reducing conditions in fluvial materials may need to be removed from this section if it is not substantiated (see Comment on Page 5-6, Paragraph 3, Section 5.2.5). Furthermore, if pump and treat is effective, maintaining fluvial materials in a reduced condition may no longer be critical (this also applies to Table 5-5).	The IM was specifically designed to control hydraulic gradients in the floodplain and has been successful in meeting this objective. The final remedy will be designed with different goals, specifically to remove Cr(VI) and reach RAOs in groundwater. In general, pump-and-treat systems have been less successful at mass removal objectives. The IM has not operated long enough to assess whether it would have limitations in reaching RAOs in groundwater. The primary challenge during operation of the IM No. 3 treatment plant has been injection well fouling and troubleshooting of this issue. However, regular maintenance of injection wells to treat/prevent fouling is normal at most sites where injection wells are in operation. No other significant limitations have been observed through operation of the IM. Please see response to comment #252 about uncertainties associated with Alternative E. Please see responses #148 and #175, for response to the issue of oxic water adversely affecting reducing conditions in fluvial materials. Data collected to date (2004 through 2008) do not indicate that the fluvial materials have been adversely affected by IM pumping (other than increasing ORP at wells MW-33-40 and MW-33-90). Nevertheless, over the long periods of time (tens to hundreds of years) that potential remedies, including pumping, are estimated to remain active, the potential for oxic river water or groundwater to adversely affect the reducing conditions present in the fluvial materials would increase, and their capacity to sustain reducing conditions with continuous loading with oxic water cannot be accurately predicted. Pump and treat could prevent movement of Cr(VI) through the floodplain while the remedial action was underway;	Please include the site specific limitation discussion presented in this PG&E response in the CMS/FS Report. Also, see response to comments 252, 148, 175. DTSC awaits revised CMS/FS language for review.		Comment resolved following agency review and input during finalization of the CMS/FS Report text. In response to this comment, the following has been added to Section 5.2.4: “Two injection wells have been operating at the site as part of IM No. 3 since mid-2004. As is typical of injection wells, regular backwashing and periodic rehabilitation have been required to maintain the performance of these wells, but no unusual maintenance or operational challenges have been encountered.” Redline final submitted to agencies on November 13, 2009. Agencies approved the report revisions.

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					however, if the reducing capacity of the fluvial sediments is exhausted, Cr(VI) concentrations in the floodplain would increase at the end of the remedial action when alluvial water containing background concentrations of Cr(VI) migrates back into the floodplain.			
263 .5	Hualapai - 8	Section 5.3.6	Hualapai Tribe via BLM	Alt F: Has this approach ever been done at this level before?	Pump–and-treat groundwater remediation systems of this size and larger have been built and operated for many years at sites across the southwest.	Agree with RTC.	DOI concurs with the response.	Comment resolved. Agencies approved PG&E response. No changes to the CMS/FS Report are required.
264	DOI-101	Section 5.3.7 General—Combine Floodplain In-Situ/Pump and Treat	U.S. Department of the Interior	The extraction wells are designed to be located on the western end of the plume where the chromium has had the longest time to migrate into the deeper fine-grained layers. Extraction of the chromium from the fine-grained layers will require additional wells and the clean-up time will be longer than predicted with the model.	**Issue resolved. Original response shown below for completeness. The changes to Section 5.3.7 (now Section 5.3.8) provided by DOI on August 4, 2009 have been incorporated, in lieu of the proposed changes to Section 5.3.7 below.** The exact distribution of chromium in fine-grained layers is not known. DOI is correct that if mass flux out of the fine-grained layers is sufficient to prevent achieving RAOs in the monitoring wells, cleanup time could be longer than projected. In response to this comment, PG&E proposes to rephrase the fourth paragraph in Section 5.3.8 in terms of pore volume flushes, rather than time to cleanup as follows: "The estimate of the time ~~to cleanup required~~ for five pore volumes to be flushed with this alternative is 20 years. This estimate of pore volume flushing time is considered appropriate for the purpose of comparing relative duration of alternatives. The actual cleanup time will be dependent on the flushing efficiency of the aquifer and is subject to considerable uncertainty. The length of time needed to attain cleanup goals in the Alluvial Aquifer would be longer if the flushing efficiency of the Alluvial Aquifer is less than indicated by the available site specific data. The likely range of cleanup time is estimated to be from 10 years (based on two pore volumes) to 100 years (based on 20 pore volumes). The estimated time for five pore volumes to be flushed from the aquifer for this alternative is derived based on the assumed configuration as described above. The estimate time for this alternative could be adjusted by modifying the number and location of wells and/or by modifying the flow rates."		Comment resolved with PG&E incorporation of language provided by DOI in the file transmittal entitled "Sec 5 DOI edits 8-4-09", pending review of final text.	Comment resolved. The discussion of cleanup time for Alternative G has been re-written by DOI for inclusion in Section 5.3.8. Redline final submitted to agencies on November 13, 2009. Agencies approved the report revisions.
265	DOI-102	Section 5.3.7, Page 5-29, Alternative G, Combined Floodplain In Situ/Pump	U.S. Department of the Interior	This alternative poses some of the same concerns to DOI as do Alternatives C, D, and E; particularly with respect to the substantial disturbance of the floodplain and the estimated timeframes for clean up. Like alternative F, this alternative does not pose the upland area new contaminant and Cr reaction reversibility concerns because in situ treatment is not	Comment noted. This comment expresses DOI judgment of the merits and tradeoffs of this alternative in comparison with others. Evaluation of the alternatives against criteria and in comparison with each other is addressed in Section 5.5. **Issue resolved. Original response shown below for completeness.** As described in responses to comments #195 and #200,	PG&E originally stated in its response, "*Response to the portions of this comment not pertaining to the estimated cleanup times for this alternative is deferred at this time.*" Therefore, DTSC awaits PG&E's deferred response to portions of this comment.	Comment resolved with PG&E incorporation of language provided by DOI in the file transmittal entitled "Sec 5 DOI edits 8-4-09", pending review of final text.	Comment resolved. The discussion of cleanup time for Alternative G has been re-written by DOI for inclusion in Section 5.3.8. Redline final submitted to agencies on

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		and Treat		proposed in the uplands. The timeframe for attaining the cleanup goals in the upland area could be substantially longer than estimated by PG&E. Timeframe estimates based on numbers of pore volumes moved through the uplands are based on a simplified hydrogeologic model and a limited data set. DOI believes this approach could require in excess of a hundred years to attain the cleanup goals in the upland area.	PG&E agrees that the cleanup time estimates are uncertain. This uncertainty is repeated in the fourth paragraph in Section 5.3.8 (see proposed revision to fourth paragraph in Section 5.3.8 in response to comment #264). As shown in Figure D4-6, projected cleanup time for Alternative G is up to 100 years. DOI is correct that under unfavorable conditions and without optimization during implementation it could be even longer.			November 13, 2009. Agencies approved the report revisions.
266	DTSC-101	Page 5-29, Paragraph 5, Section 5.3.7 Alternative G	California Department of Toxic Substances Control	The CMS Report indicates that approximately five extraction wells would be installed within the plume for a combined flow rate of 1,200 gpm (240 gpm per well). The Report should indicate if extraction at 240 gpm at the five wells is a reasonable assumption at Topock and if any wells currently exist on site that could yield these higher flow rates.	Please see response to comment #258. Past well installations at the site provide the hydrogeologic information used to estimate the flow rate of extraction and injection wells at the site. For the CMS/FS, extraction wells were assumed to have a maximum design flow rate of 620 gpm for a 12-inch well (although the maximum identified in the conceptual designs not including the freshwater supply wells was 450 gpm). Injection well design capacity was assumed to be 150 gpm, except wells only receiving freshwater, which had an assumed design capacity of 250 gpm. In response to this comment, these assumptions will be reiterated in Appendix D and in Appendix F. All well numbers and extraction and injection rates are approximate for purposes of the CMS/FS evaluation and will be modified based on the performance of the wells after they are drilled and tested.	Please explain the rationale for not including the assumptions into the text of the document?	DOI concurs referencing Appendix B and D in the text.	Comment resolved. Section 5.3 guides the reader to the appendices for the backup technical assumptions. Changes to Appendices D and F noted in the response have been made to the CMS/FS Report.
267	DTSC-102	Page 5-30, Section 5.3.7 Alternative G	California Department of Toxic Substances Control	Several comments above pertaining to floodplain and interior plume cleanup, contingencies, limitations, and monitoring apply to this alternative and will need to be incorporated into the revised Report.	Please see responses to other comments. Modification to the description and evaluation of Alternative G will be consistent with the remaining alternatives.	DTSC will review revision for consistency.		Comment resolved following agency review and input during finalization of the CMS/FS Report text. Redline final submitted to agencies on November 13, 2009. Agencies approved the report revisions.
268	DTSC-103	Page 5-32, Paragraph 3, Line 2, Section 5.3.7 Alternative G	California Department of Toxic Substances Control	The CMS Report includes the following statement: …construction activities would include installation of approximately 30 IRZ wells approximately five extraction, and approximately 10 injection wells." This does not correlate exactly with Figure 5-9 or Table 5-3 of the CMS Report or PG&E's February 18, 2009 email which responded to CWG stakeholder concerns and lists estimates for the number of wells for each alternative in the Upland and Floodplain areas. This needs to be reconciled in the revised Report.	The report will be modified to reconcile quantities expressed for the conceptual design in various locations in the report. Please note that there are stated reasons for discrepancies between cost estimates and figures. For example monitoring wells were included in cost estimates but not shown on figures, and locations requiring multiple injection wells to accept required flow are shown as a single point on the Section 5.0 figures.	DTSC agrees with RTC. PG&E should remain consistent with information. If multiple injection wells are envisioned but not shown, PG&E should clarify that information.		Comment resolved. Agencies approved PG&E response. Changes noted in the response have been made to the CMS/FS Report.
269	DOI-103	Section 5.3.8	U.S. Department of the Interior	Injecting water into the uplands area could be problematic due to the anisotropy of the system as described previously. Removal of the chromium from the fine-grained layers will	**Issue resolved. Original response shown below for completeness.** Although anisotropy, as described, almost certainly exists at	See DTSC response to comment 253. Additionally, optimally placing more extraction wells within fine grained layers or	Comment resolved with PG&E incorporation of language provided by DOI in the file transmittal entitled "Sec 5 DOI edits 8-4-09", pending review of final	Comment resolved. The discussion of cleanup time for Alternative H has been re-written by

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		General— Combined Upland In-Situ/Pump and Treat		require more wells and the clean-up time will be extended.	the site, it has not been observed to be extreme based on the relatively uniform water level response from the IM No. 3 injection wells. Based on experience with the IM No. 3 injection system, it seems unlikely that anisotropy will be a major limitation for injection for this alternative or other alternatives that rely on injection to control groundwater movement. See response to comment #240. As stated previously, the exact distribution of chromium in fine-grained layers is not known. DOI is correct that if mass flux out of the fine-grained layers is sufficient to prevent achieving RAOs in the monitoring wells, cleanup time could be longer than projected. Adding more extraction wells has questionable benefit in a system where mass flux is dominated by diffusion from fine-grained layers.	dead zones could also enhance remedial efforts.	text.	DOI for inclusion in Section 5.3.9. Redline final submitted to agencies on November 13, 2009. Agencies approved the report revisions.
270	DOI-104	Section 5.3.8, Pages 5-33 through 5-37, Alternative H, Combined Upland In Situ/Pump and Treat	U.S. Department of the Interior	This alternative poses many of the same concerns as the other alternatives, namely the creation of new contaminants and the possibility of reversal of the Cr reduction reaction in the upland area, and the estimated timeframes for clean up.	Comment noted. The concerns expressed about this alternative and corresponding changes to the CMS/FS Report are discussed in responses to other comments.		Response noted.	Comment addressed. No changes to the CMS/FS Report are required.
271	DTSC-104	Page 5-33, Paragraph 3, Section 5.3.8 Alternative H	California Department of Toxic Substances Control	Several comments above pertaining to floodplain and interior plume cleanup, contingencies, limitations, and monitoring apply to this alternative and will need to be incorporated into the revised Report.	Please see responses to other comments. Modification to the description and evaluation of Alternative H will be consistent with the remaining alternatives.	DTSC will review revisions when available.		Comment resolved following agency review and input during finalization of the CMS/FS Report text. Redline final submitted to agencies on November 13, 2009. Agencies approved the report revisions.
272	DTSC-105	Page 5-33, Paragraph 3, Section 5.3.8 Alternative H	California Department of Toxic Substances Control	The CMS Report states, *"…while the remaining portion of the extracted water would be reinjected after being amended with a carbon source near the western edge of the plume."* Discuss the potential for amended water injection wells to be prone to clogging due to metals (chromium) precipitation, etc. and the size/scale of the amendment process (does it require a large treatment plant?).	Based on experience gained during operation of the IRZ systems at the PG&E Hinkley Compressor Station and other sites, it has been demonstrated that when carbon-amended water is injected, biological fouling is the major issue. Chemical precipitation does occur but plays a much smaller role with respect to well fouling. The primary mechanism to minimize well fouling is to control the frequency and concentration of the carbon injection stream by dosing on an intermittent basis (once every few days) and by using chemical or mechanical maintenance on an as-needed basis (measured in years). The *in-situ* system will require the construction of substrate storage and delivery systems and associated pipelines. The reagent storage and mechanical injection equipment footprint for the *in-situ* reagent injection system will be approximately 2,000 square feet. A large treatment plant is not required for the *in-situ* system.	Okay with response.	DOI concurs with the response.	Comment resolved. Agencies approved PG&E response. No changes to the CMS/FS Report are required.

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273	DTSC-106	Page 5-33, Paragraph 4, Section 5.3.8 Alternative H	California Department of Toxic Substances Control	It seems that the IRZ lines/extractors pictured in Figure 5-10 will need to extend to contamination near the MW-12 area. Additionally, to address stakeholder concerns regarding the sacredness of the land, attempts should be made to reposition the easternmost IRZ line out of the maze area. Like alternatives F and G, it would seem that current IM-3 extraction centers be retained (and possibly enhanced) in Alternative H due to the proximity of contamination close to the river.	This remedial alternative will be revised in the Final CMS/FS Report to address the updated Cr(VI) target area, considering data collected since the Draft CMS/FS Report in the East Ravine. As discussed in response to comment #203, some of the alternatives were focused on treatment effectiveness and efficiency, while other alternatives attempted to locate the extraction wells, injection wells, and associated piping in previously disturbed areas. The locations of the IRZ lines shown for Alternative H were focused on treatment efficiency to attain the RAOs to reduce chromium concentrations to the preliminary cleanup goals. Relocation of the easternmost IRZ line without changing configurations of other components would affect the performance of this alternative to attain remedial action goals. At this early stage of analysis, the conceptual design of the remedial alternatives considered sensitive resources by positioning infrastructure in previously disturbed areas, where feasible. Important parameters throughout the design and implementation phases of the selected remedy will be: (1) implementing a remedial action in a manner that is respectful of and causes minimal disturbance to cultural resources, particularly resources that are of special significance to tribes in the area; (2) implementing a remedial action in a manner that limits disturbance to wildlife and their habitats; and (3) implementing a remedial action in a manner that complies with sensitive resource protection ARARs. Use of the existing IM extraction wells would not provide additional mass removal or gradient control. The well locations identified for Alternative H provide both and are therefore superior to the current extraction wells for attainment of RAOs.	DTSC agrees that this issue can be flushed out during design phase.	DOI concurs with deferring this issue until a remedy is selected.	Comment resolved. The alternative configurations have been updated in the Final CMS/FS based on the revised target area considering data collected during the East Ravine investigation.
274	DTSC-107	Page 5-36, Paragraph 3, Line 2, Section 5.3.8 Alternative H	California Department of Toxic Substances Control	The CMS Report includes the following statement: *"…construction activities would include installation of approximately 33 IRZ wells, approximately five extraction wells, and approximately 12 injection wells at various locations."* This does not correlate with Figure 5-10 or Table 5-3 of the CMS Report or PG&E's February 18, 2009 email which responded to CWG stakeholder concerns and lists estimates for the number of wells for each alternative in the Upland and Floodplain areas. This needs to be reconciled in the revised Report.	The report will be modified to reconcile quantities expressed for the conceptual design in various locations in the report. Please note that there are stated reasons for discrepancies between cost estimates and figures. For example monitoring wells were included in cost estimates but not shown on figures, and locations requiring multiple injection wells to accept required flow are shown as a single point on the Section 5.0 figures.	DTSC agrees with RTC. PG&E should remain consistent with information. If multiple injection wells are envisioned but not shown, PG&E should clarify that information.	DOI concurs with the response.	Comment resolved. Agencies approved PG&E response. Changes noted in the response have been made to the CMS/FS Report.
274 .3	Hualapai - 9	Section 5.3.8	Hualapai Tribe via BLM	Alt H1/H2: Technology application at this scale—has it been done before?	The individual components of Alternative H have been implemented before—including extraction wells, injection wells, pipelines, aboveground treatment plant, in-situ treatment—have been implemented at this and other sites. PG&E is not aware that these components have been put	Agree with RTC.	DOI concurs with the response	Comment resolved. Agencies approved PG&E response. No changes to the CMS/FS Report are required.

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					together in this configuration before.			
274 .8	Hualapai - 10	Section 5.3.8	Hualapai Tribe via BLM	Alt H1/H2: What options exist to implement an adaptive management approach?	The remedy selection process being implemented for this remedial action is consistent with the terms and procedures of the DOI Adaptive Management approach. The project will be refined as more information is gathered during the design, construction, and implementation stages. PG&E will continue to collect and evaluate data during these subsequent stages of the project and incorporate changes to ensure the continued successful operation of the remedy and attainment of RAOs. In addition, if it is discovered that a significant change is warranted, PG&E recognizes that a significant change to the remedy following the Record of Decision and the EIR certification will require an Explanation of Significant Difference or a Record of Decisions Amendment or addendum to the EIR, which include additional opportunity for public involvement.	DOI to review.	DOI concurs with the response.	Comment resolved. Agencies approved PG&E response. No changes to the CMS/FS Report are required.
275	DOI-105	5.3.9 General-- Alternative I Continued Operation of Interim Measure	U.S. Department of the Interior	As stated previously, if a large mass of the chromium is contained in fine-grained layers in the uplands, there will be a slow diffusion of the chromium into the aquifer system and the clean-up time will be longer than estimated.	The exact distribution of chromium in fine-grained layers is not known. PG&E agrees that cleanup time could be extended if a large mass of chromium is present in fine-grained layers AND if the rate of mass diffusing from these fine-grained layers is sufficient to prevent achieving RAOs.	Agree with RTC.	DOI accepts the response.	Comment resolved. Agencies approved PG&E response. No changes to the CMS/FS Report are required.
276	HA-20	Section 5.3.9 Page 5-37	Hargis & Associates, Inc. (on behalf of Fort Mojave Indian Tribe)	The Tribe notes that the goal of this Alternative as an interim measure was somewhat different from the remedial action objectives outlined in Section 3.0 of the CMS/FS. Also see comments regarding Alternative I in General Comment No. 7b.	PG&E agrees that Alternative I was not designed to attain the RAOs. As stated in Section 5.3, Alternative I (Continued Operation of the Interim Measure) has been incorporated into this CMS/FS Report per DTSC's request (DTSC letters to PG&E dated November 6, 2008 and December 5, 2008); the configuration of Alternative I has not been modified to adjust to the goals of the remedial action (Section 3.0) but instead focuses on the goals of the IM (hydraulic control of the plume only).	DTSC agrees that the Interim Measure was not designed to be a final remedy; however, since the IM3 pump and treat has been deemed successful in protecting the Colorado River and that it is accelerating the removal of Cr mass from the plume in comparison to MNA or No Action, it warrants a review of its effectiveness as a long term remedy either as a standalone alternative or as a component of a final remedy. PG&E estimated a total mass of 34,248 pounds of Cr within the plume based on the thickness and concentrations in the deep, middle and shallow layers contoured for the model. The IM3 has already removed (as of July 2009) over 5,400 lbs of the Cr . Further optimization of extraction has potential of further increasing its effectiveness. At a minimum, the existing IM3 will not require any additional infrastructure to implement.	DOI concurs with the response.	Comment addressed. No changes to the CMS/FS Report are required.
277	DTSC-108	Page 5-39, Paragraph 5, Alternative I	California Department of Toxic Substances Control	The report suggests that pump and treat has been "shown to be ineffective in achieving RAOs at many sites." DTSC notes, however, that this main limitation exists for alternative E and F because both alternatives utilize a subsurface flushing mechanism. The main difference is that alternative E pushes the contaminant toward a treatment zone versus pulling from extractors.	Please see response to comment #252; Section 5.3.6.1 will be revised to include language similar to Section 5.3.7.1.	See response to 242. DTSC will await review of revised document for consistency between Alt E and Alt F limitations.		Comment resolved. Changes to Section 5.3.6.1 noted in the response have been made to the CMS/FS Report. Redline final submitted to agencies on November 13, 2009.

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								Agencies approved the report revisions.
277 .5	Hualapai - 11	Section 5.3.9	Hualapai Tribe via BLM	Alt I: It is unclear on whether the fluvial materials would continue to serve as a treatment medium for the groundwater	As noted in Section 5.2.5, MNA may be considered a feature of the site that augments those active remedial alternatives, including Alternative I, that allow chromium in groundwater to contact the fluvial materials. There is uncertainty, however, as discussed in Section 5.3.10.1, about the persistence and capacity of the reducing conditions with sustained pumping, noting that the estimated time for implementation of Alternative I is between 150 and 1,500 years. Please see response to comment #175 and #278.	Agree with RTC.	DOI concurs with the response.	Comment resolved. Agencies approved PG&E response. No changes to the CMS/FS Report are required.
278	DOI-106	Section 5.3.9.1, Page 5-39	U.S. Department of the Interior	The discussion states that river water may be drawn in as a result of the pumping of IM-3. The text should note if currently available groundwater data indicate an influx of river water related to the current IM-3 groundwater extraction.	Please also refer to response to comments #175. As presented in the 2006 through 2009 combined Fourth Quarter and Annual Performance Evaluation Reports (CH2M HILL March 15, 2006; April 6, 2007; March 14, 2008; and March 13, 2009), stable isotope (deuterium) data for floodplain wells (completed within fluvial materials) indicates a steady increase in the isotopic signatures similar to river water has occurred in these wells since IM pumping began. Prior to IM pumping, these “river water” signatures were also present in shallow fluvial wells close to the river (MW-27-20, MW-28-20), and model simulations indicate that it is this shallow groundwater that is infiltrating the more landward and deeper floodplain wells. However, the observed gradients (supported by model simulations) indicate that oxic river water has been drawn landward to some degree. Current data indicate that the reductive capacity of the fluvial materials has generally remained similar to that observed before the start of IM pumping (other than increasing ORP at wells MW-33-40 and MW-33-90). However, it is not possible to accurately predict how long the fluvial materials will remain unaffected by a steady influx of oxic river water.	See response to comment 175.	Comment resolved per DOI discussion with PG&E on 09/08/09 regarding incorporation of floodplain data language, pending review of final text.	Comment resolved following agency review and input during finalization of Section 5.2.5 of the CMS/FS Report. Additional text about the information gathered about the reducing floodplain conditions during operation of the IM has been added to Section 5.2.5. Redline final submitted to agencies on November 13, 2009. Agencies approved the report revisions.
279	DTSC-109	Page 5-40, Section 5.4.1, Overview of Evaluation Criteria	California Department of Toxic Substances Control	General Comment: EPA guidance for conducting RI/FS, Section 6.2.3 et al, provided significant details on the factors to consider for each of the nine selection criteria. DTSC recommends, for completeness, that PG&E include all analysis factors and do not skip any despite potential for repetitive analysis and response during presentations of the comparative analysis of alternatives. Furthermore, the EPA guidance also provided key questions (Specific Factor Considerations and Basis for Evaluation) to be considered when presenting the detailed analysis of each alternative. DTSC recommends that PG&E follows and answers all of the recommended questions for each selection criteria in the individual alternative analysis in Table 5-5.	This proposed response was discussed at the September 9, 2009 RCRA/CERCLA meeting. The evaluation criteria identified in Section 5.4.1 and detailed in Section 5.4.1.1, and 5.4.1.2 are based on the requirements of the CACA (RCRA Corrective Action) and the NCP (CERCLA). Each of the criteria (except cost) in Section 5.4.1.1, and 5.4.1.2 include between two and four subcriteria. While PG&E considered USEPA guidance in establishing the criteria, the CACA and the NCP were considered to be the primary authority, rather than guidance. In addition to the guidance suggested by DTSC (*Guidance for Conducting Remedial Investigations and Feasibility Studies Under CERCLA*, OSWER Directive 9355.3-01, October 1988), PG&E also consulted additional USEPA guidance: • *Handbook of Groundwater Protection and Cleanup Policies for RCRA Corrective Action*, EPA530-R-04-030, April 2004.	DTSC agrees in concept that PG&E does not need to consider all factors stated in the EPA guidance. The points to remember, according to EPA Quick Reference Fact Sheet on the Feasibility Study: Detailed Analysis of Remedial Action Alternatives, is that the presentation of alternatives analysis should be “in a level of detail that makes the differences clear, but is not as detailed as design specifications.” Also, “focus the evaluation on the strengths and weaknesses of each alternative relative to the others with respect to each criterion.” In addition, DTSC notes that the proposed East Ravine extraction wells are located on historic route 66. If PG&E compares different options using the “Obtain Approval from Other Agencies” under Implementability, that concept perhaps will	DOI defers to DTSC.	Comment resolved following agency review and input during finalization of Section 5.4.1 of the CMS/FS Report. Redline final submitted to agencies on November 13, 2009. Agencies approved the report revisions.

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					- *RCRA Corrective Action Plan*, OSWER Directive 9902.3-2A, May 1994. - *Guidance on Remedial Actions for Contaminated Ground Water at Superfund Sites*, OSWER Directive 9283.1-2, December 1988. In response to this comment, the alternative evaluation in Section 5.4.2 (Table 5-7) of the CMS/FS Report has been modified so that each of the subcriteria identified in Section 5.4.1.1 and 5.4.1.2 are explicitly addressed (an example was distributed and discussed at the September 9, 2009 RCRA/CERCLA meeting). The individual questions in Section 6 of the *Guidance for Conducting Remedial Investigations and Feasibility Studies Under CERCLA*, OSWER Directive 9355.3-01, October 1988 are not explicitly identified in Section 5.4.2 (Table 5-7) due to the unbalanced nature of the questions (22 questions for implementability criteria, but no questions for the overall protection of human health and the environment criteria). However, these individual questions are considered and incorporated into the discussion of the appropriate subcriteria.	not be ranked as high or other options. PG&E should submit section 5 as early as possible for review of final language.		
280	DOI-107	Section 5.4.1.1, page 5-41	U.S. Department of the Interior	The paragraph discussing the threshold criterion of protection of human health and the environment makes no mention at all of how risk is factored into the evaluation of whether an alternative satisfies this criterion. Instead, this paragraph suggests that "protectiveness" is measured by long and short term effectiveness and compliance with ARARs. Long and short term effectiveness and compliance with ARARs, while relevant to an assessment of protectiveness, are their own separate remedy selection criteria and are not the primary factors by which protectiveness should be measured. Please revise this paragraph accordingly by citing, and quoting, section 300.430(e)(9)(iii)(A) of the NCP (e.g. alternatives are assessed "to determine whether they can adequately protect human health and the environment ... from unacceptable risks ... by eliminating, reducing, or controlling exposures to levels established during development of remediation goals ...").	In response to this comment, a reference to Section 300.430(e)(9)(iii)(A) has been added to the second sentence of the paragraph.	DTSC agrees with RTC if PG&E "quotes" the NCP as requested by DOI and not simply referring to it.	DOI accepts the response, pending review of the final text.	Comment resolved following agency review and input during finalization of Section 5.4.1.1 the CMS/FS Report text. Redline final submitted to agencies on November 13, 2009. Agencies approved the report revisions.
281	DOI-108	Section 5.4.1.3, page 5-43	U.S. Department of the Interior	Please revise the discussion of "State Acceptance" and "Community Acceptance" to track more closely the NCP language from section 300.430(e)(9)(iii)(H) and (I), respectively.	The descriptions of the criteria have been modified as noted below. Please also see response to comment #198 for a description of how this is implemented for this CMS/FS. **State Acceptance**. This criterion is broadly defined as meeting the technical and administrative concerns of state agencies. Assessment of state concerns may not be completed until comments on the RI/FS are received but may be discussed, to the extent possible, in the proposed plan for public comment. The state concerns that shall be	Agree with RTC.	DOI accepts the response.	Comment resolved. Agencies approved PG&E response. Changes noted in the response have been made to the CMS/FS Report, as further modified by DTSC and DOI (see comments

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					assessed include the following: 1. The state's position and key concerns related to the preferred alternative and other alternatives. 2. State comments on ARARs or the proposed use of waivers. **Community Acceptance**. Community acceptance evaluates the public's concerns about each alternative. This assessment includes determining which components of the alternatives interested persons in the community support, have reservations about, or oppose. This assessment may not be completed until comments on the Proposed Plan are received. It will be addressed in the CERCLA Record of Decision, and/or RCRA Statement of Basis.			#523-526).
282	DTSC-110	Page 5-43, Section 5.4.1.3, Modifying Criteria	California Department of Toxic Substances Control	Agencies will address the modifying criteria of "State Acceptance and Community Acceptance" beyond the comments on the CMS/FS, but up to and including comments received during the public comment period for the Statement of Basis and the Proposed Plan. These modifying criteria will be fully addressed during the final remedy selection under the Record of Decision and DTSC's final remedy adoption.	Please also see response to comments #198 and #384 for a description of how State and Community Acceptance are implemented for this CMS/FS. The text has been revised to note that the assessment includes more than the comments on the CMS/FS Report and that these two modifying criteria will not be completed until the Record of Decision.	Agree with RTC.	DOI concurs with the response.	Comment resolved. Agencies approved PG&E response. Changes noted in the response have been made to the CMS/FS Report.
283	DTSC-111	Page 5-43, Section 5.4.2	California Department of Toxic Substances Control	PG&E provided significant discussion on the selection of background as the cleanup goal, but does not acknowledge the limitations on the use of the background study and that fluvial formation waters exhibit Cr(VI) background concentrations below detection limits while Cr(VI) concentrations in alluvial waters are noted to significantly decrease with depth at the Topock site. See comment on Section 3.3.1.	Please see response to comment #87.5.	See response to comment 87.5.		Comment resolved. Agencies approved PG&E response. Changes to Section 2.3.3 as noted in response to comment #87.5 have been made to the CMS/FS Report.
284	DOI-X	Section 5.5	U.S. Department of the Interior	DOI recognizes the sensitivity of impacts along the floodplain from both a cultural and ecological standpoint. DOI is requesting PG&E to perform a comparative analysis of Alternatives C, E, and G with IRZ recirculation well installation only occurring along the National Trails Highway. Our interest would be in determining if this modification would pose a more significant risk of the plume reaching the river or if ongoing monitoring and the natural attenuation in the floodplain would suffice. The operation of the IRZ line along the national Trails Highway could be designed to both treat the upgradient groundwater plume flowing toward the floodplain and enhance the natural reducing zone that is currently protecting the river.	In response to this comment, as well as comments #148, 192, and 243, PG&E will prepare an evaluation of Alternatives C, D, E, and G without infrastructure east of National Trails Highway.	DTSC will review the proposed evaluation of the alternatives without IRZ lines east of the National Trails Highway. However, DTSC is concerned with any remedy that may potentially accelerate and/or cause migration of the plume or its equally toxic secondary products from reduction towards the Colorado River without proper monitoring.	DOI reserves judgment on the adequacy of this response pending further review of the evaluation to be provided by PG&E and discussion on the revised Alternative E.	Comment resolved. PG&E prepared a separate technical memorandum titled "Conceptual Floodplain Design Options, Pacific Gas and Electric Company Topock Compressor Station" dated October 5, 2009 that summarized conceptual options for the design of in-situ treatment systems in the floodplain, including the option of no floodplain infrastructure.
285	HA-14	Section 5.5	Hargis & Associates, Inc. (on behalf	7d. PG&E Recommended Remedial Alternative As far as the draft CMS/FS, the Tribe would	FMIT preferences are noted. Please see response to comments #198 and #384 for a description of how State and Community Acceptance are implemented for this remedial	DTSC concurs with RTC. It should be noted that the remedial action goal is not just to protect the Colorado river, but also to return	DOI would like to thank the FMIT for providing their thoughts and perspective on this area. The perspectives provided	Comment resolved. Agencies approved PG&E response.

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			of Fort Mojave Indian Tribe)	obviously prefer an alternative that would require no further disturbance to the Site, such as Alternative A.24 Moreover, the Tribe would prefer careful removal of the existing features such as wells, pipelines, and other infrastructure constructed to date and restoration of the impacted areas to the extent possible. Under this scenario, the River would be protected from Cr(VI) contamination via the naturally-occurring reductive zone, and the groundwater would be healed over time as well. The Tribe is used to thinking many generations into the future and perhaps has a more fluid view of time than some other governmental agencies or stakeholders. Next in terms of preference, the Tribe favors Alternative B, which would involve a similarly low level of Site disturbance through reliance on natural attenuation processes, but with performance confirmation via a monitoring network. Apart from Alternatives A and B, the PG&E-recommended remedial alternative presented in the CMS/FS, Alternative E, appears to be the least disruptive to Tribal lands. Nevertheless, there are potentially several modifications that could be made to this Alternative that would, in the Tribe's view, lessen its overall impact. For example, "Alternative E2," the cleanup time should be evaluated without reliance on IRZs in the floodplain (east of Park Moabi Road). Under this scenario, performance in the floodplain area could still be monitored using the existing network. If this alternative were not able to perform properly, a contingency for installing the additional IRZs in the floodplain could always be implemented. In addition, the feasibility of re-positioning the proposed injection wells in the upland areas, but away from culturally sensitive locations, so as to shorten the length of the delivery pipeline and to bring the wells closer to the area overlying the Cr(VI) plume should be evaluated. Finally, if Park Moabi Road has historic values that are somehow deemed inviolate, consideration should be given to moving the IRZ line to the east. The Tribe would also expect that, as the remedy design is further refined, the regulators and PG&E would pursue other opportunities to reduce impacts such as above-ground piping installations, use of telemetry to lessen intrusions, reducing the number of performance monitor wells, abandoning and decommissioning wells no longer needed, careful restoration of the impacted areas and other potential mitigation	action. Please also see response to comments #148, 192, 243 and 284, about preparing an evaluation of Alternatives C, D, E, and G without infrastructure east of National Trails Highway. Please note that in response to comment #242 and other comments, PG&E is proposing to modify the configuration of Alternative E to replace the floodplain IRZ lines with a line of extraction wells near the river. The conceptual design for Alternative E is intended for purposes of the CMS/FS evaluation and is based on the procedure described in Appendix F to adjust the well configuration and flow rates to achieve capture of the target volume. PG&E notes that there are other possible configurations of this alternative, and the configuration selected for evaluation in the CMS/FS Report does not mean that other injection locations are not feasible and will not be evaluated during design and implementation to optimize the alternative based on field conditions, cleanup efficiency, accessibility, sensitive habitats, historical sites, topographic constraints, existing infrastructure, ARARs compliance, and/or landowner and leaseholder requirements. These types of issues will be considered during detailed design (e.g., the feasibility of re-positioning the proposed injection wells in the upland areas, and the IRZ lines along National Trails Highway). PG&E agrees with FMIT expectations that as the remedy design is further refined, opportunities to reduce impacts would be pursued. This is expected to apply not only during design phases but also during the construction and O&M phases. It should be noted that Alternative A would not include continued operation of IM No. 3. Please see response to comments #206 and 207, which indicates that the description of Alternative A will be revised to clarify that operation of the existing interim measure would not continue.	the water quality in the basin to meet the criteria for beneficial uses.	by the FMIT and other Tribes will be considered in the selection of the remedy for the Topock groundwater. The Bureau of Land Management will continue to conduct formal Section 106 consultation with the nine federally recognized Tribes including consultation with the Fort Mohave Indian Tribe. The comments and perspectives of the Tribes will be considered during design of the final remedy.	Changes noted in the response have been made to the CMS/FS Report.

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				measures. 24 The Tribe notes that the No Action Alternative can be satisfied by showing the IM3 facility at another location that is consistent with the settlement agreements. The point of the No Action Alternative is to study what "no action" does, not to necessarily dictate how that occurs.				
286	DTSC-115	Figure 5-12	California Department of Toxic Substances Control	Although the Comparative Ratings in Figure 5-12 should reflect the discussions in Section 5.5, DTSC found it difficult to correlate the discussion with the resulting ratings. DTSC recommends reorganizing the comparative analysis discussions in text to clearly respond to each bullet in the EPA guidance (see comment 109, and then provide a rating of each alternative based on each factor under the evaluation criterion. The results of the overall rating for each criterion will hopefully be more clear and easier to understand. The current rating scale only allows for three rankings (low, medium, and high). To further spread out the alternatives, DTSC recommends adding medium low and medium high (e.g., cost effectiveness will separate Alternative C as medium low when compared with Alternatives D and E).	Please also see response to comment #279 (DTSC comment #109). The detailed evaluation and the comparative evaluation have been revised to more clearly address the subcriteria defined in Section 5.4.1. The rating scale has been adjusted as suggested in the comment.	Agree with RTC. DTSC will await final review of changes.	DOI concurs with the response, pending review of the revised text.	Comment resolved following agency review and input during finalization of Section 5.5 to the CMS/FS Report. Redline final submitted to agencies on November 13, 2009. Agencies approved the report revisions.
287	DTSC-116	Figure 5-12	California Department of Toxic Substances Control	Under implementability, summary column, Alternative I appears in both 2nd and 3rd bullets.	Alternative I has been removed from the third bullet.	Agree with RTC.	DOI concurs with the response.	Comment resolved. Agencies approved PG&E response. Changes noted in the response have been made to the CMS/FS Report.
288	DOI-109	Section 5.5.1, page 5-44	U.S. Department of the Interior	The meaning and intent of first sentence of the third paragraph ("No exposure pathway to human and ecological receptors from groundwater exists; therefore all alternatives provide additional certainty that the exposure would be prevented") is unclear. Does this suggest that all of the alternatives are equally effective in terms of protectiveness? Or does it imply, incorrectly, that all of the alternatives include institutional controls that prevent exposure? Please clarify or delete this sentence. In addition, please provide some analysis regarding baseline risk, absent institutional controls and any further treatment. If this cannot be done prior to completion of the risk assessment then, consistent with the cover letter transmitting these comments, finalization of the CMS/FS should await finalization of the risk	The intent of this sentence is to emphasize that there are no current complete exposure pathways for contact with site groundwater, as concluded in the groundwater risk assessment (GWRA). The baseline GWRA conclusions identify that the only risks at the site that warrant remedial action are due to the elevated risk levels from future hypothetical groundwater users that may be exposed to site groundwater in a residential setting. Implementing a remedial alternative will provide assurance that there will continue to be no unacceptable exposure. To clarify the lack of complete exposure pathways currently, the sentence has been replaced with the following: "As concluded in the groundwater risk assessment, there are no current direct or indirect complete exposure pathways for contact with site groundwater, and there are no human or ecological populations currently at risk of adverse health effects due to groundwater at the Topock site (ARCADIS, 2009)."	DTSC agrees with general conclusion of RTC, however, with the recent proposed PHG of 0.06 ug/L in drinking water from hexavalent chromium by the California Office of Environmental Health Hazard Assessment (OEHHA) the additional language in the fourth paragraph in Section 5.5.1 may need to be qualified or expanded to include statement regarding cancer risks.	DOI accepts the response. DOI accepts the response, pending review of Section 3.	Comment resolved. Agencies approved PG&E response. Changes noted in the response have been made to the CMS/FS Report to incorporate the results of the groundwater risk assessment in Section 3.0 and in the alternative evaluation for the protection of human health criteria.

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				assessment. Finally, this section should include a discussion of whether or not cleanup to background levels will eliminate unacceptable risks associated with exposure to groundwater. Again, this may be an analysis that can only be included after the risk assessment has been completed.	The request here for baseline risk analysis has been addressed. As described in response to comments #83 and #85, the conclusions of the GWRA have now been incorporated into Section 3.0 of the CMS/FS Report. The GWRA was prepared to evaluate baseline risks to human and ecological receptors from potential exposure to groundwater at the site, absent remediation through treatment or institutional controls. Section 3.0 has been revised to clarify that the preliminary cleanup level for Cr(VI) is lower than the calculated noncancer risk-based remediation goal of 46 µg/L for future hypothetical human groundwater users that may be exposed to site groundwater in a residential setting, and the preliminary cleanup goal for Cr(T) is lower than the California and federal MCLs of 50 µg/L and 100 µg/L, respectively. Analysis of baseline risks without institutional controls or reduction in Cr(VI) concentrations for Alternatives B through I is not appropriate for Section 5.0, because institutional controls and reduction in Cr(VI) concentrations are assumed components of these alternatives. To address the estimated risk after cleanup to background levels, the following text has been added to Section 5.5.1.2: "As discussed in Section 3.3.1, the preliminary cleanup goal for hexavalent chromium of 32 µg/L is lower than the calculated noncancer risk-based remediation goal for Cr(VI) of 46 µg/L assuming future hypothetical human groundwater users that may be exposed to site groundwater in a residential setting."		DOI accepts this response.	
289	DOI-110	Section 5.5.1, Page 5-44, Paragraph 2	U.S. Department of the Interior	This statement is incorrect. While discharges have ceased to Bat Cave Wash, it is presumptuous to state that the source has been eliminated when the potential exists for soils and sediments to be a continuing source.	In response to this comment, the paragraph has been revised (see below) and included in Section 5.5.1.3 to acknowledge the ongoing investigations being conducted to determine whether soils are a continuing source. "The historic practice of wastewater discharge to Bat Cave Wash has been eliminated; therefore, sources of wastewater have been controlled. However the evaluation of whether leaching of Cr(VI) from contaminated soils represents a significant transport pathway to groundwater has not yet been completed. There is no distinction between the alternatives with respect to this criterion."	Agree with RTC.	DOI accepts the revised text.	Comment resolved. Agencies approved PG&E response. Changes to Section 5.5.1.3 noted in the response have been made to the CMS/FS Report.
290	DOI-111	Section 5.5.1, Page 5-44	U.S. Department of the Interior	As discussed previously, DOI is concerned about conclusions regarding estimated times to cleanup and their use in comparison of alternatives. The basis for the time estimates is speculation with very limited site data to support the assumptions. DOI believes the uncertainties related to site geologic heterogeneity could result in much longer timeframes than 10 to 30 years for the active remedy alternatives, particularly the pump and treat and flushing alternatives, where diffusion from fine grained layers could continue to affect groundwater at levels above background for extended time periods. Similar concerns exist	**Issue resolved. Original response shown below for completeness. Section 5.5.1 has been revised per the rewrite provided by DOI on August 4, 2009 and discusses attainment of RAOs in terms of faster or slower rather than an emphasis on numerical values.** Refer to response to comments #195 and #200 for the first part of this comment pertaining to time to cleanup estimates and site-specific data that support the use of five pore volumes as an estimate for the time to cleanup. Also as discussed in response to comment #200, while there may be zones at the Topock site where RAOs will take	Comment resolved.	Comment Resolved. Please see the file transmittal "Sec 5 DOI edits 8-4-09" for modifications to the text in response to the RTC.	Comment resolved. The discussion of cleanup time for the remedial alternatives has been re-written by DOI for inclusion in Section 5.3. Redline final submitted to agencies on November 13, 2009. Agencies approved the report revisions.

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				for the upland in situ alternatives that involve distribution of substrates over large distances, where heterogeneity may result in recalcitrant zones that are not effectively treated. Moreover, DOI is concerned about the long term stability of the Cr reduction reaction once oxidizing conditions return to the upland area. Although PG&E acknowledges that substantial uncertainties exist in the timeframe estimates, DOI is concerned that analysis of alternatives still puts too much emphasis on the estimated timeframes when it concludes that in situ treatment and flushing/pump and treat alternatives have similar timeframes. In reality, the range of timeframes across the alternatives may be much broader than presented, ranging from a few decades for the localized high-intensity in situ treatment alternative, to hundreds of years or more for large-scale in situ and pump and treat alternatives, to over a thousand years for MNA.	longer to meet, attainment of RAOs throughout most of the aquifer would be greatly accelerated by active remedies in comparison with natural flushing. Even with significant model uncertainty, the effects of the active remedies (Alternatives C, D, E, F, G, H, and I) will greatly increase flushing and/or natural reduction processes compared to natural attenuation (Alternatives A and B). As a further breakdown of the active remedies, Alternative I will require the longest time to attain cleanup due to the flow rate and extraction/injection configuration and lack of optimization. In response to this comment, PG&E proposes to revise the text in Section 5.5.1 and Section 5.5.5 to discuss attainment of RAOs in terms of faster or slower, rather than emphasis on numerical values. In addition, the text will be revised to better explain this hierarchy: Alternatives A and B slowest, Alternative I next slowest; Alternatives C, E, F, G, and H next slowest; and Alternative D the fastest. Please also refer to response to comments #176, 181, 232, 239 regarding the stability of the chromium reduction reaction.			
291	DTSC-112	Page 5-44, Section 5.5.1	California Department of Toxic Substances Control	The CMS/FS Report concluded in various locations that the sources have been controlled since the historic practice of wastewater discharge has been eliminated. DTSC does not agree with this conclusion in that there may still be residual sources in the soils. Therefore, uncertainties still remain on source control with all remedial alternatives until the soil data and leaching to soil potentials are evaluated.	See response to comment #289. The text has been revised at all locations, with the text presented in response to comment #289.	Agree with RTC.	DOI concurs with the response.	Comment resolved. Agencies approved PG&E response. Changes to Section 5.5.1.3 noted in response to comment #289 have been made to the CMS/FS Report.
292	HA-21	Section 5.5.1 Page 5-44	Hargis & Associates, Inc. (on behalf of Fort Mojave Indian Tribe)	The discussion of minimizing disruption to sensitive resources on page 5-47 is misleading for several reasons. First, as stated earlier, the document does not demonstrate that all of the alternatives have been implemented in a manner that is respectful of or cause minimal disturbance to cultural resources. Second, as also discussed earlier, it is not necessarily true that constructing a new treatment plant at the Compressor Station results in greater disturbance than leaving in place or expanding the existing IM3 plant, which is a continuing disturbance and desecration of this sacred place. Therefore, the impact associated with Alternative I should be modified so that it does not reflect that it carries a low impact. In addition, regarding impacts to sensitive resources, from the Tribe's general viewpoint, upland impacts (i.e., wells, piping, access, trenches, etc.) should be given a lower, not equal rank to similar facilities in the floodplain area.27	Please see response to comment #203. As stated, PG&E acknowledges that there are sensitive resources in the vicinity of the remedial action alternatives. At this early stage of analysis, the conceptual design of the remedial alternatives considered sensitive resources by positioning infrastructure in previously disturbed areas where feasible. As such, the evaluation for disruption to sensitive resources focused on comparing alternatives against each other in amount of infrastructure construction, amount and type of O&M, and whether or not the infrastructure was located primarily in previously disturbed areas. The sentence "Alternative I would have the next lowest impact" will be removed from this paragraph. This paragraph will be clarified to indicate that while Alternative I does not include construction of a new aboveground treatment plant, this alternative includes a considerably longer O&M period compared with O&M for treatment plants under Alternatives F, G, and H and is therefore not considered to result in fewer disturbances than Alternatives F, G, and H. The FMIT preferences about upland infrastructure vs.	DTSC will accept PG&E's proposed revision to Section 5.5.1. Furthermore, DTSC acknowledges the Tribe's concerns. The technical merit of a proposed alternative is the key consideration in whether it is included as one of the alternatives to be further evaluated in the CEQA-based environmental review process. The CEQA process (which includes detailed consideration of cultural resources) can provide a rationale for the Lead Agency to eliminate or modify a technically feasible alternative. Federal processes under DOI include the identification of ARARs, any of which may result in the elimination of an alternative for (federal) consideration on the basis of legal infeasibility. Narrowing down of potential alternatives by the California and federal lead agencies may not occur simultaneously; however the agencies are coordinating their review of	The referenced sentence (for deletion) could not be located. The paragraph acknowledges that Alternative A would result in the least disturbance.	In response to comment #295, the paragraph discussing minimizing disturbance has been deleted from this section. Alternative I is ranked low with respect to the short-term effectiveness criterion in part because of the continuing impacts during the relatively long operations period compared to other alternatives.

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				27 See comparison of Alternative C against Alternative E, at p. 5-55.	floodplain infrastructure are noted. Please see response to comments #198 and #384 for a description of how State and Community Acceptance are implemented for this remedial action.	alternatives as closely as possible and the remedy selection will reflect input from both.		
293	DTSC-113	Page 5-44, Section 5.5.1, Paragraph 5	California Department of Toxic Substances Control	The CMS/FS concludes that "all remedial alternatives would attain the media (groundwater) cleanup goals…" and that "[Alternative] B would attain the media cleanup goals through natural attenuation over an estimated 1,000 years." There is significant uncertainty if Alternative B, (Monitored Natural Attenuation) will meet the RAOs without plume migration and spreading of contamination. It is arguable that attenuation is taking place in the deeper portion of the aquifer where Cr(VI) appears persistent. Moreover, monitoring wells to the north and south of the plume appear to have increasing trends in Cr(VI) concentration despite the operation of the current IM3 extraction system.	Comment noted. PG&E agrees that there is uncertainty about MNA meeting the cleanup goals over the long term, as stated in Section 5.3.3.1, Table 5-7, and Section 5.5.			Comment addressed. No changes to the CMS/FS Report are required.
294	DTSC-114	Page 5-44, Last sentence of paragraph 5, Section 5.5.1,	California Department of Toxic Substances Control	This sentence concludes that "Alternatives C through H are considered to be comparable in the time to achieve cleanup goals." This is only true because PG&E currently normalized the alternatives to completing the treatment in 20 – 30 years. DTSC suggests that PG&E conduct a sensitivity analysis to further differentiate the alternatives. See comment 60	As noted in response to comment #150, the selection of a 25 to 30 year target for the active remedial alternatives in the Draft CMS/FS Report was intended to help focus the assembly of alternatives, and provide a basis for comparison between alternatives for the purpose of the CMS/FS that does not arbitrarily bias the evaluation for or against any particular technology due to cleanup time. In response to this comment, PG&E will prepare a sensitivity analysis for Alternatives C, E, F, G, and H in a table format for inclusion in the Final CMS/FS Report discussing relationship between cleanup time and footprint. PG&E discuss the flexibility to decrease cleanup time and/or decrease footprint, will discuss the constraints/boundaries, and provide insight into the limiting factors.	DTSC will await submission of sensitivity analysis for review.		Comment resolved. The sensitivity analysis noted in the response is included in the Final CMS/FS Report as Table 5-2. Redline final submitted to agencies on November 13, 2009. Agencies approved the report revisions.
295	DOI-112	Section 5.5.1, page 5-47	U.S. Department of the Interior	It is unclear why the paragraph beginning "(W)ith respect to maximizing sustainability and minimizing disruption to sensitive resources" is located in the section discussing protectiveness of human health and the environment. This discussion might be better located in a discussion of attainment of ARARs.	Overall protection of human health and the environment should consider threats from not taking the action as well as threats from taking the action. Sustainability and impacts to sensitive resources are indicators of the overall protectiveness of an alternative and as such it is appropriate to discuss these under this criterion. Also, the criteria description has been revised to state that overall protection to human health and the environment considers both reduction in baseline risks (risks associated with not implementing the remedial alternative), as well as protection of human health and the environment from affects caused by implementing the remedial alternative.	Defer to DOI.	DOI disagrees with the response. The discussion in this paragraph focuses on the short term impacts (short-term effectiveness) and is better discussed in 5.5.5. Alternatively, PG&E may summarize all the other criteria as specified in the definition in 5.4.1.1. It does not appear that any change to the criteria description is necessary as it currently includes language regarding short term effectiveness.	Comment resolved. The paragraph about consideration of maximizing sustainability and minimizing disruption to sensitive resources in the overall protection of human health and the environment criteria has been deleted from Section 5.5.1 as requested.
296	DOI-113	Section 5.5.1, Page 5-47, 1st	U.S. Department of	DOI does not agree with the logic that Alternatives B and I are less protective because of the long timeframes required for institutional	The DOI revisions provided August 4, 2009 have been incorporated into this section. The section now indicates that of the alternatives incorporating an institutional control,	DTSC accepts RTC.	DOI accepts the response.	Comment resolved. Agencies approved PG&E response.

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		partial paragraph and Figure 5-12.	the Interior	controls before cleanup goals are attained. With the possible exception of Alternative D, all of the alternatives are likely to require extended timeframes of many decades to possibly hundreds of years or more to attain cleanup goals. DOI proposes that all alternatives except A be ranked either high or medium because they all suffer from similar limitations regarding the possible long timeframes to maintain groundwater use restrictions. DOI recommends Table 5-12 show Alternative A as low and the rest of the alternatives as high.	Alternatives B and I would require the longest time to attain the media cleanup goals; that the active Alternatives C, D, E, F, G, and H would attain the cleanup goals sooner through induced treatment; and that Alternative D likely requires the least time. Although the time to achieve cleanup goals is uncertain and may take longer than predicted for any alternative, PG&E has attempted to rank the alternatives differently based on relative comparisons of the estimated time to cleanup. Because alternatives B and I are predicted to take significantly longer than the other alternatives, these two should rank lower than Alternatives C through H for protection due to baseline risks associated with future hypothetical groundwater user in a residential setting. For river protection, per comment #297, Alternative I should be ranked higher than Alternatives A and B, and per comment #298, Alternatives C through H should be ranked higher than Alternative I. Therefore, in consideration of all these comments, no changes have been made to the rankings for the criteria protect human health and the environment, attain media cleanup goals, and control sources of releases.			Changes to Section 5.5.1 noted in the response have been made to the CMS/FS Report.
297	DTSC-117	Page 5-47, Paragraph 1	California Department of Toxic Substances Control	Alternatives B and I can not be equally ranked for Protection because Alternative I incorporates hydraulic control to maintain plume migration away from the Colorado River while Alternative B does not.	Alternatives B and I are not considered to rank equally with regard to river protection. As stated in Section 5.5.1.1, Alternatives A and B, which rely on natural processes to convert Cr(VI) to Cr(III) have some uncertainty about protection of the river because there is no way to prove that the reducing conditions exist everywhere, and over the centuries that would be required for natural processes to reach cleanup goals, it is possible that the geochemistry or groundwater flow directions, or even the location of the Colorado River channel, could change dramatically. Therefore, these two alternatives rank lower than the active alternatives (Alternatives C, D, E, F, G, H, and I) for protection of the river. Please also see response to comment #296. Please note that the criteria protect human health and the environment, attain media cleanup goals, and control sources of releases considers many factors—including, but not limited to, protection of the Colorado River—in terms of assessing protectiveness. The primary risk driver for the groundwater plume is a future hypothetical human groundwater user that may be exposed to site groundwater in a residential setting. This criteria also considers affects to human health and the environment during implementation (traffic accidents, fossil fuel use, air emissions, etc.) that are higher with Alternative I than with Alternative B.	DTSC accepts RTC.	DOI concurs with the response.	Comment resolved. Agencies approved PG&E response. No changes to the CMS/FS Report are required.
298	DOI-114	Section 5.5.1, Page 5-47, Paragraph 2	U.S. Department of the Interior	The presumption that verifiable river protection for Alternative I compares equally with Alternatives C through H is questionable. The considerations provided for A and B factor in to the evaluation of I as well, particularly time. It can be postulated that over 300 years, the same	If the types of changes in geochemistry, hydrogeology, or river flows do occur over the centuries required to attain cleanup goals, it is assumed that because Alternative I includes active operations, that changes would be made in the system O&M as warranted. Because Alternatives A and B rely on passive technologies, such adjustments to the	DTSC accepts the first paragraph of the RTC. However, DTSC disagrees that Alt I rank lower than others because of O&M period, in particular Alt E, which accelerates the plume toward the river.	DOI accepts the response, pending review of the final text.	Comment resolved following agency review and input during finalization of section 5.5.1 of the CMS/FS Report. Redline final

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				changes could occur (groundwater flow, location of channel, etc.).	remedy would not be made; therefore, Alternatives A and B rank lower than Alternative I with respect to this consideration. However, in response to this comment, this paragraph will be revised to clarify that because of the longer O&M period for Alternative I in comparison to the remaining active alternatives, Alternative I should rank lower than Alternatives C through H for river protection for these considerations.			submitted to agencies on November 13, 2009. Agencies approved the report revisions.
299	DTSC-118	Page 5-47, Paragraph 2	California Department of Toxic Substances Control	DTSC has significant concerns with the ability of Alternative E to control secondary products (Mn and As) migration when there is an aggressive gradient applied to the plume toward a treatment zone. There is limited contingency action (and time) to control hydraulic gradient once it is set in motion towards the river. PG&E should consider the utility of IM3 as a contingency to control adverse impacts. DTSC also has concerns regarding plume migration with respect to Alternative A and B when IM3 extraction is no longer active. How will PG&E control plume migration?	As described in response to comment #242, PG&E is proposing to revise the configuration of Alternative E in response to this and similar comments. In the revised configuration of Alternative E, a line of extraction wells is proposed to be installed near the Colorado River to provide hydraulic control in the floodplain and to capture flow lines originating in the plume. Additionally, methods and procedures to ensure that secondary byproducts in groundwater do not cause exceedances in water quality standards include: • Careful monitoring at strategic locations to evaluate changes in geochemical conditions in the floodplain. • Modification of injection rates to increase or decrease hydraulic gradient flow rates (e.g., startup procedures could involve very gradual increases in hydraulic flow rates that would allow for geochemical equilibration and optimization of the delivery systems). • Modification to the type and/or dosage rates of reactants to respond to changes in geochemical conditions. • Incorporation of a hydraulic gradient backup contingency system. As noted in Section 1.1.2, implementation of the existing IM is expected to continue until a final corrective action/remedial action is operating properly and successfully (see response to comments #19-21). As stated in Sections 5.3.2 and 5.3.3, no active treatment to reduce Cr(VI) concentrations in groundwater would occur in Alternatives A and B. These two alternatives would rely only on the naturally reducing conditions in shallow floodplain areas of the site to remove Cr(VI) from groundwater. No induced groundwater gradients would occur under these alternatives. Alternatives A and B assume that groundwater flows under natural hydraulic gradients.	Agree with RTC, but DTSC awaits PG&E's final revised Alternative E proposal. DTSC understands that this alternative has been modified by PG&E several times and awaits the final version for evaluation and comment. DTSC concurs with PG&E's "careful monitoring" concept. PG&E should acknowledge in the revised CMS/FS Report that additional monitoring wells/clusters will need to be installed at strategic locations in both the floodplain and upland areas (e.g., areas between extraction and injection wells where the least amount of hydraulic control is anticipated). Note the requested insert language to the left in PG&E's response.	DOI concurs with the response, pending review of the revised analysis for the alternative.	Comment resolved following agency review and input during finalization of Section 5.5.1 to the CMS/FS Report. Redline final submitted to agencies on November 13, 2009. Agencies approved the report revisions PG&E revised the configuration of Alternative E in response to this and other comments on the CMS/FS report. The revised alternative configuration was outlined in a Technical Work Group meeting September 28 (see comments #443 - #448).
300	DTSC-119	Page 5-47, Paragraph 2	California Department of Toxic Substances Control	Please clarify what is meant by "high level of management to ensure that the natural reducing conditions in the floodplain are not damaged or otherwise altered in a manner that diminishes the natural reductive capacity of the floodplain."	The following sentence has been added at the end of this paragraph for clarification: "Management of reducing conditions will involve regular sampling of groundwater to monitor redox conditions and possibly dosing with organic carbon to restore floodplain reducing capacity if it becomes depleted."	DTSC accepts RTC.	DOI concurs with the response.	Comment resolved. Agencies approved PG&E response. Changes to Section 5.5.1.1 noted in the response have been made to the CMS/FS Report.

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301	SDCWA-9	Section 5.5.1 Page 5-47	San Diego County Water Authority	In the second paragraph on this page, in the last sentence, the extra word "that" should be removed.	The change has been made as requested.	Agree with RTC.	DOI concurs with the response.	Comment resolved. Agencies approved PG&E response. Changes to Section 5.5.1.1 noted in the response have been made to the CMS/FS Report.
302	DOI-115	Section 5.5.1, Page 5-47, Paragraph 3, Sentence 9	U.S. Department of the Interior	This statement (last sentence) is redundant as it is stated earlier in the paragraph.	This paragraph has been removed in response to comment 295.	Agree with RTC.	DOI accepts the response.	Comment resolved. Agencies approved PG&E response. Changes to Section 5.5.1 noted in the response have been made to the CMS/FS Report.
303	DTSC-120	Page 5-47, Paragraph 3	California Department of Toxic Substances Control	PG&E states that "Alternative I would result in a very high level of O&M… than other active alternatives." PG&E should quantify the amount of brine currently generated at IM3 and compare with potential filter cakes from precipitate. Would there truly be more brine to be trucked under Alternative I than precipitate from Alternatives F, G and H due to volume difference?	Yes, the volume of brine generated by Alternative I would exceed the volume of precipitate from Alternatives F, G, and H by approximately a factor of 40, as outlined below. Current estimate for IM No. 3 brine is 2 percent of the influent (135 gpm). This equates to roughly 1,400,000 gallons of brine per year. Assuming a 300-year O&M period for Alternative I (and the simplified assumption that the production rate does not change over the remediation period), this equates to roughly 400 million gallons over the remediation period for this alternative. Sludge from a 1,200-gpm treatment plant, such as in Alternatives F or G, was estimated by assuming a chromium-treatment system similar to IM No. 3 is used, and that increase in sludge from IM No. 3's production would be linearly related to increased groundwater flow. This would be roughly nine times the current IM No. 3 sludge production. Current production is roughly 20 cubic yards per month. Extrapolated nine-fold, this would be about 2,200 cubic yards per year (or 440,000 gallons) of sludge per year. Assuming a 25-year O&M period for Alternative F or G, this equates to roughly 10 million gallons (50,000 yards) of sludge over the remediation period for these alternatives. Further, it should be noted that at this higher flow, it would likely be economical to install a filter press that would reduce the sludge quantity by dewatering sludge more than is currently done with the phase separators at IM No. 3. In response to this comment, additional information will be added to Section 5.5.5 to more explicitly compare the remedial alternatives in terms of energy use, waste generation, and vehicle traffic.	Agrees with RTC in concept. DTSC will review final language for consistency.	DOI concurs with the response, pending review of the final text.	Comment resolved following agency review and input during finalization of Section 5.5.5 of the CMS/FS Report. Redline final submitted to agencies on November 13, 2009. Agencies approved the report revisions.
304	DOI-116	Section 5.5.1, Page 5-48, Paragraph	U.S. Department of the Interior	The comparison in this sentence is for protection of human health from exposure to groundwater. Institutional controls are part of the protection factor. Alternatives B through I rather than C through H provide for protection from exposure to	PG&E agrees that the institutional controls provide protection from exposure to groundwater due to a hypothetical future groundwater user in a residential setting. As discussed in response to comment #296, and as stated in this paragraph because Alternatives B and I rely on institutional controls for	DTSC agrees with RTC in concept.	DOI accepts the response.	Comment resolved. Agencies approved PG&E response. No changes to the CMS/FS Report are required.

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		1, Sentence 3		groundwater.	a considerably longer time period, these alternatives do not rank as high as Alternatives C through H for protection from exposure to groundwater.			
305	DOI-117	Section 5.5.1, Page 5-48, Paragraph 1, Sentence 5	U.S. Department of the Interior	It should be clarified that the last part of the sentence pertains to Alternative I (last sentence).	The last sentence will be modified to add “for Alternative I” at the end of the sentence.	Agree with RTC.	DOI accepts the response.	Comment resolved. Agencies approved PG&E response. Changes to Section 5.5.1.4 noted in the response have been made to the CMS/FS Report.
306	DTSC-121	Page 5-48, Paragraph 1	California Department of Toxic Substances Control	If Alternative B can not effectively control plume migration before attenuation, DTSC may not consider it to be as protective or meeting the threshold criterion of human health and the environment when compared with other remedy alternatives.	Comment noted.			Comment addressed. No changes to the CMS/FS report are required.
307	DTSC-122	Page 5-48, Paragraph 1, Last sentence	California Department of Toxic Substances Control	PG&E ranked Alternative I as medium due to the potential to degrade the natural reducing capacity. As requested in earlier comments, PG&E needs to provide evidence of this assertion. Furthermore, this potential exists in alternatives D, F, and H as well as C, E, and G. Although the later set will add reductant which may off-set the potential impact.	Please also refer to response to comments #148, 175, 263, and 278. Note that this comment refers to the summary paragraph that considers the various factors discussed in Section 5.5.1 for this criteria. Alternatives B and I were ranked medium not only due to this issue, but also due to the long time required to attain cleanup goals, the long-term use of institutional controls, the high level of O&M over a long period, and the potential for altered conditions over the O&M period. With respect to the question of degrading the natural reducing capacity, primarily due to the long period of time that IM pumping would be required under Alternative I (estimated from 150 to 1,500 years), there are concerns about damage to the natural reductive capacity of the fluvial materials. There is no direct evidence that this has occurred to date (except increasing ORP at wells MW-33-40 and MW-33-90), noting that the IM has been operating for only 5 years. ORP has generally remained negative, and Cr(VI) has generally remained absent from wells completed in fluvial materials. In addition, there is isotopic and water-level evidence that oxic river water has moved landward since IM pumping has been active. If IM pumping continues, the continued efficacy of the natural reducing capacity is uncertain with the continuous influx of oxic river water.	DTSC accepts RTC.	DOI concurs with the response.	Comment resolved. Agencies approved PG&E response. No changes to the CMS/FS Report are required.
307 .5	CRIT-34	Section 5.5.1	Colorado River Indian Tribe via BLM	Norman Shopay asked what degree of protection is offered (high, medium, or low) for each of the 9 alternatives.	The degree of protection is assessed within the overall protection of human health and the environment criterion. Section 5.5 and Figure 5-12 present the ranking of each alternative with respect to all evaluation criteria.	Agree with RTC in concept. Will review final Section 5 for consistency.	DOI concurs with the response.	Comment resolved. Agencies approved PG&E response. No changes to the CMS/FS Report are required.
308	DOI-118	Section 5.5.2, Pages 5-48 and	U.S. Department of the Interior	Please delete the references to “an ARARs waiver per CERCLA Section 121(d)” or, in the alternative, describe specifically the waiver that might be appropriate and the basis for granting such a waiver that applies to these	To address the issue of a potential ARARs waiver, the text of Section 5.5.2 has been revised to state that Alternatives B and I may need to obtain a waiver from attaining state and federal MCLs per CERCLA Section 121(d)(4), which allows a waiver if “the remedial action selected is only part of a total	Defer to DOI.	The Department of Interior Solicitors’ Office provided revised final language for Section 5 on 10/16/2009. This language resolves the comment.	Section 5.5.2 has been substantially revised by incorporating the language provided by DOI, which focuses on

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		5-49		circumstances. In addition, the last two paragraphs of section 5.5.2 will need to be substantially revised. It is premature at this point to imply, as the draft CMS/FS does, that all alternatives will attain all ARARs based on “steps (that) will be taken during design and implementation of the selected alternative...” and it is premature to expressly state, as the draft does, that Alternatives B - I “are considered to comply with the identified chemical-, location-, and action-specific ARARs ... and are ranked high for this criterion.” As referenced in the cover letter accompanying these comments, DOI will supply PG&E with specific language concerning whether or not each alternative attains cultural resource and refuge-based ARARs for incorporation in the final CMS/FS.	remedial action that will attain such level or standard of control when completed.” In this case, use of institutional controls to prevent development of groundwater as a drinking water supply would be viewed as an interim measure until MCLs were attained.; The last two paragraphs of Section 5.5.2 will be revised to reflect DOI’s evaluation of whether or not each alternative attains cultural resource and refuge-based ARARs.			attainment of cultural resource and refuge-based ARARs and does not include a discussion of a potential ARARs waiver for attainment of MCLs.
309	DTSC-123	Page 5-48, Last sentence	California Department of Toxic Substances Control	As stated in an earlier comment, Title 22, Article 6 monitoring standards do not apply to SWMU1/AOC 1 because it is not a permitted regulated unit. Please remove this discussion from the analysis.	Reference to these requirements has been removed as requested.	Agree with RTC.	DOI concurs with the response.	Comment resolved. Agencies approved PG&E response. Changes to Section 5.5.2 noted in the response have been made to the CMS/FS Report.
310	DTSC-124	Page 5-49, Third paragraph	California Department of Toxic Substances Control	DTSC does not believe that an alternative should rank high if it meets an ARAR attainment through a CERCLA waiver.	Alternatives B and I have been re-ranked as medium for this criterion. Figure 5-12 Qualitative Comparison of Remedial Alternatives, has also been revised to reflect this ranking.	This will need to be revised as a result of Water Board ARAR evaluation.	DOI defers to DTSC noting that the Department of Interior Solicitors’ Office provided revised final language for Section 5 on 10/16/2009.	Alternatives B and I have been re-ranked as low for this criteria, based on DOI’s evaluation that they do not comply with SWRCB Resolution 92-49. Language concerning obtaining an ARARs waiver has also been deleted, as indicated in the response to comment # 308.
311	DOI-119	Section 5.5.3, Pages 5-49 and 5-50 and Figure 5-12.	U.S. Department of the Interior	DOI is concerned about the long-term effectiveness of the alternatives that involve in situ treatment in the upland area. The USGS believes the potential exists for treated areas to become re-contaminated through reversal of the Cr(VI) to Cr(III) reduction process once the aquifer re-establishes oxidizing conditions. For this reason, DOI believes that Alternatives C and D should be ranked as medium rather than high. DOI believes the distinction in the reliability of Alternative B and Alternatives C, D, and E is	Cr(III) stability was discussed in comment #176 (DOI-63) and subsequent comments. PG&E believes that the Cr(III) will remain stable at concentrations below background following treatment in the IRZ and that Alternatives C and D should remain ranked as high. The text in Section 5.2.6, leading up to Section 5.5, will be edited to add clarity with respect to these topics. Monitored natural attenuation (Alternative B) was discussed in comment #148 (HA-24) and subsequent comments. Based on the level of uncertainty associated with Alternative B and that IRZ operations can be managed to maximize		Comment resolved with the 10/13/09 modification of the language provided by DOI in the file transmittal entitled “Sec 5 DOI edits 8-4-09”, pending review of final text, As we stated earlier, given the potential uncertainty of Cr(III) coexisting with MnO2, the conclusion that the Cr(VI) reduction reaction is irreversible cannot be demonstrated with certainty. DOI therefore concludes that Figure 5-12	Comment resolved following agency review and input during finalization of Section 5.5.3 to the CMS/FS Report. Redline final submitted to agencies on November 13, 2009. Agencies approved the report revisions, including the revision of

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				overstated. While there is uncertainty associated with long term river conditions for Alternative B, there is also significant uncertainty that in situ treatment technologies will be able to reach and maintain background levels throughout the aquifer in the long term. Moreover, Alternatives C and E also may require extended timeframes to reach cleanup goals. DOI believes this factor should be the same for Alternatives B, C, D, and E. DOI recommends the rankings in Figure 5-12 for this criterion be revised to medium for Alternatives C and D to reflect the long-term risk from potential reversal of the Cr reduction reaction as the aquifer re-oxidizes.	effectiveness, PG&E believes that Alternative B is distinct from Alternatives C, D, and E. The addition of the upland and floodplain IRZ remedial elements above and beyond the natural attenuation mechanism that is operational on the floodplain has to increase the reliability beyond the natural attenuation process alone. Cleanup time frames are discussed in comment #195 (DOI-71); there is uncertainty in the cleanup time frames estimated for all alternatives; however, IRZ operations can be managed, and PG&E believes the cleanup time frames are properly ranked. Based on the above information, PG&E believes the rankings in Figure 5-12 are correct.		should be modified to reflect this uncertainty.	ranking of Alternatives C, D, and E from high to medium-high for this criterion.
312	DTSC-125	Page 5-49, Section 5.5.3	California Department of Toxic Substances Control	PG&E should balance the evaluation in that *in-situ* reduction will create secondary products near the river that may require long term monitoring and control. In addition, a substantially higher amount of Cr(III) will remain in the formation from *in-situ* treatment that may revert to Cr(VI) under changing conditions.	*In-situ* byproduct generation and attenuation was raised in comments #176 (DOI-63), 181 (DOI-66), and several subsequent comments. Cr(III) stability was discussed in comment #176 (DOI-63) and subsequent comments. Careful monitoring during the initial phase(s) of *in-situ* operation will enable early detection of these conditions. Specific contingencies will be in place to address any potential threat to the Colorado River As discussed in comment #176, the amount of Cr(III) deposited as a result of *in-situ* treatment is small compared to the naturally occurring Cr(III) in the soil matrix. The amount deposited is expected to be within one standard deviation of the average Cr(III) concentration in the soil. The chromium removed from the groundwater will be stable as very low solubility chromium hydroxide and mixed iron-Cr(III) hydroxide minerals. Cr(III) re-oxidation will be inhibited by the reduced iron minerals (FeS) that are formed during active treatment, natural alkaline groundwater pH, and continuous movement of the groundwater. Section G.7.0 of Appendix G discusses the solubility of the Cr(III) hydroxide precipitates and mixed iron-Cr(III) hydroxides that form in the IRZ. At the groundwater pH found at Topock, the maximum Cr(III)-hydroxide solubility reported in the literature is almost an order of magnitude below 32 µg/L, while the maximum reported iron-Cr(III) hydroxide solubility is almost two orders of magnitude below this target.)	Please remove highlighted portion of text. This will be address in contingency planning during design and O&M. PG&E should also acknowledge that specific contingencies will be in place to address any potential threat to the aquifer as a whole to ensure its protection. See response to comment 176 regarding chromium stability. DTSC believes there is uncertainty regarding the amount of reactive Cr(III) available as a result of *in-situ* treatment compared to the amount of naturally occurring reactive Cr(III) in the soil matrix. Precipitated *In-situ* chromium would line pore throats and be in greater communication with the aquifer. It seems that the bottom line is that the precipitated *in-situ* chromium could only add to the existing background processes that form hexavalent chromium. Also, see response to comment 299 regarding “careful monitoring”. DTSC awaits final text for review.	Defer to DTSC.	Comment resolved following agency review and input during finalization of Section 5.5.3 of the CMS/FS Report text. Redline final submitted to agencies on November 13, 2009. Agencies approved the report revisions. Table 5-3, example Contingency Actions During Remedial Alternative Implementation addresses attainment of RAOs considering the aquifer as a whole. Appendix G addresses the stability of the Cr(VI) reduction reaction.
313	DTSC-126	Page 5-50, Section 5.5.3, Second paragraph	California Department of Toxic Substances Control	PG&E should include a discussion on the limitation and uncertainty of MNA to fully attenuate the chromium plume without plume migration. Prior to implementation of IM3, there is a substantial concentration of Cr(VI) within the aquifer that did not attenuate. Although MNA can control and reduce a portion of the plume, it is unlikely to fully remediate the current plume. DTSC notes that PG&E also acknowledges this	The limitations of natural attenuation are discussed in Section 5.3.3.1, which states that although the reducing conditions in the shallow floodplain and beneath the river have been present at every location where a well has been installed or a pore water sample has been collected, there is no way to prove that these conditions exist everywhere. Over the centuries that would be required for MNA to reach cleanup goals, it is possible that the geochemistry of the river or groundwater flow directions, or even the location of the	Agree with RTC.	DOI concurs with the response.	Comment resolved. Agencies approved PG&E response. Changes to Section 5.3.3.1 noted in the response have been made to the CMS/FS Report.

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				limitation in Section 5.5.4, page 5-51.	Colorado River channel, could change significantly. See proposed changes to Section 5.3.3.1 in response to comments #174 and #214. The DTSC is correct that natural reducing conditions do not occur everywhere at the site, these conditions are observed within fluvial deposits along the Colorado River floodplain and in bedrock. Therefore, MNA would not remediate the plume in its *current l*ocation primarily in upland areas of the Alluvial Aquifer, and Alternatives A and B rely on *movement* of the plume under natural hydraulic gradients to the natural reductive conditions in the floodplain.			
314	DTSC-127	Page 5-50, Section 5.5.3, Second paragraph	California Department of Toxic Substances Control	PG&E should also provide some discussion on the limitation of Alternative E in that proper hydraulic control must be maintained to usher the contamination towards the treatment area. It may technically be equally challenging as delivering reductant to the entire plume under Alternatives C and D.	As described in response to comment #242, PG&E proposes to revise the configuration of Alternative E. The revised version involves a line of extraction wells in the eastern floodplain that will capture all groundwater from the plume. The extracted water will be carbon-amended and reinjected at the western edge of the plume. This injection, combined with clean water injection further west, will act to flush clean water through the plume. Maintaining hydraulic control under Alternative E is not expected to pose any significant challenges. The injection wells are pushing the plume in the direction it already tends to flow. There is capacity in the Alternative E injection system to completely overwhelm the effects of any seasonal or daily river fluctuations. The following sentence will be added to the paragraph: "Maintaining hydraulic control through pumping or injection is relatively easily accomplished at the Topock site due to the flat groundwater gradients and lack of extensive aquitards within the Alluvial Aquifer."	DTSC awaits PG&E's final revised Alternative E proposal, but accepts the RTC in concept. However, we still have concerns over the flow paths of the injected water (both clean and dosed) over time for the revised Alt E. DTSC understands from the latest proposal of Revised Alt E, PG&E will extract 500 gpm by the river, but inject 1000 gpm (500 clean water, 500 reinjection with carbon). There is net 500 gpm of head into aquifer. PG&E has yet to illustrate where the resulting water will end up. Additionally, the effect of combining the East Ravine proposal(s) with the alluvial plume is still to be finalized by PG&E.	DOI withholds concurrence pending review of the revised text for Alternative E.	Comment resolved following agency review and input during finalization of Section 5.5.3 to the CMS/FS Report text. Redline final submitted to agencies on November 13, 2009. Agencies approved the report revisions.
315	DTSC-128	Page 5-50, Section 5.5.3, last paragraph	California Department of Toxic Substances Control	Alternative G and H are not equal as F and I in that G and H also rely on *in-situ* to supplement *ex-situ* treatment. As stated in earlier comment, PG&E should also consider the need to monitor for secondary product as part of the remedy. As for off-site disposal, it may become a long term financial liability to PG&E, but as PG&E stated in the last paragraph of page 5-49, an offsite facility is assumed to provide reliable long-term containment.	As stated in Section 5.5.3, risk from residual contamination in groundwater would be reduced as Cr(VI) mass within the plume is treated; reduction in mass could be through in-situ treatment and/or through ex-situ treatment. Each of the alternatives that incorporates ex situ treatment still includes the requirement for long-term containment of residual wastes regardless of whether the alternative also includes in-situ treatment as a component. PG&E agrees that monitoring of secondary byproducts would be a part of all alternatives that include *in-situ* treatment. Pilot tests have indicated that byproducts would be manageable.	See response to comment 299 regarding "careful monitoring." See comment 325 regarding persistence of byproducts.		Section 5.5.4.4 includes a statement about careful monitoring, and persistence of byproducts, as follows: "It is recognized and expected that byproducts such as arsenic and manganese will exceed baseline and background concentrations during implementation of *in-situ* methods. Under ideal geochemical and hydrologic conditions described in Appendix G, arsenic and manganese byproducts should not be a significant issue.

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								However, because of uncertainty in the complexity of aquifer lithology and geochemistry, large-scale implementation of *in-situ* treatment could result in elevated concentrations of arsenic and manganese that persist for longer than expected periods of time in some portions of the aquifer. Careful monitoring during the initial phase(s) of *in-situ* operation will enable early detection of these conditions. Specific contingencies will be in place to address any potential threat to the Colorado River or the aquifer." Cost estimates for monitoring include the analytical parameters associated with in-situ treatment byproducts (e.g., arsenic and manganese). Comment resolved following agency review and input during finalization of the CMS/FS Report text. Redline final submitted to agencies on November 13, 2009. Agencies approved the report revisions.
316	SDCWA-10	Section 5.5.3 Page 5-50	San Diego County Water Authority	The first paragraph on this page states that "all the alternatives [with the exception of Alternative A] would include 5-year reviews to evaluate the effectiveness of the remedy to attain remedial action goals, and the adequacy and reliability of controls." Given that Alternatives C through H have been estimated with cleanup goals in approximately 10 to 30 years, conducting 5-year reviews could potentially limit the number of reviews to one or two. This doesn't seem to be often enough to adjust measures and controls if	PG&E agrees. There are more frequent opportunities than the 5-year reviews to adjust measures and controls if they are shown to be inadequate or unreliable. As stated in Section 5.4, optimization of the remedy would occur throughout the design, construction, and operational phases of remedy implementation. Also, as described in Appendix D, the various cost estimates assume quarterly or annual monitoring and reporting cycles to evaluate progress and system performance.	DTSC accepts RTC and notes that routine and frequent evaluation of the remedy will occur, especially during start up.	DOI concurs with the response.	Comment resolved. Agencies approved PG&E response. No changes to the CMS/FS Report are required.

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				they are shown to be inadequate or unreliable. The frequency of reviews should be more carefully considered.				
317	DTSC-129	Page 5-51, Section 5.5.3, First paragraph	California Department of Toxic Substances Control	Although PG&E considers C, D and E to be equal in long term controls, DTSC believes that because Alternative E will potentially depend on the hyporheic zone to sorb most of the secondary product (Mn and As) liberated from the reductive zone, a higher Mn and As concentration would be present near the river. A careful monitoring program will need to be developed to ensure long term protection and that control may be necessary to prevent scouring or dredging of the river bottom.	*In-situ* byproduct generation and attenuation was raised in comments #176 (DOI-63), #181 (DOI-66), and several subsequent comments. In addition, the topic of the hyporheic zone is discussed in comment #176 and in comments to Appendix G (starting with comment #425 [DTSC-187]). As described in the response to comment #242, PG&E will revise the configuration of Alternative E replace the floodplain IRZ lines with a line of extraction wells near the river to capture floodplain groundwater. Secondary products will be monitored in upgradient injection areas well away from the river. Though the hyporheic zone is important, the majority of the secondary byproducts will be attenuated prior to reaching this area. The reduced forms of manganese and arsenic will be attenuated through precipitation, sorption, diffusion, and co-precipitation. Arsenic and manganese do not need to be transported to an oxidized zone to precipitate as a carbonate (for manganese) or sulfide (for arsenic), both of which happen in reducing zones of an IRZ. Adsorption of these elements also occurs in the reducing zone to minerals that are stable in the reducing zone, including iron sulfides, mixed valence iron oxides such as magnetite or green rust, and some aluminum hydroxides and silicates. The concentrations of arsenic and manganese potentially reaching the river are not expected to be different than the arsenic and manganese that is in the natural reducing conditions in the floodplain local to the river. Careful monitoring during the initial phase(s) of *in-situ* operation will enable early detection of these conditions. Specific contingencies will be in place to address any potential threat to the Colorado River. If needed, natural recovery of byproducts can be accelerated through the injection of clean groundwater into the aquifer or some other appropriate measure, such as the injection of aerated water or air into the aquifer.	DTSC awaits PG&E's final revised Alternative E proposal. DTSC understands that this alternative has been modified by PG&E several times and awaits the final version for evaluation and comment. See response to comment 299 regarding "careful monitoring." PG&E should also acknowledge that specific contingencies will be in place to address any potential threat to the aquifer as a whole to ensure its protection.	DOI withholds comment pending discussions on 10/13.	Comment resolved following agency review and input during finalization of the CMS/FS Report text. Redline final submitted to agencies on November 13, 2009. Agencies approved the report revisions.
318	DOI-120	Section 5.5.4, Page 5-51	U.S. Department of the Interior	The USGS has expressed concern about the potential reversibility of the Cr(VI) to Cr(III) reaction as the natural oxidizing groundwater conditions re-establish in the Alluvial Aquifer over the long term. This is particularly a concern in the upland areas and hence a concern for Alternatives C, D, and H, where upland in situ treatment is proposed. PG&E's discussion in this section about the irreversibility of the reaction does not address this concern, and, in fact, its discussion of manganese transformation later in the section (top of Page 5-52) supports this concern. DOI believes the upland in situ treatment alternatives (Alternatives C, D, and H) may result in long term residual Cr(VI) in the upland area Alluvial Aquifer.	DOI's suggested text revision for this section is revised as follows: "Reduction of Cr(VI) to Cr(III) results in the formation of Cr(III) oxides that have a low solubility under the neutral and alkaline pH encountered in site groundwater. The low solubility of Cr(III) will limit the availability of Cr(III) that can be re-oxidized to Cr (VI), however the Cr(III) that is soluble may come into contact with manganese oxide (MnO2) and be re-oxidized to Cr(VI), leading to the formation of Cr(VI) in groundwater. Thus, while over the long term it cannot be said that the Cr(VI) reduction reaction is irreversible, the technical evidence presented in Appendix E, Section(##) indicates that re-oxidation of Cr(III) to Cr(VI) may be minimal and not lead to concentrations that exceed background."	Please see response to comment 176/DOI-63 regarding Cr(VI) generation from reductively precipitated *in-situ* processes. See also response to comment 312 regarding precipitated *in-situ* chromium adding to the existing background processes that form hexavalent chromium.	Comment resolved with the 10/13/09 modification of the language provided by DOI in the file transmittal entitled "Sec 5 DOI edits 8-4-09", pending review of final text, Reduction of Cr(VI) to Cr(III) results in the formation of Cr(III) oxides that have a low solubility under the neutral and alkaline pH encountered in site groundwater. However Cr(III) that comes into contact with MnO2 can be reoxidized to Cr(VI), leading to increased concentrations of Cr(VI) over time. The argument is made in Chapter 5 and Appendix E that *in-situ* treatment of the aquifer will create	DOI's suggested text revision for this section will appear as follows: "The degree to which the Cr(VI) reduction is irreversible is similar for the alternatives involving *in-situ* treatment (Alternatives A, B, C, D, E, G, and H). As discussed in Section 5.2.6, once reduced to Cr(III), chromium takes the form of the

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					As discussed in response to comment DOI-63 and DOI-89, the reaction between precipitated manganese and reduced chromium will be limited because of (1) self-limiting nature of this reaction because of passivation reactions, (2) reduced iron compounds such as FeS passivating manganese oxides from reacting with Cr(III), and (3) low rate of reoxidation at the ambient pH at Topock. Any reaction between manganese and chromium is expected to result in very low concentration of Cr(VI) because of (1-3), as well as the fact that Cr(III) will not be present at a high concentration at any one location (as opposed to Cr(III) in serpentine minerals enriched in chromite present at some locations in the Mojave River valley).		reducing conditions where MnO2 is not stable and only Mn2+ will be present. It is likely that manganese oxides are intermixed with other oxides in the aquifer solids and some MnO2 may persist after the *in-situ* reductant has been depleted. Thus, a source of Cr(III) oxidant could still be present in the same area of the aquifer where Cr(VI) has been initially reduced. Chapter 5 also states that 'by the time MnO2 could form again in downgradient oxidizing environments, chromium would not be present, having precipitated back in the reducing zone'. Given the complex injection scheme of some alternatives, it is possible that the area where this MnO2 reprecipitates may overlap zones where Cr(VI) has been reduced to Cr(III) by *in-situ* treatment in a different area of the aquifer. Given the potential uncertainty of Cr(III) coexisting with MnO2, the statement that the Cr(VI) reduction reaction is irreversible is only an educated hypothesis. Although reoxidation of Cr(III) to Cr(VI) may be minimal and not lead to concentrations that exceed background, the possibility that some Cr(III) could be reoxidized should be acknowledged.	Cr^{3+} ion and forms very low solubility oxides under the neutral and alkaline pH encountered in site groundwater. Solubility of chromium oxide Cr_2O_3 and chromium hydroxide, $Cr(OH)_3$, are low enough to maintain the Cr^{3+} concentration below the detection limit of 0.2 µg/L (Brookins, 1988; Schecher and McAvoy, 1998). Once reduced, Cr(III) does not readily become reoxidized to Cr(VI); however, Cr(III) that comes into contact with manganese oxide (MnO_2) or dissolved oxygen can be re-oxidized to Cr(VI), leading to increased concentrations of Cr(VI) over time. Two key factors are expected to limit the re-conversion of Cr(III) to Cr(VI) after *in-situ* reduction: the limited solubility of Cr(III) and the lack of availability and reactivity of an adequate oxidizer (MnO_2). Together these factors are expected to limit any reoxidized Cr(VI) concentrations to levels similar to ambient background." The response to comment #312 provides a summary of the factors that limit the precipitated *in-situ* chromium from adding to background (additional discussion is provided in Appendix G, Section G.7.3).

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319	DOI-121	Section 5.5.4, Page 5-51, Paragraph 2, Line 3	U.S. Department of the Interior	Change “insoluble oxides” to “low-solubility oxides”.	We have changed “insoluble oxides,” to “very low-solubility oxides.” Section G.7.0 of Appendix G discusses the solubility of the Cr(III) hydroxide precipitates and mixed iron-Cr(III) hydroxides that form in the IRZ. At the neutral to slightly alkaline pH groundwater pH at Topock, the maximum Cr(III)-hydroxide solubility reported in the literature is almost an order of magnitude below 32 µg/L, while the maximum reported iron-Cr(III) hydroxide solubility is almost two orders of magnitude below this target.	DTSC concurs with DOI’s response.	DOI accepts the proposed change.	Comment resolved. Agencies approved PG&E response. Changes noted in the response have been made to the CMS/FS Report.
320	DTSC-130	Page 5-51, Paragraph 2, Section 5.5.4	California Department of Toxic Substances Control	Consideration should be given to designing a remedial alternative that focuses on source zones/ high concentration zones. Alternatives described in Section 5.3 and 5.5.1 do not appear to focus on this issue. The Report should Identify the areas of highest Cr(VI) concentrations (e.g., MW-24 to MW-20) and see if alternatives can concentrate on high mass removal and/or controlling the high concentration zones.	The remedial alternatives in the CMS/FS Report were designed at a conceptual level with a focus to attain the preliminary cleanup goal throughout all areas of the plume not just high concentration zones. No additional remedial alternatives have been added to the CMS/FS in response to this comment.	DTSC agrees to defer this issue to remedy design.	DOI concurs with deferring this issue until a remedy is selected.	Comment resolved. Agencies approved PG&E response. No changes to the CMS/FS Report are required.
321	DTSC-132	Page 5-51, Paragraph 2, Section 5.5.4	California Department of Toxic Substances Control	The discussion of irreversible reduction of Cr(VI) focused on MnO2 formation in a down gradient re-oxidized areas outside the treatment zone where minimal Cr exists. The discussion, however, does not address the potential of reversal of Cr(III) to Cr(VI) in the presence of MnO2 within the plume area where most of the reduced Cr will stay when the area returns to an oxidizing state.	Cr(III) stability was discussed in comment #176 (DOI-63) and subsequent comments. The statement that “the Cr(VI) reduction reaction that occurs in all seven alternatives is irreversible under site conditions” will be removed from the text. The text in Section 5.5.4 has been edited to add clarity with respect to attenuation of and monitoring for secondary byproducts and the long-term stability of Cr(III), as detailed in response to comment #312.	Please see response to comment 176 and 318 regarding Cr(VI) generation from reductively precipitated *in-situ* processes. DTSC awaits final text for review.	DOI anticipates further discussion on 10/13.	Comment resolved following agency review and input during finalization of Section 5.5.4 to the CMS/FS Report. Redline final submitted to agencies on November 13, 2009. Agencies approved the report revisions.
322	DOI-122	Section 5.5.4, Page 5-51, Paragraph 3	U.S. Department of the Interior	This paragraph should be clarified to state that Alternatives A and B are not considered to include treatment. This criterion addresses the statutory preference for employing treatment technologies. These processes are naturally occurring and not considered treatment technologies.	In response to this comment the first sentence of the paragraph in Section 5.5.4.2 has been revised as follows: “Alternatives A and B rely on the natural reducing conditions in fluvial materials near the Colorado River to reduce Cr(VI) to Cr(III) *through no active treatment*, while the remaining alternatives involve active treatment to reduce Cr(VI) to Cr(III) either *in-situ* (Alternatives C, D, E, G and H) and/or *ex-situ* (Alternatives F, G, H, and I).”	Agree with RTC.	DOI accepts the revised text in the response.	Comment resolved. Agencies approved PG&E response. Changes to Section 5.4.4 noted in the response have been made to the CMS/FS Report.
323	DOI-123	Section 5.5.4, Page 5-51, Paragraph 3, Sentence 2	U.S. Department of the Interior	Add “through treatment” to the end of this sentence (last sentence of paragraph).	The suggested change has been made.		DOI accepts the response.	Comment resolved. Agencies approved PG&E response. Changes to Section 5.5.4 noted in the response have been made to the CMS/FS Report.

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324	DTSC-131	Page 5-51, Paragraph 3, Section 5.5.4	California Department of Toxic Substances Control	The section states, *"Solubility of chromium oxide, Cr2O3, is low enough to maintain Cr3+ concentration below the detection limit of 0.1 µg/L (Brookins, 1988)."* For clarity, The CMS should indicate the mechanisms that allow naturally occurring Cr(VI) background concentrations to occur up to the 30 ug/L range at the Topock area.	In response to this comment, the following is proposed to be added to Section 2.3: "Natural background Cr(VI) concentrations exist in groundwater in the alluvial aquifer at Topock. The source of natural Cr(VI) is primarily from pyroxene and amphibole minerals in area rocks. The chromium contained in these minerals is mobilized by oxidation of Cr(III) to Cr(VI) on the surfaces of manganese oxide minerals. Because Cr(VI) is very soluble, the natural background concentration in an oxidizing environment is limited by the following 1) the amount of chromium in the natural rock material, 2) the formation of dissolved Cr(III) from the natural rock material, and 3) the presence and availability of reactive manganese oxides. In order for Cr(III) to react with manganese oxides, it first must undergo dissolution. The groundwater pH at Topock limits the ability of Cr(III) to dissolve (Cr(III) is only very sparingly soluble at the slightly alkaline groundwater pH). In addition, not all of the Cr(III) present in the natural rock material is reactive, rather only a portion may be reactive due to weathering of the chromium minerals in the rock and the creation of labile forms of Cr(III). Aquifer materials derived from granitic rocks in the Mojave Desert to the west have shown natural Cr(VI) concentrations up to 36 µg/L (Ball and Izbicki, 2004). More mafic rocks such as diorite, basalt, and serpentinite would be expected to produce higher groundwater concentrations of Cr(VI), since these rocks contain a higher concentration of the chromium source minerals. The background value of 31.8 µg/L found in the Topock area is consistent with these observations, as the source rock for the alluvium is metadiorite."	DTSC accepts the response. Also see Comment 176.	DOI concurs with the response.	Comment resolved. Agencies approved PG&E response. Changes to Section 5.5.4 noted in the response have been made to the CMS/FS Report in Section 2.3.3.
325	DOI-124	Section 5.5.4, Page 5-52, Paragraph 3	U.S. Department of the Interior	This may be true for Mn(II), but As(III) can be relatively mobile at aquifer pH values. Both Mn(II) and As(III) have been reported to exist in oxidizing environments, even though thermodynamics predicts their oxidation. Oxidation of both species can be rate-controlled reactions.	Re-precipitation of manganese through oxidation is self-supported (auto-catalytic), especially in alkaline groundwater pH at the site, and the formation of manganese oxidation can also result in the oxidation of As(III) to As(V). More details are provided here. Manganese oxidation rates are dependent upon the concentration of oxygen and the square of the hydroxide concentration and are therefore more rapid at elevated pH. In addition, Mn(II) oxidation has been shown to be autocatalytic—once manganese oxide solids begin to form as Mn(II) oxidation increases with the concentration of solid surfaces that are formed (von Langen et al., 1997). Work by Oscarson et al. (1981a, 1981b, 1983) has shown that manganese oxides can oxidize arsenic (III), as can ferric iron. These reactions are expected to limit the As(III) concentration and may accelerate the transformation from As(III) to As(V). These processes were also shown to be a factor in the transformation of As(III) to As(V) during seasonal processes in a eutrophic lake (Kuhn, et al., 1993).	DTSC concurs with DOI's requests identified in the last paragraph of the DOI response. DTSC awaits PG&E's proposed revised CMS language regarding Appendix E (see PG&E response to the left). DTSC notes that results of the *in-situ* pilot study in the upland and floodplain area do show that arsenic, iron, or manganese do persist and remain elevated above baseline concentrations documented at pilot test wells prior to test start up. Additional discussion should be added to Appendix E to include discussion of this information. PG&E's use of the term "baseline" that is based on data from one anomalous well (well PT-6S) is inappropriate.	Comment resolved with the language provided by DOI in the file transmittal entitled "Sec 5 DOI edits 8-4-09", pending review of final text, The von Langen reference refers to nanomolar concentrations in sea water, not mg/L concentrations in an aquifer. Depending on location in the aquifer, Mn sorption may be a more important attenuation mechanism than oxidation and precipitation. This assumes that As(III) comes into contact with manganese oxides, which may be valid in some parts of the aquifer but not others where Mn has been reduced. Acknowledgement of the uncertainty should be stated and a statement that ongoing monitoring during implementation will occur and	Comment resolved following agency review and input during finalization of Section 5.5.4 to the CMS/FS Report. Text has been added to Section 5.5.4 to address the generation of secondary byproducts and monitoring and contingencies, as detailed in response to comment #312. Appendix G has been updated to provide additional discussion of the pilot study data. Redline final submitted to agencies on November 13, 2009.

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							contingencies will be in place should be provided.	Agencies approved the report revisions.
326	DOI-125	Section 5.5.4, Page 5-52, Paragraph 4	U.S. Department of the Interior	Reprecipitation may not be rapid if a large reducing zone is created. There is the possibility that more time could be needed for reestablishing oxic conditions than was needed to remove the Cr(VI).	Discussion will be provided as per the suggested revised text detailed in response to comment #181 (DOI-66). Estimated concentrations will be provided in this section. DOI's suggested revision to text in this section has been revised as follows: "Byproducts from in-situ treatment are expected to be localized to the reducing zone and within the range of naturally occurring concentrations found at the site (Appendix E), but could be temporarily elevated above background in some portions of the aquifer." Re-precipitation of byproducts will occur within the reduced zone through sulfide mineral precipitation, sorption to reduced iron minerals, as well as carbonate precipitation (in the case of iron and manganese). Outside of this zone, re-precipitation will be more rapid and travel distances for byproducts will be limited because of the co-precipitation of iron (hydr)oxides and arsenic and the oxidation of manganese and subsequent manganese oxide precipitation. The establishment of oxic conditions within the IRZ will take longer than the time required to precipitate Cr(VI) due to the quantity of reduced minerals that build up within the IRZ balanced against the natural rate of oxygen recharge. However, the size of the reducing zone will be controlled through recirculation, and control of the concentration of injected total organic carbon and the re-precipitation mechanisms will be active downgradient of the IRZ.	DTSC requests that DOI's originally requested modification to this section be incorporated into the Report. Please also see the DTSC response to comment 176/DOI-63 regarding byproduct persistent in the fluvial aquifer adjacent to the Colorado River.	Comment resolved with the modification of the language provided by DOI in the file transmittal entitled "Sec 5 DOI edits 8-4-09", pending review of final text, There is acknowledgment within the text that "limited migration out of the reduced zone" will occur. This is of particular concern adjacent to the river. Provide estimated concentrations within the text, noting monitoring will be continues throughout implementation and acknowledge that contingencies will be in place.	DOI's suggested revision to text in this section has been finalized (Section 5.5.4.5): "Byproducts from *in-situ* treatment are expected to be localized to the reducing zone formed by the IRZ and within the range of naturally occurring concentrations found at the site (Appendix G) but could remain temporarily elevated above baseline and background concentrations in some portions of the aquifer." Discussion is provided in Appendix G (Section G.8) with respect to re-precipitation mechanisms.
327	DOI-126	Section 5.5.4, Page 5-53, last paragraph of section	U.S. Department of the Interior	This criterion typically addresses whether or not a reduction of toxicity, mobility, or volume is achieved through active treatment activities, not through natural attenuating factors. Alternatives A and B should be ranked low because they rely solely on natural attenuation to reduce contaminant concentrations and do not achieve reduction of toxicity, mobility, or volume through active treatment. DOI recommends the rankings in Table 5-12 be revised to low for Alternatives A and B since they do not involve active treatment. Alternatives C and H should be medium because of the potential for long-term reversibility of the Cr reduction reaction in the upland area.	As noted in Section 5.5.4.5, Alternatives A and B rank lower for this criterion than the other alternatives because these alternatives are passive and the amount of the plume that may be treated is less certain, rather than because Alternatives A and B do not involve chemical conversion of Cr(VI) to Cr(III). No change to the rankings for Alternatives C and H have been made; please also refer to response to comments #176, #181, #232, and #239 about the stability of the chromium reduction reaction.		DOI disagrees with the response and maintain that Alternatives A and B should be ranked low because they are not active treatment.	Comment resolved following agency review and input during finalization of Section 5.4.4 to the CMS/FS Report. Redline final submitted to agencies on November 13, 2009. Agencies approved the report revisions.
328	CRIT-7	Section 5.5.4	Envirometrix (on behalf of the Colorado River Indian Tribe)	For each remedial alternative it is critical to determine and compare the estimated quantity of actual chromium contamination that will be removed from the groundwater system and transported offsite. For comparison purposes, we request that for each remedial alternative presented, PG&E determine the total amount of	In response to this comment, graphs will be added to Appendix F to show the relative percentage of Cr(VI) mass removed by *in-situ* and *ex-situ* methods in the different remedial alternatives. Estimates of plume mass that would be treated by ex-situ methods and transported offsite for each alternative will be provided.	DTSC agrees with RTC in concept and will review graphs in Appendix D.	DOI concurs with the response.	Comment resolved following agency review and input during finalization of Appendix F to the CMS/FS Report. Redline final submitted to agencies on

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				actual chromium that will be removed from the groundwater and transported offsite. We believe that this is fundamental information that should be presented for each alternative in this CMS/FS. We would like to be clear that we are interested in the amount of chromium contamination that each alternative will actually remove from the groundwater and transported offsite and not what may be converted from one form of contamination in groundwater into another form of contamination in soil and remain onsite.				November 13, 2009. Agencies approved the report revisions.
328 .1	CRIT-35	Section 5.5.4	Colorado River Indian Tribe via BLM	He also wanted to know how much Cr VI is being removed from groundwater with each alternative	Estimates of plume mass that would be treated and transported offsite for each alternative will be provided.	See 328.	DOI concurs with the response.	Comment resolved following agency review and input during finalization of Appendix F to the CMS/FS Report. Redline final submitted to agencies on November 13, 2009. Agencies approved the report revisions.
328 .3	CRIT-39	Section 5.5.4	Colorado River Indian Tribe via BLM	Michael Tsosie noted that they have held the position all along to remove all contaminants from the water and soil	The CRIT preference is noted. Please see response to comments #198 and #384 for a description of how State and Community Acceptance are implemented for this remedial action. RCRA and CERCLA requirements that emphasize reduction in toxicity, mobility, or volume through treatment very often result in the use of *in-situ* treatment. In this remedial action, the remedial action goals described in Section 3.0 are to reduce the concentrations of Cr(T) and Cr(VI) in groundwater. Cr(T) exists naturally in the environment in soil, and chromium is the thirteenth most abundant element in the earth's crust. As discussed in response to comment #152, the amount of additional total chromium that will be added by the *in-situ* treatment is very small compared to the naturally occurring concentration of Cr(T) in the soil and will be at or much below the standard deviation of the background data set. As described in the CMS/FS Report, extraction of groundwater, ex-situ treatment, and offsite disposal of the waste sludge from the ex-situ treatment plant is an effective and feasible process option for this remedial action that is incorporated into several remedial alternatives. It should be noted that protection of human health and the environment is not limited to just the site and that there are potential affects to human health and the environment from moving the Cr(III)-containing sludge from an ex-situ treatment plant to another location (traffic accidents, fossil fuel use, air emissions, etc.). In response to this comment, graphs will be added to Appendix F to show the relative percentage of Cr(VI) mass removed by *in-situ* and *ex-situ* methods in the different	See response to comment 312 regarding precipitated *in-situ* chromium adding to the existing background processes that form hexavalent chromium.	DOI concurs with the response. DOI would like to thank the CRIT for providing their thoughts and perspective on this area. The perspectives provided by the CRIT and other Tribes will be considered in the selection of the remedy for the Topock groundwater. The Bureau of Land Management will continue to conduct formal Section 106 consultation with the nine federally recognized Tribes.	Comment resolved following agency review and input during finalization of Appendix F to the CMS/FS Report. Redline final submitted to agencies on November 13, 2009. Agencies approved the report revisions.

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					remedial alternatives.			
328 .5	CRIT-40	Section 5.5.4	Colorado River Indian Tribe via BLM	Michael Tsosie said PG&E has ignored the request for how much Cr VI is being removed from groundwater with each alternative	Please see response to comment # 328 and #328.1.	See 328.	DOI concurs with the response.	Comment resolved following agency review and input during finalization of Appendix F to the CMS/FS Report. Redline final submitted to agencies on November 13, 2009. Agencies approved the report revisions.
328 .7	CRIT-43	Section 5.5.4	Colorado River Indian Tribe via BLM	Michael Tsosie wants to know how much Chromium is removed with each alternative	Please see response to comment # 328 and #328.1.	See 328.	DOI concurs with the response.	Comment resolved following agency review and input during finalization of Appendix F to the CMS/FS Report. Redline final submitted to agencies on November 13, 2009. Agencies approved the report revisions.
328 .9	CRIT-47	Section 5.5.4	Colorado River Indian Tribe via BLM	It is very important to extract the pollutant and not simply convert it to another form, e.g., Cr VI to Cr III	Please see response to comment #328.3.	See 328.	DOI concurs with the response.	Comment resolved following agency review and input during finalization of Appendix F to the CMS/FS Report. Redline final submitted to agencies on November 13, 2009. Agencies approved the report revisions.
329	DTSC-133	Page 5-52, Last sentence, Paragraph 2	California Department of Toxic Substances Control	The CMS report should clarify the meaning of the statement the soluble As in the IRZ "is at a lower maximum concentration than the fluvial zone found adjacent to the Colorado River."	This statement will be clarified in the revised CMS/FS Report. The statement is intended to convey the point that the fluvial zone adjacent to the Colorado River is naturally reducing and therefore contains soluble arsenic as a result of these reducing conditions. The concentration of arsenic detected in the floodplain *in-situ* pilot test was lower than the maximum concentration of arsenic detected in the floodplain. The concentration of arsenic detected in the fluvial zone found adjacent to the Colorado River is discussed in response to comment #231 and #424). See response to comment #325.	DTSC awaits PG&E's proposed revised CMS language. The response does not address the issue of arsenic byproduct generation significantly above pre-pilot test well concentrations and well above mean concentrations for the floodplain. See comments 176 and 325 regarding byproduct formation.		Comment resolved following agency review and input during finalization of Section 5.5.4 to the CMS/FS Report. Redline final submitted to agencies on November 13, 2009. Agencies approved the report revisions.
330	DTSC-134	Page 5-52, Section 5.5.4	California Department of Toxic Substances Control	In general, DTSC remains concerned of the uncertainties associated with the mobility of the soluble treatment byproducts (Mn and As) and their potential adverse impacts to the aquifer and the river. See comments on Appendix E below.	The response to comment 181 provides the following paragraph to be added to Section 5.2.6; this will also be included in Section 5.5.4: "It is recognized that byproducts such as As and Mn will exceed background concentrations during implementation of in-situ methods. Under ideal geochemical and hydrologic conditions described in Appendix E, As and Mn byproducts should not be a significant issue. However, because of uncertainty in the complexity of	DTSC accepts the first paragraph language with edits contained in the column to the left. Also, see response to comment 299 regarding "careful monitoring". See response to comment 326 regarding the last proposed PG&E edit.		See response to Comment #315. The following text will be included in Section 5.5.4.4: "It is recognized and expected that byproducts such as arsenic and

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					aquifer lithology and geochemistry, large-scale implementation of in-situ treatment could result in elevated concentrations of As and Mn that persist for longer than expected periods of time in some portions of the aquifer. Careful monitoring during the initial phase(s) of in-situ operation will enable early detection of these conditions. Specific contingencies will be in place to address any potential threat to the Colorado River or the aquifer. If needed, natural recovery of byproducts can be accelerated through the injection of clean groundwater into the aquifer or some other appropriate measure - such as the injection of aerated water or air into the aquifer. Carbon loading will be managed and adjusted in response to monitoring results, and carbon loading near the river will be performed only when a landward gradient is maintained." In addition, as discussed in the response to comment 326, the following text will be added to the end of Section 5.5.4 to address this issue: "Byproducts from in-situ treatment are expected to be localized to the reducing zone and within the range of naturally occurring concentrations found at the site (Appendix E), but could be temporarily elevated above background in some portions of the aquifer			manganese will exceed baseline and background concentrations during implementation of *in-situ* methods. Under ideal geochemical and hydrologic conditions described in Appendix G, arsenic and manganese byproducts should not be a significant issue. However, because of uncertainty in the complexity of aquifer lithology and geochemistry, large-scale implementation of *in-situ* treatment could result in elevated concentrations of arsenic and manganese that persist for longer than expected periods of time in some portions of the aquifer. Careful monitoring during the initial phase(s) of *in-situ* operation will enable early detection of these conditions. Specific contingencies will be in place to address any potential threat to the Colorado River or the aquifer." In addition, as discussed in the response to comment #326, the following text has been added Section 5.5.4.5 to address this issue: "Byproducts from *in-situ* treatment are expected to be localized to the reducing zone formed by the IRZ and within the range of naturally occurring concentrations found at the site (Appendix G) but could remain temporarily

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								elevated above baseline and background concentrations in some portions of the aquifer.”
331	DOI-127	Section 5.5.5, Page 5-53	U.S. Department of the Interior	A clear distinction of the weight applied to each factor for this criterion should be provided. It appears from the content of this section that equal weight is not applied.	As discussed in response to comments #279 and #286, the comparative evaluation has been revised to more clearly address the subcriteria defined in Section 5.4.1. In addition, the rating scale has been revised as requested by comment #286. The weighting applied to the each of the factors under this, and other criteria is subjective by nature; however, the revisions made in response to this and other comments (see for example, response to comments #279 and #286) are intended to clarify the ranking of alternatives.	DTSC accepts RTC in concept but will await review of final CMS/FS revision.	DOI withholds their acceptance of this response pending review of the final text.	Comment resolved following agency review and input during finalization of Section 5.5 to the CMS/FS Report. Redline final submitted to agencies on November 13, 2009. Agencies approved the report revisions.
332	DOI-128	Section 5.5.5, Page 5-53, Paragraph 4	U.S. Department of the Interior	Alternative B received a medium ranking. It appears that the lower ranking than C through H is a result of the long-term monitoring activities. While monitoring activities do pose some risk to workers, it should be considered minimal when compared to drilling operations, infrastructure development and construction of water treatment plants. Long-term groundwater monitoring would also be a part of all the alternatives (excluding A). Additionally, minimal impacts to the HNWR, cultural resources and the community should carry more weight than is implied by the discussion. This would apply to Alternative A as well.	As stated in Section 5.5.5.5, Alternative B is ranked medium because of the minimal footprint but relatively longer time to cleanup. Alternative B ranks higher for this criteria in comparison to Alternatives A, D, F, G, H, and I. PG&E agrees that monitoring activities are minimal when compared to drilling operations, infrastructure development, and construction of water treatment plants in most aspects. However, those construction activities occur over a period of months, while the monitoring activities associated with Alternative B (including site workers, vehicular traffic, and associated energy use, and maintenance and replacement of monitoring wells) would occur a period of up to thousands of years. Please see response to comment #336 for changes to rankings of alternatives for short-term effectiveness.	DTSC accepts RTC in concept but will await review of final CMS/FS revision.	DOI accepts the response.	Comment resolved following agency review and input during finalization of Section 5.5.5 to CMS/FS Report. Redline final submitted to agencies on November 13, 2009. Agencies approved the report revisions.
333	DTSC-135	Page 5-53, Section 5.5.5	California Department of Toxic Substances Control	This section is difficult to follow and digest for a comparative analysis. PG&E should reorganize the write up so that readers can properly follow the comparative analysis of all alternatives based on each of the factors listed in the EPA guidance.	As discussed in response to comments #279 and #286, the comparative evaluation has been revised to more clearly address the subcriteria defined in Section 5.4.1.	DTSC accepts RTC in concept but will await review of final CMS/FS revision.	DOI concurs with the response, pending review of the final text.	Comment resolved following agency review and input during finalization of Section 5.5.5 of the CMS/FS Report. Redline final submitted to agencies on November 13, 2009. Agencies approved the report revisions.
334	DOI-129	Section 5.5.5, Page 5-53, Paragraph 5, Sentence 3	U.S. Department of the Interior	Since the previous sentence is inclusive of alternative B through I, it is implied by the lead in “Additionally, these alternatives …” that the third sentence pertains to B through I as well. This is not the case.	The lead-in to the third sentence has been revised to: “Alternatives C through I address the second RAO stated in Section 3.0...”	DTSC accepts RTC.	DOI accepts the response.	Comment resolved. Agencies approved PG&E response. Changes to Section 5.5.5 noted in the response have been made to the CMS/FS Report.
335	DTSC-136	Page 5-53, Paragraph 5, Section 5.5.5	California Department of Toxic Substances	The report indicated that MNA (Alternative B) would cause the least short-term disturbance. DTSC disagrees because all the components and infrastructures are already in place for	Although the components and infrastructure for Alternative I are currently in place, Alternative I includes periodic replacement of the system components over the O&M period, such as construction of replacement wells. In	DTSC accepts RTC.	DOI concurs with the response.	Comment resolved. Agencies approved PG&E response. No changes to the CMS/FS

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			Control	Alternative I.	addition, there is a high level of O&M associated with Alternative I that is not associated with Alternative B, including staffing 24 hours each day, 7 days each week, energy use, chemical use, and offsite transportation of waste products, including both brine waste and sludge.			Report are required.
336	DOI-130	Section 5.5.5, Page 5-53, last partial paragraph	U.S. Department of the Interior	Alternatives C, E, F, G, H, and I could all require extended timeframes in excess of 100 years to attain background levels throughout the aquifer. Alternative D may be able to attain background levels throughout the aquifer in a period of a few decades or less, but would result in the highest risk to the environment because of the intensive nature of the disruption. DOI believes that all of the alternatives except A could be implemented in a manner protective of the community, workers, and the environment, but agrees that the ex situ treatment alternatives involve management and trucking of residual waste material that increases hazards to workers and the community. DOI recommends the rankings for Short-term Effectiveness in Table 5-12 be revised to low for all alternatives except B because they could require extended timeframes to attain background levels throughout the aquifer (C, E, F, G, H, and I), result in high disturbance to the environment of the floodplain (C, D, E, and G), or result in higher risks to workers and the community because of residuals that must be managed and trucked off site (F, G, H, and I)	**Issue pertaining to describing time to cleanup resolved. Original response shown below for completeness.** As stated in response to other comments, PG&E anticipates that with standard level of optimization, all of the active remedies (except Alternative I) could remove the majority of the plume in much less than 100 years (note that Alternative I specifically excludes optimization of the remedy over the operation and maintenance period). Whether RAOs could be met everywhere in that time frame is much less certain, and that uncertainty is discussed in multiple places within the CMS/FS Report (e.g., Section 5.3, Section 5.4, Appendix F). PG&E disagrees that any of the active alternatives would require similar cleanup time to natural attenuation. While it is agreed that there is a high level of uncertainty in the absolute values developed for each of the alternatives, the relative ranking of the alternatives in terms of time to cleanup relative to one another - active alternatives (Alternatives C, D, E, F, G, H, and I) will attain cleanup faster than the passive alternatives (Alternatives A and B), and that of the active alternatives, Alternative I will require the longest time to attain cleanup due to the flow rate and extraction/injection configuration. In response to this comment, PG&E proposes to revise the text in Section 5.5.1 and Section 5.5.5 to discuss attainment of RAOs in terms of faster or slower, rather than emphasis on numerical values. In addition, the text will be revised to better explain this hierarchy: Alternatives A and B slowest, Alternative I next slowest; Alternatives C, E, F, G, and H next slowest, and Alternative D expected to achieve the RAOs the fastest. In response to this comment, the short-term effectiveness rankings for Alternatives C and E were changed from medium to medium-low. This results in a lower ranking for these two alternatives than Alternative B, as suggested by this comment, but also separates these two alternatives from Alternative D (that includes construction in previously undisturbed areas); Alternative A (that includes no controls during the remediation period); and Alternatives F, G, H, and I (that includes waste management, higher energy use, and vehicular traffic associated with an ex-situ treatment plant).	PG&E's response has been modified. It originally stated, "Response to the portions of this comment not pertaining to the estimated cleanup times for the alternatives is deferred at this time" DTSC's comment below pertains to PG&E's deferred language. DTSC awaits PG&E's deferred response to portions of this comment and PG&E's proposed revisions. DTSC concurs with PG&E's statement indicating that any of the active alternatives would require a shorter cleanup time when compared to natural attenuation.	Comment resolved. Please see the file transmittal "Sec 5 DOI edits 8-4-09" for modifications to the text in response to the RTC. DOI accepts the response.	Comment resolved following agency review and input during finalization of Section 5.5.5 to the CMS/FS Report text. DOI text on estimated cleanup times incorporated. Redline final submitted to agencies on November 13, 2009. Agencies approved the report revisions.
337	DTSC-138	Page 5-55, Paragraph 1, Section 5.5.5	California Department of Toxic Substances Control	The report concludes that alternatives C through I are equally effective in protecting river water quality during the remediation period. DTSC remains concerned that for *in-situ* alternatives, in particular, Alternative E will create a net flux of contaminated water towards the river and that the mobility of treatment by products are	In response to this comment, PG&E will revise the configuration of Alternative E to replace the floodplain IRZ lines with a line of extraction wells near the river. The extraction wells would provide capture and pull carbon across the floodplain. Water extracted from the line of extraction wells near the river would be amended with a carbon reagent and injected into a new set of injection wells	See comment for 314.		PG&E revised the configuration of Alternative E in response to this and other comments on the CMS/FS report. The revised alternative

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				uncertain.	near the western edge of the plume. Freshwater injection at wells outside the plume would continue to be used to control gradients, but flow rates would be reduced. As such, Alternative C through I are considered to provide equal protection of the Colorado River in the short term and are considered equal for this aspect of the criteria.			configuration was outlined in a Technical Work Group meeting September 28 (see comments #443 - #448).
338	DTSC-139	Page 5-55, Paragraph 2, Section 5.5.5	California Department of Toxic Substances Control	DTSC is unclear of the meaning "Greater trucking requirements for chemical delivery and waste transportation and disposal would generate the greatest amount of waste." Please clarify.	The sentence has been clarified as follows: "Operation of the *ex-situ* system would result in greater trucking requirements for chemical delivery and waste disposal than the in-situ treatment systems."	Agree with RTC.	DOI concurs with the response.	Comment resolved. Agencies approved PG&E response. Changes to Section 5.5.5 noted in the response have been made to the CMS/FS Report.
339	DTSC-140	Page 5-56, Paragraph 2, Section 5.5.5	California Department of Toxic Substances Control	Alternatives F, G, H and I were all ranked low due to various reasons. However, Alternative I will not have construction activities and have much less visual impacts and electrical power requirements than the other alternatives. Likewise, H will require a smaller treatment plant and less visual impacts and electrical requirements. It is unclear how the rankings were assigned.	As discussed in response to comments #279 and #286, the comparative evaluation has been revised to more clearly address the subcriteria defined in Section 5.4.1. In addition, the rating scale has been revised as requested by comment #286. As discussed in response to comment #335, although the components and infrastructure for Alternative I are currently in place, Alternative I includes periodic replacement of the system components over the O&M period, such as construction of replacement wells. In addition, the O&M period for Alternative I is predicted to be much longer (e.g., 200-300 years) in comparison to the other active alternatives (e.g., 20 to 40 years). For example, while Alternative I will have lower electrical power requirements than alternatives with larger treatment plants (Alternatives F and G) on an annual basis, due to the longer O&M period, Alternative I will result in much greater energy use over the O&M period. In addition, please refer to response to comment #303 regarding the amount of waste generated by Alternatives I, F, and G. DTSC is correct that, in comparison to the other alternatives that use ex-situ treatment (Alternatives F, G, and I), Alternative H would result in the least disturbance to the community and environment from construction and operation. However, this alternative is still considered to have a higher degree of disturbance due to construction and operation than the alternatives that do not include ex-situ treatment (Alternatives A through E). In response to this comment, additional information has been added to Section 5.5.5 to more explicitly compare the remedial alternatives in terms of energy use, waste generation, and vehicle traffic. Please see response to comment #336 for the proposed revised ranking of alternatives for short-term effectiveness.	DTSC accepts RTC but awaits review of revised rating scale for consistency.	DOI concurs with the response, pending review of the final text.	Comment resolved following agency review and input during finalization of Section 5.5 of the CMS/FS Report. The comparative analysis has been reorganized and the rating scale adjusted from three rankings to five. Redline final submitted to agencies on November 13, 2009. Agencies approved the report revisions.
340	DTSC-141	Section 5.5.5	California Department of	Please include in this section a discussion on the impacts of the use of fresh potable water under	In response to this comment, Table 5-6B has been added to Section 5.5.5 (see response to comment #136) showing the	Although PG&E concluded that except for Alt I, there is zero consumptive use of water		Comment resolved following agency review

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			Toxic Substances Control	Alternative E. Also include a discussion on the short and long term impacts with respect to delivery of reductants for the *in-situ* alternatives.	groundwater extraction rate and injection rate for each of the alternatives. As will be noted, the only alternative with a net consumptive use is Alternative I because not all extracted groundwater is returned to the basin through reinjection. In Alternative I, approximately 5 percent of the extracted groundwater is trucked off-site as waste brine from the reverse osmosis system. The remaining active alternatives (including Alternative E) result in zero consumptive use because the amount of water extracted equals the amount of water injected. In addition, additional information has been added to Section 5.5.5 to more explicitly compare the remedial alternatives in terms of energy use, waste generation, and vehicle traffic, including traffic associated with delivery of the reagent or substrate material from an offsite supplier to the site for Alternative E.	for all alternatives, there has not been any discussion in comparison of water quality associated with TDS and general chemistry. As for new information to be presented in CMS/FS, DTSC awaits review of revised section.		and input during finalization of the CMS/FS Report text. Changes to Table 5-6B noted in the response have been made to the CMS/FS Report Redline final submitted to agencies on November 13, 2009. Agencies approved the report revisions. PG&E will evaluate water quality during the design phase.
341	MWD-6	Section 5.5.5 Page 5-55	The Metropolitan Water District of Southern California	The second sentence in the third paragraph beginning “However, data show that these elements naturally reprecipitate within the anaerobic zone . . .” is confusing. It is not clear what is trying to be stated here. This sentence should be reworded.	The text in section 5.5.5 will be edited: *However, data show that these elements naturally attenuate through sorption, diffusion, precipitation or co-precipitation within the anaerobic zone, or become re-oxidized and attenuate through sorption and precipitation in the aerobic zones. These mechanisms are discussed in detail in Sections 8.3 and 8.4 of Appendix E*	While DTSC accepts this language, it is believed that there is significant uncertainty as to the degree and extent to which byproducts might attenuate in the anaerobic zone near the Colorado River (see responses to comment 176). Movement of arsenic or other undesirable byproducts toward the river is unwanted.	DOI concurs with the response.	This paragraph has been rewritten based on this comment and other DTSC and DOI comments. The paragraph is now located in new Section 5.5.5.4 and reads: “For those alternatives that include *in-situ* treatment (Alternatives C, D, E, G, and H), concentrations of byproducts such as manganese and arsenic are likely to temporarily increase within portions of the treatment zone. Although these elements are expected to naturally re-precipitate within the anaerobic zone (as part of sulfide or iron precipitates) or to become re-oxidized and attenuate through sorption and precipitation in the aerobic zones outside the treatment zone over time (Appendix G); because of uncertainty in the complexity of aquifer lithology and geochemistry, large-

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								scale implementation of *in-situ* treatment could result in unacceptably high concentrations of arsenic and manganese that persist for longer than expected periods of time in some portions of the aquifer. For these alternatives, monitoring and continued enforcement of institutional controls may be required for some time period to assess *in-situ* treatment byproducts once the remedy is complete." Redline final submitted to agencies on November 13, 2009. Agencies approved the report revisions.
342	DOI-131	Table 5-3, Page 5-54	U.S. Department of the Interior	For clarity, please identify the name of each alternative in the first column rather than the associated letter. Non-renewable power/fuel use for the No Action alternative is zero, not low.	The alternative names have been added to Table 5-6 as requested. The entry under the power use for the No Action alternative has been changed to zero.	Agree with RTC.	DOI accepts the response.	Comment resolved. Agencies approved PG&E response. Changes to Table 5-6 noted in the response have been made to the CMS/FS Report.
343	DTSC-137	Table 5-3	California Department of Toxic Substances Control	Although this is a nice summary table, PG&E did not provide any basis for the conceptual design. Additional details on how these concepts were calculated and derived would be required.	As stated in Section 5.3, the groundwater model was used for conceptual design of the alternatives and was used to estimate well locations, flow rates, and time to cleanup for each alternative. Appendix F provides detailed descriptions of how the model was used in the development of the remedial alternatives. Appendix D provides assumptions used in development of the cost estimates for wells, treatment facilities, pipelines, utilities, roads, and other components. In response to this comment, a footnote will be added to Table 5-6A to refer the reader to Appendices B and D for assumptions supporting the conceptual design.	Okay with RTC.	DOI concurs with the response.	Comment resolved. Agencies approved PG&E response. Changes to Table 5-6A noted in the response have been made to the CMS/FS Report.
344	CRIT-31	Table 5-3 Page 5-54	Envirometrix (on behalf of the Colorado River Indian Tribe)	Since protection of the Colorado River is fundamentally important, we would find if beneficial to include in this table an additional column and expanded discussion during the explanation of each alternative regarding the estimated level of protection (factor of safety each alternative would potentially provide to the	The evaluation of each of the remedial alternatives to attain the RAOs of Colorado River protection is discussed in Section 5.4.2 under protection of human health and the environment criteria, as well as compliance with ARARs criteria. These are the threshold criteria for the remedial action, and protectiveness of the Colorado River is assessed based on the conclusions of the groundwater risk	Agree with RTC.	DOI concurs with the response.	Comment resolved. Agencies approved PG&E response. No changes to the CMS/FS Report are required.

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				Colorado River.	assessment and ARARs identification. In addition, in the comparative evaluation, the alternatives are compared to each other in terms of protectiveness to the Colorado River and compliance with surface water ARARs in Sections 5.5.1 and 5.5.2, respectively. In addition, the alternatives are compared against each other for protection of surface water quality during the remediation period in Section 5.5.5. The purpose of Table 5-5 is to show engineering design factors and infrastructure quantities for comparison of alternatives against each other, not attainment of remedial action goals.			
345	HA-25	Section 5.5.5	Hargis & Associates, Inc. (on behalf of Fort Mojave Indian Tribe)	<u>Appendix F – PG&E Response to FMIT General Comment No. 4</u> As an action item during the February 11, 2009, meeting of the CWG, it was requested that PG&E include a table comparing the number of new wells in the upland versus the floodplain areas associated with each alternative. In response to that request, the table shown below was prepared by PG&E and provided to CWG participants by DTSC.[29] This table should be incorporated into the final CMS/FS. [29] See e-mail transmittal from A. Yue, DTSC, dated February 19, 2009.	The table has been included in the revised report (Table 5-6), as requested. Well numbers have been revised to reflect the modified alternative configurations.	Agree with RTC in concept, however, this table should disclose that the numbers are mere estimates and conceptual and that the actual number of wells will be determined during remedy design.	DOI concurs with the response.	Comment resolved. Agencies approved PG&E response. Changes to Table 5-6 noted in the response have been made to the CMS/FS Report.

Extraction, Injection, IRZ, and Monitoring Wells by Location	A	B	C	D	E	F	G	H	I
Upland	0	2	49	98	12	18	21	47	0
Floodplain	0	6	50	19	36	1	36	8	0
Total	0	8	99	117	48	19	57	55	0

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346	DOI-132	Section 5.5.6, Page 5-56	U.S. Department of the Interior	DOI does not accept the rationale for a medium ranking for Alternative A. Alternative A is the easiest implemented of all the alternatives. The ranking should be high.	This section has been revised per the DOI revisions provided August 4, 2009 to change the ranking for Alternative A from medium to high.	Agree with RTC.	DOI accepts the response.	Comment resolved. Agencies approved PG&E response. Changes to Section 5.5.6 noted in the response have been made to the CMS/FS Report.
347	DOI-133	Section 5.5.6, Page 5-57	U.S. Department of the Interior	It would be appropriate to discuss the technical and administrative feasibility aspect of Alternative D with respect to coordinating the archeological recordation required for the presumed impacts to cultural and historical sites. This alone may reduce the overall implementability of this alternative.	The following paragraph has been added to Section 5.5.6 (new subsection 5.5.6.2): “There may be challenges associated with administrative requirements of location-specific ARARs, such as archeological recordation. These administrative challenges increase for alternatives with the most infrastructure and highest level of operation and		The ARAR evaluation does not impact the comment. PG&E should provide text noting impacts to schedule and the high level of agency and tribe coordination required for the level of archeological recordation.	Comment resolved. CMS has been revised to include statement for each alternative about administrative requirements of location-specific ARARs

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					maintenance.”			compliance.
348	DTSC-142	Page 5-57, Paragraph 1, Section 5.5.6	California Department of Toxic Substances Control	Alternative C was singled out as an alternative with technical challenge of balancing reductant delivery throughout the plume while having to maintain hydraulic containment. Wouldn’t these parameters be required of Alternatives D, E, G and H as well?	Because of the relatively large volumes of water that would be pumped and injected within the plume and the relatively large distances between the wells, Alternative C has more possibility to spread the plume than Alternative D. Alternatives E, G, and H include a component of pumping and/or injection around the perimeter of the plume to maintain hydraulic control during the implementation of the *in-situ* portion of the remedy. As noted in response to comment #314, maintaining hydraulic control with pumping or injection wells around the perimeter of the plume is not technically challenging at the Topock site.	Although DTSC will accept the RTC, DTSC is less certain over the degree of control PG&E will have during fresh water flushing in Alt E. DTSC understands that the revised Alt E will incorporate an extraction component which may assist in hydraulic control, there is, however, still significant distance between injection and extraction points. Proper monitoring of the plume will be required during remedy implementation.	Defer to DTSC.	Comment resolved. Agencies approved PG&E response. No changes to the CMS/FS Report are required.
349	DOI-134	Section 5.5.6, Page 5-57, Paragraph 3	U.S. Department of the Interior	This paragraph contains information that addresses a combination of technical and administrative factors. It is recommended that landowner approvals and coordination with off-site facilities be separated from the technical aspects of waste generation.	The first two sentences of the paragraph describing the installation of a new water supply well and pipeline for Alternative E have been moved to a separate paragraph.	Defer to DOI, but DTSC believes that ability to gain approval for proposed work is an important consideration on implementability.	DOI accepts the response.	Comment resolved. Agencies approved PG&E response. Changes to Section 5.5.6 noted in the response have been made to the CMS/FS Report.
350	DTSC-143	Page 5-57, Paragraph 3, Section 5.5.6	California Department of Toxic Substances Control	Water is an important resource and in a drought condition, sustainability of potable water supply is an important factor to implementability. Please expand on discussion of current allocation and why additional water rights are not necessary.	PG&E has allocated water rights for remediation of 322 acre-feet per year (200 gallons per minute). With the exception of Alternative I, the remedial alternatives in the CMS/FS result in little or no consumptive use of water as essentially all the water that is extracted from the ground is reinjected back into the aquifer. The operation of the remedial alternatives has no effect on the volume of groundwater available in the basin or the flow in the river. All the remedial alternatives are able to accommodate fluctuations in groundwater levels associated with changes in river stage. During drought, it is likely that the river would remain at fairly low levels, and changes in groundwater levels would be less than in times of normal river flow. Thus, the remedial alternatives that are designed to work at times of normal river flow should work just as well in times of drought. In response to this comment, as well as comment #136, an additional table (Table 5-5) will be added to the CMS/FS Report that outlines water use for each of the remedial alternatives.	See response to comment 136.	DOI concurs with the response.	Comment addressed. The table noted in response to comment #136 has been added to the CMS/FS Report.
351	DTSC-144	Page 5-57, Paragraph 4, Section 5.5.6	California Department of Toxic Substances Control	The report singled out Alternative A as not requiring construction of remedial and/or monitoring facilities outside of PG&E property. Please note that Alternative I will also not need additional construction since it is already in place.	As described in Section 5.3.10, Alternative I will require construction activities periodically throughout the O&M period to replace wells or other structures that may become worn, clogged, or damaged. This is also repeated in Section 5.5.6.2. In addition, Alternative I requires ongoing O&M (e.g., periodic groundwater sample collection, staffing 24-hours/day, 7 days/week, materials handling/storage, and management of waste streams), and maintenance of an institutional control that are not included for Alternative A.	DTSC accepts RTC.	DOI concurs with the response.	Comment resolved. Agencies approved PG&E response. No changes to the CMS/FS Report are required.
352	DTSC-145	Page 5-57, Section	California Department of	What about evaluation of implementability of Alternatives C through H based on need to	In response to this comment, the first sentence in the fourth	Agree with RTC.	DOI concurs with the response.	Comment resolved. Agencies approved

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		5.5.6	Toxic Substances Control	construct infrastructures, piping, electrical lines and monitoring wells near I-40 and or crossing the BNSF railroad line?	paragraph of Section 5.5.6.2 will be revised as follows: "Each of the alternatives, with the exception of Alternative A, would require construction of remedial and/or monitoring facilities outside of PG&E property. Construction and operation of these facilities would need to be coordinated with and approved by the respective landowners, including Burlington Northern-Santa Fe and Caltrans for Alternatives C through H."			PG&E response. Changes to Section 5.5.6 noted in the response have been made to the CMS/FS Report.
352.5	Chemehuevi-2	Section 5.5.6	Chemehuevi Tribe via BLM	Seems the pump and treat is more practical, but the Cr VI may be bound up longer in the fine-grained soils	As discussed in Section 5.2.3, pump-and-treat technology is very successful at controlling migration of contaminant plumes but has been shown to have a poor success rate at achieving cleanup goals at most sites where it has been applied. This is due in large part to the difficulty in flushing contaminants from fine-grained portions of the aquifers.	RTC is equally true for any technology that requires water movement as primary transport mechanism. There will be recalcitrant areas with direct injection *in-situ* treatment as well. Recommend PG&E to include uncertainty statements for all alternatives and not just pump and treat.	DOI concurs with the response.	Comment addressed. The statement: "Due to the limitations of flushing as a remedial technology, there would likely be some zones of the aquifer where RAOs would not be met in a timely manner without further optimization of the remedy." Has been added to the limitations discussion for Alternatives E, F, G, H and I in response to this comment.
353	DOI-135	Section 5.5.7, Cost, Table 5-4	U.S. Department of the Interior	Alternative A should show a cost of $0.	This change will be made in Table 5-6.	Agree with RTC.	DOI accepts the response.	Comment resolved. Agencies approved PG&E response. Changes to Table 5-7 noted in the response have been made to the CMS/FS Report.
354	DTSC-146	Page 5-58, Cost	California Department of Toxic Substances Control	IM#3 decommissioning is not included in the alternatives and cost estimate (also see Section B.2.3.2). This may affect the relative comparison between alternatives, especially for Alternatives G, H, and I.	In response to this comment, the cost estimates will be revised to include costs for IM decommissioning for Alternatives B, C, D, E, F, G, H, and I.	Agree with RTC.	DOI concurs with the response.	Comment resolved. Agencies approved PG&E response. Changes to the cost assumptions for Alternatives B through I as noted in the response have been made to the CMS/FS Report.
355	DOI-136	Table 5-5, Page 5-59	U.S. Department of the Interior	Please ensure that any changes to the alternative analyses, as a result of comments, are reflected in the table(s).	Table 5-5 and Figure 5-12 have been revised to be consistent with the revised text.	Agree with RTC, but awaits review of table for consistency.	DOI accepts the response, pending completion of comment resolution and review of the final text.	Comment resolved following agency review and input during finalization of Sections 5.4 and 5.5 to the CMS/FS Report. Redline final submitted to agencies on November

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								13, 2009. Agencies approved the report revisions. See also comments #637-640.
356	DOI-137	Table 5-5, Page 5-59	U.S. Department of the Interior	Table 5.5 (general): The statement that “Steps will be taken during design and implementation to ensure compatibility with the National Wildlife Refuge Administration Act” does not address all of the requirements of the Act and implies that compatibility is the only concern for the refuge. Compatibility is just one part. Each of the Alternatives has varying degrees of negative effects to the refuge. Each of the alternatives should be judged based on its effect to refuge resources. A blanket statement that makes each alternative equally palatable to the refuge is not productive and does not really compare actions.	PG&E defers response to DOI.		The Department of Interior Solicitors’ Office provided revised final language for Section 5 on 10/16/2009. This language resolves the comment.	Table 5-5 has been revised to include language provided by DOI about compliance with the National Wildlife Refuge Administration Act.
357	DTSC-147	Table 5-5, Individual Analysis of Remedial Alternatives	California Department of Toxic Substances Control	There are errors in this table that apply to all alternatives: 1. Potential source in soil has not been defined. It is therefore inaccurate to consider sources to be controlled just because historic discharge practice has stopped. 2. Clean closure is not an issue for SWMU 1/ AOC 1 because it is not a permitted regulated unit. SWMU 1/ AOC 1 needs to comply with corrective action requirements only and not RCRA closure and post closure. 3. Because SWMU1/ AOC 1 is not a permitted regulated unit, the RCRA water quality protection standards under 22 CCR, 66264.100 does not apply either. DTSC requests that this table and narratives be structured to clearly respond to all proposed questions raised in the EPA guidance for each of the alternative evaluation criterion.	In response to this comment, the following sentence will be added to the evaluation for each of the alternatives: “However, the evaluation of whether leaching of soil contamination to groundwater represents a significant transport pathway has not yet been completed.” See also response to comment #289. As requested in the comment, references to RCRA closure and post-closure and water quality protection standards have been removed. See also response to comments #104 and #105. Please also see response to comment #279 (DTSC comment #109). The detailed evaluation for each of the alternatives has been revised to more clearly address each of the subcriteria defined in Section 5.4.1.	DTSC accepts RTC in concept and will review revised section for consistency.	DOI concurs with the response.	Comment resolved. Agencies approved PG&E response. Changes to Table 5-5 noted in the response have been made to the CMS/FS Report.
358	MWD-7	Table 5-5 Pages 5-61 through 5-67	The Metropolitan Water District of Southern California	In the fifth column it states, “The Cr(VI) reduction reaction is not reversible.” The reaction is not reversible under the current pH conditions of the aquifer. We recommend that the following be added to the sentence “. . . . under current conditions.”	The sentence will be changed to read ”The degree of reversibility of the Cr(VI) reduction reaction is expected to ultimately result in CrVI concentrations similar to ambient background DOI comments on Section 5 suggest eliminating discussion of the irreversibility of chromium reduction reaction, however the degree to which treatment is irreversible is a subcriteria that needs to be addressed for the criteria of reduction of toxicity, mobility, or volume through treatment.	DTSC accepts RTC, and agrees that irreversibility of chromium should be discussed. DTSC believes, however, that there is uncertainty on the degree of which the reduced Cr can revert. DTSC supports DOI’s current modifications regarding this topic.		In response to this comment, as well as additional input from DOI and DTSC on the reversibility of the reaction (as further modified by comments #637-640), the sentence has been replaced for each alternative as follows: For Alternatives A and B, the following text has

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								been added: “Once reduced to Cr(III), chromium takes the form of the Cr^{3+} ion and forms very low-solubility oxides under the neutral and alkaline pH encountered in site groundwater. Solubility of chromium oxide Cr_2O_3 and chromium hydroxide, $Cr(OH)_3$, are low enough to maintain the Cr^{3+} concentration below the detection limit of 0.2 µg/L (Brookins, 1988; Schecher and McAvoy, 1998). Once reduced, Cr(III) does not readily become reoxidized to Cr(VI); however, Cr(III) that comes into contact with manganese oxide (MnO_2) or dissolved oxygen can be re-oxidized to Cr(VI), leading to increased concentrations of Cr(VI) over time. Two key factors are expected to limit the re-conversion of Cr(III) to Cr(VI) after *in-situ* reduction: the limited solubility of Cr(III) and the lack of availability and reactivity of an adequate oxidizer (MnO_2). Together these factors are expected to limit any reoxidized Cr(VI) concentrations to levels similar to ambient background.” For the *in-situ* treatment alternatives (Alternatives C, D, and E), the following has been added:

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								“The degree of reversibility of the Cr(VI) reduction reaction is expected to ultimately result in Cr(VI) concentrations at levels similar to ambient Cr(VI).” For the *ex-situ* treatment alternatives (Alternatives F and I). the following has been added: “The Cr(VI) reduction reaction is not reversible. The Cr(VI) is removed from the groundwater through chemical reduction by ferrous iron compounds followed by alkaline precipitation and filtration. The resulting sludge is transported offsite to an appropriate permitted disposal facility for long-term management. The reversibility of the Cr(VI) reduction reaction depends on the geochemical conditions in the offsite permitted disposal facility.” For the alternatives that include both *in-situ* and *ex-situ* treatment (Alternatives G and H), the following has been added: “The degree of reversibility of the *in-situ* Cr(VI) reduction reaction is expected to ultimately result in Cr(VI) concentrations at levels similar to ambient Cr(VI). The *ex-situ* Cr(VI) reduction reaction is not reversible.”

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359	HA-4	Section 5.4.2/ Table 5-5	Hargis & Associates, Inc. (on behalf of Fort Mojave Indian Tribe)	<u>1c. Accounting for Tribal Values in Remedy Selection</u> Tribal cultural considerations need to be taken into account *when considering and choosing* a remedy, and not just in designing and implementing a remedy that has *already been chosen*. The constraints on implementation of any particular remedy could be so significant as to impact remedy effectiveness to the point that another remedy should have been chosen at the outset. By taking tribal considerations into account when choosing a remedy, problems regarding effectiveness of implementation can be avoided. Set forth below in the specific comments are examples of where cultural constraints were not imposed in designing certain alternatives and how these omissions may seriously compromise remedy implementability and effectiveness. The Tribe appeals to both the DTSC and the DOI to begin exercising a greater level of coordination with each other, the FMIT and other tribes in regard to the formulation and design of this groundwater remedy, and for future remedies under consideration for the other affected media (such as soils). In particular, coordination with the tribes at the work plan preparation stage is important. Only when this level of consideration occurs can it be said that the project is operating in the spirit of the Kaizen process, which was initially proposed as a tool useful to this project by DTSC leadership, and in which many of the project stakeholders have made significant investments of time and resources. Please keep in mind that the Tribe is looking for an assurance that, not only will the decision seek to avoid physical disturbances, but also consideration be rightfully accorded to the spiritual values at stake.	Please also see response to comments #162, #189, and #198. Because compliance with ARARs is a threshold criterion for the remedial alternative evaluation, compliance with cultural resources ARARs will be evaluated prior to remedy selection. The alternative analysis in the Final CMS/FS Report will be revised to evaluate compliance with ARARs, including compliance with cultural resources ARARs. Community acceptance is a modifying criteria under CERCLA, and the agencies will formally address the modifying criteria at the time of the Record of Decision. This assessment will consider input beyond the comments on the CMS/FS Report, up to and including comments received during the public comment period for the Statement of Basis and the Proposed Plan. This modifying criterion will be addressed during the final remedy selection under the Record of Decision and DTSC's final remedy adoption. Additionally, tribal comments on cultural resources and viewpoints are currently being evaluated by DTSC for inclusion in the draft Environmental Impact Report and by the DOI in a manner consistent with federal law.	DTSC accepts RTC and acknowledges the Tribe's concerns. The technical merit of a proposed alternative is the key consideration in whether it is included as one of the alternatives to be further evaluated in the CEQA-based environmental review process. The CEQA process (which includes detailed consideration of cultural resources) can provide a rationale for the Lead Agency to eliminate or modify a technically feasible alternative. Federal processes under DOI include the identification of ARARs, any of which may result in the elimination of an alternative for (federal) consideration on the basis of legal infeasibility. Narrowing down of potential alternatives by the California and federal lead agencies may not occur simultaneously; however the agencies are coordinating their review of alternatives as closely as possible and the remedy selection will reflect input from both.	BLM has consulted with the tribes to solicit tribal input on the draft Corrective Measures Study/ Feasibility Study (CMS/FS) Report including face-to-face meetings with four tribes. This consultation on the draft study that first identifies and evaluates remedial alternatives is early in the CERCLA remedy selection process. This consultation will inform DOI's perspective as it directs PG&E on revisions to be made in the final CMF/FS Report (including revisions related to attainment of applicable or relevant and appropriate requirements (ARARs)), and as it proposes and then selects a remedy from among the alternatives now being evaluated. BLM will continue to conduct formal Section 106 consultation with the nine federally recognized Tribes including consultation with the Fort Mohave Indian Tribe.	Comment addressed. No changes to the CMS/FS Report are required.
360	HA-6	Section 5.4.2/ Table 5-5	Hargis & Associates, Inc. (on behalf of Fort Mojave Indian Tribe)	<u>3. ARARs</u> Tribal input regarding proposed remedies is a required "threshold criterion" for the CMS/FS, and not the "modifying criterion" of "community acceptance."[4] A preliminary determination of ARARs has been done and includes statutes that consider and protect cultural resources, including tribal heritage resources.[5] Appendix A of the CMS/FS identifies the following ARARs, among others: NHPA, American Indian Religious Freedom Act (AIRFA), Native American Graves Protection and Repatriation Act (NAGPRA), and Religious Freedom Restoration Act (RFRA). All of these ARARs require early tribal input for	PG&E defers response to DOI.	See response to 359.	DOI agrees that the cultural resource ARARs compliance determinations in the January 2009 Draft CMS/FS are deficient. DOI will direct PG&E to revise the Draft CMS/FS with specific language for inclusion in the final CMS/FS regarding cultural resource ARARs attainment. This language will provide an analysis of whether or not each alternative can attain each ARAR considering potential impacts on culturally sensitive resources, potential mitigation measures, and other factors relevant to attainment of the ARAR. This language will be drafted after	The CMS/FS has been revised to incorporate language provided directly from DOI on ARARs compliance to include in Sections 5.4 and 5.5.

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				government agencies to provide a threshold determination of compliance of proposed remedies at the Site. As it is currently written, the CMS/FS is deficient because it is wholly missing analysis applying the preliminary cultural resource ARARs.[6] Even though there is no determination of whether the alternatives comply with these ARARs, the CMS/FS still concludes, without any support, that Alternatives B, C, D, E, F, G, H, and I “are considered to comply” with identified location and action specific ARARs, and then proceeds to rank them all “high” for this criterion. In reality, the Tribe believes, on the basis of the data provided and its cultural beliefs, that at least Alternatives C through I, as presently configured and to varying degrees, do not meet the identified cultural resource ARARs, are not acceptable to the Tribal community, and that the CMS/FS should be corrected to reflect this information before remedial recommendations are made.[7] Confidential, face-to-face consultation with FMIT is necessary for the agencies to obtain the information necessary for any non-arbitrary determination of compliance with these ARARs. Indeed, the purpose of the detailed analysis of alternatives in a CMS/FS is to present the relevant information needed to allow the selection of a site remedy. As the U.S. Environmental Protection Agency (EPA) asserts in its guidance manual for the Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA), “The results of the analysis provide the basis for identifying the preferred alternative and preparing the proposed plan.”[8] The EPA goes on to explain that, as a threshold criterion, the evaluation of whether proposed remedies comply with ARARs: *“… is used to determine whether each alternative will meet all of its Federal and State ARARs … that have been identified in* ***previous*** *stages of the RI/FS process. The detailed analysis should summarize which requirements are applicable or relevant and appropriate to an alternative and describe how the alternative meets those requirements.”*[9] Thus, the alternatives cannot be properly evaluated in the CMS/FS, and a preferred alternative chosen, when it is still unclear if the alternatives will comply with ARARs, whether cultural or otherwise.			DOI has fully considered all comments received, including input received during formal consultation with each of the tribes, including face-to-face consultation as requested. There has been no proposal to invoke a waiver of any ARAR with regard to any proposed remedial alternative. In the event an ARAR waiver is proposed, DOI will evaluate such proposal as specified by Section 121(d)(4) of CERCLA.	

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				In fact, there is no way to determine whether the “cultural ARARs” could be met if an alternative is chosen before consideration of protection of culturally sensitive areas. Cultural resource ARARs are not mere documentation exercises.[10] The language and implications of the cultural resource ARARs require due consideration of the impacts on, and protection of, culturally sensitive areas before a decision is made as to any actions that can be taken that could affect those areas.[11] Similarly, the Tribe further requests that no waivers from cultural resource ARARs be granted. Even though it should have been clear to the agencies, after the Tribe has consistently expressed its views on the subject in one form or another over the last four years, that certain alternatives would not meet cultural resource ARARs, the deficiency could likely be directly remedied through direct consultation with the Tribe. Thus, while the cultural resources sections of the CMS/FS are currently insufficient to support any determination of compliance with cultural resource ARARs, this information can (and must) be supplemented by direct consultation with the tribes as soon as possible. [4] See Table 5-2. The Tribe appreciates PG&E’s response to its previous Comment No. 7 that “PG&E understands the need to safeguard and protect culturally sensitive and sacred grounds.” However, the Tribe disagrees with the implication of the response that protection of culturally sensitive areas is only a factor to be considered upon the selection of alternatives, and not a criterion to be considered when developing the range of the alternative measures themselves. (See App. F, p. F-3.) As discussed herein, consideration of the protection of culturally sensitive areas is included within the threshold criterion of ARARs. [5] See pp. 3-3 through 3-6. [6] See p. 5-49 (deferring any analysis to some undefined future time). [7] This is not to say that all of the remedies are equally unacceptable. Some are completely unacceptable to the Tribe, but Alternative E, subject to some conditions and modifications, may present the least disruptive remedial alternative.				

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				[8] EPA, 1988. *Guidance for Conducting Remedial Investigations and Feasibility Studies under CERCLA, Interim Final*, EPA/540/G-89/004, p. 6-4. [9] *Ibid*., p. 6-6 (emphasis added). It should also be noted that this is not the first time that the Tribe has raised this issue. Consistent with this EPA Guidance, the Tribe previously requested that DTSC include a broader discussion in the RI/FS of the cultural and religious significance of this area to the Tribe, but DTSC rejected that comment. Thus, there remains an information "gap" that must be corrected so that DTSC and DOI can rationally evaluate compliance with cultural resource ARARs. [10] As inferred from discussion on p. 6-2. [11] See, for example, NHPA Section 106, which requires federal agencies to consider the effect of an undertaking on anything that is included in or eligible for inclusion in the National Register before approving any expenditure of federal funds on the undertaking.				
361	DOI-138	Table 5-5. Alternative A, Implement-ability	U.S. Department of the Interior	Remove the sentence on landowner and agency acceptability. This alternative is implementable.	The sentence has been removed as requested.		DOI withdraws the comment. The text should remain as originally written.	Comment addressed. No change to the CMS/FS Report is required.
362	DOI-139	Table 5-5, Page 5-60	U.S. Department of the Interior	In two different paragraphs, there is a general reference to eligibility for "an ARARs waiver per CERCLA Section 121(d)." Please delete this reference, or, in the alternative, describe specifically the particular waiver and the basis for the eligibility of such a waiver.	’References to the ARARs waiver have been revised in Table 5-5 to state that Alternatives B and I may need to obtain a waiver from attaining state and federal MCLs per CERCLA Section 121(d)(4), which allows a waiver if, "the remedial action selected is only part of a total remedial action that will attain such level or standard of control when completed." In this case, use of institutional controls to prevent development of groundwater as a drinking water supply would be viewed as an interim measure until MCLs were attained.		The Department of Interior Solicitors' Office provided revised final language for Section 5 on 10/16/2009. This language resolves the comment.	The CMS/FS has been revised to incorporate DOI's revisions to Table 5-5, which deleted references to the ARARs waiver for attaining state and federal MCLs for Alternatives B and I.
363	DOI-144	Table 5-5. Alternative B	U.S. Department of the Interior	DOI does not agree that the RCRA water quality protection standard (22 CCR 66264.100) will not be met. DOI is not aware of a specific timeframe applicable to this ARAR. Revise the implementability discussion to address implementability, not feasibility. All of the alternatives have been determined to be feasible at this stage of alternatives analysis. The cost range shown in the table does not agree with Table 5-4. It should show	In response to comments #104 #105, and #357, references to the RCRA water quality protection standard have been removed. As described in Section 5.4.1.2 and per the NCP, the implementability criterion includes the technical feasibility and administrative feasibility (i.e., the ease or difficulty) of implementing each alternative and the availability of required services and materials during its implementation. However in response to this comment, the word "feasible" will be changed to "implementable" in the alternative evaluation.	Agree with RTC.	DOI accepts the response. This was also partially addressed in the file transmittal "Sec 5 DOI edits 8-4-09" for modifications to the text in response to the RTC. DOI accepts the response. DOI accepts the response, pending review of the final text.	Comment resolved. Agencies approved PG&E response. Changes to the alternative evaluations and cost estimates noted in the response have been made to the CMS/FS Report.

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				$19,000,000 to $37,000,000	The cost estimate has been updated for this alternative.			
364	DTSC-148	Page 5-60, Table 5-5, Alternative B	California Department of Toxic Substances Control	Under the Short-term Effectiveness criterion, please explain the basis for assuming specific number of wells and other design parameters	As stated in Section 5.3, the groundwater model was used for conceptual design of the alternatives and was used to estimate well locations, flow rates, and time to cleanup for each alternative. Appendix F provides detailed descriptions of how the model was used in the development of the remedial alternatives. Appendix D provides assumptions used in development of the cost estimate. In response to this comment, Table 5-5 has been revised to reference Appendices D and F for assumptions supporting the conceptual design.	DTSC accepts RTC in concept, but See response to comment 345 and ensure that the conceptual nature of the estimates for number of wells, well locations, etc. is clearly identified.		Comment resolved. Agencies approved PG&E response. Changes to Table 5-5 noted in the response have been made to the CMS/FS Report.
364	DTSC-148	Page 5-60, Table 5-5, Alternative B	California Department of Toxic Substances Control	Under the Short-term Effectiveness criterion, please explain the basis for assuming specific number of wells and other design parameters	As stated in Section 5.3, the groundwater model was used for conceptual design of the alternatives and was used to estimate well locations, flow rates, and time to cleanup for each alternative. Appendix F provides detailed descriptions of how the model was used in the development of the remedial alternatives. Appendix D provides assumptions used in development of the cost estimate. In response to this comment, Table 5-5 will refer the reader to Appendices B and D for assumptions supporting the conceptual design.			Comment addressed. Changes to Table 5-5 noted in the response have been made to the CMS/FS Report.
365	DTSC-149	Page 5-61, Table 5-5, Alternative C	California Department of Toxic Substances Control	Under Protect Human Health and Environment, the table states that "steps would be taken during construction and operation of the remedial facilities to limit disturbance to sensitive resources. Please provide specifics steps.	In response to this comment, the following sentence is proposed to be added: "Steps to limit disturbance to sensitive resources may include moving locations of infrastructure away from sensitive resources, modification of construction techniques (e.g., equipment or schedules), and modification of design elements (e.g., materials, configurations, sizes). Steps may also include programmatic elements such as awareness training for site personnel."	DTSC accepts RTC.	DOI concurs with the response.	Comment resolved. Agencies approved PG&E response. Changes to Table 5-5 noted in the response have been made to the CMS/FS Report.
366	DTSC-150	Page 5-61, Table 5-5, Alternative C	California Department of Toxic Substances Control	Under Reduction of Toxicity, the report concluded that the reduced forms of Mn and As will be attenuated by adsorption and eventually immobilized. Since it will take time transporting from a reducing zone to an oxidizing zone for adsorption, would Mn and As be released into the river?	A more detailed description of the chemistry of the secondary byproducts is provided in Sections G.8.3 and G.8.4 of Appendix G. These sections describe how the processes of sorption, diffusion, precipitation, and co-precipitation act to attenuate the arsenic and manganese. The text in Table 5-5 will be edited: "The most significant residual byproducts will be manganese and arsenic, natural constituents of the aquifer matrix released into solution by reduction reactions. Because of the uncertainties associated with the aquifer complexities there is the potential for elevated by-product concentrations persisting in some portions of the aquifer. Once released, the reduced forms of manganese and arsenic will likely be attenuated through precipitation, sorption, diffusion, and co-precipitation. Residual byproducts will be managed through system monitoring and operations."			Comment resolved. Changes to Table 5-5 noted in the response have been made to the CMS/FS Report.

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367	DTSC-151	Page 5-61, Table 5-5, Alternative C	California Department of Toxic Substances Control	Please reconcile the differences in conceptual design numbers between this Table, the text in Section 5, the cost estimate and Table 5-3 for extraction wells, injection wells, IRZ wells and piping, etc.	The report will be modified to reconcile quantities expressed for the conceptual design in various locations in the report. Please note that there are stated reasons for discrepancies between cost estimates and figures. For example, monitoring wells were included in cost estimates but not shown on figures, and locations requiring multiple injection wells to accept required flow are shown as a single point on the Section 5.0 figures.	DTSC agrees with RTC. PG&E should remain consistent with information. If multiple injection wells are envisioned but not shown, PG&E should clarify that information.	DOI concurs with the response.	Comment resolved. Agencies approved PG&E response. Changes noted in the response have been made to the CMS/FS Report.
368	DTSC-152	Page 5-61, Table 5-5, Alternative C	California Department of Toxic Substances Control	This table concluded that no off-site actions or permits would be required for this alternative. DTSC believes that access agreements and permits will be required for crossing the railroad and under or within the freeway right of way.	The distinction must be made between offsite activities that must comply with both administrative and substantive requirements of applicable requirements and onsite activities that must comply with the substantive (but not administrative) requirements of ARARs. Separate from ARAR compliance, PG&E must also attain access to property not owned by PG&E. The implementability evaluation discusses both the administrative feasibility of attaining permits for offsite actions in compliance with ARARs, as well as the administrative feasibility of accessing neighboring property. In response to this comment, the following sentence will be revised to clarify that access to property outside of PG&E property includes the BNSF and Caltrans properties: "Coordination and approval by respective landowners and leaseholders, including Burlington Northern-Santa Fe (BNSF), Caltrans, and other entities, would be required because installation of the extraction wells, injections wells, pipelines, utilities, reagent storage and delivery systems, and process controls/instrumentation would be constructed primarily outside of PG&E property."	Agree with RTC.	DOI concurs with the response.	Comment resolved. Agencies approved PG&E response. Changes to Table 5-5 noted in the response have been made to the CMS/FS Report.
369	DOI-145	Table 5-5. Alternative C	U.S. Department of the Interior	DOI does not agree that the Cr reduction reaction has been demonstrated to be irreversible in the upland area. Remove the statement that the reaction is irreversible from the table. In order to maintain the stability of Cr(III) in the upland area, it may be necessary to maintain reducing conditions indefinitely through ongoing injection of substrate. Under these conditions, and the reducing conditions of the down gradient floodplain, increased concentrations of As and Mn in groundwater may persist. PG&E has not demonstrated that As and Mn will not continue to exceed water quality standards in the future as a result of the treatment process. Remove the statements that As and Mn will be immobilized as they migrate out of the reducing zone. Attainment of background levels throughout the aquifer through active treatment may prove to be impossible without adding injection sites in previously undisturbed areas. The heterogeneity of the aquifer may result in recalcitrant zones that cannot be addressed by simply injecting more	The statement "The Cr(VI) reduction reaction is not reversible" will be replaced with the following statement (similar to the discussion added at DOI's request to Section 5.2.6 (see response to comment #318): "Reduction of Cr(VI) to Cr(III) results in the formation of Cr(III) oxides that have a low solubility. The stable Cr(III) minerals that are formed through in-situ treatment will have minimal opportunity for re-oxidation through interaction with MnO_2. Re-oxidation of Cr(III) to Cr(VI) is not believed to result in Cr(VI) concentrations that would significantly exceed~~ing~~ background concentrations" It will not be necessary to maintain reducing conditions indefinitely. The Cr(III) that is formed through *in-situ* treatment of Cr(VI) will be stable relative to re-oxidation, as described above (additional detail is provided in the response to comment #176). With respect to the generation of byproducts by this alternative, the statement that arsenic and manganese will be immobilized as they migrate out of the reducing zone has been removed and replaced with text described in response to comment #366.	See response to comment 312 and 318 regarding precipitated *in-situ* chromium adding to the existing background processes that form hexavalent chromium. See suggested edits to the left. See response to comment 176 and 341 regarding byproduct formation. Please also delete highlighted statement in RTC.	Comment remains unresolved with the modification of the language provided by DOI in the file transmittal entitled "Sec 5 DOI edits 8-4-09", pending review of final text. Duration and implementability are resolved. DOI withdraws "The table should reflect the substantial impact of the floodplain cleanup activities (Phase 1)." In original comment.	Comment resolved following agency review and input during finalization of Table 5-5 in the CMS/FS Report. The language in the response about the Cr(VI) reduction reaction has been changed to: "The degree of reversibility of the Cr(VI) reduction reaction is expected to ultimately result in Cr(VI) concentrations at levels similar to ambient Cr(VI)." Further, the text modifications provided by DOI have been incorporated. DOI language on

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				substrate at the planned locations. DOI does not agree that 20 years is the best engineering estimate for this alternative. The estimate is based on a simplified hydrogeologic model and assumptions that are founded on a limited data set. DOI believes this estimate could take in excess of a hundred years or more and may ultimately have to rely on natural attenuation processes to attain background levels throughout the aquifer unless additional densely spaced injection locations are added in undisturbed areas to address recalcitrant zones. In that case, this alternative becomes similar to Alternative D. Revise the implementability discussion to address implementability, not feasibility. All of the alternatives have been determined to be feasible at this stage of alternatives analysis.	DOI is correct in its assertion that the estimated time to cleanup could be much longer than projected if no optimization is conducted. The table states in the sentence that follows the 20-year estimate that there is considerable uncertainty associated with the estimate. However, a cleanup time must be estimated using the same tools for each alternative in order to assign and compare costs associated with each alternative. The phrase “best engineering estimate” will be replaced, as it may imply that no other estimate could be more accurate, which was not the intent. Given the scope, context, and schedule constraints, PG&E feels that this is a reasonable estimate for comparison. In response to this comment, the first sentence under Short-term Effectiveness in Table 5-5A for Alternative C will be revised to state: “It is estimated that 10 -70 years would be required to achieve the RAOs for this alternative.” References to technical and administrative feasibility within the implementability criterion are consistent with the NCP and are appropriate considerations for evaluation of implementability (see response to comment #279 and 363). However, in response to this comment, the word “feasible” will be changed to “implementable” in the alternative evaluation.			estimated cleanup time has also been incorporated. Redline final submitted to agencies on November 13, 2009. Agencies approved the report revisions.
370	DOI-146	Table 5-5. Alternative D	U.S. Department of the Interior	DOI does not agree that the Cr reduction reaction has been demonstrated to be irreversible in the upland area. Remove the statement that the reaction is irreversible from the table. In order to maintain the stability of Cr(III) in the upland area, it may be necessary to maintain reducing conditions indefinitely through ongoing injection of substrate. Under these conditions, and the reducing conditions of the down gradient floodplain, increased concentrations of As and Mn in groundwater may persist. PG&E has not demonstrated that As and Mn will not continue to exceed water quality standards in the future as a result of the treatment process. Remove the statements that As and Mn will be immobilized as they migrate out of the reducing zone. DOI does not agree that 10 years is the best engineering estimate for this alternative. The estimate is based on a simplified hydrogeologic model and assumptions that are founded on a limited data set. DOI believes this estimate could take longer to attain background levels throughout the aquifer due to aquifer heterogeneity. However, DOI does believe that this alternative offers the highest probability of	The statement “The Cr(VI) reduction reaction is not reversible” will be replaced in Table 5-7 with the following statement (similar to the discussion added at DOI’s request to Section 5.2.6 (see response to #comment 318): “Reduction of Cr(VI) to Cr(III) results in the formation of Cr(III) oxides that have a low solubility. The stable Cr(III) minerals that are formed through in-situ treatment will have minimal opportunity for re-oxidation through interaction with MnO$_2$. Re-oxidation of Cr(III) to Cr(VI) will therefore not result in Cr(VI) concentrations exceeding background” It will not be necessary to maintain reducing conditions indefinitely. The Cr(III) that is formed through *in-situ* treatment of Cr(VI) will be stable relative to re-oxidation, as described above (additional detail is provided in the response to comment #176). With respect to the generation of byproducts by this alternative, the statement that arsenic and manganese will be immobilized as they migrate out of the reducing zone has been removed and replaced as discussed in response to comment #366. As discussed in response to comments #195 and #200, PG&E agrees that the cleanup time estimates are highly uncertain.	See response to comment 369 above and make similar edits. Also please delete highlighted statement in RTC.	Comment remains unresolved with the modification of the language provided by DOI in the file transmittal entitled “Sec 5 DOI edits 8-4-09”, pending review of final text. Duration and implementability are resolved. DOI withdraws “The table should reflect the substantial impact of the floodplain cleanup activities (Phase 1).” In original comment.	Comment resolved following agency review and input during finalization of Table 5-5 in the CMS/FS Report. The language in the response about the Cr(VI) reduction reaction has been changed to: “The degree of reversibility of the Cr(VI) reduction reaction is expected to ultimately result in Cr(VI) concentrations at levels similar to ambient Cr(VI).” Further, the text modifications provided by DOI have been incorporated. Redline final submitted to agencies on November 13, 2009. Agencies approved the

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				attaining cleanup goals in the short term because of the densely spaced injection pattern. Long term stability of the Cr(III) in the upland area without ongoing substrate injection remains a concern. Revise the implementability discussion to address implementability, not feasibility. All of the alternatives have been determined to be feasible at this stage of alternatives analysis.	In response to this comment, the first sentence under Short-term Effectiveness in Table 5-5A for Alternative D will be revised to state: "It is estimated that 8-16 years would be required to achieve the RAOs for this alternative." References to technical and administrative feasibility within the implementability criterion are consistent with the NCP and are appropriate considerations for evaluation of implementability (see response to comment #279 and 363). However in response to this comment, the word "feasible" will be changed to" implementable" in the alternative evaluation.			report revisions.
371	DTSC-153	Page 5-62, Table 5-5, Alternative D	California Department of Toxic Substances Control	See comment 143 above. The design numbers will need to be reconciled in various places within the report	The report has been modified to reconcile quantities expressed for the conceptual design in various locations in the report. Please note that there are stated reasons for discrepancies between cost estimates and figures. For example, monitoring wells were included in cost estimates but not shown on figures, and locations requiring multiple injection wells to accept required flow are shown as a single point on the Section 5.0 figures.	DTSC accepts RTC but requests that these limitations and qualifiers be footnoted on figures, tables, and text for clarity to readers. See also response to comment 345 and ensure that the conceptual nature of the estimates for number of wells, well locations, etc. is clearly identified.	DOI concurs with the response.	Comment resolved. Agencies approved PG&E response. Changes noted in the response have been made to the CMS/FS Report.
371	DTSC-153	Page 5-62, Table 5-5, Alternative D	California Department of Toxic Substances Control	See comment 143 above. The design numbers will need to be reconciled in various places within the report	The report will be modified to reconcile quantities expressed for the conceptual design in various locations in the report. Please note that there are stated reasons for discrepancies between cost estimates and figures. For example, monitoring wells were included in cost estimates but not shown on figures, and locations requiring multiple injection wells to accept required flow are shown as a single point on the Section 5.0 figures.	DTSC agrees with RTC. PG&E should remain consistent with information. If multiple injection wells are envisioned but not shown, PG&E should clarify that information.		Comment resolved. Agencies approved PG&E response. Changes noted in the response have been made to the CMS/FS Report.
372	DOI-140	Table 5-5, Page 5-63, Protect Human Health and the Environment, Paragraph 4	U.S. Department of the Interior	Editorial: remove the phrase "to the river" in the first sentence.	The phrase has been removed as requested.	Agree with RTC.	DOI accepts the response.	Comment resolved. Agencies approved PG&E response. Changes to Table 5-5 noted in the response have been made to the CMS/FS Report.
373	DOI-142	Table 5-5, Page 5-63, Protect Human Health and the Environment, Paragraph 4	U.S. Department of the Interior	Please provide a more detailed explanation and discussion on the methods or procedures planned to handle the challenges of a flow gradient towards the river.	As described in response to comment #242 and in response to this and similar comments, PG&E is proposing to revise the configuration of Alternative E. In the revised configuration of Alternative E, a line of extraction wells is proposed to be installed near the Colorado River to provide hydraulic control in the floodplain and to capture flowlines originating in the plume. In addition to these extraction wells, methods or procedures to handle the challenges of a flow gradient towards the river to meet the objective of ensuring concentrations in groundwater do not cause exceedances in water quality standards that support the designated uses of	DTSC accepts RTC but still has concerns with the revised Alt E as presented. See response to comment 314, and response to comment 299.	DOI accepts the response, pending review of the final text.	PG&E revised the configuration of Alternative E in response to this and other comments on the CMS/FS report. The revised alternative configuration was outlined in a Technical Work Group meeting September 28 (see

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					the Colorado River including: • Careful monitoring to evaluate changes in geochemical conditions in the floodplain. • Modification of injection rates to increase or decrease hydraulic gradient flow rates (e.g., startup procedures could involve very gradual increases in hydraulic flow rates that would allow for geochemical equilibration and optimization of the delivery systems. • Modification to the type and/or dosage rates of reactants to respond to changes in geochemical conditions. • Incorporation of a hydraulic gradient backup contingency system. As noted in Section 1.1.2, implementation of the existing IM is expected to continue until a final corrective action/remedial action is operating properly and successfully (see response to comments #19-21).			comments #443 - #448).
374	DOI-143	Table 5-5, Page 5-63, Reduction of Toxicity, Mobility, or Volume through Treatment, Paragraph 3	U.S. Department of the Interior	Please revise " . . . and therefore residual Cr(VI) in groundwater is expected to be less than . . ." to read "demonstrated to be less than . . ."	The change has been made to each occurrence of this sentence in the table.	Agree with RTC.	DOI accepts the response.	Comment resolved. Agencies approved PG&E response. Changes to Table 5-5 noted in the response have been made to the CMS/FS Report.
375	DTSC-154	Page 5-63, Table 5-5, Alternative E	California Department of Toxic Substances Control	Under Long-term Effectiveness, it is stated that uncertainties exist whether the technology can achieve the RAOs. What can be done as a contingency should flushing fail?	As stated in Section 5.3 for Alternatives C, D, E, F, and G, optimization of the remedy would occur throughout the design, construction, and operational phases of remedy implementation to enhance performance of the remedy to attain the cleanup goals and respond to site conditions and performance issues. In response to this comment, PG&E proposes to add a table to the Final CMS/FS Report identifying contingencies for example scenarios under which the alternatives would not meet the stated objectives of the remedial action. Example actions for Alternative E may include adding injection, extraction or IRZ wells; modifying amendment delivery type, modifying amendment delivery rates, and increasing or decreasing pumping rates, The table would also note that a contingency plan would be prepared for the selected alternative, as required by the CACA. In response to this comment, PG&E will revise the configuration of Alternative E, as noted in response to comment #242.	Revision of Alternative E will need to be further developed for the purpose of the CMS/FS. DTSC awaits submission of the revisions for review.		Comment resolved following agency review and input during finalization of the CMS/FS Report. Table 5-3: text. Example Contingency Actions During Remedial Alternative Implementation has been added to the CMS/FS Report. Redline final submitted to agencies on November 13, 2009. Agencies approved the report revisions. In addition, PG&E revised the configuration of Alternative E in response to this and other comments on the CMS/FS report. The

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								revised alternative configuration was outlined in a Technical Work Group meeting September 28 (see comments #443 - #448).
376	DTSC-155	Page 5-63, Table 5-5, Alternative E	California Department of Toxic Substances Control	See comment 143 above. The design numbers will need to be reconciled in various places within the report.	The report will be modified to reconcile quantities expressed for the conceptual design in various locations in the report. Please note that there are stated reasons for discrepancies between cost estimates and figures. For example, monitoring wells were included in cost estimates but not shown on figures, and locations requiring multiple injection wells to accept required flow are shown as a single point on the Section 5.0 figures.	DTSC agrees with RTC. PG&E should remain consistent with information. If multiple injection wells are envisioned but not shown, PG&E should clarify that information.	DOI concurs with the response	Comment resolved. Agencies approved PG&E response. Changes noted in the response have been made to the CMS/FS Report.
377	DTSC-156	Page 5-63, Table 5-5, Alternative E	California Department of Toxic Substances Control	Please provide more specifics on measures to be taken to minimize disturbance under short term effectiveness. Also, more specifics are needed on technical challenges with reliance on flushing, and PG&E's current water rights with respect to locating and installing a potable water extraction well under implementability.	In response to this comment, the following sentence will be added to the short-term effectiveness evaluation: "Measures to minimize environmental disturbance may include moving locations of infrastructure away from sensitive resources, modification of construction techniques (e.g., equipment or schedules), modification of design elements (e.g., materials, configurations, sizes), or implementation of programmatic elements such as awareness training for site personnel." In response to this comment, the following sentence in the implementability evaluation will be modified: "There will be technical challenges associated with reliance on flushing to remove contaminants due to the possibility of rate-limited back diffusion from low-permeable material and it is expected that optimization of the remedy would occur throughout the design, construction, and operational phases to enhance performance of the remedy to attain the cleanup goals and to respond to site conditions and performance issues." In response to this comment, the following sentence in the implementability evaluation will be modified: "Water rights under for alternative would be covered under existing remediation water rights so that no additional water rights need to be procured. There is no net consumptive use in this alternative because extracted groundwater is returned to the basin through reinjection."	Editorial: Word missing in highlighted text. DTSC accepts proposed modifications.	DOI concurs with the response.	Comment resolved. Agencies approved PG&E response. Changes to Table 5-5 noted in the response have been made to the CMS/FS Report.
378	DOI-147	Table 5-5. Alternative E	U.S. Department of the Interior	The statement that rebound of Cr(VI) concentrations after the injection wells are shut down would be short duration is made without any supporting evidence or analysis. Long term diffusion from fine grained zones could continue to affect groundwater at concentrations above background levels for extended durations. Attainment of background levels throughout the	**Issue pertaining to describing time to cleanup resolved. Original response shown below for completeness.** DOI is correct in stating that there is no specific evidence to indicate how diffusion from low-permeability layers may affect the rebound after the injection system is shut down. However, qualitative evaluation and technical judgment suggest that rebound will be no more of a problem at this site than at most cleanup sites. Specific supporting rationale	DTSC awaits PG&E's deferred revisions to the CMS/FS Report. PG&E states that MNA may be appropriate for recalcitrant zones at the end of the active phase of remediation. DTSC concurs, but notes that it would not substitute for prior optimization of a selected active measure.	Comment resolved. Please see the file transmittal "Sec 5 DOI edits 8-4-09" for modifications to the text in response to the RTC.	Comment resolved following agency review and input during finalization of Table 5-5 in the CMS/FS Report. The text modifications provided by DOI have been incorporated.

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				aquifer through active flushing via water injection may prove to take nearly as long as natural flushing. The heterogeneity of the aquifer may result in recalcitrant zones that cannot be addressed by injecting clean water at the planned locations. DOI does not agree that 20 years is the best engineering estimate for this alternative. The estimate is based on a simplified hydrogeologic model and assumptions that are founded on a limited data set. DOI believes this estimate could take in excess of a hundred years or more and may ultimately have to rely on natural attenuation processes to attain background levels throughout the aquifer. Revise the implementability discussion to address implementability, not feasibility. All of the alternatives have been determined to be feasible at this stage of alternatives analysis.	include that (1) Cr(VI) is only very slightly sorbed compared to organic contaminants and most inorganics, and (2) the fine-grained portions of the Topock aquifer are generally composed of silt and sandy silt rather than clay. There will likely be some zones where RAOs are not met without further optimization of the remedy, but because of the above factors, PG&E believes that, across most of the plume, the effects of diffusion out of low-permeability layers will not result in significant rebound in concentrations measured in monitoring wells. Language to this effect will be added to Section 5.3.5.3. This discussion of time to cleanup for Alternative E in Table 5-5A will be rephrased in terms of time for pore volume flushing. Per DOI input received August 4, 2009, the first sentence under short-term effectiveness in Table 5-5A for Alternative E will be changed to: "It is estimated that it would take 8 to 70 years to achieve the RAOs for this alternative." PG&E agrees that it could take longer than 20 years to reach RAOs across the entire plume. As noted in Section 5.3.5.2 and Figure D4-4, the time to cleanup may be up to 70 years based on 20 pore volume flushing. PG&E also agrees that MNA may be appropriate for recalcitrant zones at the end of the active phase of remediation. The text describing the time to cleanup has been revised per the DOI text revisions provided August 4, 2009. References to technical and administrative feasibility within the implementability criterion are consistent with the NCP and are appropriate considerations for evaluation of implementability (see response to comment #279 and #363). However, in response to this comment, the word "feasible" will be changed to" implementable" in the alternative evaluation.	Please delete highlighted text.	DOI accepts the response, pending review of the final text. DOI accepts the response.	Redline final submitted to agencies on November 13, 2009. Agencies approved the report revisions.
379	DOI-148	Table 5-5. Alternative F	U.S. Department of the Interior	The statement that rebound of Cr(VI) concentrations after the injection wells are shut down would be short duration is made without any supporting evidence or analysis. Long term diffusion from fine grained zones could continue to affect groundwater at concentrations above background levels for extended durations. Attainment of background levels throughout the aquifer through active pumping may prove to take nearly as long as natural flushing. The heterogeneity of the aquifer may result in recalcitrant zones that cannot be addressed by injecting clean water and pumping contaminated water at the planned locations. DOI does not agree that 30 years is the best engineering estimate for this alternative. The estimate is based on a simplified hydrogeologic model and assumptions that are founded on a	**Issue pertaining to describing time to cleanup resolved. Original response shown below for completeness.** DOI is correct in stating that there is no evidence to indicate how diffusion from low-permeability layers may affect the rebound after the pump and treat system is shut down. However, qualitative evaluation and technical judgment suggest that rebound will be no more of a problem at this site than at most cleanup sites. Specific supporting rationale include that (1) Cr(VI) is only very slightly sorbed compared to organic contaminants and most inorganics, and (2) the fine-grained portions of the Topock aquifer are generally composed of silt and sandy silt rather than clay. There will likely be some zones where RAOs are not met without further optimization of the remedy, but because of the above factors, PG&E believes that across most of the plume the effects of diffusion out of low-permeability layers will not result in significant rebound in concentrations measured in monitoring wells. Language to this effect will be added to Section 5.3.6.1 and will be referenced in the section for this	See DTSC response to Comment 378 above.	Please see the file transmittal "Sec 5 DOI edits 8-4-09" for modifications to the text in response to the RTC.	Comment resolved following agency review and input during finalization of Table 5-5 in the CMS/FS Report. The text modifications provided by DOI have been incorporated. Redline final submitted to agencies on November 13, 2009. Agencies approved the report revisions.

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				limited data set. DOI believes this estimate could take in excess of a hundred years or more and may ultimately have to rely on natural attenuation processes to attain background levels throughout the aquifer. Revise the implementability discussion to address implementability, not feasibility. All of the alternatives have been determined to be feasible at this stage of alternatives analysis.	alternative. This discussion of time to cleanup for Alternative F in Table 5-5A will be rephrased in terms of time for pore volume flushing. Per DOI input received August 4, 2009, the first sentence under short-term effectiveness in Table 5-5A for Alternative F will be changed to: "It is estimated that 10 to 100 years would be required to achieve the RAOs for this alternative." PG&E agrees that it could take longer than 30 years to reach RAOs across the entire plume. As noted in Section 5.3.6 and Figure D4-5, the time to cleanup may be up to 100 years based on 20 pore volume flushing. PG&E also agrees that MNA may be appropriate for recalcitrant zones at the end of the active phase of remediation. The text describing the time to cleanup has been revised per the DOI text revisions provided August 4, 2009. References to technical and administrative feasibility within the implementability criterion are consistent with the NCP and are appropriate considerations for evaluation of implementability (see response to comment #279 and 363). However, in response to this comment, the word "feasible" will be changed to" implementable" in the alternative evaluation.		DOI accepts the response.	
380	DTSC-157	Table 5-5, Alternative F, G, H and	California Department of Toxic Substances Control	Similar to issues above, DTSC would like more detailed analysis of the alternatives and the need to reconcile the design numbers in various places of the report, plus inclusion of the basis of design elements.	As stated in Section 5.3, the groundwater model was used for conceptual design of the alternatives, and was used to estimate well locations, flow rates, and time to cleanup for each alternative. Appendix F provides detailed descriptions of how the model was used in the development of the remedial alternatives. Appendix D provides assumptions used in development of the cost estimate. In response to this comment, Table 5-7 will refer the reader to Appendices D and F for assumptions supporting the conceptual design. In addition, the report will be modified to reconcile quantities expressed for the conceptual design in various locations in the report.	DTSC agrees with RTC. PG&E should remain consistent with information. If multiple injection wells are envisioned but not shown, PG&E should clarify that information.	DOI concurs with the response	Comment resolved. Agencies approved PG&E response. Changes noted in the response have been made to the CMS/FS Report.
381	DOI-149	Table 5-5. Alternative G	U.S. Department of the Interior	The statement that rebound of Cr(VI) concentrations after the injection wells are shut down would be short duration is made without any supporting evidence or analysis. Long term diffusion from fine grained zones could continue to affect groundwater at concentrations above background levels for extended durations. Attainment of background levels throughout the aquifer through active pumping may prove to take nearly as long as natural flushing. The heterogeneity of the aquifer may result in recalcitrant zones that cannot be addressed by injecting clean water and extracting	**Issue pertaining to describing time to cleanup resolved. Original response shown below for completeness.** DOI is correct in stating that there is no evidence to indicate how diffusion from low-permeability layers may affect the rebound after the pump and treat system is shut down. However, qualitative evaluation and technical judgment suggest that rebound will be no more of a problem at this site than at most cleanup sites. Specific supporting rationale include that (1) Cr(VI) is only very slightly sorbed compared to organic contaminants and most inorganics, and (2) the fine-grained portions of the Topock aquifer are generally composed of silt and sandy silt rather than clay. There will likely be some zones where RAOs are not met without	See DTSC response to Comment 378 above.	Comment resolved. Please see the file transmittal "Sec 5 DOI edits 8-4-09" for modifications to the text in response to the RTC.	Comment resolved following agency review and input during finalization of Table 5-5 in the CMS/FS Report. The text modifications provided by DOI have been incorporated. Redline final submitted to agencies on November 13, 2009. Agencies approved the report revisions.

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				contaminated water at the planned locations. DOI does not agree that 20 years is the best engineering estimate for this alternative. The estimate is based on a simplified hydrogeologic model and assumptions that are founded on a limited data set. DOI believes this estimate could take in excess of a hundred years or more and may ultimately have to rely on natural attenuation processes to attain background levels throughout the aquifer. The table should reflect the substantial impact of the floodplain cleanup activities (Phase 1). Revise the implementability discussion to address implementability, not feasibility. All of the alternatives have been determined to be feasible at this stage of alternatives analysis.	further optimization of the remedy, but because of the above factors, PG&E believes that across most of the plume the effects of diffusion out of low-permeability layers will not result in significant rebound in concentrations measured in monitoring wells. Language to this effect will be added to Section 5.3.7.1 and will be referenced in the section for this alternative. This discussion of time to cleanup for Alternative G in Table 5-5A will be rephrased in terms of time for pore volume flushing. Per DOI input received August 4, 2009, the first sentence under short-term effectiveness in Table 5-5A for Alternative G will be changed to: "It is estimated that 10 to 100 years would be required to achieve the RAOs for this alternative." PG&E agrees that it could take longer than 20 years to reach RAOs across the entire plume. As noted in Section 5.3.7 and Figure D4-6, the time to cleanup may be up to 100 years based on 20 pore volume flushing. PG&E also agrees that MNA may be appropriate for recalcitrant zones at the end of the active phase of remediation. The text describing the time to cleanup has been revised per the DOI text revisions provided August 4, 2009. Table 5-7 has been modified to reflect that there will be infrastructure proposed on the floodplain between National Trails Highway and the Colorado River in this alternative. PG&E presumes that substantial impacts are defined by non-compliance with ARAR. As stated in Table 5-7, construction of wells and piping in floodplain or wetland areas will be performed in a manner that complies with federal floodplain and wetlands protection requirements. References to technical and administrative feasibility within the implementability criterion are consistent with the NCP and are appropriate considerations for evaluation of implementability (see response to comment #279 and #363). However, in response to this comment, the word "feasible" will be changed to" implementable" in the alternative evaluation.		DOI accepts the response.	
382	DOI-150	Table 5-5. Alternative H	U.S. Department of the Interior	The statement that rebound of Cr(VI) concentrations after the injection wells are shut down would be short duration is made without any supporting evidence or analysis. Long term diffusion from fine grained zones could continue to affect groundwater at concentrations above background levels for extended durations. Attainment of background levels throughout the aquifer through upland in situ injection and floodplain active pumping may an extended period. The heterogeneity of the aquifer may result in recalcitrant zones that cannot be addressed by injecting substrate or extracting	**Issue pertaining to describing time to cleanup resolved. Original response shown below for completeness.** DOI is correct in stating that there is no evidence to indicate how diffusion from low-permeability layers may affect the rebound after the pump and treat system is shut down However, qualitative evaluation and technical judgment suggest that rebound will be no more of a problem at this site than at most cleanup sites. Specific supporting rationale include that (1) Cr(VI) is only very slightly sorbed compared to organic contaminants and most inorganics, and (2) the fine-grained portions of the Topock aquifer are generally composed of silt and sandy silt rather than clay. There will likely be some zones where RAOs are not met without further optimization of the remedy, but because of the above	See DTSC response to Comment 378 above.	Comment resolved. Please see the file transmittal "Sec 5 DOI edits 8-4-09" for modifications to the text in response to the RTC.	Comment resolved following agency review and input during finalization of Table 5-5 in the CMS/FS Report. The text modifications provided by DOI have been incorporated. Redline final submitted to agencies on November 13, 2009. Agencies approved the report revisions.

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				contaminated water at the planned locations. DOI does not agree that 30 years is the best engineering estimate for this alternative. The estimate is based on a simplified hydrogeologic model and assumptions that are founded on a limited data set. DOI believes this estimate could take in excess of a hundred years or more and may ultimately have to rely on natural attenuation processes to attain background levels throughout the aquifer. Revise the implementability discussion to address implementability, not feasibility. All of the alternatives have been determined to be feasible at this stage of alternatives analysis.	factors, PG&E believes that across most of the plume the effects of diffusion out of low-permeability layers will not result in significant rebound in concentrations measured in monitoring wells. Language to this effect will be added to Section 5.3.8.1 and be referenced in the section for this alternative. Per DOI input received August 4, 2009, the first sentence under short-term effectiveness in Table 5-5A for Alternative H will be changed to: "It is estimated that 12 to 120 years would be required to achieve the RAOs for this alternative." PG&E agrees that it could take longer than 30 years to reach RAOs across the entire plume. As noted in Section 5.3.8 and Figure D4-7, the time to cleanup may be up to 120 years. PG&E also agrees that MNA may be appropriate for recalcitrant zones at the end of the active phase of remediation. The text describing the time to cleanup has been revised per the DOI text revisions provided August 4, 2009. References to technical and administrative feasibility within the implementability criterion are consistent with the NCP and are appropriate considerations for evaluation of implementability (see response to comment #279 and 363). However, in response to this comment, the word "feasible" will be changed to "implementable" in the alternative evaluation.		DOI accepts the response.	
383	DOI-151	Table 5-5. Alternative I	U.S. Department of the Interior	The statement that rebound of Cr(VI) concentrations after the injection wells are shut down would be short duration is made without any supporting evidence or analysis. Long term diffusion from fine grained zones could continue to affect groundwater at concentrations above background levels for extended durations. Attainment of background levels throughout the aquifer through active pumping may prove to take nearly as long as natural flushing. The heterogeneity of the aquifer may result in recalcitrant zones that cannot be addressed by injecting clean water and pumping contaminated water at the planned locations. DOI does not agree that 300 years is the best engineering estimate for this alternative. The estimate is based on a simplified hydrogeologic model and assumptions that are founded on a limited data set. DOI believes this estimate could take much longer and may ultimately have to rely on natural attenuation processes to attain background levels throughout the aquifer. Revise the implementability discussion to address implementability, not feasibility. All of the	**Issue pertaining to describing time to cleanup resolved. Original response shown below for completeness.** DOI is correct in stating that there is no evidence to indicate how diffusion from low-permeability layers may affect the rebound after the pump and treat system is shut down However, qualitative evaluation and technical judgment suggest that rebound will be no more of a problem at this site than at most cleanup sites. Specific supporting rationale include that (1) Cr(VI) is only very slightly sorbed compared to organic contaminants and most inorganics, and (2) the fine-grained portions of the Topock aquifer are generally composed of silt and sandy silt rather than clay. There will likely be some zones where RAOs are not met without further optimization of the remedy, but because of the above factors, PG&E believes that across most of the plume the effects of diffusion out of low-permeability layers will not result in significant rebound in concentrations measured in monitoring wells. Language to this effect will be added to Section 5.3.9.1 and be referenced in the section for this alternative. This discussion of time to cleanup for Alternative I in Table 5-5A will be rephrased in terms of time for pore volume flushing. Per DOI input received August 4, 2009, the first sentence under short-term effectiveness in Table 5-5 for	See DTSC response to Comment 378 above.	Comment resolved. Please see the file transmittal "Sec 5 DOI edits 8-4-09" for modifications to the text in response to the RTC. DOI accepts the response.	Comment resolved following agency review and input during finalization of Table 5-5 in the CMS/FS Report. The text modifications provided by DOI have been incorporated. Redline final submitted to agencies on November 13, 2009. Agencies approved the report revisions.

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				alternatives have been determined to be feasible at this stage of alternatives analysis.	Alternative I will be changed to: "It is estimated that 150 to 1,500 years would be required to achieve the RAOs for this alternative." PG&E agrees that it could take longer than 300 years to reach RAOs across the entire plume. As noted in Section 5.3.9 and Figure D4-8, the time to cleanup may be up to 1,500 years based on 20 pore volume flushing. PG&E also agrees that MNA may be appropriate for recalcitrant zones at the end of the active phase of remediation. The text describing the time to cleanup has been revised per the DOI text revisions provided August 4, 2009. References to technical and administrative feasibility within the implementability criterion are consistent with the NCP and are appropriate considerations for evaluation of implementability (see response to comment #279 and 363). However, in response to this comment, the word "feasible" will be changed to "implementable" in the alternative evaluation.			

Section 6 Comments - Recommended Remedial Action Alternative

	Comment Number	Section/ Page	Commenter	Comment	PG&E Response	DTSC Response	DOI Response	Final Comment Resolution
384	DOI-152	Section 6.0	U.S. Department of the Interior	As noted in the cover letter accompanying these comments, this chapter should be clarified to reflect that it offers a PG&E recommendation as to the preferred alternative. In addition, it should be explicit that this recommendation does not take into consideration state and community acceptance criteria. Finally, DOI will supply PG&E with specific language for inclusion in the final CMS/FS regarding ARARs attainment prior to the issuance of the final CMS/FS.	In response to this comment, the first sentence in the fourth paragraph in Section 6.0 will be revised as follows: "PG&E's recommendation for the preferred alternative, based on the conclusions of the comparative analysis in Section 5.5, is that Alternative E, *In-situ* Treatment with Fresh Water Flushing. Alternative E provides the best balance of advantages and tradeoffs for the remedial action." The second full paragraph on page 6-2 (after the bullets) will be revised to state: "As discussed in Section 5.5, the comparative analysis did not consider the evaluation criteria of state and community acceptance. DTSC and DOI will formally address the modifying criteria of State Acceptance and Community Acceptance during the final remedy selection under the Record of Decision and DTSC's final remedy adoption."	DTSC notes that PG&E will need to add the appropriate alternative designation in RTC.	DOI accepts the response.	Comment resolved. Agencies approved PG&E response. Changes noted in the response have been made to the CMS/FS Report.
385	CRIT-8	Section 6.0 Page 6-1	Envirometrix (on behalf of the Colorado River Indian Tribe)	We find the proposed recommended groundwater remedial action alternative of Alternative E, *In-situ* Treatment with Fresh Water Flushing to be inappropriate, disturbing, non-protective of the Colorado River, and extremely objectionable. To propose any remedy that would include a proposal to push groundwater contamination and the groundwater plume closer to the Colorado River is irresponsible. To push groundwater contamination closer to the Colorado River and later determine the remedy is in error, not working as envisioned, or through the normal future remedial process it is determined that additional chemicals are present	The CRIT preferences are noted. Please see response to comments #198 and #384 for a description of how State and Community Acceptance are implemented for this remedial action. In response to this and similar comments, PG&E will revise the configuration of Alternative E to replace the floodplain IRZ lines with a line of extraction wells near the river. The extraction wells would provide capture of groundwater emanating from the plume and pull carbon across the floodplain from the IRZ near National Trails Highway, negating the need for the IRZ lines in the floodplain. Water pumped from the line of extraction wells near the river would be amended with a carbon reagent and injected into a new	DTSC accepts RTC and acknowledges the Tribe's concerns. The technical merit of a proposed alternative is the key consideration in whether it is included as one of the alternatives to be further evaluated in the CEQA-based environmental review process. The CEQA process (which includes detailed consideration of cultural resources) can provide a rationale for the Lead Agency to eliminate or modify a technically feasible alternative. Federal processes under DOI include the identification of ARARs, any of which may result in the elimination of an alternative for (federal) consideration on the	DOI would like to thank the CRIT for providing their thoughts and perspective on this area. The perspectives provided by the CRIT and other Tribes will be considered in the selection of the remedy for the Topock groundwater. The Bureau of Land Management will continue to conduct formal Section 106 consultation with the nine federally recognized Tribes.	Comment resolved. Agencies approved PG&E response. Changes noted in the response have been made to the CMS/FS Report.

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				in groundwater (i.e. dioxin, metals, or future emerging chemicals) or additional chemicals are present in soil that may impact groundwater is not rationale or responsible. This proposed alternative is not protective of human health and the environment since pushing the groundwater plume closer to the Colorado River may increase the likelihood that contamination could enter the Colorado River and impact human health and the environment. There are also significant risks and uncertainty related to the exact knowledge of the subsurface geology, fractures, faults, porosity and permeability within the groundwater flow pathway. This is a three dimensional groundwater flow system and significant uncertainties exist regarding this system to make this a viable alternative. There are many examples where regulatory Agencies approved remedial actions that were proposed by other large companies and later resulted in disastrous consequences as a result of intended remedy solutions that yielded significantly different results. With the Colorado River we can not afford to take any risk. CRIT is immediately downstream and in the immediate pathway for any surface waters that may carry contamination and we will be directly affected by any contamination emanating from the PG&E Topock Compressor Station. Any contamination entering the Colorado River will directly affect and impact our health and well being and the millions of people of Southern California and Arizona who rely on the Colorado River as a primary source of drinking water, agricultural water supply and recreational use. The proposed alternative as presented by PG&E demonstrates a significant lack of understanding of these basic fundamental issues and corporate responsibility to the downstream Tribes and the people of Southern California and Arizona. Is it possible that PG&E's final selection of the CMS/FS remedy may be based more on meeting the terms of the settlement agreement rather than seeking to select an appropriate remedy that will fundamentally be protective of human health and the environment, remove the contamination from the groundwater, and protect the Colorado River from possible impact or contamination. Further, it is our opinion that in areas where the CMS/FS may be inconsistent with any possible interpretation or terms of the settlement agreement, PG&E states that they have received direction by a regulatory agency to include a specific action or provision, such as the	set of injection wells near the western edge of the plume. Freshwater injection at wells further to the west of the plume would still be used to control gradients, but the freshwater injection flow rates would be reduced from those proposed in the original Alternative E. Please see response to comment #250. As described in Section 5.3.6, the offsite potable water is assumed to be the same as the water source for the Topock Compressor Station. The Topock Compressor Station is currently purchasing its water from wells in Arizona from Southwest Water Inc. Future water supply may be from the Colorado River or from wells on the California side of the river. These sources are within an approximately 2-mile radius of the proposed injection locations. Please also see response to comment #328.3. In-situ treatment is an acceptable approach at many sites under both RCRA and CERCLA to reduce toxicity, mobility, or volume of constituents to protect human health and the environment. The reduced form of chromium is a naturally occurring element in the environment.	basis of legal infeasibility. Narrowing down of potential alternatives by the California and federal lead agencies may not occur simultaneously; however the agencies are coordinating their review of alternatives as closely as possible and the remedy selection will reflect input from both.		

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				continued operation of the IM No. 3 treatment system. This supports our continued concern that PG&E may have predetermined a remedy or actions that are based on the terms of the settlement agreement. The proposed alternative does not evaluate the resulting potential negative chemical impacts of injecting water with a different chemical makeup, characteristic, and water quality into the existing groundwater system. This proposed alternative does not reduce the volume and mass of contamination. This proposed alternative only converts one type of contamination (hexavalent chromium) into another type of contamination (chromium) and places it in the soil, in excess of what is normally present. A contaminate still remains that was not originally present. This contamination is the result of PG&E discharging this chemical onto surface soils resulting in contamination to the soil and groundwater. Further, this alternative does not address the stated fundamental remedial action objective identified in Section 3, No. 3 “reduce the mass of Cr(T) and CR (VI) in groundwater at the site”, it only converts and places the contamination in the soil. In order to begin the process to heal the land and water, this toxic chemical must first be removed in order to allow the healing process to begin. This alternative does not control the source of the release. Rather, it pushes the groundwater source closer to the Colorado River. The lateral and vertical extent of any residual contamination source remaining in soil is also not known completely known. Groundwater mounding will occur at the injection sites and pushing additional groundwater through this contaminated source material may unnecessarily add to an increased amount of groundwater contamination or create additional new groundwater contamination. This alternative does not provide short-term and long-term reliability. Since the conversion and placement of this chromium in soil does not guarantee or ensure short-term or long term effectiveness. This chromium may also be reconverted to hexavalent chromium under certain conditions and re-enter the groundwater. Finally, this proposed alternative is not acceptable to CRIT as a stakeholder.				
Appendix A Comments - Applicable or Relevant and Appropriate Requirements (Appendix B in Final Report)								

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386	ADEQ-1	Appendix A	Arizona Department of Environmental Quality	The VRP has reviewed the chemical -specific Applicable or Relevant and Appropriate Requirements (ARARs) proposed for surface water in the CMS/FS, and compared the hexavalent and total chromium numbers to Arizona's Numeric Water Quality Criteria for surface water, found in Title 18, Chapter 11 of the Arizona Administrative Code. The VRP concurs with Appendix A of the CMS/FS, which indicates the Federal Surface Water Pollution Control Act standard of 11 micrograms per liter (ug/L) for hexavalent chromium meets or is more stringent than Arizona's Numeric Water Quality Criteria for both Human Health and Agricultural Designated Uses – Domestic Water Source (21 ug/L) and Aquatic & Wildlife Designated Uses – Effluent Dependent Water/Cold Water/Warm Water Source (11 ug/L), as designated for this portion of the Colorado River. However, due to the nature of the Topock release and its proximity and potential impact to the Waters of the State of Arizona, the VRP does not concur with the conclusion in Appendix A that the Arizona Numeric Water Quality Criteria are not ARARs because they are not more stringent than the federal standards.	PG&E defers response to DOI		Pursuant to Section 121(d)(2)(A)(ii) of CERCLA, only those state standards that are more stringent than their federal counterparts qualify as ARARs under CERCLA (see response to comments numbered 97 and 98). Arizona's surface water quality standards for hexavalent and total chromium are not more stringent than their federal counterparts. Therefore, these standards are not ARARs for this Site.	Comment addressed. DOI revised the ARARs list and provided the updated list to PG&E in October 2009. The updated ARARs list is included in the Final CMS/FS as Appendix B.
387	ADEQ-3	Appendix A	Arizona Department of Environmental Quality	The VRP concurs with the CMS/FS that the Federal Safe Drinking Water Act and California Safe Drinking Water Act standards for total chromium in groundwater both meet or are more stringent than Arizona's Aquifer Water Quality Standard (AWQS) of100 ug/L for total chromium. The VRP again does not concur with the conclusion in Appendix A that the AWQS is not a relevant chemical-specific ARAR for the site.	PG&E defers response to DOI		Pursuant to Section 121(d)(2)(A)(ii) of CERCLA, only those state standards that are more stringent than their federal counterparts qualify as ARARs under CERCLA (see response to comments numbered 97 and 98). Arizona's Aquifer Water Quality Standards for total chromium are not more stringent than their federal counterparts. Therefore, these standards are not ARARs for this Site.	Comment addressed. DOI revised the ARARs list and provided the updated list to PG&E in October 2009. The updated ARARs list is included in the Final CMS/FS as Appendix B.
388	RWQCB-1	Appendix A (This comment was to RFI/RI Volume 2 addendum. RFI/FI Volume 2 and the CMS/FS report contain identical ARARs appendices	Regional Water Quality Control Board	Regional Board staff agrees with the Applicable, or Relevant and Appropriate Requirements (ARARs) and Constituents of Potential Concern (COPCs) described in the RFI Vol. 2 Addendum for the remedial activities discussed. If the remediation alternatives selected result in a discharge to land and/or surface waters, however, then that discharge will also need to comply with the Water Quality Objectives specified in the Regional Board's Water Quality Control Plan (Basin Plan).	PG&E defers response to DOI		DOI is currently evaluating this comment. DOI will provide PG&E with a revised Appendix A for the final CMS/FS and will include revisions to Appendix A with respect to this comment as appropriate.	Comment addressed. DOI revised the ARARs list and provided the updated list to PG&E in October 2009. The updated ARARs list is included in the Final CMS/FS as Appendix B.

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389	HA-13	Appendix A	Hargis & Associates, Inc. (on behalf of Fort Mojave Indian Tribe)	7c. Consideration of the Settlement Agreement The Tribe believes that the Settlement Agreement should be treated as a "to be considered" (TBC) item.	PG&E defers response to DOI		DOI has reviewed the Settlement Agreement entered between FMIT and DTSC and has identified no requirement that pertains or is otherwise relevant to the evaluation and selection of a CERCLA remedial action by DOI.	Comment addressed. No changes to the CMS/FS Report are required.
Appendix B Comments - Remedial Alternative Cost Estimates (Appendix D in Final Report)								
390	DOI-153	Appendix B, Page B-1, General Comments	U.S. Department of the Interior	The cost estimates provided are very general with complete systems and miscellaneous costs included as lump sum costs. These would be considered more along the line of parametric or assembly estimates. Break down the costs for each alternative into detailed cost estimates with specific elements/sub-elements and associated unit costs The Tables reference USEPA costing guidance. Provide the reference(s) used in development of the cost estimates. The tables or text should include a definition of the abbreviations for LF, LS, ICs, 5 Yr Rev, GC, SDC, G&A, sub mob, sub GC, Bio/Cult, and Reg/Stake. The costs for restoration and remedy deconstruction of IM-3 should be included within the costs for alternatives B through H. The text in B.2.2 describes a PDI configuration while the estimate sheets specify a pump-C-inject system. Correct this inconsistency.	In response to this comment, the cost estimates for each of the alternatives in Appendix D have been revised to provide additional detail. Rather than a one-page-per-alternative cost spreadsheet, the cost spreadsheets will be expanded to two pages per alternative, and additional tables and text will also be added to Appendix D to provide basis for the cost estimates. The USEPA cost estimating guidance, referenced in the report and text in Appendix D, will also be added to the cost estimate summary tables for each of the alternatives. An additional table will be added in Section 5.0 explaining the acronyms and abbreviations of terms used in the cost summaries. The costs for restoration and deconstruction of IM No. 3 will be added to the cost estimates for Alternatives B through I. Estimate sheets include cost for both PDI (Alternative H) and Pump-C-inject configurations on other alternatives. No change required.	DTSC awaits revised estimates for review.	Pending final review of the tables with the detailed cost estimates and additional text, DOI accepts the response. DOI accepts the response. Pending final review, DOI accepts the addition of a Table to Section 5 with abbreviations and acronyms. DOI accepts the response. DOI accepts the response.	Comment resolved following agency review and input during finalization of Appendix D to the CMS/FS Report. Redline final submitted to agencies on November 13, 2009 with the cost estimate detail. Agencies approved the report revisions, as modified by comments #587- #603.
391	DTSC-158	Appendix B	California Department of Toxic Substances Control	General Comment: The current cost estimates are inadequate. The cost estimates should include supporting evidence for the cost basis. Additional information and breakdown of costs are critical for review and approval of the cost estimates.	In response to this comment, the cost estimates for each of the alternatives in Appendix D have been revised to provide additional detail. Rather than a one-page-per-alternative cost spreadsheet, the cost spreadsheets will be expanded to two pages per alternative, and additional tables and text will also be added to Appendix D to provide basis for the cost estimates.	DTSC awaits revised estimates for review.	DOI concurs with the response pending review of the tables.	Comment resolved following agency review and input during finalization of Appendix D to the CMS/FS Report. Redline final submitted to agencies on November 13, 2009. Agencies approved the report revisions as modified by comments #587- #603.
392	HA-22	Appendix B	Hargis & Associates, Inc. (on behalf of Fort Mojave Indian Tribe)	What are the cost assumptions for cultural/tribal resources for each Alternative? What is included specifically in "cultural monitoring," "cultural surveys," and "oversight" as used in Appendix B? Are costs for tribal monitors included in these estimates? Please separate out biological and cultural resource costs into separate line items to facilitate review. Without such a breakdown, it is	In response to this comment, the cost estimating summary tables for each of the alternatives have been revised to include separate line items for biological monitoring and cultural monitoring. In addition, the cost estimating summary tables will provide additional detail on the basis for the cost estimates, which are assumed to include onsite monitors during construction and an annual allowance for cultural	Since costs for tribal monitors are real costs associated with this project, inclusion of line items for this appears reasonable. Since the estimate in the CMS/FS is for alternative comparison only, DTSC will accept the deferral of this cost to the final cost estimate as part of design and remedy	Pending final review of the tables with the detailed cost estimates and additional text, DOI concurs the response.	Comment resolved following agency review and input during finalization of Appendix D to the CMS/FS Report. Redline final submitted to agencies on November 13, 2009.

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				difficult to ascertain the accuracy of the cost estimates and whether the estimates comply with the requirements of ARARs. Additionally, the cost tables should include a line item for restoration costs for mitigating damages occurring during and after completion of the remedial action. Finally, an explanation should be provided for why certain costs were excluded[28] from the estimates. [28] See last paragraph in Section B.2.3.4.	surveys during the O&M period. Costs for tribal monitors are not included in the cost estimates. As described in response to comment #144, the site restoration activities included in the remedial alternative cost estimates are assumed to include deconstruction or decommissioning of treatment and monitoring facilities, including roads, extraction wells, IRZ wells, injection wells, monitoring wells, pipelines, tanks, instrumentation, foundations, and other equipment associated with the remedial facilities. In addition, an allowance for restoration of construction areas is provided as a separate line item. The cost estimates were developed following USEPA guidance for conceptual cost estimates, and the list of excluded costs generally is consistent with that guidance.	implementation.		Agencies approved the report revisions.
393	DTSC-159	Appendix B, tables	California Department of Toxic Substances Control	Please explain "restoration and remedy deconstruction" under "capital costs" vs "post-remediation deconstruction" under "present value analysis".	This will be clarified in the revised cost estimates. These refer to the same activity and will therefore be described consistently. The costs are different in the two locations on the spreadsheet because the present value analysis includes the 25 percent contingency (bottom of the capital cost section). Replaced term "restoration and remedy deconstruction" with "post-remediation deconstruction" in the cost estimate tables.	Agree with RTC.	DOI concurs with the response.	Comment resolved. Agencies approved PG&E response. Changes to the cost estimate tables noted in the response have been made to the CMS/FS Report.
394	DTSC-160	Appendix B, tables	California Department of Toxic Substances Control	As discussed in Section 5.4.1.2, cost evaluation (page 5-43), for remediation periods longer than 30-yr, a total project cost (cost without discounting) in addition to the present worth should be evaluated.	This information will be added to Table 5-7.	Agree with RTC.	DOI concurs with the response.	Comment resolved. Agencies approved PG&E response. Changes noted in the response have been made to Table 5-7 to the CMS/FS Report.
395	DTSC-161	Appendix B, Tables B-4, B-5, B-6, B-8	California Department of Toxic Substances Control	Clarification is needed on how the "quantity" is determined for IRZ, and what the unit cost for "1000-ft" means. DTSC understands that the estimate is based on measurements taken from the Figures in Section 5, DTSC wonders if there are better methods of establishing and estimating the length of pipes required.	The unit cost was based on construction of a per-1,000-foot length. The estimated pipeline lengths are based on the conceptual pipeline routes, considering factors such as well locations, terrain, and accessibility. The actual length and cost of pipeline will be refined during the remedial design. The pipeline costs are a relatively small percentage of the overall alternative cost; therefore, the alternative cost estimates are not particularly sensitive to the pipeline lengths. Consistent with USEPA cost estimating guidance, a 25 percent contingency has been added to the cost estimate to account for this and other scope uncertainties associated with the fact that the alternatives are based on conceptual designs. For the purposes of developing the order of magnitude cost estimates in the CMS/FS Report, these estimated lengths and costs provide sufficient information to compare and evaluate the various alternatives.	Agree with RTC.	DOI concurs with the response.	Comment resolved. Agencies approved PG&E response. No changes to the CMS/FS Report are required.
396	DTSC-162	Appendix B, Table B-	California Department of	It is not clear if the off-site production well and piping costs (as discussed on page 5-57) are	The costs for the offsite production well and piping costs are included in the cost for Alternative E. In addition, the costs	Agree with RTC.	DOI concurs with the response.	Comment resolved. Agencies approved

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		6	Toxic Substances Control	included. For fresh water O&M, only pumping cost is included (as discussed on page B-20). However, the cost of fresh water does not seem included. This cost could range from $180 to $350/ac-ft, which would increase the O&M cost significantly.	for water rights are also included for Alternative E, as well as the other alternatives. In response to this comment, the cost estimate summary tables will be revised to clarify the detail on these line items. The cost of water rights will be quite small since the basis for payment is the net consumptive use. For the active alternatives (except Alternative I), the amount of water extracted equals the amount of water injected back to the groundwater, resulting in no net consumptive use. As described in response to comment #136, a new table will be included in the CMS/FS Report to show water extraction, injection, and net consumptive use for each alternative. The cost estimate basis for water rights is: - $108.33/acre-foot - Assumed credit of 90% for water that is re-injected			PG&E response. Changes noted in the response have been made to the cost estimate tables in the CMS/FS Report. The cost estimates now include separate line items in O&M for freshwater source (electricity and well maintenance) and water rights.
397	DTSC-163	Appendix B, page B-12	California Department of Toxic Substances Control	The rationale for the number of injection wells at each injection location is discussed here. This should be reflected in the main text under each alternative description.	Section 5.3 states that the remedial alternatives were designed to a conceptual level of detail sufficient to develop remedial cost estimates consistent with USEPA guidance and the reader is referred to Appendix D for the cost estimate assumptions. In response to this comment, the third sentence in Section 5.3 is proposed to be revised to state: "Appendix D provides the cost estimates, including alternative components, assumptions, and cost estimating factors."	Agree with RTC.	DOI concurs with the response.	Comment resolved. Agencies approved PG&E response. Changes to Section 5.3 noted in the response have been made to the CMS/FS Report.
398	DTSC-164	Appendix B, page B-19	California Department of Toxic Substances Control	The equipment replacement costs are discussed for IM#3. Besides the useful life of monitoring wells discussed in the next page, other useful life and replacement costs for other alternatives are not discussed.	Costs and useful life of equipment are assumed as follows: - As described in Appendix D, assumed life of monitoring wells is 40 years. Replacement has been included in Alternatives B through I. - Assumed replacement of equipment at a pump-and-treat plant in Alternative I every 20 years because of longer active cleanup time. Replacement of equipment in the shorter cleanup Alternatives (F, G, H) are estimated as part of general maintenance. This will be clarified with additional text in page B-19. - Assumed life of injection wells is 10 years. Replacements are included in assumed O&M costs for the wells, This will be clarified in Appendix D. Other well maintenance (including pump replacements) are assumed as part of a annual 10 percent of capital operating cost	According to RTC, PG&E assumed a useful life for monitoring wells under Alt B and I. Shouldn't this assumption be the same for all other remedial alternatives?	Please ensure that these assumptions are applied consistently to all alternatives.	Clarified the cost estimate assumption as to the well replacement cost. Applied the assumption consistently across all alternatives. Comment resolved following agency review and input during finalization of Appendix D to the CMS/FS Report. Redline final submitted to agencies on November 13, 2009. Agencies approved the report revisions**.**
Appendix C Comments - Demonstration of Groundwater Flow Model Accuracy (Appendix E in Final Report)								
399	DOI-154	Appendix C General	U.S. Department of the Interior	The report states that the model reasonably duplicates observed water levels. Most of the observations are in the fluvial deposits that are dominated by river stage. The model does a good job of simulating the changes in river stage in the fluvial deposits. Observations of the alluvial aquifer are mostly confined to the injection wells.	The model was calibrated in a manner that minimized the average error in wells across each area where observed data were available. This resulted in the model slightly underpredicting levels in some wells while slightly overpredicting in others. The use of four model layers to simulate the Alluvial Aquifer was based upon the general distribution of screened intervals at the time of model		DOI requests that written documentation be provided by PG&E for inclusion into the Administrative Record supporting the estimated pore volume or range of pore volume flushing required for cleanup. Additionally, the response does not address the point regarding the result if	PG&E will submit a technical memorandum, separate from the CMS/FS report, that provides supporting information for inclusion into the Administrative

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				Inspection of these graphs indicate that the models leakance values between layers is too high—essentially there is more hydraulic connection between layers in the model than there is in the aquifer system. The model is highly parameterized where data are available to calibrate the model and average values are used in the remainder of the model domain. Most of the mass of the plume in the uplands area is in an area of the model where there are few data to calibrate the model. Therefore, there is a high degree of uncertainty in the models ability to accurately predict water levels in response to pumping or injection in this part of the model domain. As stated earlier in this review, the model uses 4 layers to simulate a complex aquifer system Although the model does a reasonable job of matching water levels where it has been calibrated to measured data, it is not designed for nor capable of predicting cleanup times. The assumptions used to estimate cleanup timeframes are not valid if a significant percentage of the mass of the chromium is retained in the fine-grained layers of the aquifer system. The average model properties will underestimate the cleanup timeframes if chromium is retained in the fine-grained layers of the aquifer system (see 01_TW-2D_LithComparison.pdf). The figures showing the deconvolution of MW-54 during the May 2008 extraction well shut-down indicate that the deconvolution program was not properly fitted during the pumping period. More work is needed in deconvoluting the measured data at MW-54 to determine if the model adequately simulates the measured response on the eastern side of the Colorado River.	formulation. They were designed to account for average properties across depth zones that could be directly compared to observed data, as opposed to stratigraphically correlated layers that could have very few observation wells with which to compare results. The estimation of cleanup times was based on an estimate of five pore volume flushing to account for aquifer heterogeneity, desorption kinetics, and other contributing processes that affect cleanup time but cannot be measured with accuracy, A range of two to 20 pore volumes is shown on the cleanup curve figures to account for uncertainty. The pore volume flushing estimates were made with observed data from three sources: (1) *in-situ* pilot study tracer tests, (2) IM-3 injection water breakthrough at observation wells, and (3) stable isotope data in floodplain wells, which have become progressively lighter as river-influenced groundwater is drawn landward as a result of IM-3 extraction. Estimates target 95 percent reduction of initial concentration of the constituent in question, (dye tracer, specific conductance, and alluvial-signature deuterium, respectively). The pore volume flushing estimates are approximate and have ranged from 0.7 to 16.8. PG&E worked closely with the USGS on deconvoluting the May 2008 data, and correspondence from Keith Halford of USGS to CH2M HILL on July 7, 2008 described an approximate response of 0.05 foot in well MW-54-195 "with some imagination". This is consistent with the <0.10 foot that was reported in the CMS/FS Report. The deconvolution of data from the September 2008 shutdown was presented in the Third Quarter 2008 Performance Monitoring Report (Appendix E of that report). Data collected during this shutdown test was affected to a lesser extent by "noise" from river level fluctuations, and as a result the response in well MW-54-195 could be quantified. The September deconvolutions will be used in Appendix E in place of those for the May 2008 data. Parameters of the alluvial aquifer were adjusted for best fit of data for all wells in the IW-2/IW-3 area, based on injection well (IW-2 and IW-3) testing. As described in the original modeling report in 2005, the injection wells and associated monitoring wells were installed after the model had been calibrated against the other calibration targets. The parameters estimated from interpretation of injection well testing were inserted into the model in a 2,000-foot radius surrounding the injection area, replacing the average parameters from the previous calibration. The fits to these aquifer tests are provided in the appendix to the modeling report. The simulated response to river stages represents a discrepancy between the assigned local properties and the attempt to fit all wells to the river influence. PG&E feels the parameters are more accurately estimated by calibrating to the nearby aquifer test rather than with the slight perturbations caused by rising and falling river levels more		the percentage of the mass of the chromium is retained in the fine-grained layers of the aquifer system. DOI would like to reiterate that a definitive number of pore volumes is not the primary issue but rather how the uncertainty of this number is built into the assessment of the alternatives. DOI has provided PG&E with recommended revised language for Section 5 that also pertains to Appendix C.	Record supporting the assumptions for estimating cleanup time as used in this CMS/FS report. Comment resolved following agency review and input during finalization of the CMS/FS Report Appendix E. Redline final submitted to agencies on November 13, 2009. Agencies approved the report revisions, as modified by comment #604-#606.

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					than a quarter-mile away. Refer also to response to comment #195 for general model considerations.			
Appendix D Comments - Groundwater Flow Model Simulation Procedures for Remedial Alternative Development and Comparison and Modeled Flowlines (Appendix F in Final Report)								
400	DTSC-165	Appendix D, page D-2	California Department of Toxic Substances Control	The 190-days travel zone discussion is misleading. As discussed in Appendix E.4.3.5, the 190-day was calculated based on injection concentration of 1,000 mg/l, a half-life time of 25-day, and residual concentration of 3 mg/l for sustaining IRZ. Any change to initial concentration and half-life would affect the travel zone.	The 190-day travel time is supported by data obtained during the *in-situ* pilot test and documented in Appendix G. DTSC is correct in stating that changes in assumptions of initial conditions would affect the travel time, but PG&E believes the assumptions made are sound for the purposes of conceptual design in the CMS/FS and are supported by site-specific data.	DTSC requests that the CMS/FS include discussion clearly indicating the affect on travel time if travel time assumptions (e.g., half-life, injection concentration) were to change.		Comment resolved following agency review and input during finalization of the CMS/FS Report. The following was added to Section F.2 "Assumptions such as half-life and injection concentration, made in Appendix G, may change during final design, which would in turn increase or decrease the travel time. Adjustments would be made to compensate for these changes should they occur. For example, if the half-life were found to be shorter, flow rates may be increased in the IRZ to compensate. Also, the well spacing may be adjusted during design or implementation, depending on the concentration of carbon to be used, with closer well spacing corresponding to lower concentrations." Agencies approved the report revisions.
401	DTSC-166	Appendix D Page D-2, Paragraph 2, Bullet 2, Section D.2	California Department of Toxic Substances Control	The section states: *"For remedies that include in-situ treatment, nodes within IRZ areas where carbon substrate is distributed were considered clean as soon as the carbon substrate reached that node."* This assumption seems overly optimistic as based on pilot test data. Can modeling be modified to account for lag time or incomplete contaminant degradation?	The kinetics of chromium reduction are very rapid, occurring in a matter of days once the reducing zone is established. The rapid disappearance of Cr(VI) once reducing conditions are established is supported by data from the pilot tests. On the scale of a remediation system operating for decades, a reaction occurring in a matter of days is essentially instantaneous. Although the modeling approach could theoretically be modified to account for the additional few days that would be required for Cr(VI) reduction to occur after reductant arrival, it would require an inordinate amount of simulation time and would result in insignificant changes in	DTSC accepts the response.		Comment resolved. Agencies approved PG&E response. No changes to the CMS/FS Report are required.

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					the final results.			
402	DTSC-167	Appendix D	California Department of Toxic Substances Control	The bedrock contact is pictured in all the Flowline Maps. With the discovery of alluvium at well MW-59, the bedrock contact will now need to be adjusted in the model and flowline analysis redone. Additionally, the bedrock contact does not change with different layers as would be expected. Is this an oversight that needs to be revised? The Appendix should comment on this issue. The contact does not appear to be accurately placed west of Bat Cave Wash (compare to Figure 5-9 of the RFI/RI Volume 2).	The groundwater model has been revised to incorporate a bedrock surface that incorporates the East Ravine investigation data and corrects the discrepancy noted in the area west of Bat Cave Wash. Figures in the Final CMS/FS Report will show the bedrock contact specific to each model layer.	DTSC awaits the revised figures proposed by PG&E and any associated text.		Comment resolved following agency review and input during finalization of Appendix F to CMS/FS Report, including revision due to incorporation of information collected from East Ravine investigation Redline final submitted to agencies on November 13, 2009. Agencies approved the report revisions.
403	DTSC-168	Appendix D Flowline Maps	California Department of Toxic Substances Control	These figures need a legend so that injection and extraction rates (red and green numbers on figures) for wells are clearly denoted.	The figures in the revised CMS/FS Report will include the requested information	DTSC awaits the revised figures proposed by PG&E.		Comment resolved following agency review and input during finalization of Appendix F to the CMS/FS Report. Redline final submitted to agencies on November 13, 2009 with legend on flowline maps. Agencies approved the report revisions.
404	DTSC-169	Appendix D Flowline Maps	California Department of Toxic Substances Control	The following issue applies to other figures and alternatives and PG&E should address this concern for all alternatives. Figure D3-49 indicates that two wells are extracting groundwater at 450 gpm and that water is being injected at two wells at 450 to 500 gpm. The Report should indicate if this is a reasonable assumption and the minimum number of wells (including well diameters) that would be required to create such flow. The location and number of wells believed to be necessary should be included in revised text, cost estimates, and on all figures (e.g., Figure 5-10).	Please see response to comment #258. Past well installations at the site provide evidence of the capacity of wells to produce water at the site. For the CMS/FS, extraction wells were assumed to have a maximum design flow rate of 620 gpm for a 12-inch well (although the maximum identified in the conceptual designs not including the freshwater supply wells was 450 gpm). Injection well design capacity was assumed to be 150 gpm, except wells only receiving freshwater without carbon, which had an assumed design capacity of 250 gpm. In response to this comment, these assumptions will be reiterated in Appendix D and in Appendix F. Appendix D includes the cost estimating assumptions used for the number of wells and well diameters; the cost estimates account for having multiple wells at a single location when needed for flow. The locations of the extraction and injection wells for the various alternatives are located on figures in Section 5.3, as well as on flowline figures in Appendix F. Using these assumptions and for cost estimating purposes, the number of wells assumed for the flow configuration noted on Figure F3-49 was five extraction wells (one well per point) and 10 injection wells (multiple wells per point). In response to this comment, the figures in Section 5.3 will include an additional note to state that multiple wells could	DTSC awaits the revised language and figures proposed by PG&E.		Comment resolved following agency review and input during finalization of Appendices D and F to the CMS/FS Report. Redline final submitted to agencies on November 13, 2009 including well capacity assumptions and the note on Section 5.3 figures. Agencies approved the report revisions.

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					be installed at each of the identified locations depending on actual performance.			
405	DTSC-170	Appendix D Estimated Cleanup Times	California Department of Toxic Substances Control	Basic background assumptions should be included in the discussion for completeness and ease of reference (e.g., total plume mass, average groundwater flow velocities). A summary table should be included to quickly present relative cleanup times and ranges.	The plume mass will be reiterated in Appendix F. Simulated groundwater flow velocity is highly variable for all the alternatives so calculating an average would not provide meaningful information. The cleanup time estimates will be included in Table 5-5A.	DTSC awaits the revised language and table proposed by PG&E.		Comment resolved following agency review and input during finalization of the CMS/FS Report. The plume mass assumption is documented in Appendix F and the cleanup time estimates are included in Table 5-6A. Redline final submitted to agencies on November 13, 2009. Agencies approved the report revisions.
406	DTSC-171	Appendix D.3	California Department of Toxic Substances Control	For Alternatives C, E, and G, since no flowlines were run for the recirculation wells, it is not clear how cleanup time was estimated for the floodplain.	For floodplain cleanup, it was assumed that 2 years would be required to construct and dose the IRZ lines. This is determined more by the time required for construction than by the time required for distribution of amendment between the closely spaced well couplets in the IRZ line. The text will be revised in Appendix F to better describe this assumption.	DTSC awaits deferred language PG&E has proposed in response to this comment. Please note that this will require edits to section 5 as well where the 2 year cleanup time is posted for several alternatives. The first paragraph on page 5-20 of section 5 CMS/FS Report states, *"It is estimated that approximately 1.5-2 years would be required to fully distribute carbon across each of the treatment zones."* The preceding statement does not suggest that the time is based more on the time to construct as indicated in PG&E's response.		Comment resolved following agency review and input during finalization of Section 5.3 and Appendix F to the CMS/FS Report. The following was included in Section F.4.2: "It was estimated that the floodplain cleanup would require between 1 and 5 years, with the baseline estimate at 2 years. This estimate is based on the expected time for construction of the IRZ wells and distribution of carbon substrate to establish the IRZ. Construction activities in the floodplain may have to be sequenced to avoid nesting season of endangered birds, which could delay completion of the wells. If it is determined that additional wells are needed to achieve adequate distribution of carbon substrates, additional construction and implementation time would ensue. Thus, it is assumed that it could require up

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								to 5 years to fully complete and confirm the effectiveness of the floodplain cleanup.” Redline final submitted to agencies on November 13, 2009. Agencies approved the report revisions.
Appendix E Comments - Supporting Information for In Situ Treatment Design Elements (Appendix G in Final Report)								
407	DTSC-172	Appendix E Certification Page	California Department of Toxic Substances Control	It seems appropriate for a professional engineer to also sign Appendix E: In Situ Reactive Zone Treatment Design Elements.	A Registered Professional Engineer has reviewed and signed the final version.	DTSC concurs with the response.		Resolved.
408	DTSC-173	Appendix E Page 2/29, Paragraph 2 Line 1	California Department of Toxic Substances Control	The sentence indicates that chromium is permanently removed from groundwater after the treatment process. Text within the main body of the CMS Report must discuss the potential for chromium to leach back into the aquifer after treatment. The Cr(VI) concentration that might leach back under site conditions should be stated. PG&E should contact USGS representatives for assistance in responding to this comment.	Section 5.5.4 and Appendix E have been edited to include the following: “Once reduced, Cr(III) does not readily become reoxidized to Cr(VI): however Cr(III) that comes into contact with manganese oxide (MnO_2) or dissolved oxygen can be re-oxidized to Cr(VI), leading to increased concentrations of Cr(VI) over time. Two key factors are expected to limit the re-conversion of Cr(III) to Cr(VI) after *in-situ* reduction: the limited solubility of Cr(III) and the lack of availability and reactivity of an adequate oxidizer (MnO_2). Together these factors are expected to limit any reoxidized Cr(VI) concentrations to levels similar to ambient background.” Table 5-5 has been edited to include the following: “The degree of reversibility of the Cr(VI) reduction reaction is expected to ultimately result in Cr(VI) concentrations at levels similar to ambient Cr(VI).” The Cr removed from the groundwater will be stable as very low solubility chromium hydroxide and mixed iron-Cr(III) hydroxide minerals. Cr(III) re-oxidation will be inhibited by the reduced iron minerals (FeS) that are formed during active treatment , natural alkaline groundwater pH and continuous movement of the groundwater The stability of Cr(III) relative to re-oxidation is discussed in Section 7 of Appendix E.	DTSC awaits any deferred language PG&E has proposed in response to this comment (i.e., Appendix E, Section 5.5.4, and Table 5-5). DTSC supports the following language prepared by DOI regarding this issue and requests that it be inserted into the CMS Report: “However Cr(III) that comes into contact with manganese oxide (MnO_2) can be re-oxidized to Cr(VI), leading to increased concentrations of Cr(VI) over time. Although re-oxidation of Cr(III) to Cr(VI) may be minimal and not lead to concentrations that exceed background, there is the possibility that some Cr(III) could be re-oxidized to Cr (VI).” See also response to comment 176.		DOI text changes were incorporated into Section 5 and Appendix G and reviewed by DOI and DTSC. Comment resolved.
409	DTSC-174	Appendix E Page 2/29, Paragraph 2	California Department of Toxic Substances Control	Discussion related to the affects of chromium in-situ treatment on associated COPCs (selenium, molybdenum, and nitrate) should be discussed in the main text similar to what is done in the following excerpt from Appendix E: *In addition, anaerobic IRZs developed to treat Cr(VI) may also be beneficial for other metals that are found in groundwater at the site. For instance, under proper conditions, selenium can be reduced to form insoluble elemental selenium (or possibly iron selenide in the presence of sufficient ferrous iron), and molybdenum can be precipitated as a*	Appendix E was developed as a discussion on Cr reduction. The original text has been incorporated into Appendix E.	Please incorporate PG&E’s original June 15, 2009 response into the CMS/FS Report. The text has been copied below for convenience. “The following text (To describe the effects of IRZ operations on selenium, molybdenum and nitrate) will be inserted in Appendix E and the text in the main body of the CMS report: *Selenium, molybdenum, and nitrate will all be treated by a reductive in situ approach,*		September 22, 2009 meeting. Original proposed text was incorporated into Appendix E. The discussion was qualified to indicate that although treatment of nitrate, molybdenum, and selenium was achieved, the IRZ pilot was not designed to optimize

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				sulfide mineral (its most common natural form). Text within the main body of the CMS Report should also comment if selenium, molybdenum, and nitrate would be permanently removed from groundwater.		*along with chromium, as follows:* *Nitrate is removed by denitrification forming nitrogen gas.* *Molybdenum exists as highly soluble molybdate in groundwater and it is transformed to very low solubility forms of molybdenum (sulfide) during in-situ treatment. The process is similar to chromate, where hexavalent Cr (Cr(VI)) is transformed to trivalent Cr (Cr(III)) which is much less soluble. Molybdenum is reduced from Mo(VI) to Mo(IV) and precipitates as molybdenum sulfide.* *Selenium exists as highly soluble selenate in groundwater and it too is transformed to less soluble forms during in-situ treatment. Selenate (Se(VI)) is reduced to selenite (Se(IV)) and then to Se(0) and even Se(-II). Selenite can sorb to aquifer soil, Se(0) is insoluble, and Se(-II) combines with iron to form selenide that exhibits very low solubility.* *The reductive in situ treatment will therefore create very low solubility or insoluble forms of chromium, selenium and molybdenum. Along with chromium, the molybdenum and selenium are therefore effectively "locked up" in the aquifer solid phase after treatment."*		their treatment. No change to Section 3 is required.
410	DOI-155	Appendix E, Page 3/29, Section 3, Paragraph 1, Line 5	U.S. Department of the Interior	In line 5 of the first paragraph of this section (and in other places in the CMS report), the term "insoluble Cr(III)" is used. Change to "low solubility Cr(III) minerals" as is stated on p. 16/29, first paragraph of section 7.	The term "insoluble oxides," has been changed to "very low-solubility oxides."	DTSC concurs with the response and reminds PG&E that it applies to other sections of the report.	DOI accepts the response and directs PG&E to make the change to the text.	Resolved.
411	DTSC-175	Appendix E Page 3/29, Paragraph 1 Section 3 Proof of Concept	California Department of Toxic Substances Control	The section discusses how field applications have demonstrated that Cr(VI) is effectively removed from groundwater. The section should also summarize field results for selenium, molybdenum, and nitrate.	Appendix E was developed as a discussion on Cr reduction. The original text has been incorporated into Appendix E.	Please incorporate PG&E's original June 15, 2009 response into the CMS/FS Report. The text has been copied below for convenience. "The text in Section 3.1 will be edited: *Following a period of 6 injections over 18 months, the reactive zone has continued to treat Cr(VI) for at least 14 months following the final injection event. While the IRZ operations were not focused on treatment of compounds other than Cr(VI), nitrate concentrations in well PT-1D decreased from pre-test concentrations of approximately 2.27 mg/L to below the 0.5 mg/L limit of detection.* The text in Section 3.2 has been edited: *Again, while the IRZ operations were not*		September 22, 2009 meeting. Original proposed response text was incorporated into Appendix E. The discussion was qualified to indicate that although treatment of nitrate, molybdenum, and selenium was achieved, the IRZ pilot was not designed to optimize their treatment. No change to Section 3 is required.

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						focused on treatment of compounds other than Cr(VI), nitrate concentrations decreased from a maximum pre- test concentration of 30.4 mg N/L at PT-7M to not detected (0.5 mg/L N) at pilot test wells PT-7M, PT-7D, PT-8S, and MW-24A. In addition, molybdenum concentrations decreased from a maximum pre-treatment concentration of 203 µg/L in PT-7D to below the 5 µg/L limit of detection in PT-7M, PT-7D and MW-24A. Selenium concentrations decreased from a maximum pre-treatment concentration of 101 µg/L in PT-7M to below the 5 µg/L limits of detection in PT-7M, PT-7D and MW-24A.		
412	DTSC-176	Appendix E Pages 3&4/29 Sections 3.1 to 3.5	California Department of Toxic Substances Control	A better summary of each case study should be prepared. Each case study should state the area (width/length) and volume affected by the remedial system. Map view figures and cross section(s) should be prepared for each test to quickly summarize the data and findings. The hydraulic conditions including the groundwater flow velocity of each site should be defined (e.g., was nearby extraction occurring). Specific byproducts observed should be specified as well as their distribution.	The intent of these discussions was to summarize/describe Cr removal. Each study is discussed in greater detail with figures in the appropriate references. Copies of the final reports for the pilot studies have been provided.	Without describing the setting and fundamental parameters for each case study, significant uncertainty remains regarding the applicability of the findings of the study to the Topock site. Please provide copies of the final pilot tests ASAP to DTSC as offered by PG&E in its response.		September 22, 2009 meeting. Comment resolution DTSC has been provided supplemental information (for review).
413	DTSC-177	Appendix E Pages 3&4/29 Sections 3.2 and 3.4	California Department of Toxic Substances Control	Well spacings of 150 feet are discussed for two of the pilot tests, yet alternatives (e.g., Alternative E, Figure 5-7) propose well spacings over 500 feet (east-wet) and approximately 200 feet (north-south). The Report should discuss what effects would be anticipated from using greater spacings at Topock.	The figures included in Section 5 of the CMS are conceptual only. Well spacings for the alternatives will be based on the results of the pilot studies and the hydraulic modeling of the site. The final spacing will be refined during the design process. The spacing between lines of wells (500 feet) is based on groundwater flux along the groundwater flow path and the generation of a reducing zone to treat groundwater that flows through the IRZ.	The conceptual nature of the remedial action alternative designs should be stated several times throughout the CMS/FS report to ensure that this important issue clearly documents the uncertainty with the conceptual design.		Resolved.
414	DTSC-178	Appendix E Page 4/29 Section 3.4 Line 5 Hinkley	California Department of Toxic Substances Control	The Report should discuss why lactate was initially used at the Hinkley Central Area prior to switching to ethanol.	The text in Section 3.4 has been edited: *Operation of the system has been ongoing since November of 2007, distributing an organic carbon substrate; initially lactate, and now ethanol (selected because it was a more cost-effective source of carbon for the Central Area system) through the operation of paired injection and extraction wells spaced 150 feet apart,………..*	DTSC directs PG&E to revise the CMS/FS language as proposed in this response.		Resolved.
415	DTSC-179	Appendix E Page 4/29 Section 3.4 Hinkley	California Department of Toxic Substances Control	Several photos of the Hinkley Central Area IRZ should be included in the CMS Report to clearly illustrate a typical system and potential above ground disturbances. A field trip to the Hinkley site is requested so that all interested stakeholders can become more familiar and witness IRZ systems.	Photographs similar to those used in posters generated by PG&E for stakeholder meetings have been added to Appendix E. A field trip can be arranged if desired.	Any photographs illustrating infrastructure, appurtenances, and associated ground disturbance are requested. DTSC plans on attending a tour of the Hinkley site as already conducted by some other stakeholders.		Resolved; photographs have been added to Appendix E.
416	DTSC-180	Page 5/29 Paragraph 1 Section 4	California Department of Toxic Substances	The following edits are suggested to the section: "*There are two different IRZ application strategies that are being considered for use at Topock. The first involves ~~widespread~~ treatment*	The first edit is accurate and has been incorporated. The second edit does not appear accurate as the wells will not be placed throughout the plume but as a cut-off line; "across" the plume is better. The third edit is accurate and has been	DTSC directs PG&E to revise the CMS/FS language as proposed in this response.		Resolved.

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			Control	*throughout the plume through a large network of IRZ circulation wells and/or alternating lines of groundwater extraction wells and IRZ injection wells. The second involves an IRZ barrier <u>throughout the plume </u>in the floodplain <u>with a smaller network of IRZ wells</u> as a component of alternatives that rely on pumping or flushing with clean water to remove chromium from the main body of the plume."*	incorporated.			
417	DTSC-181	Page 5/29 Paragraph 2 Section 4	California Department of Toxic Substances Control	Key advantages of IRZ systems are discussed in the paragraph. To promote a neutral, unbiased evaluation of the technique, it would be appropriate to insert a paragraph after this one and discuss limitations of the IRZ (e.g., byproduct formation, deliverance of reductant to appropriate portions of the aquifer).	The text in Section 4 has been edited to include: *In-situ technology has not often been applied to treat an entire plume of this size and depth. There is uncertainty regarding the ability to obtain complete distribution of substrates across this large an area. Concentrations of byproducts such as Mn and As are expected to temporarily increase within portions of the treatment zone<u> and will require monitoring to ensure they are properly managed</u>.*	DTSC directs PG&E to revise the CMS/FS language as proposed in this response and as modified by DTSC (Please note the underlined DTSC insert language to the left modifying PG&E's response).		Resolved. The revised text has been incorporated into Appendix E and has been reviewed by DTSC and DOI.
418	DTSC-182	Page 8/29 Paragraph 1, First bullet Section 4	California Department of Toxic Substances Control	Sustainable injection rates are discussed (to avoid fracturing). The section should indicate how any excess extracted water will be handled. Would excess water require more injection wells or above ground treatment systems?	The text in Section 4.1 has been edited to include: *Recirculation systems are designed to accommodate variable flow rates and are typically operated in a balanced manner so that extraction rates will equal injection rates.* By operating an IRZ system in this manner the need for above ground treatment is avoided.	DTSC directs PG&E to revise the CMS/FS language as proposed in this response.		Resolved. The revised text has been incorporated into Appendix E and has been reviewed by DTSC and DOI.
419	DOI-156	Appendix E, Page 10/29, Section 4.3.1	U.S. Department of the Interior	If whey is seriously being considered for IRZ, a brief description of its chemical properties should be included. For example, molecular weight, molecule size, whether it is small enough to penetrate pores in silts and clays. Also, it should be specified whether whey is being considered for both the upland and floodplain areas.	The following has been added to Section 4.3.1: "Up to 85% (by weight) of whey is comprised of soluble milk proteins (casein, lysine) and the milk sugar, lactose (a disaccharide). Neither of these poses a challenge from an injection or distribution perspective, and they can diffuse into fine grained materials the same way that other soluble carbon substrates can. The proteins and lactose are slightly less easily metabolized by microbes than alcohols or simple sugars (monosaccharide) found in other substrates, which helps the organic carbon from whey last longer." Whey is being considered in the Uplands in order to maximize the footprint of carbon without expanding the injection well infrastructure	DTSC concurs with the response and assumes language included in PG&E's response will be added to the report. DTSC awaits PG&E's deferred revision language.	DOI accepts the response pending review of the final text to be included in the document regarding the chemical properties.	Resolved. The revised text has been incorporated into Appendix E and has been reviewed by DTSC and DOI.
420	DTSC-183	Page 15/29 Paragraph 1 Section 6	California Department of Toxic Substances Control	A figure(s) illustrating a specific portion(s) of the Topock site (e.g., floodplain) should be selected to illustrate IRZ monitoring concepts and placement of new and existing wells envisioned to form a monitoring network. This should provide stakeholders, including agencies, with a general understanding of the type of monitoring proposed and its associated footprint.	A detailed monitoring plan will be included in the O&M Plan for the selected alternative. The monitoring plan would include a description and purpose of monitoring, monitoring schedule, and field and laboratory quality control. It is expected that the corrective action monitoring program would be dynamic and would be adjusted as needed to promote optimization of the alternative to attain the RAOs.	DTSC directs PG&E to provide the figures to agencies ASAP to ensure tight review schedules are met.		September 22, 2009 meeting. Response modified to be consistent with # 196 and 211 (i.e., monitoring plan deferred to design stage). Agencies concur with deferral of monitoring plan.
421	DOI-157	Appendix E, Page 15/29,	U.S. Department of the Interior	The tracer and pilot studies are to be used to evaluate the longevity of the substrate. The pilot tests used lactate and ethanol. DOI questions	The estimate of substrate longevity for whey was not determined by extrapolation from lactate and ethanol half-lives. A data set for powdered and liquid whey at a site in	DTSC acknowledges the response, but requests that the cited paragraph be revised to clarify that "the tracer and pilot test	DOI accepts the response pending review of the final text to be included in the document regarding the analysis.	Resolved. The new text has been incorporated into Appendix E and

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		Section 6, Paragraph 5		extrapolating substrate longevity from ethanol experiment data to predict behavior of whey.	Colorado was used, along with data for a conservative tracer injected at the same time. The half-life of the whey was determined by comparison of the change in concentration of the whey to the change in concentration of the tracer. The half-life determined for whey at the site in Colorado was then corrected for the site-specific groundwater temperature at Topock (an increase in temperature of 10 degrees C results in a doubling of microbiological activity). The details of this analysis have been added to Appendix E, Section 4.3.5.	studies" are not limited to Topock (as already done on page 12/29 of Appendix E of the CMS/FS Report). If whey has been used at Hinkley, it should be included in the discussion. DTSC awaits PG&E's deferred revision language.		reviewed by DTSC and DOI.
422	DTSC-184	Page 18/29 Paragraph 4, Section 8	California Department of Toxic Substances Control	The section on Secondary Water Quality should comment on whether the organic injections to groundwater and resultant anaerobic conditions would impart undesirable aesthetic characteristics to water quality (e.g., taste or odor).	The text in the first paragraph of Section 8 has been edited to include: "The overall aesthetic quality of the Topock groundwater will not be negatively impacted by operation of IRZs in the short and long term."	The response suggests that some short term aesthetic issues exist. The CMS/FS Report should indicate what these issues are including explanation as to why they are not long term concerns. DTSC awaits PG&E's revised language.		Comment resolved. Revised text incorporated into Appendix E and reviewed by DTSC and DOI.
423	DTSC-185	Page 19/29 and Page 22/29 Section 8 and Section 8.3	California Department of Toxic Substances Control	The discussion on limited flushing of As/Mn out of the reduction zone may not be applicable to some alternatives, as the flushing and natural attenuation capability may be changed due to enhanced flushing, recirculation, etc. The discussion in the main text (section 5 and table 5-5) does not properly reflect what is presented in Appendix E, i.e,. the more reliable re-stabilization of As/Mn is out side the reduction zone into the re-oxidizing zone.	Text in Sections 7 and 8 of Appendix E has been edited to show that attenuation and precipitation of manganese and arsenic will occur in a reliable manner in the reducing zone, as well as in the oxidizing zone. The bulk of the iron, manganese, and arsenic are not mobilized and transported out of the reducing zone, but remineralized within the reducing zone, with only a limited amount mobilized and transported to the downgradient oxidizing zone). The text in Section 5.2.6 has been edited to reflect this: "It is recognized that there is potential for transient byproducts such as As and Mn to exceed baseline and background concentrations during implementation of in-situ methods. Under ideal geochemical and hydrologic conditions described in Appendix G, As and Mn byproducts should not be a significant issue. However, because of uncertainty in the complexity of aquifer lithology and geochemistry, large-scale implementation of in-situ treatment could result in elevated concentrations of As and Mn that persist for longer than expected periods of time in some portions of the aquifer. Careful monitoring during the initial phase(s) of in-situ operation will enable early detection of these conditions. Specific contingencies will be in place to address any potential threat to the Colorado River or the aquifer. " In addition, the text in Table 5.5 has been edited: "The most significant residual byproducts will be manganese (Mn) and arsenic (As), natural constituents of the aquifer matrix released into solution by reduction reactions. Because of the uncertainties associated with the aquifer complexities there is the potential for elevated by-product concentrations persisting in some portions of the aquifer. Once released, the reduced forms of Mn and As will likely be attenuated through precipitation, sorption, diffusion, and co-precipitation."	DTSC awaits deferred language PG&E has proposed in response to this comment (i.e., Sections 7 and 8 Appendix E). Also see response to Comment 341/366.		Comment resolved. Text has been incorporated into Appendix E and reviewed by DTSC and DOI.
424	DTSC-186	Page 19/29 Paragraph 1,	California Department of Toxic Substances	The paragraph indicates that the natural fluvial zones immediately adjacent to the Colorado River typically have dissolved iron, manganese, and sometimes arsenic in groundwater. This	New figures and text have been prepared in Section 8 of Appendix E to present data from select wells to accurately describe the processes taking place as water from the fluvial	DTSC awaits deferred language and figures PG&E has proposed in response to this comment (i.e., Sections 8 Appendix E).		Data set has been provided to DTSC. PGE-09S was excluded

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		Section 8	Control	statement needs to be substantiated with a better data presentation. Figures like those used in the RFI Volume 2 Addendum (e.g., Figure 2-12 – Arsenic) should be prepared to illustrate average concentrations <u>and</u> the total number of analyses. A sortable electronic data base that includes all data cited (the RFI Volume 2 data base does not include all the data cited in the CMS Report) should also be available to allow for evaluation of the data (e.g., identify spurious data). For example, the arsenic value of 49.9 ug/L from well PT-6S appears anomalous and is probably not representative and, therefore, the data point should be excluded from data presentations and evaluations. The electronic data base should also allow one to sort fluvial from alluvial wells. Evaluation of the new figures will quickly alert the reader regarding the size of the data set. For arsenic, it is apparent that the data set is limited as it is common for wells with only two to three rounds of data. Based on this evaluation it is recommended that PG&E immediately begin to sample for arsenic in fluvial wells on a quarterly basis to ensure a robust baseline data set exists prior to remedy selection and implementation.	zone enters the hyporheic zone. Discussion of the regional background study has been added to Appendix E. Discussion of well PGE-09S has been removed from the Appendix. The maximum As concentration measured in a sample collected from PT-6S was 49.4 µg/L. Additional As data from the shallow fluvial wells has been recently obtained during the September 2009 sampling event and showed an arsenic concentration 65 µg/L (MW-32-20) and 53 µg/L (MW-32-35). This data is discussed in Appendix E, along with an explanation as to why the data for PT-6S is not anomalous. Figure E6e has been updated to show the range and average concentration of arsenic measured in the floodplain wells.	Please provide a comprehensive data set so reviewers can assess and evaluate the existing data set as part of this document. It is crucial that PG&E release these site data to assist in document review. DTSC's notes that data from old production well PGE-09S yielded exceptionally high metal concentrations, including arsenic that resulted in data exclusion from the regional background study. Reference to this excluded data is inappropriate. Reference to the regional arsenic background study value (24.3 ug/L) in PG&E's discussion is notably lacking. DTSC still contends that PT-6S arsenic data appears anomalous (see response to Comment 431) and again requests the electronic data set be provided for easy assessment. Furthermore, DTSC would like to reiterate the necessity for PG&E to conduct quarterly arsenic samples in fluvial wells to establish baseline data prior to remedy implementation.		from the data set, as were other data after discussion with DTSC. Text and figures in Section 8 have been updated based upon a revised data set (with select wells excluded based upon discussion with DTSC). These figure have been included in Appendix E and reviewed by DTSC. Text has been added with respect to the collection of additional arsenic data.
425	DTSC-187	Page 19/29 Paragraph 2, Section 8	California Department of Toxic Substances Control	The section states, "*The available information on both the natural fluvial zone around the Colorado River and the temporary reducing zones created in the floodplain IRZ pilot test leads to the conclusion that implementation of anaerobic IRZs as part of the site restoration will not increase the flux of iron, manganese, arsenic or overall TDS to the Colorado River.*" DTSC believes that the flux of byproduct contaminants towards the river will increase. Item 3 on page 19 of Appendix E supports this statement when it is discussed that metals liberated from IRZs operations will limit flux out of the treatment zone. Figure E4 illustrates manganese generation associated with IRZ from a baseline concentration of approximately 50 ug/L at chromium contaminated well PT-1D increasing to over 8,000 ug/L. Certainly this is resulting in an increased flux as compared to pretreatment conditions. Uncontaminated wells neighboring PT-1D suggest that manganese in the area should range from 50 to 2,000 ug/L with an average concentration less than a 1,000 ug/L. This and related sections throughout the Report should be revised to address this issue.	New figures and text have been added to Section 8 of Appendix E to present data from Topock, the PG&E Hinkley site and other sites to add clarity. Increased concentration in a well hundreds of feet or more from the river does not necessarily equate to increased flux into the river. Transport of iron, manganese, or arsenic from the reducing zone is not conservative with groundwater flow, because these constituents attenuate with distance, in both reducing zones and in oxidizing zones. Appendix E Sections 8.3 and 8.4 outline mechanisms of attenuation both during remedy operation and after cessation of injection. Attenuation processes in reducing zones such as the floodplain natural reducing zone or the reducing zone associated with an IRZ include precipitation as sulfide and carbonate minerals, and in mixed valence iron minerals. Sorption to iron sulfide or mixed valence iron minerals and to aluminum hydroxides and silicates will also limit the soluble concentration and enhance attenuation. Several examples of byproduct attenuation with time and distance are presented in Appendix E.	DTSC awaits deferred language and figures PG&E has proposed in response to this comment (i.e., Sections 8 Appendix E).		Comment resolved. Additional discussion of byproduct attenuation has been added to Appendix E and reviewed by DTSC and DOI.
426	DTSC-188	Page 19/29	California	The following revision to the paragraph is	Text and Figures in Section 8 of Appendix E have been	DTSC awaits deferred language and figures		Comment resolved;

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		Paragraph 3, Item 1 Section 8	Department of Toxic Substances Control	requested due to inherent uncertainties in the statement. Please recall that the reductive capacity in portions of the middle and deep zones of the fluvial aquifer may have been exhausted in a span of less than 50 years. *"Conditions in the shallow floodplain are naturally reducing, with some variability (there is a range in redox conditions and resulting water quality).* In addition, the zone where groundwater and surface water interface beneath the river (hyporheic zone) is an important natural control mechanism.	updated to add clarity, including additional information on the hyporheic zone. This statement refers to the hyporheic zone, not the reducing conditions associated with the fluvial materials. The hyporheic zone is a dynamic zone where reducing materials from organic materials in fluvial deposits interacts with oxidizing water continuously oxygenated from the atmosphere. The deposition of carbon by the river and the oxygenated water flowing in the river are the critical aspects of the hyporheic zones, which are sustainable mechanisms that can be projected for the foreseeable future. The highly reactive geochemical conditions in a hyporheic zone do act as a sustainable natural control mechanism because freshly formed hydrous ferric oxides and manganese oxides are efficient scavengers of trace metals. The water and sediments in the hyporheic zone are more oxidized at more shallow depths beneath the river bottom and there is a constant resupply of oxidizing capacity as the river elevation fluctuates several feet per day, forcing oxygenated water into the hyporheic zone. These conditions will preclude Mn and As being released to the river over long time frames. The exhaustion of reducing capacity in the middle and deep zones of the fluvial aquifer is a speculation not based on actual analysis of geochemical traces of formerly reduced materials that are now oxidized. Installation of a floodplain IRZ or National Trails highway IRZ as planned in Alternative E will prevent consumption of reducing capacity, even if it were occurring.	PG&E has proposed in response to this comment (i.e., Sections 8 Appendix E).		Additional text has been added to Appendix E, and figures have been updated and reviewed by DTSC and DOI.
427	DTSC-189	Page 19/29 Paragraph 3, Item 2 Section 8	California Department of Toxic Substances Control	The paragraph states, "…*and the range of iron, manganese, and arsenic expected in the proposed IRZ remedies*…". The CMS Report should quantify the expected range of byproducts anticipated from proposed remedies.	Appendix E, Section 8 has been updated to include a discussion of the expected range of iron, manganese, and arsenic in the proposed IRZ remedies. The expected range of Fe, Mn and As is within the range observed in natural reducing zones at the site, or approximately 0 to 30,000 µg/L Fe, 0 to 10,000 µg/L Mn, and 0 to 50 µg/L As. This range is consistent with the range observed in the floodplain IRZ pilot test. Higher concentrations were temporarily observed in a few upland pilot test monitoring wells, but this test had far higher carbon loading concentrations than would be utilized in IRZs at the Topock site as proposed in these alternatives. Close to injection wells where organic carbon is being injected the high range will likely be observed, and a short time after cessation of injection, these concentrations will drop off. With further distance from the injection wells, substantially attenuated concentrations of these constituents will be observed, which in time will return to baseline conditions associated with the natural aquifer conditions (fluvial materials typically reducing, and alluvial materials typically oxidizing). As demonstrated in Appendix E Figs E12 through E14 controlling the carbon dose will limit the generation of metals. The specific concentrations observed will be unique to each	DTSC awaits deferred language and figures PG&E has proposed in response to this comment (i.e., Sections 8 Appendix E). See also responses to Comment 238.		Comment resolved. Additional discussion of the range of byproducts was added to Appendix E and reviewed by DTSC and DOI.

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					site, but the process has been observed at many IRZ sites. In a full-scale IRZ remedy, TOC would likely be added at a concentration not greater than 1000 mg/l, this was the maximum concentration used in the floodplain pilot test. Figure E9 presents the range of concentrations of Mn and As generated by 1000 ppm TOC.			
428	DTSC-190	Page 20/29 Last Paragraph Section 8.1	California Department of Toxic Substances Control	The paragraph discusses a shift in geochemical conditions in the hyporheic zone. The speculative nature of this discussion should be clarified as it does not appear to be based on data from the hyporheic zone itself. Please recall that the pore water/sediment study in Sections 8 and 9 of the RFI Volume 2 stresses the highly reductive conditions from six foot depth pore water samples and even suggested a reductive zone from 0.5 to 2.5 feet below the bottom of the river. It appears that this same zone is now suggested by PG&E in the CMS Report to be aerobic as influenced by the river. The RFI volume 2 indicated the six foot samples were outside the influence of oxic river water as based on a temperature survey. Site specific data, if any, supporting the oxidative capacity of the zone should be cited or identified as lacking. The discussion must include the scale of the hyporheic zone. Based on the RFI Volume 2, it must be less than 0.5 to 6 feet thick and is therefore quiet thin. The processes that might affect the thickness of this zone should be discussed including erosion and deposition of sediment at the base of the river. The effects of historic and future dredging on the thin zone should also be discussed. The seemingly contradictory nature of this section with the RFI may require significant revision.	Section 8.1.1 has been added to Appendix E to provide additional detail on the hyporheic zone and Figures E7 provides data for relevant geochemical parameters at a depth of 6' below the river bottom. Figure E8 provides a schematic of the geochemical processes that occur within the hyporheic zone. In a hyporheic zone there is dissolved oxygen in the river water and within the pore water within the hyporheic zone, and the pore water also contains reduced forms of iron and manganese. These are constantly reacting and forming fresh iron and manganese oxides. The nature of the hyporheic zone is one of constant geochemical flux, which in the Colorado river is dominated by daily and seasonal fluctuations of water levels of several feet or more. Minerals formed in this type of constantly changing environment include mixed valence iron minerals containing both ferrous iron and ferric iron. These minerals, such as green rusts and magnetite, and the dissolved ferrous iron, are reactive with Cr(VI), which is the factor discussed in the RFI. In this environment mixed valence manganese oxides containing both Mn(III) and Mn(IV) forms are also prevalent. These minerals are also efficient scavengers of dissolved arsenic and also sorbents for dissolved manganese and catalysts for oxidation of the sorbed Mn(II) to the low solubility Mn(III/IV) oxides. In a zone with both reductive inputs and oxidative inputs (documented in the RFI) both reductive and oxidative chemistry can and will occur. The RFI in sections 8 (Pore Water Investigation) and 9 (River Sediment Characterization) presents a snap shot of data to support that reducing conditions exist at depths greater than 6 feet below the river bottom in the sediments, and these conditions are also in some locations observed in more shallow sediments. These reducing conditions assure that Cr(VI) will not reach the river as it will be converted to Cr(III) in this zone. The RFI focused on the reductive chemistry and did not provide any discussion on the fact that the hyporheic zone is a region of chemical transition; that the water and sediments become more oxidized at more shallow depths beneath the river bottom and that there is a constant resupply of oxidizing capacity.	DTSC awaits deferred language and figures PG&E has proposed in response to this comment (i.e., Sections 8 Appendix E).		Comment resolved. Hyporehic zone discussion was added to Appendix E and reviewed by DTSC and DOI.
429	DTSC-191	Page 21/29 Paragraph 2, Line 5	California Department of Toxic Substances Control	The sentence states, *"This test was completed in the deeper alluvial sediments underlying the shallow fluvial zone."* when referring to graphs of well PT-1D contained on Figure E4. Table 4-2 of the RFI Volume 2 indicates the well PT-1D is a	Text in Section 8.2 of Appendix E has been edited to add clarity: *This test was completed in the deeper fluvial and alluvial sediments underlying the shallow fluvial sediments. These*	DTSC accepts the change and notes that Table 4-2 from RFI Volume 2 was incorrect, but has been corrected.		Resolved.

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		Section 8.2		fluvial well, not alluvial. Clarification is requested. If the table is incorrect, the entire table should be reviewed by PG&E for accuracy and a revised table provided to all stakeholders.	*deeper fluvial and alluvial sediments are relatively aerobic compared to the shallow fluvial sediments where naturally reducing conditions are already prevalent.*			
430	DTSC-192	Page 21/29 Paragraph 2, Line 10 Section 8.2	California Department of Toxic Substances Control	The paragraph states, "…*and the range of iron, manganese, and arsenic expected in the proposed IRZ remedies*…". The CMS Report should quantify the expected range of byproducts anticipated from proposed remedies.	Text in Section 8 of Appendix E has been edited to add clarity, including the range of concentrations expected in the proposed IRZ remedies. As demonstrated in Appendix E Figs E12 through E14 controlling the carbon dose will limit the generation of metals. This process is site-specific. In a full-scale IRZ remedy, TOC would likely be added at a concentration not greater than 1000 mg/l, this was the concentration used in the floodplain pilot test. Figure E9 presents the range of concentrations of Mn and As generated by 1000 ppm TOC.	See response to Comment 427.		Comment resolved. Text has been added to Appendix E to clarify and discuss the range of concentrations of byproducts and reviewed by DTSC and DOI.
431	DTSC-193	Page 22/29 Paragraph 2, Section 8.2	California Department of Toxic Substances Control	The paragraph states, *"As a point of comparison, the pump and treat alternatives can have similar effects on the aquifer geochemistry if dissolved organic carbon in the fluvial zone is pulled into the alluvial materials deeper in the Floodplain, allowing the establishment of reducing conditions and resulting in the dissolution of iron, manganese, and arsenic in the newly reduced sediments."* The CMS Report should indicate if this is or is not occurring to any measurable extent in the IM-3 area. The Report should accurately summarize the amount of iron, manganese, and arsenic created/liberated in response to IM-3 activity.	Text in Section 8.2 of Appendix E has been edited to add additional details as follows:. In floodplain pilot test data from wells PT-5S and PT-6S, which are upgradient and outside the influence of the pilot test, organic carbon concentrations increased from March 06 to Dec 06, potentially indicating that more naturally reduced water was being pulled to those locations. During that time and into 2007, dissolved iron and dissolved arsenic increased at PT-5S (Fe 971 to 4,090 µg/L, As 8.86 to 18.8 µg/L). Dissolved manganese was relatively stable at PT-5S, but the elevated baseline concentrations are indicative of naturally occurring reducing conditions). At PT-6S, the TOC concentration increased similarly along with dissolved iron (3,530 to 24,900 µg/L) and arsenic (12.6 to 49.4 µg/L). Please see response to comment 424 for a discussion of well PT-6S.	DTSC awaits deferred language (and data) PG&E has proposed in response to this comment (i.e., Sections 8 Appendix E). Please include discussion regarding the possibility that well PT-6S has been impacted by organic materials associated with the floodplain pilot test.		Comment resolved. Text has been added to Appendix E and reviewed by DTSC and DOI.
432	DTSC-194	Page 23/29 Paragraph 2, Section 8.3/ Figure E8	California Department of Toxic Substances Control	This section discussing Figure E8 needs additional clarification/discussion. Are the data presented from one well or several along a flow path? If along a flow path, then the anaerobic zone was not realized in the downgradient location and downgradient chromium cleanup would therefore not be anticipated. Concern arises if the byproduct metals are allowed to enter the anaerobic fluvial zone or are released from an IRZ within a fluvial zone that then allows byproduct metals flux towards the river with little retardation. Maximum metals concentrations presented as normalized values in Figure E8 should be expressed as actual concentrations either in text or on the figure.	Figure E8 (now Figure E15 in the updated appendix) has been edited to add additional details with respect to the flow path and configuration of the IRZ. In addition, Section 8.3 of Appendix E has been edited to add clarity. Figure E8 (now Figure E15) represents data from different wells along a flow path. The x-axis represents how many days it takes groundwater to travel from the injection wells to each monitoring well along the flow path. The data from this site is presented, because many wells along the flow path were monitored, providing a robust data set demonstrating attenuation within the IRZ and in the downgradient recovery zone. The commenter accurately observes that the anaerobic zone was created extended 250 feet downgradient of the injection locations and beyond that the redox conditions recovered to the baseline oxic conditions. The limit on the length of the anaerobic zone, however, is intentional and does not limit the extent of in situ treatment. Treated groundwater continues to migrate downgradient of the reactive zone, and treated groundwater arrives at	DTSC awaits deferred language PG&E has proposed in response to this comment (i.e., Sections 8 Appendix E).		Comment resolved. Updated figures have been included in Appendix E and reviewed by DTSC and DOI.

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					locations in the redox recovery zone. As presented in several of the in situ treatment alternatives, the chromium present downgradient of the reactive zone of one IRZ would be treated in the subsequent IRZ as treated groundwater arrives in the area, flushing the chromium originally present into the downgradient IRZ. Normalized concentrations are presented, because the actual concentrations are from another site; the absolute concentrations are site specific due to variations in mineralogy and carbon loadings for different COCs. The starting and ending concentrations are the only relevant data. A discussion related to flux is provided in detail in response to DTSC comment #425.			
433	DTSC-195	Page 25/29 Paragraph 3, Section 8.5	California Department of Toxic Substances Control	The section states, *"Anionic substrates, such as lactate, may contain a counter ion, such as sodium, which would contribute to TDS….Regardless of the substrate used, the impact of the substrate itself is not expected to result in an increase in TDS concentrations. The total TDS concentrations at working strengths for each is lower than the baseline TDS at Topock."* The TDS concentrations of undiluted sodium lactate and working strength lactate should be cited for completeness.	As stated in Appendix E most of the organic substrate will be converted to microbial biomass or carbon dioxide. If present in the chosen alternative, any counter ion could add to the site TDS. The text in Section 8.5 has been edited to include the following: *Regardless of the substrate used, the impact of the substrate itself is not expected to result in an increase in TDS concentrations. The total TDS concentrations at working strengths for each is lower than the baseline TDS at Topock. The ionic strength of the sodium lactate injection solutions used during the Floodplain pilot test averaged approximately 4,900 mg/L TDS. The TDS of undiluted sodium lactate is 786,000 mg/L.*	DTSC directs PG&E to revise the CMS/FS language as proposed in this response.		Resolved. Text added to Appendix E and reviewed by DTSC and DOI.
434	DTSC-196	Appendix E Figure E1	California Department of Toxic Substances Control	Figure E1 needs to be modified to more accurately represent site conditions. First, ORP measurements should be included in the three tables (alluvial, fluvial and hyporheric zone) since this measurement best assesses reductive groundwater conditions (see RFI Volume 2). The mean arsenic, iron, and manganese concentration should also be included in each table for reference along with MCLs. Dissolved oxygen listed under the hyporheic zone should be removed as it is not a sensitive measure of oxidizing/reducing conditions at this site. TOC should be added to the hyporheic zone for consistency. The upper ranges for the three constituents should be checked to ensure they are representative (e.g., the 49.9 ug/L arsenic value cited for the fluvial aquifer should be removed). Text on page 20 citing these same numbers will also need to be revised and also present mean concentrations.	Figure E1 (now Figure E5) has been edited to include ORP, Dissolved oxygen has been removed and TOC, mean concentrations, and number of samples have be added to the graphic. ORP measurements are subject to a wide variety of interferences and are not reliable as a standalone indicator of redox status. This is consistent with the RFI text describing ORP as a general index of redox conditions. The most accurate measures of redox conditions are the actual concentration of redox sensitive species that could participated in redox reactions. Recently collected (September 2009) data show arsenic at 65 µg/L (MW-32-20) and 53 µg/L (MW-32-35) in the fluvial aquifer; this data has been included in the average and range of concentrations for the fluvial aquifer. Arsenic ranges presented represent the variation of arsenic that was accurately measured in fluvial wells, and are presented to show concentrations that may enter the hyporheic zone from the naturally reduced fluvial aquifer. Ranges of concentrations are more important for the depiction of conditions in the fluvial environment. It is critical that these data not be excluded for proper understanding of actual site conditions. Arbitrary exclusion of high range data	DTSC awaits deferred language PG&E has proposed in response to this comment. Please include ORP as done for figures in the RFI understanding inherent variability. See Comment 424 regarding arsenic concentrations in wells.		Comment resolved. Figures have been edited and included in Appendix E and reviewed by DTSC and DOI. Arsenic and manganese data (range and average) have been revised, figures updated, and reviewed by DTSC.

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					prevents understanding the potential range of arsenic removal mechanisms in the hyporheic zone.			
435	DTSC-197	Appendix E Figure E2a	California Department of Toxic Substances Control	Figure E2a is inappropriate. It does not illustrate all the fluvial arsenic data. For example, elevated arsenic values at PT-6S are included, but the undetected values at PT-6M and PT-6D are omitted. Revise Figure E2a to include all data. Include the arsenic MCL in the legend.	Figure E2a (now Figure E6a) has been updated with the latest arsenic data for the shallow fluvial aquifer, and the title of the figure has been changed to “Near-Site Arsenic Data for Shallow Fluvial Aquifer” to reflect the fact that the shallow fluvial aquifer data is shown. Figure E2a is meant to illustrate fluvial water adjacent to the river. Thus PT-6S is in the same interval as the river, while PT-6M and PT-6D are relatively deeper, and groundwater at PT-6M and PT-6D may or may not pass through a zone similar to PT-6S before reaching the hyporheic zone. Regardless, it is not all of the fluvial data that are relevant to what is entering the hyporheic zone, but shallow fluvial groundwater. Ranges of concentrations are more important for the depiction of conditions in the fluvial environment, but shallow fluvial conditions are most relevant for understanding what might reach the hyporheic zone.	DTSC awaits deferred language/figures PG&E has proposed in response to this comment. Please respond to the comment. Treatment byproducts will likely occur in all groundwater zones: shallow, middle, and deep and water quality criteria will apply to all zones, not just one.		Comment resolved. Figures revised and included in Appendix E and reviewed by DTSC and DOI.
436	DTSC-198	Appendix E Figure E2c	California Department of Toxic Substances Control	Figure E2c does not illustrate all the fluvial manganese data. For example, elevated manganese values at PT-6S are included, but levels below 400 ug/L at PT-6M and PT-6D are omitted. Revise Figure E2c to include all data. Include the manganese MCL in the legend.	Figure E2c (now Figure E6c) has been edited to include the MCL in the legend. This figure is meant to illustrate fluvial water adjacent to the river. Thus PT-6S is in the same interval as the river, while PT-6M and PT-6D are relatively deeper, and groundwater at PT-6M and PT-6D may pass through a zone similar to PT-6S before reaching the hyporheic zone. Regardless, it is not all of the fluvial data that are relevant to what is entering the hyporheic zone, but shallow fluvial groundwater. Ranges of concentrations are more important for the depiction of conditions in the fluvial environment, but shallow fluvial conditions are most relevant for understanding what might reach the hyporheic zone.	See response to Comment 435 above.		Comment resolved. Figures have been edited and included in Appendix E and reviewed by DTSC and DOI.
437	DTSC-199	Appendix E Figure E3	California Department of Toxic Substances Control	See Figure E1 and Appendix E, page 29 comments above.	Figure E3 (now Figure E7) has been edited to show ORP, TOC as well as average concentrations in addition to the range of concentrations and number of samples. Dissolved oxygen has been removed. ORP measurements are subject to a wide variety of interferences and are not reliable as a standalone indicator of redox status. This is consistent with the RFI text describing ORP as a general index of redox conditions. The most accurate measures of redox conditions are the actual concentration of redox sensitive species. Ranges of concentrations are more important for the depiction of conditions in the fluvial environment, but shallow fluvial conditions are most relevant for understanding what might reach the hyporheic zone. Arsenic ranges presented represent the variation of arsenic that was accurately measured in fluvial wells, and are	See response to Comment 434 above.		Comment resolved. Figures have been edited and included in Appendix E and reviewed by DTSC and DOI.

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					presented to show concentrations that may enter the hyporheic zone from the naturally reduced fluvial aquifer. Ranges of concentrations are more important for the depiction of conditions in the fluvial environment. It is critical that these data not be excluded for proper understanding of actual site conditions. Arbitrary exclusion of high range data prevents understanding the potential range of arsenic removal mechanisms in the hyporheic zone.			
438	DTSC-200	Appendix E Figure E4	California Department of Toxic Substances Control	This figure titled "*Optimizing TOC keeps manganese and arsenic below background*" is inappropriately establishing background concentrations for fluvial sediments without an approved process for determining background concentrations. The title must be changed unless formal background numbers are prepared for review. The maximum ranges displayed in the graphs in Figure E4 include nonrepresentative data and will need to be revised. The mean arsenic and manganese concentrations should be included on the corresponding graphs. The graph/text must clearly state/discuss baseline concentrations for neighboring fluvial wells.	The word 'baseline' has been substituted for the word 'background'. The maximum concentration of arsenic and manganese has been included based upon a summary of the data, and the arithmetic mean arsenic and manganese concentrations have been added to the graphs.	DTSC does not object to the use of the word "baseline". However, please also respond to the rest of the comment.		Comment resolved. Figures have been edited and included in Appendix E and reviewed by DTSC and DOI.
Appendix F Comments - Responses to Tribal Comments (Not Included in Final CMS/FS Report)								
439	CRIT-1	Appendix F	Envirometrix (on behalf of the Colorado River Indian Tribe)	While PG&E has provided responses to our January 9, 2009 comments, in this version of the CMS/FS, we request that both DTSC and DOI review our comments and the corresponding responses provided by PG&E and that both DTSC and DOI provide appropriate additional direction to PG&E as may be necessary to ensure that PG&E has fully and adequately responded to our current and previous comments.	PG&E defers response to DTSC and DOI	DTSC values all comments from stakeholders and will fully consider stakeholder comments and PG&E's responses.	Duly noted.	Comment addressed. No changes to the CMS/FS Report are required.
440	CRIT-2	Appendix F	Envirometrix (on behalf of the Colorado River Indian Tribe)	A number of our previous comments presented in the January 9, 2009 letter, in addition to comments contained in this current letter, may request or require and additional response from DTSC and/or DOI. In the past where a response from DTSC or DOI is needed, PG&E has simply stated that they have deferred this comment. PG&E should ensure that our comments are tracked and a timely response is provided by DTSC or DOI. We would suggest adding a separate column in the response to comment table that would document specific DTSC and DOI responses as may be appropriate.	PG&E defers response to DTSC and DOI	DTSC, DOI and PG&E have discussed and devised a logical methodology on the response to comments so that agencies input to the comments are appropriately tracked and responded to on this official draft CMS/FS.	Duly noted.	Comment addressed. No changes to the CMS/FS Report are required.
441	CRIT-32	Appendix A (This comment was to the	Envirometrix (on behalf of the Colorado River Indian	The Discussion Draft states: *The DOI has led the solicitation and evaluation of applicable or relevant and appropriate requirements (ARARs) for the Topock site. The*	PG&E defers response to DOI		DOI will identify and ensure that the appropriate numeric standards which flow from the selected ARARs are attained during the remedial design and remedial action phases of the CERCLA	Comment addressed. No changes to the CMS/FS Report are required.

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		Discussion Draft CMS/FS Report - comment deferred to DOI).	Tribe)	*ARARs were developed during the RFI/RI to allow early opportunity for review and comment. The ARARs were issued to DOI in December 2007 and were updated in June 2008 (DOI 2007b, 2008a). The ARARs for the Topock site are provided in Appendix A.* In reviewing the ARARs in Appendix A, we do not observe any actual numbers for associated chemicals. For example, on the first page of the table, Item 3, it states “These are federally promulgated Water Quality Standards for Surface waters.” However, no actual numbers are provided in Appendix A that would indicate what the surface water protection standard for Hexavalent Chromium would be. In Section 3.2.1, PG&E has documented the concentration for some ARARs. Since no concentrations are listed in Appendix A, is it PG&E responsibility to ensure that concentrations for corresponding ARARs are include and accurate?			cleanup.	
442	CRIT-33	Section 4 (This comment was to the Discussion Draft CMS/FS Report - comment deferred to DOI).	Envirometrix (on behalf of the Colorado River Indian Tribe)	Under containment, Vertical Barriers and Treatment Permeable Reactive Barriers. We request that DTSC or DOI engineers conduct an additional review of these technologies and evaluate the basis PG&E uses for removing them from consideration. As example, in the case of Permeable Reactive Barriers, PG&E states that Traditional Trenching methods have not been used at the required depth and trench stability becomes an issue at depths greater than 150 feet. CRIT with our limited resources, realize that effective Permeable Reactive Barriers have been installed to equivalent depths; not by trenching but by injection of reactive material. This procedure was successfully conducted at the California DuPont Oakley Facility. Therefore, we are not completely confident that an unbiased evaluation of remedies was provided.	PG&E defers response to DTSC and DOI	Please see response to comment 106 above.	(same as DTSC)	Comment addressed. No changes to the CMS/FS Report are required.
Additional Comments on Alternative E								
443	MWD-8	September 28, 2009 Technical Work Group Presentation of Revised Alternative E Configuration	The Metropolitan Water District of Southern California	Alternative E involves a line of extraction wells close to the river that will extract substantial of amounts Colorado River Water (CRW) along with groundwater from the floodplain. Perchlorate had been a contaminant of concern in CRW but is currently being mitigated. There is a potential for future increases in perchlorate into Colorado River. This may affect the ability to reinject the extracted water back into the basin. In 1997 perchlorate-contaminated groundwater was discovered to be seeping into Lake Mead through the Las Vegas Wash. Levels as high as 20 parts per billion (ppb) were detected in Lake	All of the active remedial alternatives are described in the CMS/FS to include ongoing operation and maintenance, ongoing performance evaluation assessments, and ongoing optimization to enhance performance and respond to changes in site conditions. In addition, contingency plans for the selected alternative are expected to include procedures to address emergency situations (for example fire, earthquake, flooding) similar to the situation contemplated by MWD. PG&E agrees that if the situation outlined by MWD were to occur - perchlorate concentrations increase to above MCLs in the Colorado River in the vicinity of the Topock site - that this could affect the ability to reinject groundwater extracted	Agrees with RTC. However, because the mechanics of the proposed Revised Alternative E is to mobilize Cr(VI) toward the river, albeit through the treatment zone by national trails highway, it is possible that PG&E will need to maintain hydraulic controls to keep secondary by-products from discharging toward the River. DTSC believes, however, that this issue could be addressed as part of the contingency measures during the remedial design phase.	DOI concurs with the response provided by PG&E.	Comment resolved. Agencies approve PG&E response. No changes to the CMS/FS Report are required.

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				Mead and levels as high as 9 ppb had been detected at the intake to Metropolitan's conveyance system, located approximately 160 miles south of the Las Vegas Wash. The source of perchlorate contamination in the Colorado River was traced to a chemical manufacturing facility formerly owned by Kerr-McGee Corp., and now owned by Tronox, Inc. Tronox, previously a chemical subsidiary of Kerr-McGee, has assumed the responsibility of the ongoing perchlorate remediation activities in Henderson, Nevada. On January 12, 2009, Tronox filed for Chapter 11 bankruptcy protection (U.S. Bankruptcy Court, Southern District of New York). The company cited the significant environmental liabilities taken on from Kerr-McGee as a primary cause of its financial liabilities. Tronox has indicated plans to restructure the company while continuing its operations. Metropolitan is concerned that the outcome of the bankruptcy proceedings could potentially impede or even reverse the ongoing cleanup efforts aimed at remediating perchlorate contamination entering the Colorado River. If perchlorate treatment in the Las Vegas Wash area were discontinued, modeling results suggest that perchlorate levels in the Colorado River could spike to concentrations as high as 9 ppb in as little as 18 months. This level of perchlorate is above the California MCL of 6 ppb. In-situ biological treatment is an effective treatment for reducing perchlorate. However, it is not known whether the in-situ process at Topock will reduce the perchlorate at ppb levels while simultaneously reducing chromium 6 at mg/L levels. Tests would need to be conducted to verify the simultaneous reduction efficiency of perchlorate along with chromium 6. Reinjection of this water into the groundwater basin would require approval by the Regional Water Quality Control Board.	near the river back into the basin. It should be noted however, that this situation (or any analogous situation causing a drastic change in Colorado River water quality) would unlikely occur suddenly or without warning. Further, the extraction wells on the floodplain will draw some Colorado River water into the floodplain aquifer, which will mix with native groundwater, and the extracted water will be a mixture of groundwater and river water. In addition to the mixing effects, it is also reasonable to expect that in the anaerobic fluvial materials, natural degradation of perchlorate will be supported, limiting its transport to an extraction well. If the situation outlined by MWD was to occur Alternative E was the selected alternative, and concentrations in extracted water were to be detected at unacceptable levels, the likely response would be to reduce or cease the operation of the inner recirculation loop during the period of time that the situation persisted. Because the O&M period for Alternative E is expected to be decades-long, it is expected there could be multiple and various situations occurring during that time when the flow rates and strategies for both the inner recirculation loop and the freshwater injection loop are adjusted. One possibility is to consider the inner recirculation loop in Alternative E an intermittent or contingent element of the overall remedy, rather than an integral part of the remedy. The inner recirculation loop may just be operated during the early years of the O&M period, long enough to attain chromium mass removal goals in the floodplain and to attain geochemical equilibrium in the floodplain. Following a period of performance testing showing favorable results, the extraction wells could cease operation until site conditions or performance issues suggested that start-up of the inner recirculation loop would be beneficial. Changes and adjustments to the flow rates for the inner recirculation loop would likely result in changes to the freshwater injection flow rates to reduce the O&M period and maintain hydraulic capture of the target remediation area.			
444	DTSC-200	September 28, 2009 Technical Work Group Presentation of Revised Alternative E Configuration	California Department of Toxic Substances Control	Not having been at the TWG so relying on the hand-out only, it looks to me that this would require less freshwater (presumably helpful given uncertainties on this topic) and lessen floodplain impacts (good for bio and other resource issues). Some concern that shift might mean more activity out of the floodplain and in proximity to the Topock Maze, but it is not clear that would be an outcome. Some concern about high-end of duration for clean-up (100 years). We would need to fully understand the variables and explain why it might take a long time for clean-up in the EIR if that is the case. I don't	The statements in the comment are noted, no changes to the CMS/FS are proposed in response to this comment.		DOI defers to DTSC.	Comment resolved. Agencies approved PG&E response. No changes to the CMS/FS Report are required.

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				sense any fatal flaws.				
445	HA-33	September 28, 2009 Technical Work Group Presentation of Revised Alternative E Configuration	Hargis & Associates, Inc. (on behalf of Fort Mojave Indian Tribe)	<u>Design Changes</u> As discussed during the TWG meeting, the conceptual designs for all of the alternatives presented to date have not fully factored in important siting constraints related to cultural and biological resources. The Tribe understands that the configurations of the various extraction, injection, and *in situ* reduction zone (IRZ) wells do not represent a final design, but rather general locations assumed for the purpose of modeling. As such, the Tribe is concerned that, during implementation of the remedy, efforts to optimize the remedy on technical grounds may lead to further modifications to the wellfields. In fact, during the TWG meeting there was considerable discussion with regard to the possibility of optimizing the siting of these various wells. These matters concern the Tribe for several reasons: a. The locations of wells, particularly in the upland area, are within the Tribe's spiritually important cultural landscape, amid multiple, identified cultural sites. While it appears that PG&E has attempted to site wells in existing transportation and utility corridors, there is no guarantee that future information and decisions will not necessitate adjustments to these locations. What provisions will the agencies enact to ensure that proper consideration is given to the protection of this culturally important landscape during the final design and implementation of the remedy? Timely and meaningful consultation with the Tribe prior to final siting or any subsequent consideration of adjusting well locations is of critical importance to the Tribe. b. Well siting is also important in terms of the additional disturbances, including visual and more general impacts to the Tribe's spiritual landscape that would result from related water-conveyance infrastructure, monitoring infrastructure, and maintenance activities associated with these infrastructures. The revised Alternative E drawings presented to date depict only wells directly associated with the primary remedial activities of extracting and injecting water and amendments for IRZ maintenance. Water pipelines, as shown, only connect with the clean water injection wells. The drawings do not illustrate the monitor well network that will be used for performance monitoring (PM), nor do they illustrate the additional infrastructure that	The FMIT is correct that the conceptual designs for all alternatives have not fully factored in all the siting constraints. As discussed in the CMS/FS, the remedial action alternatives were designed to a conceptual level of detail, sufficient to develop the remedial cost estimates consistent with USEPA guidance for developing cost estimates for Feasibility Studies. The numbers and locations of remedial facilities and described operational elements are largely assumptions at this point in the definition of the alternatives, and are used as means to compare alternatives against each other. It is fully expected that changes to the numbers, locations, methods, configuration and other assumptions made in development of the remedial costs for the CMS/FS will change for the selected alternative as it moves through the design, construction, and operational phases. Changes to the conceptual design for the alternative ultimately selected will be made during design, construction, and implementation in order to optimize the remedy to enhance performance to attain the cleanup goals, provide for adjustments due to field conditions, and comply with location- and action-specific ARARs and landowner and leaseholder requirements. a. PG&E understands that there will be tribal consultation during design and construction of the final remedy. In addition, PG&E's Settlement Agreement with the Tribe outlines a process for early communication during design and construction. b. The figure in the CMS/FS report depicting the conceptual remedial approach for Alternative E will be revised from what was presented in the TWG meeting to include pipelines connecting the extraction wells and injection wells for carbon-amended water. The FMIT is correct, however, that the figures for conceptual design of all alternatives as shown in the CMS/FS do not include locations of additional monitoring wells, although an assumption about the number of monitoring wells is included in the cost estimates. As discussed in responses to comments #145, 196 and 211, PG&E agrees that a monitoring program would be established for the selected alternative. With the exception of Alternative A, all of the alternatives assume that the corrective action monitoring program would occur until the cleanup goals are attained, including long-term monitoring following completion of active treatment. As required by the CACA, a monitoring plan will be prepared and included in the Operation and Maintenance Plan for the selected alternative. The corrective action monitoring program is assumed to rely on the existing network of approximately 100 monitoring	DTSC agrees that for the purpose of the CMS/FS, the design can remain at conceptual level, however, the highlighted statement of the RTC is not complete in that the reason for developing the conceptual design should not only be for cost estimate purposes. Cost is only one of several key factors in the evaluation of the remedy alternatives. The main goal for conceptual designs in the CMS/FS is to allow a comparative evaluation of the pros and cons of each alternative. This means that PG&E must provide sufficient information in the conceptual design to allow agencies to provide an objective comparative evaluation. Refinement of design details will be part of the Remedial Design Work Plan after the remedy selection.	The Department of the Interior has the following responses to the concerns raised by the FMIT. a. In addition to the forthcoming Programmatic Agreement (PA) that will outline the process for tribal consultation during design and construction for final remedy, DOI through BLM, BOR, and USFWS will be engaged in regular informal information sharing with the tribes to ensure that tribal concerns involving protection of cultural resources and associated cultural landscape are given due consideration and attention. b. See response to a. above. c. See response to a. above. d. Although DOI concurs with the response, it is expected that further evaluation and refinement of the selected alternative would occur during the design phase. Additionally, a monitoring plan will be prepared for the selected alternative to ensure that it is performing as expected.	Comment resolved. Agencies approved PG&E response. Figure 5-7depicts pipelines connecting the extraction wells and injection wells for carbon-amended water.

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				would be necessary to convey water extracted from wells along the Colorado River to the proposed locations of the IRZ injection wells. The existing IM utilizes a rather extensive network of PM wells downgradient from the points of injection in the upland as well as conveyances from the point of extraction to the treatment plant and then on to the injection wells. A question was raised during the TWG meeting as to the adequacy of the existing monitor well network for the purposes of remedy performance monitoring. However, at this time, the agencies have not committed to the type of performance monitoring network that will ultimately be needed Again, the agencies need to ensure proper consideration of the cultural setting, with a view toward designing and implementing the least intrusive remedy that can achieve the project's remedial objectives. A comprehensive depiction of the all remedy components is crucial to the assessment. To the extent that such a depiction is not practicable at this time, the provisions that are proposed to ensure consideration of the Tribe's concerns take on added importance and should be presented. c. The general area proposed for siting the IRZ injection wells avoids the archeologically designated Locus A of the Maze; however the Tribe considers the entire Topock landscape, and not just the Maze or the many smaller cultural features identified within the area proposed for IRZ siting, to be a religiously and historically important area. While it is apparent that PG&E has presented a proposal that avoids Locus A of the Maze, which the Tribe appreciates, the agencies need to assure proper consideration and protection of the landscape as a whole. Consideration of the entire landscape is required – for example, not just the siting of individual wells, but critical examination of the *necessity* of each well. The Tribe has also noted that there are several other smaller cultural features identified within the area proposed for IRZ siting. That they may be smaller in size than the Maze does not mean they are not important individually or as part of the overall sacred landscape. d. The Tribe notes that there is a balance between the volume of water that would be extracted at the River's edge and the amount of make-up water that would need to be imported for the purpose of injection. Presently, it appears	wells, potentially supplemented by additional monitoring wells. Exact locations of additional monitoring facilities will depend on final alternative configuration and data collected during construction. As noted in Section 5.2.8, final locations of monitoring wells depend on accessibility, landowner and leaseholder requirements, cultural resources, sensitive habitats, historical sites, topographic constraints, and locations of existing infrastructure. c. PG&E acknowledges there are multiple and varied cultural resources near the Topock Compressor station. Section 2.2.6 of the CMS/FS report has been revised to acknowledge the cultural resources near the site d. FMIT is correct in their understanding that if pumping wells were located too close to an IRZ, the groundwater might be drawn so quickly through the IRZ that treatment effectiveness could be compromised. PG&E has evaluated the groundwater velocity that would be expected across the IRZ and believes that with the current flow rates and well locations, the effectiveness of the IRZ will not be compromised by groundwater velocity. The total volume of water crossing the IRZ with the revised Alternative E is only slightly more than in the previous Alternative E. So long as the extraction wells are located far enough from the IRZ to avoid the high groundwater velocity that occurs locally near the pumping wells, the IRZ in the revised Alt E would not be stressed significantly harder than in the original Alt E. If the extraction wells were located too close to the IRZ, the effectiveness of IRZ treatment could be compromised due to excessive groundwater velocity in local areas near the pumping wells. Careful monitoring would occur to evaluate the effectiveness of the IRZ and optimize the treatment strategy.			

TABLE C-1 RESPONSES TO COMMENTS
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				that PG&E has assumed essentially equal volumes of approximately 500 gallons per minute. It is further noted that extracting a large volume of water at the River's edge and downgradient from the IRZ along National Trails Highway would greatly increase the gradient across floodplain between the IRZ and the River's edge. This raises the same type of concern that was raised by other stakeholders for the original Alternative E – that there may be a risk that an increased gradient will reduce the effectiveness of the IRZ. Has PG&E evaluated this possibility?				
446	HA-34	September 28, 2009 Technical Work Group Presentation of Revised Alternative E Configuration	Hargis & Associates, Inc. (on behalf of Fort Mojave Indian Tribe)	East Ravine Another aspect of the revised Alternative E design is the incorporation of the East Ravine area into the CMS/FS and the context of remedial Alternative E. The Tribe has a number of concerns over the manner in which this investigation is unfolding and is taking this opportunity to express its displeasure with this situation. a. On multiple occasions the Tribe has explained that every well drilled into the sacred ground, regardless of its location, is an affront to its cultural and religious values. During a recent meeting with the Department of the Interior (DOI), the Tribe complained about the seeming attitude that favors avoidance of Euro-American historic sites (such as old U.S. Route 66), while essentially ignoring the Tribe's religious and cultural sites and values unless they are associated with what Euro-American archeologists define as "archeological sites." Based on the discussions regarding the East Ravine Groundwater Investigation (ERGI) during the TWG meeting, it seems that the path forward in the ERGI is open-ended. Questions continue to be raised about the area, and more and more field intrusions are proposed toward their resolution. However, the Tribe strongly believes that the primary question that needs to be raised is whether the additional information is essential to, or even affects at all, the proposed remedial design. Indeed, it is likely that many questions will not be resolved until the remedy is implemented. Others may never be resolved, yet the remedial goals might still be successfully met without such answers. The DOI indicated at the TWG meeting that, under its Comprehensive Environmental Response, Compensation, and Liability Act	a. PG&E understands the Tribe's concerns regarding the sensitivity of additional wells, and the Tribe's interest in limiting the number of wells that are drilled in the area. b. PG&E also agrees that future remedial facilities should be limited to only those needed to attain the remedial objectives. Simulations with the current model show that it is not possible to capture the area of the bedrock plume without multiple wells in bedrock in the lower portion of the East Ravine. After gaining a better understanding of the chromium plume in the bedrock, the remedy (with pumping as an essential element) will be designed to minimize intrusions, and in compliance with ARARs. PG&E also agrees that future additional monitoring wells should be limited to only those needed to help delineate and characterize the plume, and welcomes the Tribe's input during planning of additional characterization in this area. c. The CMS/FS has been revised to update the target remediation area for hexavalent chromium based on data collected during the East Ravine investigation. The suggestion by the USGS commenter to position an extraction well in the alluvium in the vicinity of monitoring well MW-59 has been incorporated into several of the Alternatives.	DTSC acknowledges the Tribe's concerns, but agrees with PG&E's RTC. DTSC has been and will continue to solicit input from the tribes with respect to the investigation at the site. Furthermore, it is DTSC's goal to limit the number of wells necessary for investigation in this area. We will continue to welcome tribal input.	The Department of the Interior will utilize the information provided by the Tribe in making an informed decision regarding the remedy selection and design. a. DOI and its agencies (BLM, BOR, and USFWS) are all aware of and sensitive to the Tribe's concerns regarding the issue of additional wells, and the Tribe's interest in minimizing the total number of wells that are drilled in the APE. b. DOI supports PG&E's recommendation that future additional monitoring wells should be limited to only those needed to delineate and characterize the plume. To that end, DOI and its agencies welcome the Tribe's input during planning for additional wells of the area and monitoring during construction. c. It is expected that further evaluation and refinement of the selected alternative will occur during the design phase.	Comment resolved. Agencies approved PG&E response. As noted in the response, The CMS/FS has been revised to update the target remediation area for hexavalent chromium based on data collected during the East Ravine investigation. The suggestion by the USGS commenter to position an extraction well in the alluvium in the vicinity of monitoring well MW-59 has been incorporated into several of the Alternatives.

TABLE C-1 RESPONSES TO COMMENTS
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				(CERCLA) mandate, it retains the authority to impose additional requirements on the remedy, and the Department of Toxic Substances Control (DTSC) also indicated that the Resource Conservation and Recovery Act (RCRA) may provide similar authority. The Tribe does not support further exploration associated with the ERGI, unless it will minimize the impact of the remedy in this area. b. When PG&E proposed that some of these types of ERGI questions could be deferred to the soils investigation, a DOI reviewer disagreed and implied that the remedy cannot properly be designed until the nature of the source is properly understood. The Tribe disagrees with this position. It seems that the current level of effort being expended is disproportionate to the magnitude of the problem in this area relative to the overall groundwater conditions at the Site. This disproportionate level of study of course leads to further impacts to the Tribe's cultural values. The drilling of 12 wells to date, coupled with the prospect of an unspecified additional number of wells or exploratory borings, plus perhaps another 20 or more extraction wells to support the remedy as conceptualized in the handouts, is a huge spiritual disturbance, even if these facilities are sited in areas already disturbed from past and ongoing activities. None of these additional wells should be placed unless and until PG&E and the agencies have demonstrated that they are the least intrusive way to obtain essential information needed to design or implement the remedy. It is the Tribe's view that this necessity has not been demonstrated. c. The Tribe is interested in the suggestion by the U.S. Geological Survey commenter that the number of extraction wells necessary to complete remediation in the East Ravine area might be reduced by a strategically-positioned extraction well in the alluvium (i.e., in the vicinity of monitor well MW-59). This design option should be evaluated further.				
447	HA-35	September 28, 2009 Technical Work Group Presentation of Revised Alternative E	Hargis & Associates, Inc. (on behalf of Fort Mojave Indian Tribe)	Contingency Although it was not mentioned in conjunction with this Alternative, the Tribe is aware that there has been discussion with regard to maintaining the existing IM treatment plant on ready standby to address remedy contingencies. The Tribe is opposed to such a provision. The Tribe notes that this revised conceptual design for Alternative E effectively negates the need for a contingency	As noted in response to comments #19-21, Section 1.1.2 of the CMS/FS will be revised to state that "Implementation of the IM is expected to continue until a final corrective action/remedial action of the site is operating properly and successfully, and the regulatory agencies terminate the requirement for IM." It is expected that this would occur early in the O&M period for the selected alternative. Further, as noted in response to comments #145, 196, 202.5, 229, 242, 245, PG&E proposes to add a table to the	Agree with RTC.	DOI concurs with the response.	Comment resolved. Agencies approved PG&E response. Changes noted in the response have been made to the CMS/FS Report.

TABLE C-1 RESPONSES TO COMMENTS
Comments on the January 27, 2009 *Draft Corrective Measures Study/Feasibility Study Report For Chromium In Groundwater*
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		Configuration		that would rely on a treatment plant because the extraction wells at the River's edge provide the "safety net" that would capture contaminants before entering the River.	Final CMS/FS report identifying contingencies for example scenarios under which the alternatives would not meet the stated objectives of the remedial action. The table would also note that a contingency plan would be prepared for the selected alternative. PG&E agrees that the extraction wells at the river's edge under Revised Alternative E provide infrastructure that would facilitate adjustment of hydraulic gradients and/or mass removal as needed to maintain water quality standards in the Colorado River.			
448	RWQCB-2	September 28, 2009 Technical Work Group Presentation of Revised Alternative E Configuration	Water Quality Control Board - Colorado River Basin Region	Conceptually, Regional Water Board staff are not opposed to Revised Alternative E as a potential corrective action to remediate groundwater contaminated with hexavalent chromium in the vicinity of PG&E's Topock Compressor Station. However, as listed below, there are several areas in which Regional Water Board staff would appreciate more information: 1. Will the selected corrective measure include a time schedule in which PG&E evaluates the effectiveness of the chosen technology to reach a specified cleanup level? An evaluation is necessary since PG&E states that "[i]t is not possible to predict what the limit of concentration reduction might be for flushing technology at the Topock site." 2. Construction details and map(s) showing the locations and exact number of IRZ wells, extraction wells, and injection wells are needed. Including possible alternate locations of wells, as discussed during the TWG meeting on September 28, 2009. 3. A discussion of the effects of the change in groundwater storage (build up of hydraulic head) within and surrounding the plume, and the impact of high TDS groundwater being discharged to the Colorado River alluvium as a result of the clean-up program.	1. It is expected that the selected alternative would be evaluated on a frequent and routine basis to assess and respond to performance issues. As described in Appendix B, the various cost estimates assume quarterly or annual monitoring and reporting cycles to evaluate progress and system performance. 2. As required by the CACA, a Corrective Measures implementation (CMI) Workplan will be prepared for the selected remedial alternative. The CMI workplan will clearly describe the size, shape, form, and content of the proposed corrective measure, the key components or elements needed, and will include conceptual drawings and schematics. The CACA also requires the submittal of plans and specifications that are based on the CMI Workplan but include additional design details. It is expected that numbers and locations of wells would be adjusted during construction following installation and performance testing. Following construction, the CACA requires the submittal of the construction completion report that will include as-built drawings, showing final locations of the remedial facilities. 3. There will be minimal change in groundwater storage; the localized extraction and injection for Revised Alternative E will cause a slight buildup for the purposes of creating a hydraulic gradient, and the system is expected to achieve steady state flow within several days following startup. No net change in TDS concentrations is anticipated from implementation of Revised Alternative E. The two circulation loops in Revised Alternative E extract and inject water from and within the same basin, in the case of the inner circulation loop - within the site. The distribution of TDS in the aquifer is primarily correlated with the depth above bedrock where wells are screened. There will be significant vertical mixing of water during the operation of Alternative E that will result in homogenization of TDS across the depth of the aquifer, but there will be no net increase in TDS as a result of operating this alternative. As stated in response to comment #433, use of reagents for in situ treatment is not expected to result in an increase in TDS concentrations. The total TDS concentrations at working strengths for each reagent is lower than the baseline TDS at Topock.	Agrees with RTC. For the record, DTSC will continue to involve stakeholders in our decision making during the remedy design process. Therefore, the specific design details will be shared with stakeholders prior to approval or implementation.	DOI concurs with the response. It is expected that continued monitoring and evaluation of the effectiveness of the selected alternative will occur in accordance with the monitoring plan. Additionally, Section 121 of CERCLA, as amended by SARA, requires that remedial actions which result in any hazardous substances, pollutants, or contaminants remaining at the site be subject to a five-year review.	Comment resolved. Agencies approved PG&E response. No changes to the CMS/FS Report are required.

Appendix C-2

Responses to Comments on the November 13, 2009 Redline Final Corrective Measures Study/Feasibility Study Report

TABLE C-2 RESPONSES TO COMMENTS
Comments on the November 13, 2009 *Final Corrective Measures Study/Feasibility Study Report For SWMU 1/AOC 1 and AOC 10*
PG&E Topock Compressor Station, Needles, California

	Section/ Page	Commenter	Comment	Final Comment Resolution
Section 1.0 Comments - Introduction				
449	Pg iii, certification	DTSC	The language here is not appropriate. If the P.E. wants to qualify the approval because of opinion of others, it can be specifically stated in text. As presented P.E. prep and certification is useless, there is no distinction between interpretations of others vs. preparer. It is recommended that the qualification regarding interpretations of others is deleted.	The language on the certification page about authorship of portions of the report by agencies has been removed as requested.
450	Section 1.1.1, paragraph 1	DTSC	Why did the figure change from the RFI/RI Vol 1 SWMU/AOC maps? Including the approximate boundaries of the SWMU 1? (see second paragraph Section 1.2) Figure 1-2 is missing the yellow “Undesignated Area” on the east side of the figure For completeness, indicate that an RFI/RI Volume 1 Addendum will be prepared in the future.	The figure was intended to match the analogous figure from RFI/RI Volume 2 and has been revised as requested. The following sentence has been added to the end of the paragraph. “An addendum to RFI/RI Volume 1 will be prepared in the future.”
451	Section 1.1.1, paragraph 3	DTSC	Update date to final version.	References to the groundwater risk assessment have been updated to reflect the final approved version.
452	Section 1.1.1, end of paragraph 4	DTSC	To the end of the last sentence in the paragraph that starts “Subsequent to the RFI/RI Volume 2 and Volume 2 Addendum…” add: “…and additional investigation is planned for this area as outlined in the last section of Appendix A.”	The requested change has been made.

TABLE C-2 RESPONSES TO COMMENTS
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453	Section 1.1.1, paragraph 5	DTSC	In the second sentence of the paragraph "SWMUs" should be added to the last part of the sentence as such: "RFI/RI Volume 3 will include final characterization data to complete the RFI/RI requirements for remaining Topock Compressor Station operations, including the results of investigations of the other SWMUs, AOCs and undesignated areas."	The requested change has been made.
454	Section 1.1.1, paragraph 7	DTSC	Rewrite the first sentence as follows: "This document addresses ~~chromium~~ groundwater contamination ~~in groundwater~~ resulting from the historic discharge of wastewater to the percolation beds in Bat Cave Wash, as well as ~~chromium~~ groundwater contamination within the East Ravine."	The requested change has been made.
455	Section 1.1.1, end of paragraph 7	DTSC	DTSC disagrees with this statement. Although the risks are much lower than Cr(VI), they do have risks above a hazard index of one and do contribute to a hazard quotient greater than one at localized areas within the plume.	In response to this comment, the requested paragraph has been added with modifications for consistency with language in agencies' approval letters for the GWRA as follows: "The GWRA determined that other COPCs were not either associated with SWMU 1/AOC 1 and/or not present in site groundwater at levels of potential concern to human health or the environment. DTSC and DOI, however, concluded that although the non-cancer hazards associated with selenium, molybdenum, and nitrate are much lower than those associated with Cr(VI), these constituents do have risks above a hazard index of 1 and they do contribute to a hazard quotient greater than 1 at localized areas within the plume. DTSC directed that molybdenum, selenium, and nitrate be monitored in the groundwater monitoring program and their associated impacts be considered in future soil and soil to groundwater risk (DTSC 2009c, DOI 2009c)."

TABLE C-2 RESPONSES TO COMMENTS
Comments on the November 13, 2009 *Final Corrective Measures Study/Feasibility Study Report For SWMU 1/AOC 1 and AOC 10*
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456	Section 1.2, paragraph 4	DTSC	DTSC recommends that the paragraph be rewritten with the following edits: “AOC 10 (East Ravine) is located southeast of the compressor station, and includes four subareas, designated as AOC 10a, 10b, 10c, and 10d. Subarea 10a is the location of the termination of a storm drain leading from the southeastern portion of the compressor station. The remaining subareas are locations within the East Ravine where water and sediment have collected within low areas or behind one of three earthen embankments. Two historical aerial photographs of this portion of the site show a low area within the AOC 10c subarea that apparently contained liquids behind the largest embankment. While the composition of such liquids is not known, it is noted that this is the location of some of the highest chromium concentrations detected in site soil sampling. Thin layers of white powdery waste have also been identified in the East Ravine area that appear similar to the white waste layers located in Bat Cave Wash and the Railroad Debris Site. Drainage to this ravine includes minor runoff from the access road to the facility, runoff from the mountains to the south, and some runoff from the compressor station.”	The paragraph was rewritten as requested with minor changes as follows: “AOC 10 (East Ravine) is located southeast of the compressor station, and includes four subareas, designated as AOC 10a, 10b, 10c, and 10d. Subarea 10a is the location of the termination of a storm drain leading from the southeastern portion of the compressor station. The remaining subareas are locations within the East Ravine where water and sediment have collected within low areas or behind one of three earthen embankments. Two historical aerial photographs of this portion of the site show a low area within the AOC 10c subarea that apparently contained liquids behind the largest embankment. While the composition of such liquids is not known, it is noted that this is the location of some of the highest chromium concentrations detected in site soil sampling. Thin layers of white powdery material have also been identified in the East Ravine area that are visually similar to the white waste layers located in Bat Cave Wash and the Railroad Debris Site (DTSC 2008a). Drainage to this ravine includes minor runoff from the access road to the facility, runoff from the mountains to the south, and some runoff from the compressor station.”
457	Section 1.3, paragraph 3	DTSC	Because PG&E accepted/agreed to and/or modified language provided by the agencies, DTSC recommends deleting the following sentence: “As documented in Appendix C, text in certain sections of this report was provided directly by agency or agency contractors, to be published herein.”	As discussed with the agencies, the sentence was not deleted in order to provide a record of the input from agencies on the CMS/FS Report.

	Section/ Page	Commenter	Comment	Final Comment Resolution
Section 2.0 Comments – Description of Current Conditions				
458	Section 2.1.2, last paragraph	DTSC	Remove the word “small” from the second to last sentence regarding the portion of the refuge that borders the compressor station.	The requested change has been made.
459	Section 2.2	DTSC	DTSC wonders if the number “1,800 acre APE” is changing.	As discussed with the agencies, no changes were made to the CMS/FS Report. PG&E is not aware of changes to the APE.
460	Section 2.2.6, paragraph 2	DTSC	Change the following sentence: “Portions of two of the three geographically-distinct parts of the Topock Maze overlie the groundwater plume.” To: “Although the Maze is viewed as one contiguous element of a larger area having unique value to some tribes, archaeological documents refer to three geographically-distinct parts, two of which overlie the groundwater plume.”	The requested change has been made.
461	Section 2.2.6, paragraph 2	DTSC	Add the following sentence to the end of the paragraph: “Properties on and near the project site that are listed on the National Register of Historic Places include Native American cultural resources and elements of the historic ‘built environment.’”	The requested change has been made.

TABLE C-2 RESPONSES TO COMMENTS
Comments on the November 13, 2009 *Final Corrective Measures Study/Feasibility Study Report For SWMU 1/AOC 1 and AOC 10*
PG&E Topock Compressor Station, Needles, California

	Section/ Page	**Commenter**	**Comment**	**Final Comment Resolution**
462	Section 2.3, paragraph 2	DTSC	Add the following after the first sentence of the paragraph: "Other constituents of potential concerns include Selenium, Molybdenum and nitrate. These constituents were found to have occurrences within the site exceeding a hazard index of one and contribute to a hazard quotient greater than one. Due to limited sampling data and comparatively lower risks contributions at the site, these constituents will be monitored through out the remediation process and will be further evaluated under a site wide risk evaluation in a future document. Aside from these constituents…"	In response to this comment, the additional information has been added to Section 2.3 with modifications consistency with the language in agencies' approval letters of the GWRA: "Selenium, molybdenum, and nitrate were found to exceed an HI of 1 and contribute to a hazard quotient greater than 1 at localized areas within the plume. Due to limited sampling data and comparatively lower risks contributions at the site, these constituents will be monitored throughout the remediation process (DTSC 2009c, DOI 2009c). Aside from these constituents…"
463	Section 2.3, paragraph 2	DTSC	DTSC wants to ensure that the following sentence is retained: "Nearly all of the Cr(VI) present in groundwater at the site is believed to have been released during the 1951 to 1964 period when untreated wastewater from the compressor station was discharged to Bat Cave Wash."	The sentence was retained with the following minor edits: "Nearly all of the Cr(VI) ~~present in~~ releases to groundwater at the site ~~released~~ are believed to have occurred during the 1951 to 1964 period when untreated wastewater from the compressor station was discharged to Bat Cave Wash."
464	Section 2.3, paragraph 3	DTSC	PG&E must retain all discussions on selenium, molybdenum, and nitrate in Section 2.0, including the last two sentences of this paragraph. DTSC disagrees with the removal of these discussions.	The resolution of comment #462 described above also resolves this comment.
465	Section 2.3.1, paragraph 1	DTSC	Change the second sentence of the paragraph as follows: "The calculated statistical upper tolerance limit (UTL) of natural background levels for Cr(VI) in alluvial groundwater, obtained from sampling monitoring and water supply wells surrounding the Topock site, is 31.8 µg/L (CH2M HILL, 2008c)."	The requested change has been made.

TABLE C-2 RESPONSES TO COMMENTS
Comments on the November 13, 2009 *Final Corrective Measures Study/Feasibility Study Report For SWMU 1/AOC 1 and AOC 10*
PG&E Topock Compressor Station, Needles, California

	Section/ Page	Commenter	Comment	Final Comment Resolution
466	Section 2.3.1, paragraph 3	DTSC	Change the word “likely” in the following sentence to “may have also” “Pumping at former facility supply wells PGE-1 and PGE-2, located adjacent to Bat Cave Wash at the present site of the Interstate-40 right-of-way, ~~likely~~ may have also created downward gradients that acted to distribute Cr(VI) over multiple depth intervals beneath the wash.”	The requested change has been made.
467	Section 2.3.1 paragraph 4	DTSC	There is still uncertainty of the extent of contamination. Safe to say, “Currently, investigation data suggest…” at the beginning of the third sentence of the paragraph: “Cr(VI) greater than or equal to 32 µg/L in the shallow and mid-depth wells extends approximately 1,500-feet east southeast of the Compressor Station.”	The requested change has been made.
468	Section 2.3.2, paragraph 5	DTSC	Add “in the alluvial aquifer” to the first sentence of the paragraph as follows: “Calculations suggest that there is sufficient capacity within the floodplain and beneath the river in the alluvial aquifer to reduce at least a significant portion of the Cr(VI) plume were the plume to come in contact with these sediments (CH2M HILL, 2008e, and 2009g).”	The requested change has been made.
469	Section 2.3.2, paragraph 5	DTSC	To the end of the paragraph add the following sentence: “This calculation does not apply to the bedrock aquifer.”	The requested change has been made.
470	Section 2.3.3, last paragraph	DTSC	DTSC also provided acceptance of the “Final Background Study Report”.	Section 2.3.3 has been updated to reference the revised background study report submitted in November 2009, and DTSC and DOI approval thereof.

	Section/ Page	Commenter	Comment	Final Comment Resolution
Section 3.0 Comments – Remedial Action Objectives				
471	Section 3.1, paragraph 2	DTSC	At the end of the first sentence of the paragraph insert “for impacts by activities at the SWMU1/AOC1 and SWMU2”. The sentence should now read: “The GWRA documented the conceptual site model, including identified sources of groundwater contamination, potential transport mechanisms, potential exposed populations and exposure pathways, and potential exposure point concentrations for impacts by activities at the SWMU/AOC1 and SWMU2 (ARCADIS, 2009).”	The requested change has been made.
472	Section 3.1, paragraph 9	DTSC	PG&E is required to include discussion of selenium, molybdenum, and nitrate in the CMS/FS. PG&E can elect to simply quote the GWRA in this section that DTSC is requiring these substances to be carried into the CMS/FS, however the following is more robust on rationale: “Although the GWRA did not recommend Selenium, Molybdenum and Nitrate to be COCs, DTSC notes that these substances may be site related and quantitative analysis did exceed non-cancer hazard index of 1 at some locations and contributes to a hazard quotient greater than 1. Because the relative contribution and risks from these substances are significantly lower than Cr(VI), and that there are limited data set for these substances, DTSC is requiring PG&E to continue the monitoring of these COPCs as part of this remedial action.”	In response to this comment, the requested paragraph has been added with modifications for consistency with language in agencies’ approval letters for the GWRA as follows: “The GWRA determined that other COPCs were not either associated with SWMU 1/AOC 1 and/or not present in site groundwater at levels of potential concern to human health or the environment. DTSC and DOI, however, concluded that although the non-cancer hazards associated with selenium, molybdenum, and nitrate are much lower than those associated with Cr(VI), these constituents do have risks above a hazard index of 1 and they do contribute to a hazard quotient greater than 1 at localized areas within the plume. DTSC directed that molybdenum, selenium, and nitrate be monitored in the groundwater monitoring program and their associated impacts be considered in future soil and soil to groundwater risk (DTSC 2009c, DOI 2009c).”

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473	Section 3.2, paragraph 2	DOI	Rewrite this paragraph as follows: “The identification of site-specific ARARs is provided in Appendix B. As the CERCLA remediation process advances past the CMS/FS, new information may become available, prompting DOI to revise the list of ARARs for the final Record of Decision.”	The requested change has been made.
474	Section 3.2.2, paragraph 3	DOI	Rewrite this paragraph as follows: “**National Wildlife Refuge System Administration Act.** This Act ~~affects~~ governs the use and management of the HNWR portion of the Topock site. It requires that the USFWS evaluate ongoing and proposed activities and uses to ensure that such activities are appropriate and compatible with the mission of the National Wildlife Refuge System, as well as the specific purposes for which the HNWR was established. Figure 2-2 illustrates the portions of the groundwater plume within the HNWR. The Topock site includes portions of the HNWR. Prior to the selection of a remedial action by DOI/FWS, that remedial action must be found by the Refuge Manager to be both appropriate an appropriate use of the HNWR and compatible with the mission of the HNWR and the Refuge System as a whole. Any remedial action proposed to be implemented on the HNWR that was not selected by DOI/FWS would be subject to the formal appropriate use/compatibility determination process.”	The requested change has been made, with a slight modification to the following sentence: Prior to the selection of a remedial action by DOI/FWS, that remedial action must be found by the Refuge Manager to be both ~~appropriate~~ an appropriate use of the HNWR and compatible with the mission of the HNWR and the Refuge System as a whole.

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475	Section 3.2.2, paragraph 5	DOI	Replace the paragraph with the following: "**National Historic Preservation Act.** This statute and the implementing regulations require that a federal agency undertaking a remedial action at or near historic properties must take into account the effects of such undertaking on the historic properties. The federal agency must determine, based on consultation, if an undertaking's effects would be adverse and consider feasible and prudent alternatives that could avoid, mitigate, or minimize such adverse effects on a National Register or eligible property. The agency must then specify how adverse effects will be avoided or mitigated or acknowledge that such effects cannot be avoided or mitigated. The APE includes historic properties, as discussed in Section 2.2.6. Measures to avoid or mitigate adverse effects of any selected remedial action that are adopted by the agency through consultation must be implemented by the remedial action to comply with the NHPA."	The requested paragraph has been added with a modification as follows for consistency with Appendix B and the regulations: This statute and the implementing regulations require that a federal agency undertaking a remedial action at or near historic properties must take into account the effects of such undertaking on the historic properties. The federal agency must determine, based on consultation, if an undertaking's effects would be adverse and ~~consider feasible and prudent alternatives~~ seek ways that could avoid, mitigate, or minimize such adverse effects on a National Register or eligible property. The agency must then specify how adverse effects will be avoided or mitigated or acknowledge that such effects cannot be avoided or mitigated. The APE includes historic properties, as discussed in Section 2.2.6. Measures to avoid or mitigate adverse effects of any selected remedial action that are adopted by the agency through federal consultation must be implemented by the remedial action to comply with the National Historic Preservation Act.
476	Section 3.2.3, paragraph 3	DOI	At the end of the last sentence of the bullet titled "Endangered Species Act" add "or their habitats".	The requested change has been made.

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477	Section 3.2.3, paragraph 5	DOI	Change the paragraph as follows: "**Religious Freedom Restoration Act.** Under this Act, the government shall not substantially burden a person's exercise of religion, unless the application of the burden is in furtherance of a compelling government interest, and it is the least restrictive means of furthering that compelling interest. ~~A determination regarding compliance with this Act will be made upon final guidance by the regulatory agencies and the results of consultation by those agencies with stakeholder tribes.~~ To constitute a "substantial burden" on the exercise of religion, a government action must (1) force individuals to choose between following the tenets of their religion and receiving a governmental benefit or (2) coerce individuals to act contrary to their religious beliefs by the threat of civil or criminal sanctions. If any remedial action selected imposes a substantial burden on a person's exercise of religion, it must be in furtherance of a compelling government interest and be the least restrictive means of achieving that interest."	The requested change has been made.
478	Section 3.2.3, paragraph 6	DTSC	Change reference of "PG&E-owned land" to "privately-owned land". Modification is necessitated by transfer of land to FMIT.	The requested change has been made.

	Section/ Page	Commenter	Comment	Final Comment Resolution
479	Section 3.2.3, paragraph 8	DOI	Change the paragraph as follows: "**SWRCB Resolution 88-63.** This resolution specifies that, with certain exceptions, all surface and ground waters of the State are to be considered suitable, or potentially suitable, for municipal or domestic water supply. ~~Exceptions include water with TDS exceeding 3,000 mg/L that is not reasonably expected to supply a public water system, and water sources that do not support an average sustained yield of 200 gallons per day from a single well. Much of the groundwater at the site would likely meet these exception criteria. However, the Water Board has not revised the beneficial use designations of municipal or domestic supply in the Basin Plan based on the exception criteria in this resolution.~~ The Regional Water Quality Control Board and State Water Resources Board have designated the beneficial use of the ground and surface waters in the Topock Site area as "municipal and domestic water supply." This designation is set forth in the Basin Plan."	The requested change has been made.

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480	Section 3.2.3, paragraph 9	DOI	Change the paragraph as follows: "**SWRCB Resolution 92-49.** This resolution establishes policies and procedures for investigation and cleanup and abatement of discharges under Water Code Section 13304, including the requirement that cleanup attain background water quality or the best water quality that is reasonable if background water quality cannot be restored. ~~The identification of any substantive requirements in this resolution, as well as any analysis pertaining to the necessary steps to comply with such requirements, will be performed after a remedial alternative is selected and a remedial design is developed.~~ In addition, Section III.A of this Resolution states that the Regional Water Board shall" "concur with any investigative and abatement proposal which the discharger demonstrates and the Regional Water Board finds to have a substantial likelihood to achieve compliance within a reasonable time frame…"	The requested change has been made.

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481	Section 3.2.3, paragraph 10	DOI	Change the paragraph as follows: "**Water Quality Control Plan: Colorado River Basin-Region 7, June 2006**. The Basin Plan designates the Colorado River and Colorado Hydrologic unit as having the beneficial use of "MUN" (municipal or domestic water supply). The Basin Plan also prescribes General Surface Water Objectives and Ground Water Objectives in addition to Specific Surface Water Objectives for the Colorado River, which include a flow-weighted average annual numeric criterion for salinity for the portion of the Colorado River on the Topock Site of 723 mg/L. This TDS value must not be exceeded in any remedial alternative being considered. ~~These objectives must be considered in the design of any remedial alternative.~~	The requested change has been made.
482	Section 3.3.3, paragraph 2	DTSC	Need to stay consistent with the definition of a COC. As stated in the GWRA, it is "potential" health risk, and not determined by the significance. See first paragraph of Section 3.1 and GWRA. Recommend proposed insert language in Section 3.1.	The first sentence of the paragraph has been rewritten as follows: "Although the GWRA concludes that these three constituents are not believed to be a source of significant risk/noncancer hazard, the regulatory agencies have requested that molybdenum, selenium, and nitrate continue to be monitored through the remediation process (DTSC 2009c, DOI 2009c)."

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483	Section 3.3.3, last paragraph	DTSC	DTSC notes that there is evidence of molybdenum in East Ravine area as well as in MW24 bench. Due to limited sampling data, it is better to be less definitive regarding the extent of detection at the site.	The end of the first sentence of the paragraph has been revised as follows: "In summary, within the treatment area, Cr(VI) in groundwater represents the predominant health hazard associated with any potential future domestic use of the groundwater; other potential facility-related constituents (molybdenum, selenium, and nitrate) were detected at elevated levels in localized areas associated with ~~only a few wells and at comparatively insignificant~~ lower levels of risk ~~concentrations~~."
Section 4.0 Comments – Identification and Screening of Remedial Action Technologies				
484	Table 4-1	DTSC	Under "Primary Screening Comments" for "Treatment" and "In-situ Physical-Chemical Treatment" and "Pneumatic Fracturing", DTSC comments "What about the East Ravine? It may be a useful technology."	The primary screening comment has been revised as follows: "The alluvial aquifer at Topock has adequate permeability so that fracturing methods are not needed, however, this technology is retained for potential application to supplement treatment in low-permeability portions of the site." In addition, Table 4-1 has been revised to show that pneumatic fracturing has been retained in the primary screening and pneumatic fracturing has been added to Table 4-2.

	Section/ Page	Commenter	Comment	Final Comment Resolution
485	Table 4-2	DTSC	Under “Hydraulic Barriers” DTSC asks “What about freshwater injection or injection wells for hydraulic barriers?”	In response to this comment, the “Process Options” have been changed to “Extraction/Injection Wells” and the “Effectiveness” column has been rephrased as follows: “Effective method of hydraulic control; vertical wells are proven technology in widespread use for remediation projects. The hydrogeologic properties at the site are very conducive to groundwater extraction/injection with vertical wells. However, ~~these techniques~~ extraction wells may not be effective if the contamination is contained in low-permeability, fine-grained layers and, depending on the array of the wells, there could be extensive surface disturbance.
486	Table 4-3	DTSC	Under the “Containment” general response action, DTSC notes that fresh water injection wells may be evaluated for containment.	Similar to the changes described above for Table 4-2 in RTC #485, injection wells have been included as a process option under Containment.
Section 5.0 Comments – Development and Analysis of Remedial Action Alternatives				

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487	Section 5.0, heading	AECOM	In comparing the revised CMS/FS with the comments received on the EIR March 2009 Project Description, we have noted that there is still inconsistency with the way the number of wells is presented between the two documents. The EIR text was revised by PG&E to show ranges (for example, the east ravine would require from 5 to 30 wells) though in the CMS it is presented as the middle number (approximately 15). We believe, as expressed in previous meetings, that the CMS/FS also needs to present the range. We understand that one number is needed for cost estimating purposes; however, we feel that the CMS/FS can present both a range and a more specific number, and the text is already largely in the document. For example, this could be read as the following: "For the purposes of cost estimating and evaluating feasibility of this alternative, preliminary estimates suggest that construction activities for this alternative would include the installation of approximately 15 wells. Optimization of the remedy would occur throughout the design, construction, and operational phases of remedy implementation. Changes to the number, location, and configuration of the extraction, treatment, and injection systems could occur. As such, the anticipated range for all wells associated with this alternative is from 5 to 15"…. Alternatively, a footnote could be added explaining the difference between the range and the approximate value.	In response to this comment, additional information has been added to Appendix D to estimate the maximum number of wells, lengths of pipelines and utilities, and size of above-ground infrastructure for the remedial alternatives to assist with evaluating environmental impacts pursuant to CEQA. As discussed with the agencies, no changes to Section 5.0 were made.

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488	Section 5.1 and 5.2, first paragraph in both	DOI &DTSC	Edit the first sentence of Section 5.1 to read: "Remedial action alternatives for the Alluvial Aquifer and bedrock in the East Ravine are identified and evaluated in this section." Edit the first sentence of Section 5.2 to read: "In this section, remedial alternatives are assembled to address Cr(VI) in alluvial groundwater and in bedrock groundwater in the East Ravine."	The requested change has been made.
489	Section 5.2, paragraph 2	DTSC	Insert "RCRA and…" to the second to last sentence in the paragraph	The revision has been made as requested, the sentence now finishes as follows: "…while meeting the requirements of RCRA and the National Contingency Plan (NCP).
490	Section 5.2, paragraph 4	DTSC	Insert "RCRA and…" to the second sentence of the paragraph.	The revision has been made as requested, the sentence now reads as follows: "These considerations are consistent with RCRA and the NCP requirements listed above and help to further focus the assembly of alternatives."
491	Section 5.2, second bullet in second set of bullets	DTSC	This arbitrary time to cleanup will likely be false for East Ravine. Need qualifier for AOC 10.	The sentence has been revised as follows: "Target Alluvial Aquifer cleanup (estimated as the time at which 98 percent mass reduction occurs in the groundwater model simulations) in 40 years or less for those remedies that use active remediation."
492	Section 5.2, last paragraph	DTSC	Delete "Each of the" and insert "the representative process" in the first sentence of the paragraph.	The requested change has been made. The sentence now reads: "Technology types and the representative process options that passed the screening in Section 4.0 are discussed in the subsections below."

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493	Section 5.2.3, paragraph 2	DTSC	In the second sentence of the paragraph insert the word “federal” here and at other mentions of “consultation” to clarify that it’s a federal process.	The requested change has been made. The sentence now reads: “Further considerations include appropriate mitigation measures to protect wildlife habitat and cultural resources, identified by the HNWR Manager and federal consultation related to cultural and historic properties.”
494	Section 5.2.3, paragraph 3	DTSC	Delete “be allowed to” from the last sentence of the paragraph.	The requested change has been made. The sentence now reads: “…and construction and operation of remedial facilities would be designed to not interrupt those existing operations.”
495	Section 5.2.4, paragraph 3	DTSC	Delete “be allowed to” from the last sentence of the paragraph.	The requested change has been made. The sentence now reads: “…and operation of remedial facilities would be designed to not interrupt those existing operations.”
496	Section 5.2.5, paragraph 1	DTSC	Change to “Cr(III) with low solubility” and delete “and remains permanently in the aquifer formation” from the second sentence of the paragraph.	The requested change has been made, with slight revisions as noted below: “…where reducing materials in the aquifer chemically and biochemically convert Cr(VI) to low solubility ~~insoluble~~ Cr(III) that precipitates out of solution and ~~remains permanently in~~ binds to the aquifer formation.”
497	Section 5.2.5, paragraph 2	DOI	Move this paragraph to follow the paragraph starting with “Under non-pumping conditions…” Delete the word “this” in the second sentence.	The requested change has been made.
498	Section 5.2.6, paragraph 8	DTSC	Delete “be allowed to” from the last sentence of the paragraph.	The requested change has been made. The sentence now reads: “…and construction and operation of remedial facilities would be designed to not interrupt those existing operations.”

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499	Section 5.2.7, paragraph 5	DOI	Rewrite the last sentence of the paragraph as follows: "The locations and number of wells installed will affect the extent of piping and disturbances at the surface."	The requested change has been made.
500	Section 5.2.8, paragraph 1	DTSC	In the second sentence of the paragraph, change the phrase "does nothing to" to "will not".	The requested change has been made.
501	Section 5.3, paragraph 1	DOI	Add "…and bedrock groundwater in the East Ravine…" to the first sentence of the paragraph following the phrase "…for the Alluvial Aquifer…"	The requested change has been made.
502	Section 5.3, paragraph 2	DTSC	Unless PG&E is proposing to reopen CMS/FS for East Ravine, this document is to evaluate East Ravine alternatives. Replace the phrase "remedial alternatives" in the last sentence to "remedy" and the word "final" in the last sentence to "remedy".	The revision has been made as requested, the last sentence of the paragraph now reads: "The bedrock remedy will be developed further during design."
503	Table 5-2, Alternative E, Time Optimized	DTSC	With additional volume of fresh water flush, would larger volume of extraction be necessary to control hydraulics?	The description has been changed to read: "Assuming that there was adequate freshwater available, cleanup time could be shortened by increasing the rate of clean water flushing by injection wells and/or extraction in the floodplain."
504	Table 5-2, Alternative G, Footprint Optimized	DTSC	Wouldn't this possibly lead to inability to fully establish an IRZ, therefore failing threshold criteria especially in the deep zone of the aquifer?	The description has been changed to read: "**Floodplain cleanup:** Fewer injection wells could be used in the floodplain at the cost of achieving a ~~only partial~~ slower distribution of carbon substrate and having to wait for ~~natural~~ groundwater flow to move contaminated groundwater through treatment zone. Because of the slow landward movement of floodplain groundwater under the influence of the upland pump and treat system at the site, this could add substantially to the cleanup time.

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505	Table 5-3, Alternative B, Example Causes	DTSC	What about insufficient reductive zone at depth above bedrock contact?	The sentence has been changed as follows: “Change in natural conditions over time or insufficient reductive zone at depth.”
506	Table 5-3, Alternative B, Example Failure Modes and Causes	DTSC	No background has been established for bedrock. If Ca PHG for Cr(VI) becomes MCL, East Ravine cleanup goal will need to be revised possibly to health based. (Applies to all alternatives for East Ravine.)	As discussed with agencies, no change to the CMS/FS Report has been made. The contingency information in the CMS/FS is not intended to capture potential changes to legal or statutory requirements.
507	Section 5.3.1, heading	AECOM	The groundwater plume boundary symbol in the legend of all graphics in the CMS/FS is presented as a solid blue line. In previous discussions (in particular the RCRA/CERCLA meeting on November 4), it was our understanding that the legend text would not be revised, but the symbol would be updated to match the plume boundary itself with the dashed lines for east ravine.	In response to this comment, the legend of the Section 2.0 Section 5.0 figures that depict the plume boundary have been revised to include dashed lines in the symbol depicting a portion of the plume boundary.
508	Section 5.3.1, paragraph 1, sentence 4	DTSC	There is little evidence at this time to support this statement. See comments in Appendix A (East Ravine Report).	The sentence has been changed to read: “…and the ~~presence of strong~~ observations of ~~geochemical~~ reducing conditions in the deeper bedrock wells.”

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509	Section 5.3.1, paragraph 4	DTSC	Second sentence: Replace with "The design of the East Ravine remedy' will occur during the remedial design phase of the project." Third sentence: Replace the word “alternative” with "remedial design" Last sentence: Delete sentence unless PG&E is making a distinction between an East Ravine remedy from the AOC 1/SWMU 1 remedy	The requested change has been made, as follows:. “The development of a hydraulic capture system for bedrock is assumed herein instead of developing and evaluating a range of remedial alternatives to attain RAOs in bedrock. ~~The final development of remedial alternatives for bedrock will occur following the next phase of investigation during the final design phase of the project.~~ The design of the East Ravine remedy will occur during the remedial design phase of the project. Due to the low volume of water from the bedrock compared to the volume of water in the Alluvial Aquifer, it is anticipated the remedial ~~alternative~~ design for bedrock can be readily incorporated within any of the proposed active remedial alternatives for the Alluvial Aquifer. ~~Thus, the uncertainty about the eventual remedial action for bedrock should not affect the selection of the remedial action for the Alluvial Aquifer.~~”
510	Section 5.3.1, paragraph 5	DTSC	In the first sentence replace the word “evaluation” with “CMS/FS”.	The requested change has been made.
511	Section 5.3.1, last paragraph	DTSC	Add other potential remedial technologies, otherwise only these two will be allowed for selection (e.g. fracturing, etc?).	The last sentence of the paragraph has been changed as follows: “In addition to pumping for hydraulic control, technologies that may be applicable to East Ravine bedrock would include, but are not limited to, freshwater injection for flushing and injection of carbon amendments for *in-situ* reduction of Cr(VI).”

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512	Section 5.3.3, paragraph 1, sentence 11 (deleted)	DTSC	PG&E needs to clarify why the cleanup times have changed. The change is significant. Time should be longer due to the MW-59 “embayment” (plume volume increased).	The comment was resolved with the following clarification regarding why cleanup times changed: The estimated mass removal times changed from the January 2009 Draft CMS/FS Report due to a combination of the following: (a) the Cr(VI) concentration distribution has been reconfigured with more recent data, most notably the East Ravine area investigation, (b) the local recharge to groundwater in the model has been redistributed in the model as a result of the East Raving investigation, which affects flushing during natural attenuation, and (c) the estimated cleanup times are based on 98% mass removal, as opposed to 100% in the previous draft. As discussed with the agencies, no change to the CMS/FS Report has been made in response to this comment.
513	Section 5.3.3, paragraph 2	AECOM	For all alternatives that include the institutional controls on the use of groundwater within the plume, what is the estimated “buffer” area that would be applied to prohibit future use during remedy operation?	The paragraph has been rewritten as follows: “Under this alternative, an institutional control would be maintained during the remediation period to restrict use of impacted groundwater ~~in the plume area~~ until the cleanup goals are attained, thereby eliminating the pathway for human health risk from direct exposure to groundwater. ~~The area subject to the institutional control would include a buffer area surrounding the plume to prevent the consumption of water that potentially could migrate from the plume in other directions as a result of pumping from hypothetical future local water supply wells~~.”
514	Section 5.3.3, paragraph 3	AECOM	Section 5.3.3 should state the estimated range of the number of monitoring wells that are likely. Comments on the EIR Project Description indicate that this number ranges from 5-40.	In response to this comment, the range in numbers of wells has been revised in Appendix D. As discussed with the agencies, no changes were made within Section 5.
515	Section 5.3.4.2, paragraph 5	DOI	The intent of comment #228 (from Appendix C Table 1) was to ensure that appropriate agencies and stakeholders were contacted and that approval gained by the appropriate agencies.	The phrase “and stakeholders” was removed from the second sentence of the paragraph.

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516	Section 5.3.4.3, paragraph 1	DTSC	Reinsert byproduct formation as a limitation. Still a potential problem. Update language similar to other inserts.	The following sentences removed by DOI have been reinserted as requested: “Concentrations of byproducts such as Mn and As are likely to temporarily increase within portions of the treatment zone. These byproducts are not expected to be a significant issue as documented in Appendix G.”
517	Section 5.3.6, paragraph 1	DOI	Change the first sentence of the paragraph to: “Alternative E involves flushing to ~~push the plume~~ accelerate plume movement through an IRZ barrier located along National Trails Highway.”	The requested change has been made.
518	Section 5.3.6, paragraph 6, sentence 9 (deleted)	DTSC	Cleanup times getting slightly longer. Why? Embayment? Alternative B times were much shorter that the first draft.	The comment was resolved with the following clarification: The estimated mass removal times have changed from the January 2009 Draft CMS/FS Report due to a combination of the following: (a) the Cr(VI) concentration distribution has been reconfigured with more recent data, most notably the East Ravine area investigation, (b) the local recharge to groundwater in the model has been redistributed in the model as a result of the East Raving investigation, which affects flushing during natural attenuation, and (c) the estimated cleanup times are based on 98% mass removal, as opposed to 100% in the previous draft. In addition, for this alternative, the alternative configuration was revised and flow rates revised. As discussed with the agencies, no change to the CMS/FS Report has been made in response to this comment.

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519	Section 5.3.6, paragraph 8	AECOM	Where is the likely location of the "small system" that would be needed for potential chemical adjustments or filtering to the estimated 500 gpm of pumped water from the offsite source? Would it be located near the potential site of extraction, or along the pipeline somewhere? Is any information available on the potential dimensions or capacity of this facility.	The comment was resolved with the following clarification: The small system would be located along the pipeline corridor. The sixth sentence of the paragraph has been changed as follows: "If needed, this pH adjustment would require a small system located along the pipeline corridor with equipment such as chemical storage tank(s), secondary containment, feed pump, and security enclosure such as a building or fence."
520	Section 5.3.8, paragraph 3	DTSC	Delete "for a" from the beginning of sentence 7 of the paragraph.	The requested change has been made.
521	Section 5.3.9, paragraph 3, first bullet	AECOM	Since only one half of the water would be sent to the treatment plant but the other half would be directly re-injected, would the size of the treatment plant need to be the same as under Alternative F?	The comment was resolved with the following clarification: The *ex-situ* treatment process in Alternative H would be similar to the *ex-situ* treatment in Alternative F, although the size of the treatment plant facilities would be smaller, The assumed flow rate to an above-ground treatment plant in Alternative H is about 200-300 gpm, while the assumed flow rate to an above-ground treatment plant in Alternative F is about 1,200 gpm. The estimated footprint sizes of treatment plants for each alternative are included in Appendix D.

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522	Section 5.3.10, paragraph 1, sentence 5	DTSC	Why the decrease in cleanup times? Increasing plume volume at embayment.	The comment was resolved with the following clarification: The estimated mass removal times have changed from the January 2009 Draft CMS/FS Report due to a combination of the following: (a) the Cr(VI) concentration distribution has been reconfigured with more recent data, most notably the East Ravine area investigation, (b) the local recharge to groundwater in the model has been redistributed in the model as a result of the East Raving investigation, which affects flushing during natural attenuation, and (c) the estimated cleanup times are based on 98% mass removal, as opposed to 100% in the previous draft. In addition, for this alternative, the alternative configuration was revised and flow rates revised. As discussed with the agencies, no change to the CMS/FS Report has been made in response to this comment.
523	Section 5.4.1.3, “State Acceptance”	DTSC	Under the paragraph for state acceptance replace the term “RI” with “CMS”.	The change has been made as requested.
524	Section 5.4.1.3, “State Acceptance”	DOI	Revise the paragraph as follows: “**State Acceptance**. This criterion is broadly defined as ~~meeting~~ addressing the technical ~~and administrative~~ concerns of state agencies. Assessment of state concerns may not be completed until after comments on the ~~RI~~CMS/FS are received and evaluated. State concerns can then be ~~fully but may be~~ discussed ~~to the extent possible~~ in the Proposed Plan for public comment. The state concerns that shall be assessed include:”	The requested change has been incorporated

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525	Section 5.4.1.3, “Community Acceptance”	DTSC	Replace the phrase “Statement of Basis” at the end of the paragraph with “Responsive Summary and Statement of Basis”	The requested change has been made. The last sentence of the paragraph now reads: “~~It will be addressed in the CERCLA~~ Community acceptance can then be fully assessed in the Proposed Plan and Record of Decision and/or RCRA Responsive Summary and Statement of Basis.”
526	Section 5.4.1.3, “Community Acceptance”	DOI	Revise the last sentence as follows: “~~It will be addressed in the CERCLA~~ Community acceptance can then be fully assessed in the Proposed Plan and Record of Decision and/or RCRA Responsive Summary and Statement of Basis.”	The requested change has been incorporated.
527	Section 5.4.1.4, first sentence		Revise the first sentence as follows: ~~The DOI has prepared the following section pertaining to the consultation process on the CMS/FS to date.~~ Federal agency consultation, by and through the BLM in cooperation with FWS, Reclamation, and DOI, has been ongoing throughout the development of this CMS/FS to date. According to DOI, the investigation . . .”	The requested change has been incorporated.
528	Section 5.4.1.4, last paragraph	DTSC	Add “by the federal agencies” to the first sentence of the last paragraph.	The requested change has been made. The sentence now reads: “Tribal consultation will continue going forward as a preferred alternative is identified in the Proposed Plan by the federal agencies and the plan is issued for review and comment by the tribes and members of the public.”

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529	Section 5.4.2, paragraph 1	DOI	Clarify the purpose of Table 5-5 (formerly Table 5-7).	This paragraph has been revised as follows: "The alternative analysis consists of two steps. The first step is the individual detailed analysis ~~The performance~~ of each alternative against seven of the nine evaluation criteria (Section 5.4.1). This analysis is discussed in detail in Table 5-5, ~~located at the end of this section~~. The table identifies how key components of each remedy address the specific criteria. The second step is the comparative analysis of alternatives relative to each other. This analysis is presented in the text of Section 5.5 ~~evaluates how each of the alternatives compares with each other~~."
530	Section 5.5.1.3, paragraph 2	DOI	Add the following paragraph to the end of the section: "The source of contaminated groundwater in bedrock at AOC 10 has not yet been determined. Surface discharge from the Topock Compressor Station to the East Ravine does not currently occur. However, the evaluation of whether leaching of Cr(VI) from contaminated soils represents a significant transport pathway to groundwater has not yet been completed. There is no distinction between the alternatives with respect to this criterion."	The paragraph has been added with the following edits: "However, the historic source of contaminated groundwater in bedrock at AOC 10 has not yet been determined, and the evaluation of whether leaching of Cr(VI) from contaminated soils represents a significant transport pathway to groundwater has not yet been completed. There is no distinction between the alternatives with respect to this criterion."
531	Section 5.5.1.4, last sentence	DTSC	This potential is noted for any alternatives with influx of water including Alternatives E and H. Level of operational maintenance and control is similar with F, G, H and I. In fact the larger the treatment plant, the more operational maintenance issue can become albeit for shorter duration due to clean-up time.	The following has been removed from the last sentence of the paragraph: "and potential for degradation of the natural reducing capacity in the floodplain due to flow of aerobic river water through the fluvial sediments from long-term extraction in the floodplain"

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532	Section 5.5.2, paragraph 2	DOI	Add the following to the end of the last sentence in paragraph 2: “ . . .and have been determined to be ARARs for this site by the DOI. In addition, each alternative described in this CMS/FS has been evaluated by DOI in terms of its attainment of ARARs.”	The requested change has been made to paragraph 1 in Section 5.5.2.
533	Section 5.5.2, paragraph 3	DOI	Revise the third sentence as follows: As a threshold matter, none of the alternatives under consideration in this CMS/FS has been determined to fail ~~can be eliminated based on the alternative’s inability~~ to satisfy these cultural resource ARARs.	The requested change has been made.
534	Section 5.5.2, paragraph 5	DTSC	Insert “the DTSC, as the lead State agency forwarded the recommendation from the…” to the sentence that starts “In a letter, dated October 7, 2009…”	The sentence has been changed to read: “In a letter, dated October 7, 2009, the DTSC as the lead State agency forwarded the recommendation from the Water Board stated that:…”
535	Section 5.5.2, paragraph 6	DOI	Revise the paragraph as follows: “In summary, alternatives C, D, E, F, G and H have been determined to comply with all ARARs. As a threshold matter, none of the alternatives under consideration in this CMS/FS has been determined to fail ~~can be eliminated based on the alternative’s inability~~ to satisfy cultural resource ARARs or the National Wildlife System Administration Act. ~~However,~~ Alternatives A, B, and I would not satisfy the ARAR requirements of the California State Water Resources Control Board Resolution 92-49, and thus fail to meet this threshold criterion.”	The requested change has been made.
536	Section 5.5.3.3, header	DOI	The title needs to include “…Permanence and Reliability”	The title of Section 5.5.3.3 was changed to: “Long-term Effectiveness, Permanence, and Reliability”

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537	Section 5.5.4.4, paragraph 7	DTSC	The issue is if the Mn and As are mobilized and reinjected with carbon into an aquifer outside of the current 32 ppb boundary (alt C, D, E, H), the remedy would be spreading a highly toxic substance (e.g. As) above its naturally forming concentration outside of the Cr plume. Furthermore, flow line suggests that there will not be full capture of the reinjected water thus spreading of Mn and As before it is returned to a solid phase is a distinct possibility.	The following sentence has been added to the paragraph: “Careful monitoring of potential byproducts both inside and outside the plume will be conducted.”
538	Section 5.5.4.5, paragraph 1	DTSC	Because of the possibility of mobilizing Mn and As outside of plume in comment above, Alt C, D, E, and H should not be ranked high.	The first sentence of the paragraph has been changed to read” “In summary, Alternatives F, G, and I are ranked high because the toxicity…” And the following sentence has been added to the paragraph: “For these reasons, Alternatives C, D, E, and H are ranked medium high.”

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539	Section 5.5.5.2, paragraph 4	DTSC	What about *ex-situ* alternatives? Alternative F-I should also be evaluated for protection of community and ranked against the *in-situ* alternatives.	The text for the *ex-situ* alternatives was inadvertently deleted. The following text has been re-instated: "The four *ex-situ* treatment alternatives, Alternatives F, G, H and I, were ranked low with respect to effects to the community, workers and environment during implementation of the remedy from construction and operation of an aboveground treatment plant. Construction of an aboveground treatment plant (Alternatives F, G, and H) would include foundation, exterior structure, tanks, piping, pumps, equipment, controls and instrumentation. Operation and maintenance of the aboveground treatment plant would include periodic sample collection, chemical controls, equipment maintenance and inspection, and process chemical and waste management. Construction and operation of the *ex-situ* system would result in greater environmental disturbance than the *in-situ* treatment alternatives due to the greater amount of construction, aboveground visual impact, worker/operator presence onsite, and electrical power that would be required for the building and operation of a treatment plant. Operation of the *ex-situ* system would result in greater trucking requirements for chemical delivery and waste disposal than the *in situ* treatment systems. Greater trucking requirements for chemical delivery and waste transportation and disposal would generate the greatest amount of waste. Alternative I does not require construction of a new treatment plant, but does include a high level of operation and maintenance for a substantially longer period than the treatment plant associated with Alternatives F, G, and H."

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540	Section 5.5.5.3, paragraph 3	DTSC	Delete or reinsert previously deleted language.	The sentence has been revised as follows: The four *ex-situ* treatment alternatives—Alternatives F, G, H, and I—are considered to rank lower than the other alternatives with respect to protection of workers due to construction and operation of the aboveground treatment plant associated with these alternatives.
541	Section 5.5.6.2, paragraph 1	DTSC	Change the word “beneath” to “associated with” and also clarify the use of the term “institutional control”.	The paragraph has been updated to read: “Alternatives B through I would each include administration of an institutional control to prohibit use of groundwater associated with ~~beneath~~ the plume until attainment of cleanup goals. The institutional control would need to be coordinated with the various landowners that overlie the plume. Alternatives B through I are considered equal in the administrative challenges associated with the institutional control, although the institutional control associated with Alternatives B and I would be in place considerably longer than the institutional control associated with Alternatives C, D, E, F, G, and H.”
542	Section 5.5.6.2, paragraph 3	DTSC	Remove off-site wording. Anything that is installed outside of PG&E property is considered off-site. See next paragraph which states all alternatives will require construction… outside of PG&E property.	The first sentence has been rewritten as follows: “Alternative E is the only alternative that includes ~~an offsite construction component,~~ installation of a new water supply well, and a pipeline to transport the water.”
543	Section 5.5.6.2, last paragraph	DTSC	O&M replacements for all alternatives will require same coordination.	The last sentence has been rewritten as follows: “Since the remedial facilities for Alternative I are already in place, there would be no new construction for Alternative I; however, operation and maintenance for this and other alternatives (that may require construction to replace system components due to equipment aging and breakdown) would need to be coordinated with and approved by the respective landowners.”

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544	Table 5-5, Alt B, ARARs, paragraph 1	DTSC	How can this be if RAO of 32 ppb is achieved between 220 and 2,200 years?	In response to this comment, the time period for chromium in groundwater to remain above MCLs has been corrected to 220 to 2,200 years (rather than 700 to 3,000 years).
545	Table 5-5, Alt C, Short-term effectiveness, paragraph 2	DTSC	Change to “may be affected by..." This should be done for all subsequent alternatives.	The sentence was edited to read: “The community would face limited disturbance ~~risk~~ from construction noise,…” Other alternatives were updated similarly.
546	Figure 5-4	DTSC	Figure 5-4: Bedrock contact should be retained in this figure.	The figure has been revised as requested.
547	Figures 5-4 to 5-11	DTSC	Figures 5-4 to 5-11: DTSC request that PG&E retain the shape and extent of contamination beyond the river from previous draft. The change of the Cr(VI) extent beyond the river is unsupported.	The comment was resolved with the following clarification: The plume boundary as shown on Figures 5-4 to 5-11 is the same as shown on figures in Section 2.0, and is based on the outermost boundary of the plume depiction by depth in Figures 2-10, 2-11, and 2-12, based on a more recent data set than the data set used in the Draft CMS/FS Report.
548	Figure 5-7	DTSC	Locations of proposed freshwater source should be expanded to be similar to EIR (i.e. California locations as well).	In response to this comment, an additional figure has been added to the CMS/FS Report, Figure 5-7B, that shows conceptual locations of alternate sources of fresh water for Alternative E.
Section 6.0 Comments – Recommended Remedial Action Alternative				
549	Section 6.0, paragraph 4	DTSC	Should clarify here that “capture of the plume” does not equate to capture of the carbon amended and injected water and refer to Appendix with model flow paths.	The following sentence has been added to the paragraph: “Carbon amended water from injection wells, within and outside of the plume, will be monitored for potential byproducts migration and managed through careful design and operation.”

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550	Section 6.0, last paragraph	DTSC	Make the following changes to the last paragraph of Section 6.0: Change to “propose a final”. Delete remainder of sentence. Begin new sentence with “After evaluation and response to public comments, DTSC and DOI will select a final remedy through the preparation of the final Statement of Basis and the signing of a CERCLA Record of Decision by DOI.” Add “by DTSC and DOI”. “The final remedy design process…”	In response to this comment, the paragraph has been updated to read: “Following completion of this CMS/FS Report, DTSC will propose ~~select~~ a remedy through a RCRA Statement of Basis, and DOI will issue a proposed plan identifying a preferred alternative for public comment, ~~select a remedy through a CERCLA Record of Decision~~. After evaluation and response to public comments, DTSC and DOI will select a final remedy through the preparation of the final Statement of Basis and a CERCLA Record of Decision, respectively. Following selection of the remedy by DTSC and DOI, the final remedy design and approval processes will begin, wherein additional detail on the implementation of the remedy will be developed and documentation required by various location- and action-specific ARARs will be prepared. As required by the CACA, PG&E will prepare a Corrective Measures Implementation Work Plan that more specifically describes the size, shape, form, and content of the selected remedy; describes the key components or elements needed; provides conceptual drawings and schematics; and includes procedures and schedules for implementing the selected remedy. Other operations and maintenance and construction plans may also be prepared prior to construction and operation of the selected remedy.”
Appendix A Comments – Summary of Findings Associated with the East Ravine Groundwater Investigation				
551	Appendix A, Section 1.0, 1st paragraph	DTSC	Looking at more than just chromium at site.	In response to this comment, the first sentence of this paragraph has been re-written as follows: Pacific Gas and Electric Company (PG&E) is addressing ~~chromium in~~ groundwater contamination at the Topock Compressor Station located in San Bernardino County, approximately 15 miles to the southeast of Needles, California, as shown in Figure A-1.

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552	Appendix A, Section 1.0, Paragraph 3	DTSC	Following the first sentence, add the rationale for the ERGI: i.e., historic surface impoundment in the 1960s containing liquids and some soil samples collected in the impoundment exhibit very high chromium. Need to have pieces available to reader to be able to establish a viable conceptual model. If not discussed, the real reason for doing the ERGI is not contained in the Introduction Section.	The following paragraph has been added the text to address this comment: As described in the East Ravine Work Plan, the rationale for the ERGI are related to the elevated concentrations of hexavalent chromium (Cr[VI]) that were observed sporadically in well MW-23 (Miocene Conglomerate bedrock monitoring well), which is located immediately north of the East Ravine. Additionally, historic soil sampling data indicate some of the highest chromium concentrations in soils at the site have been detected in the drainage depressions in the East Ravine (areas designated AOC-10). Historical aerial photographs of this portion of the site (attached as Appendix A) show the presence of an impoundment within the AOC 10c subarea that contained liquids of unknown composition during several years in the 1960s (CH2M HILL, 2007b). The AOC 10c subarea, where the highest concentrations of chromium were detected in soil, is coincident with the western portion of the area identified as drilling Site A on Figure 2. DTSC and DOI have directed that additional drilling and groundwater investigation are needed to characterize the groundwater flow pathway and groundwater conditions of bedrock formations in the East Ravine and MW-23 area.
553	Appendix A, Section 1.0, 1st bullet	DTSC	DTSC requested that the bullet be revised to read: Determine whether elevated concentrations of hexavalent chromium (Cr[VI]) and other inorganic and organic constituents are present in groundwater beneath the East Ravine area.	The bullet has been revised as suggested.

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554	Appendix A, Section 1.0, 2nd bullet	DOI	Revise to read "… evaluate the presence, **source**, and extent of …" (bold added for comment clarity)	In response to this comment the bullet has been revised to read: If elevated concentrations of Cr(VI) were confirmed in bedrock, evaluate the presence, source, and ~~potential~~ extent of the groundwater impact.
555	Appendix A, Section 2.0, 1st paragraph	DTSC	DTSC requested that the 2nd sentence be revised to read: Investigation activities were initiated as Sites A and B, which were designated in the work plan as "primary" investigation locations (Figure A-2).	The sentence has been revised as suggested.
556	Appendix A, Section 2.0, 1st paragraph	DTSC	DTSC request that the 3rd sentence be revised to read: Based on data collected from Sites A and B, ~~PG&E was directed by DTSC and DOI to expand~~ the investigation was expanded per the work plan to Sites C, E, F, and G, which are designated in the work plan as "contingency" investigation locations.	The sentence has been revised as suggested.
557	Appendix A, Section 2.0, 2nd paragraph	DOI	Please add to the appropriate bullet that preliminary screening level groundwater samples were collected that were analyzed at the on-site PG&E IM-3 laboratory.	In response to this comment the following bullet has been added to the text: Collection and analysis of screening level groundwater samples from the open boreholes prior to construction of the monitor wells.

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559	Appendix A, Section 2.9, 3rd paragraph	DTSC	Some soils will need to be disposed of at an appropriate landfill (if not already done so) due to high concentrations of chromium and hexavalent chromium contained within Site A shallow soils.	Based on the analytical results for the waste characterization samples, the drill cuttings were profiled as non-hazardous waste. In response to this comment the following sentence has been deleted from the text: Final disposal or placement of the drill cuttings are pending discussions between PG&E and various stakeholders based on the laboratory analytical results of the characterization samples and the investigation-derived waste management plan presented in the Work Plan. The following sentence has been added to the text: Drill cuttings from the ERGI were profiled as non-hazardous waste and transported to an offsite disposal facility.
560	Appendix A, Section 3.3	DOI	Add a summary of the screening level water quality data to Table 3-3. This information is important to the overall consideration of site conditions, particularly since there is no clear explanation for why screening level results are generally higher than subsequent groundwater samples. In particular, at Site A, screening level results indicated the presence of Cr(VI) contamination at concentrations as high as 230 ppb, but subsequent results were below detection.	In response to this comment a summary of the screening level water quality data presented in Attachment A2-3 has been added to Table A-4 (formerly table 3-3).

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561	Appendix A, Section 3.3, 1st paragraph, last sentence	DTSC	Need to evaluate validated “screening” data with completed wells as discussed below. Modify text to capture this and next comment. DTSC believes that the validated laboratory data for Site A and C Alternate indicate that there was hexavalent chromium contamination at these locations at values greater than current action levels. There is no reason to doubt these data. There appears to be reason to doubt the FLUTE data (see below).	The following sentence was deleted from the text to address this comment: Therefore, the screening-level samples are not evaluated with laboratory analytical data obtained from completed monitoring wells provided in Section 3.5. The following sentences were added to the text to address this comment and the next comment: Screening level samples are collected from open boreholes that have not been fully purged. The samples may not be representative of the depth interval where they were collected, and the depth intervals of the screening samples generally do not match those of the completed wells. As a result, inconsistencies commonly occur between screening level samples from open boreholes and samples from subsequently completed wells. The reasons for these inconsistencies in the ERGI investigation have not been determined. In addition, DTSC has noted that the FLUTe wells generally exhibit elevated concentrations of total organic carbon (TOC) in comparison to other East Ravine wells. Leaching of organic carbon from FLUTe liners was documented in Cherry et al. (2007). DTSC has suggested that the TOC might be leaching from the FLUTe well materials and altering the geochemical conditions in the aquifer so that the FLUTe wells could be underestimating the actual Cr(VI) concentrations in the groundwater.
562	Appendix A, Section 3.3, 2nd paragraph, 1st sentence	DTSC	DTSC is concerned that the FLUTE system may be adversely affecting the geochemical environment of the groundwater due to leaching of TOC and, therefore, may underestimate chromium if present. A discussion regarding this issue is required.	See response to previous comment.

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563	Appendix A, Section 3.3, paragraph 5	DTSC	DTSC requested that the 2nd sentence be revised as follows: Results of ambient depth-specific samples collected near the bottom of the MW-58BR and MW-62BR boreholes (Attachment A2-3) were less than laboratory reporting limits for both Cr(VI) and Cr(T), which is consistent with the results of samples collected after FLUTe™ multilevel systems were installed.	The text has been revised as suggested.
564	Appendix A, Section 3.3, paragraph 6, last 2 sentences	DTSC	This comment is highly unlikely and it is recommended that it be removed. It currently suggests that the soils/vadose zone at Site C Alt area are contaminated with chromium. Is there documentation of leachable hexavalent chromium in the surface soils/ vadose zone within this area that would contaminate a groundwater column with concentrations up to 100 ug/L? Background UTL for alluvial aquifer = 32 ppb. See comment above re. FLUTE systems.	The following sentence has been deleted from the text in response to this comment and the next comment: Given the absence of detectable intervals of groundwater flow during hydrophysical testing, initial detections of Cr(VI) in the screening-level samples may be associated with mixing or wash down of chromium from the vadose zone into the borehole during drilling. It is possible that purging had not completely removed this Cr(VI) before the initial screening samples were collected.
565	Appendix A, Section 3.3, paragraph 6	DOI	The concept of "... washdown of chromium from the vadose zone .." was not previously discussed with DOI, nor is it well developed here as an explanation for the observations. In reality, we do not understand why chromium was detected during screening but is not present in the samples collected after well installation, development, and sampling. The text should not put forward speculation as explanation for these observed conditions.	See response to previous comment.

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566	Appendix A, Section 3.5, 1st paragraph	DTSC	Please confirm antimony data for Spring 2009 are correct. There is a data discrepancy with data set emailed to DTSC on 7/2/09 by Mike Cavaliere. Sb was greater than MCLs. DL is too high in July 2009 data set. Need lower DL limit in future analyses.	The comment was resolved with the following clarification: There appears to be an interferent present in East Ravine groundwater that affected the preliminary antimony results reported to DTSC on 7/2/09. These same samples were re-analyzed using a more accurate analytical method (ICP-MS and all antimony values were found to be below MCLs. PG&E will work with DTSC to determine detection limits for future antimony samples. As discussed with the agencies, no changes to the CMS/FS Report were made in response to this comment.
567	Appendix A, Section 3.5.1, 1st paragraph	DTSC	Figure A-8 and Table A-1 indicate that deep and mid wells are almost exclusively FLUTE wells. Therefore, there is some uncertainty regarding the vertical extent of contamination that should be documented in the report.	In response to this comment the paragraph was revised to read: Table A-4 presents laboratory groundwater analytical results for Cr(VI) and Cr(T) and field measurements for the new ERGI wells. Figures A-7 and A-8 present Cr(VI) results for the July 2009 sampling event for the shallow and mid-depth/deep wells, respectively. These figures illustrate that, during the initial sampling event, Cr(VI) ~~is~~ was largely limited to shallow water table wells, ~~is~~ was absent from deep wells, and was detected in one mid-depth well (detection of 74 µg/L of Cr(VI) in the well MW-62-110). The initial sample results from newly installed wells at Topock are sometimes inconsistent with later samples. In addition, as noted above, DTSC believes that TOC in FLUTe wells may be contributing to underestimates of the Cr(VI) concentrations. Therefore, it should be recognized that there is uncertainty with regard to interpretation of the ERGI results at this time.

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568	Appendix A, Section 3.5.1, paragraph 3	DOI	Based on the two cross-sections presented, the correlation between ORP and Cr(VI) concentration is not as apparent as suggested by the text. For example, low concentration and ND values are associated with positive ORP values at MW-57 and MW-64 and at MW-61 a Cr(VI) value of 620 ppb is associated with a negative ORP value of -119.	The following text was deleted from the document in response to this comment: These figures demonstrate that the lowest ORP is generally found in the deep monitoring well locations. Consistent with data for other site wells, the data in Figures A-5, A-6, and Table A-2 reveal that there is a strong correlation between low to non-detect Cr(VI) concentrations where there are also reducing conditions (negative ORP values) (CH2M HILL, 2009a). This observation is further supported by the sample results for other redox-sensitive geochemical parameters discussed in Section 3.5.4. Specific conductance is also generally greater in deep wells compared to shallower wells, consistent with observations at site alluvial and fluvial wells (CH2M HILL, 2009a).
569	Appendix A, Section 3.5.2, 1st paragraph	DTSC	DTSC requested that the last sentence in the paragraph be revised as follows: Sample results for all VOCs were below the laboratory reporting limits at all wells except for those VOCs discussed in Section 3.7.2.	The text has been revised as suggested.
570	Appendix A, Section 3.5.2.1, 2nd paragraph	DTSC	Note: Highest molybdenum is coming from FLUTE wells. Is molybdenum also leaching from FLUTE material? Sample annular FLUTE water for metals and organics? DTSC suggested that the following sentence be added to address this comment: Additional groundwater monitoring is planned to further evaluate molybdenum distribution and occurrence due to the limited data set.	The text has been revised as suggested.

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571	Appendix A, Section 3.5.2.2, 1st paragraph	DTSC	DTSC suggested that fourth sentence be revised as follows: These results are less than those historically reported for a large amount of site wells and less than the alluvial wells UTL (10.3 µg/L) calculated for the background study (CH2M HILL, 2009a).	The text has been revised as suggested.
572	Appendix A, Section 3.5.2.3, 1st paragraph	DTSC	DTSC suggested that the 8th sentence be revised as follows: The UTL for nitrate calculated in the background study for site alluvial wells was 5.03 mg/L (expressed as nitrogen) (CH2M HILL, 2008b).	The text has been revised as suggested.

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573	Appendix A, Section 3.5.4, 2nd paragraph	DTSC	In discussing Table A-5, include the notably elevated TOC that occurs only in FLUTE wells and is probably leaching out of the liner (Cherry, Parker, Keller, 2007). Can the TOC affect chromium concentrations via redox conditions? Need to address and solve this issue.	There is some toluene that leaches from the liner material. The reference cited states that it decreases over time to low or non-detect values. In response to this comment the following text was added to Section 3.7.2: Cherry et al. (2007) states: *The leaching of toluene, total organic carbon (TOC), and arsenic from the liner material has been documented in field systems and laboratory leach tests. These compounds are seen in the sample water to varying degrees depending upon the time and whether the prescribed purge procedure was performed.* *Toluene, which is used in the production of the urethane coating, has been found in the ground water samples at concentrations of several hundred micrograms per liter, with more typical values of 10 to 70 µg/L soon after the liner installation. The concentrations of toluene have been shown to decrease with time to near nondetectable levels after several months to a year. Concentrations of TOC in ground water obtained from FLUTe systems have ranged from ''nondetect'' to several milligrams per liter immediately following installation but typically decrease with time to less than 1 mg/L. A recent side-by-side comparison of a FLUTe system and three cluster wells showed good agreement for TOC concentrations ranging from 1 to 14 mg/L in sampling intervals at the elevations of the three well screens (T. Roeper, personal communication, 2005).* PG&E is currently purging the FLUTe wells multiple times prior to each sampling event to assist with flushing out any compounds that may be leaching from the liner materials. PG&E anticipates that any issues with leaching from the FLUTe liners will diminish with time.

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574	Appendix A, Section 3.5.4, paragraph 4	DOI	The industrial and non-industrial signatures do not necessarily have the same relevance for bedrock groundwater in the East Ravine as they do when discussing alluvial groundwater potentially contaminated by the main Cr(VI) plume emanating from Bat Cave Wash. The source of contaminated groundwater in bedrock in the East Ravine has not been identified and it is not accurate to imply that a non-industrial isotopic signature is evidence that deep groundwater has not been affected by PG&E operations.	The text has been modified as follows to address this comment: A review of this figure indicates that well MW-63-065 has a similar isotopic signature to Colorado River water and that ~~wells MW-57-185, MW-58-115, MW-58-205, MW-62-190, and MW-64-150 have isotopic signatures consistent with non-industrial water wells reported in the PMR. Cr(VI) was absent from wells exhibiting an isotopic signature consistent with other non-plume wells onsite. Conversely, the isotope data for MW-59-100, the alluvial well containing the greatest Cr(VI) concentrations, point to it being an industrial plume well, consistent with other site wells containing elevated concentrations of Cr(VI). These data provide another line of evidence that plume water has not reached deep monitoring locations, making it unlikely that the molybdenum detected in deep wells are a result of previous industrial practices. Generally, wells not mentioned above have an isotopic signature consistent with a blend of industrial and non-industrial water and Cr(VI) present~~ alluvial well MW-59-100 has the heavy isotopic signature typical of other alluvial plume wells. The remaining bedrock wells have signatures between these two end members, with those containing elevated Cr(VI) tending to have heavier signatures than those that do not, also similar to the trend observed in the Alluvial Aquifer. Further investigation will be aimed at determining characteristics of the facility water source in the East Ravine.

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575	Appendix A, Section 3.6.1, 1st paragraph	DOI	The statement that bedrock is "relatively impermeable" is subjective and not consistent with the observations of groundwater occurrence and contamination in the East Ravine. The sentence should be revised to read "The estimated hydraulic conductivities of the Miocene conglomerate and pre-Tertiary metadiorite range from 0.016 to 0.18 and 0.0011 to 1.56 ft/d, respectively, based on the slug test analyses. These estimates are similar to previous estimates for these units at other bedrock well locations at the Topock site."	In response to this comment the suggested text was added to the paragraph. The following text was deleted from the paragraph: A review of this table demonstrates that both the Miocene conglomerate and pre-tertiary metadiorite are relatively impermeable with hydraulic conductivities (K) ranging from 0.016 to 0.18 and 0.0011 to 1.56 feet/day, respectively. These results were generally similar to properties estimated for other bedrock wells onsite completed in Miocene conglomerate and pre-tertiary metadiorite.

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576	Appendix A, Section 3.7.2, 1st paragraph, 3rd sentence	DTSC	Also include discussion regarding the elevated TOC that occurs only in FLUTE wells and is probably leaching out of the liner (Cherry, Parker, Keller, 2007). Can the TOC affect chromium concentrations via redox conditions? Need to address and solve this issue.	There is some toluene that leaches from the liner material. The reference cited states that it decreases over time to low or non-detect values. In response to this comment the following text was added to this section: Cherry et al. (2007) states: *The leaching of toluene, total organic carbon (TOC), and arsenic from the liner material has been documented in field systems and laboratory leach tests. These compounds are seen in the sample water to varying degrees depending upon the time and whether the prescribed purge procedure was performed.* *Toluene, which is used in the production of the urethane coating, has been found in the ground water samples at concentrations of several hundred micrograms per liter, with more typical values of 10 to 70 µg/L soon after the liner installation. The concentrations of toluene have been shown to decrease with time to near nondetectable levels after several months to a year. Concentrations of TOC in ground water obtained from FLUTe systems have ranged from ''nondetect'' to several milligrams per liter immediately following installation but typically decrease with time to less than 1 mg/L. A recent side-by-side comparison of a FLUTe system and three cluster wells showed good agreement for TOC concentrations ranging from 1 to 14 mg/L in sampling intervals at the elevations of the three well screens (T. Roeper, personal communication, 2005).* PG&E is currently purging the FLUTe wells multiple times prior to each sampling event to assist with flushing out any compounds that may be leaching from the liner materials. PG&E anticipates that any issues with leaching from the FLUTe liners will diminish with time.

	Section/ Page	Commenter	Comment	Final Comment Resolution
577	Appendix A, Section 4.0	DOI	From our previous discussions, three main data gaps have been identified for the East Ravine that must be addressed through additional characterization: • Identification of the source of contaminated bedrock groundwater in the East Ravine through installation of wells, particularly at the compressor station • Determination of the lateral extent of contamination to the east Determination of the vertical extent of contamination where not currently defined (e.g., at MW-60 and MW-61).	The following text was added to Section 4.3.1 in response to this comment: At this time, three main data gaps have been identified for the East Ravine that must be addressed through additional characterization: • Identification of the source of contaminated bedrock groundwater in the East Ravine through installation of wells, including at the compressor station • Determination of the lateral extent of contamination Determination of the vertical extent of contamination where not currently defined (e.g., at MW-60 and MW-61)
578	Appendix A, Section 4.2.3, 1st bullet	DOI	The 1st sentence of the bullet should be revised to say “The available data indicate that groundwater hydraulic gradient is upward and northeastward.” The local directions of groundwater flow within the fractured bedrock may or may not be predictable from the gradients. The distribution of Cr(VI) contamination in bedrock groundwater in the East Ravine would not be predicted by a conceptual model of northward flow, assuming a source within the ravine. While northward flow is one possibility, localized eastward flow toward the river has not been ruled out.	In response to this comment the suggested text was added to the bullet. The following text was deleted from the bullet: The available data indicate that groundwater in the ERGI area flows upward and generally northward toward the Alluvial Aquifer. A groundwater elevation map that incorporates data from the East Ravine shallow bedrock wells and posted data from other alluvial wells in the East Ravine area indicates the horizontal gradient for the water table zone in the East Ravine and surrounding area ranges from northerly to northeasterly.
579	Appendix A, Section 4.3	DOI	A bullet needs to be added stating “The source of chromium in bedrock groundwater in the East Ravine has not been identified based on the available data.	In response to this comment a bullet was added to this section as requested: The source of chromium in bedrock groundwater in the East Ravine has not been identified based on the available data.

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580	Appendix A, Section 4.3.1, 1st paragraph, 1st sentence	DTSC	DTSC requested the following changes to the sentence: The ERGI confirmed the presence of elevated chromium in bedrock groundwater, with some concentrations above site alluvial aquifer background levels.	The text has been modified as requested.
581	Appendix A, Section 4.3.1, 1st paragraph, 1st sentence	DTSC	Note: A groundwater background chromium concentration does not exist for bedrock wells. Based on available data, DTSC assumes it is less than method detection limits.	Comment noted.
582	Appendix A, Section 4.3.1, 1st paragraph, 2nd sentence	DOI	The lateral and vertical distribution of chromium in East Ravine bedrock groundwater is not completely defined in all locations, particularly to the east and northeast. This conclusion either needs to be revised or eliminated.	In response to this comment the sentence has been revised to read: The installed wells and established surface water/shoreline sampling locations have ~~defined~~ provided partial definition of the lateral and vertical extent of the chromium impact in bedrock ~~at most locations~~.
583	Appendix A, Section 4.3.1, 1st paragraph, 3rd sentence	DTSC	DTSC requested that the following changes be made to the sentence: Additional information will be collected to enhance the understanding of the ~~Cr(VI) plume~~ groundwater contamination in the area, and that information will be incorporated into the design of the final remedy.	The sentence has been modified as requested.

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584	Appendix A, Section 4.3.1, 1st paragraph, 3rd sentence	DTSC	Insert PG&E's anticipated plans to install wells West of East Ravine and possibly to the South and East.	In response to this comment the following text was added to Section 4.3.1: At this time, three main data gaps have been identified for the East Ravine that must be addressed through additional characterization: • Identification of the source of contaminated bedrock groundwater in the East Ravine through installation of wells, including at the compressor station • Determination of the lateral extent of contamination Determination of the vertical extent of contamination where not currently defined (e.g., at MW-60 and MW-61)
585	Appendix A, Section 4.3.1, last paragraph	DTSC	Add paragraph discussing the potential source(s) of groundwater contamination in the East Ravine area and how it is captured in the site conceptual model. Add paragraph (or link to PG&E's proposed plan to install additional wells) discussing the need to gather more information to understand the conceptual model.	In response to this comment the following text has been added to this paragraph: Additional investigation is also necessary to determine the source of contaminants in East Ravine groundwater. Possible sources that have been identified to date include the former cooling water discharge in Bat Cave Wash, infiltration of water into bedrock beneath the compressor station, and discharge or runoff of contaminated surface water from the compressor station into the East Ravine.
586	Appendix A, Attachment A2-3	DTSC	Add sample dates to data table.	In response to this comment sample dates have been added to this table.
Appendix D Comments – Remedial Alternative Cost Estimates				
587	Appendix D, Table D-1	DTSC	Does cost estimate also include periodic road/access maintenance?	The comment was resolved with the following clarification: Yes. Refer to the "Other Facilities - Road maintenance" line item in the Operations and Maintenance Cost section in each alternative. Made change to Table D-1.

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588	Appendix D, Table D-1, Alternative B	DTSC	Maintenance of wells will also be necessary for MNA.	The comment was resolved with the following clarification: Agreed. The "Operate and Maintain Other Systems (pipelines, wells, etc.) during Remediation Period" column has been checked for Alternative B to indicate that well maintenance would be required for this alternative. Made change to Table D-1.
589	Appendix D, Tables	DTSC	What is included in "permit compliance" line that costs $360,000 per year when it is based on IM3 compliance?	The comment was resolved with the following clarification: This item includes Waste Discharge Reporting (WDR), Hazardous Material Business Plan reporting and management, stormwater monitoring and reporting, and other miscellaneous tasks.
590	Appendix D, Table D-3	DTSC	If cost is rounded to "3 places" that should be rounded to the nearest thousand. For injection/ extraction well capital costs, number should be 1,702,400 or 1,702,000 rounded down. Not $1,700,000.	In response to this comment the footnote in the table has been changed to indicate the total costs have been rounded to three significant figures.
591	Appendix D, Table D-3	DTSC	Prime contractor cost factors – adding the percentages should only be 60%, why 75% as subtotal? If numbers are cumulative as discussed in Table D-21, then summary table should calculate numbers and sum subtotals instead of citing 75%.	In response to the comment, the individual percentages and calculated costs have been broken out on Table D-3.
592	Appendix D, Table D-3	DTSC	Misc, soil cuttings – what is this for? Disposal, analytical, removal…?	In response to this comment the tables were revised to refer to Section D.2.1.7.
593	Appendix D, Table D-3	DTSC	High Range – There is inconsistent rounding within table. Assuming +50 of cost, the amount should be $10,845,000 if rounded to nearest $10,000 as it is the case for all other numbers. Not $10,800,000.	In response to this comment the footnote in the table has been changed to indicate the total costs have been rounded to three significant figures.
594	Appendix D, Table D-3	DTSC	Should print all tables with dash lines as page 2 of Alt B under O&M cost.	Tables are printed with dash lines as requested.

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595	Appendix D, Table D-3	DTSC	Maintenance of wells – where did $393,000 come from? Assuming 10% of capital cost of wells that should be $170,000.	The comment was resolved with the following clarification: The cost of $393,000 includes 10% capital cost for monitoring and extraction wells, 20% capital cost for injection wells, and replacement costs for the existing monitoring well network assuming a 40-year life using an amortized replacement cost.
596	Appendix D, Table D-3	DTSC	Groundwater/ Surface Water Monitoring – Why $67,000 if one event cost $135,000? Also, this line is not set up for changing monitoring frequencies as stated in note. There is no way of telling how many events took place according to cost estimate when unit is in "YR".	The comment was resolved with the following clarification: Alternative B includes sampling events every two years. For simplicity, the sampling event cost was divided by two.
597	Appendix D, Table D-3	DTSC	Reporting – Site-wide: Where is the first year amount ($156,000) captured in summary table? Only reporting cost per subsequent years of $120,000 per year.	The comment was resolved with the following clarification: For simplicity, the first year was averaged with the succeeding years to annualize the cost.
598	Appendix D, Table D-3	DTSC	Why would there not be road/access maintenance cost? There will need to be some maintenance even if there no new roads developed. Access over time will require maintenance.	The comment was resolved with the following clarification: There is a very short length of roads that have been built in the past 5 years that would require maintenance. Most of the wells are on the floodplain. Without final locations for the new monitoring wells, it is not possible to account for the cost except as an allowance. It is anticipated that the cost to maintain the recently constructed roads would be very small (~$1,000 to 2,000/year). Consequently, this small cost was neglected.
599	Appendix D, Table D-3	DTSC	What is the annual allowance used for the cultural survey and the regulatory /stakeholder oversight? Why 20% for MNA? Once OPS for remedy, all remedies will require nearly identical evaluation and monitoring.	The comment was resolved with the following clarification: The annual allowance was $50,000 for the cultural survey and $100,000 for regulatory oversight. All alternatives have a similar assumption that costs drop to 20% during MNA or long-term monitoring (LTM). It was assumed that there would be less activity and the activity becomes more consistent (monitor wells, replace wells, etc.) during MNA or LTM.

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600	Appendix D, Table D-3	DTSC	Present Value Analysis – how was the discount factor derived? Also why wasn't the annual O&M cost multiplied by 540 years corresponding to years 1-540?	The comment was resolved with the following clarification: The discount factors shown were calculated using the Excel PV function. The discount factor at 540 years is correct as shown, but the rate of change in the discount is very small once the duration exceeds 100 years. At 200 years it is 31.48, at 150 years it is 31.25 and at 100 years it is 30.15.
601	Appendix D, Table D-3	DTSC	Nominal Cost – as presented, there is no good way of tracking the math for this figure. Please show in spread sheet.	In response to this comment the calculation has been added to the Present Value Analysis section of each cost table.
602	Appendix D, Table D-14	DTSC	What factors are considered for "operational uptime for IRZ? Uptime between 35 – 50% seems extremely low especially at the initial years.	The comment was resolved with the following clarification: The 50% uptime number is based on experience at other sites and the response we have seen in the floodplain at Topock. The conceptual in situ system is expected to receive carbon for a period of 6 to 9 months and then the TOC feed will be stopped for a similar period of time and then restarted again. Actual operations may vary in duration of uptime and downtime based on field data, but on average TOC will be fed 50% of the time. The 35% uptime listed in Alternatives E and H has been changed to 50% for consistency across the alternatives for this feasibility analysis.

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603	Appendix D, Table D-14a	DTSC	What is the basis for lump sum for carbon? Alt C Phase 1 should be similar to Alt C phase 1, but Alt D phase 1 is 5.7 million compared to 760K for Alt C.	The comment was resolved with the following clarification: The carbon load is based on the injected flowrate and the average organic carbon target feed rate. Although Alternative D Phase 1 and Alternative C Phase 1 are similar in targeting the floodplain, the approach in Alternative D is a very aggressive pumping approach (1,500 gpm for about 18 months) across the entire floodplain. This is different than the more targeted injection approach used in both Alternative C Phase 1 and Alternative G Phase 1 – the IRZ consists of several lines of wells along the National Trails Highway and within the floodplain operating at a total pumping rate of 500 gpm for 2 years. The average carbon feed concentration is the same for Alternatives C, D, and G Phase 1. It should be noted that upon review of the basis used in the original estimate discrepancies, in flowrates were noted in the spreadsheets, which have been corrected. The updated costs reflect the corrected values; nonetheless, there is still a difference in the costs between Alternative C and Alternatives D and G that is related to the flowrates being employed. The updated values are correct.
Appendix E Comments – Demonstration of Groundwater Flow Model Accuracy				

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604	Appendix E, Section E.1, 3rd bullet	DTSC	Is this reasonable? What was it prior to the change?	The comment was resolved with the following clarification: Prior to the change, the recharge from precipitation in the Chemehuevi Mountain front extended to the surface interface between bedrock and alluvium, which includes the East Ravine area. At that time, there was no attempt to simulate actual hydraulic head distributions in the bedrock, and this recharge distribution was applied solely as a water balance component for the alluvial aquifer. With the installation of East Ravine wells and observed head distributions, the recharge was moved away from this area to a higher elevation range, to avoid overpredicting bedrock groundwater elevations in the East Ravine. It was necessary to keep the total recharge constant in the model however, in order to maintain the calibrated alluvial aquifer head distribution. This comment was discussed during a teleconference with DTSC on December 3, 2009. No revisions to the CMS/FS report are required.
605	Appendix E, Section E.1, last paragraph	DTSC	Replace with “conditions”? Why “control measures”?	The term “control measures” was used to specify the use of the model for the East Ravine. It was used to estimate number of wells and pumping rates required to capture East Ravine groundwater that was impacted by facility activity. This comment was discussed during a teleconference with DTSC on December 3, 2009. No revisions to the CMS/FS report are required.

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606	Appendix E, Section E.2.3, last paragraph	DTSC	Suggest adding more text to support accuracy as simulated contours in figures often do not correlate with measured well data.	The following text has been added to the section to address this comment: Groundwater elevation contour maps were prepared to compare these contours to averages calculated from observed data over the June 1 through July 15, 2009 period for all five model layers. The objective at this stage was not to recalibrate the model, but to configure the model to incorporate the East Ravine bedrock and simulate a direction and magnitude of groundwater gradient within the East Ravine bedrock that reasonably approaches that of observed data. The simulated contours and observed heads presented in Figures E-3a through E-3e demonstrate that, although absolute head values in East Ravine wells were not always closely matched, the simulated groundwater gradient is similar to that inferred by observed data. No changes were made to alluvial aquifer parameters in order to preserve the calibration in the original model configuration. The groundwater model is, like all models, only an approximation of the real system. This model was calibrated in 2005, based on pre-pumping conditions. The model was developed and calibrated prior to the installation of PE-1 and the model grid does not include a node at the exact location of PE-1. Therefore, we have simulated pumping from PE-1 from a location that is a few feet away from the true location of the well. This inaccuracy of location of PE-1, in addition to the fact that the model was not calibrated to match the observed water level response from PE-1 pumping, results in larger than average differences between observed and simulated heads under the influence of PE-1. In the CMS/FS, the model is being used to simulate future groundwater flow patterns under complex distributions of pumping and injection, for the ultimate purpose of comparing alternatives.

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Appendix F Comments – Demonstration of Groundwater Flow Model Accuracy				
607	Appendix F, Section F.2, 2nd paragraph	DTSC	Is it a remedial alternative if it will not attain RAOs?	The text was changed as follows in response to this comment: It is ~~anticipated~~ planned that the ~~remedial alternative~~ remedy for East Ravine bedrock groundwater will be further developed during the ~~final~~ design phase ~~for the selected alternative~~.
608	Appendix F, Section F.2, 2nd paragraph	DTSC	Is this concept introduced early on in Sections 1, 3, 4 and 5. Title of document and section 3 indicates bedrock is to be cleaned up, not controlled.	As discussed with the agencies, no changes to the CMS/FS are required to address this comment. Section 5.3 in the CMS/FS report describes the approach to address chromium in bedrock in the East Ravine for purposes of the alternatives development and evaluation.
609	Appendix F, Section F.2, 3rd paragraph, 4th sentence	DTSC	Suggest clarifying that injected water outside the plume boundary is not necessarily captured.	In response to this comment the following sentence was added to the paragraph: Water injected outside the plume area was not evaluated in this capture analysis.
610	Appendix F, Section F.2, 3rd paragraph, 5th sentence	DTSC	Re. Deleted Text. Where specifically does (2) now not apply.	No significant changes to flowline pathways have occurred since the draft version. This text was altered to provide a more accurate description of the criteria applied to defining capture. As in the draft report, there are few cases in which flow lines run slightly outside the boundary of the plume on their way to an extraction well. These areas are very small, and the plume boundary is only approximate. Given these facts, it was decided to alter the text so that the extent of flowlines was not an absolute criterion for capture, but instead that all efforts were made to minimize their extent outside the estimated boundary plume. This comment was resolved during a teleconference with DTSC on December 3, 2009. No revisions to the CMS/FS Report are required.

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611	Appendix F, Section F.2, 3rd paragraph, 7th sentence	DTSC	Insert "…entire alluvial and bedrock plume…" ????. Clarify if this excludes bedrock.	In response to this comment the sentence was revised to read: Only configurations of wells that achieved capture of the entire alluvial and bedrock plume were retained.
612	Appendix F, Section F.2, 4th paragraph, 1st sentence	DTSC	Where does this now occur? Are there any real changes from the first draft flow lines.	No significant changes to flowline pathways have occurred since the draft version. This text was altered to provide a more accurate description of the criteria applied to defining capture. As in the draft report, there are few cases in which flow lines run slightly outside the boundary of the plume on their way to an extraction well. These areas are very small, and the plume boundary is only approximate. Given these facts, it was decided to alter the text so that the extent of flowlines was not an absolute criterion for capture, but instead that all efforts were made to minimize their extent outside the estimated boundary plume. This comment was resolved during a teleconference with DTSC on December 3, 2009. No revisions to the text are required.
613	Appendix F, Section F.3, 7th bullet	DTSC	F3-series figures don't show the bedrock contact, therefore the bullet is confusing.	In response to this comment the text has been revised to refer the reader to Section 5 figures as follows: The bedrock contact shown on each figure in Section 5 (Figures 5-5 through 5-11) represents the point at which the saturated thickness of the Alluvial Aquifer becomes zero.
614	Appendix F, Section F.3, 7th bullet	DTSC	Entire alluvial and bedrock plume is shown. Include plume area in figure legend.	In response to this comment the figures have been revised as requested.

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615	Appendix F, Section F.3, 7th bullet	DTSC	Suggest indicating layer properties do change to simulate lith. boundaries.	In response to this comment the following text has been added to the section: Where all of the saturated groundwater thickness is within bedrock, the properties of the top four model layers change to those of bedrock, and their thicknesses increase to either a default value or those that reflect the screened intervals of East Ravine wells.
616	Appendix F, Section F.3.2, 1st bullet	DTSC	Figures for Phase 9 only show green injection wells. Add red “dots” to figures.	In response to this comment the requested change has been made to the figures.
617	Appendix F, Section F.3.3	DTSC	Please also include the injected water flow lines for Alt. E as previously completed by PG&E. Do for others as time permits (e.g., Alt H.)	Injected water flow lines were included for Alternative E as requested. Injected water flow lines were not included for other alternatives. The following text was added to this section: Flowpaths emanating from the four carbon-amended water injection wells and the clean water injection wells are shown for each model layer in Figures F3-53 through F3-56. As discussed in Appendix G, the potential for in situ byproducts to be mobile in groundwater is believed to be limited to the immediate area of influence of carbon-amendment, with an estimated soluble residence time similar to that estimated for the organic carbon (190 days). With this assumption, flowpaths for one-year travel time are shown in green to represent the maximum expected travel of in situ byproducts. The flowpaths extending from one year to 30 years are shown in blue, and represent clean water with no byproducts.

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618	Appendix F, Section F.3.3	DTSC	Red extraction wells for East Ravine are missing to east from Alt E. and some other alternatives. Must add ER to all alternatives equally.	In response to this comment the following text was added to Section F.3.2: A line of closely spaced wells pumping from bedrock along National Trails Highway at the eastern edge of the East Ravine was required to achieve capture in some but not all alternatives. This line of wells was included as a common element for all alternatives in the alternative descriptions in Section 5 and the cost estimates. It was assumed that, even though some alternatives didn't require bedrock wells to achieve capture in East Ravine in this groundwater modeling analysis, the line of pumping wells would be needed as a component of a more robust East Ravine final remedy.
619	Appendix F, Section F.3.4	DTSC	Why are two new injection wells added to Alt F (also Alt G) to the south. Clarify or remove them as they don't seem appropriate or needed.	New injection wells were added for these alternatives in order to cover the additional alluvial plume area defined by recent data from the East Ravine investigation. The wells were added to the simulations to ensure complete plume containment and to keep mass removal time in the targeted range. This comment was resolved during a teleconference with DTSC on December 3, 2009. No revisions to the text are required.
620	Appendix F, Section F.4.3	DTSC	Why extra lines/phases?	New lines of extraction/injection wells were added to Alternative D in order to cover the additional alluvial plume area defined by recent data from the East Ravine investigation. The wells were added to the simulations to ensure complete plume containment and to keep mass removal time in the targeted range. This comment was resolved during a teleconference with DTSC on December 3, 2009. No revisions to the text are required.
Appendix G Comments - Supporting Information for *In-situ* Treatment Design Elements				

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	Section/ Page	Commenter	Comment	Final Comment Resolution
621	7.3/25	DTSC	Thought deletion below was to be retained. Same as 5.2.6?	PG&E added the sentence “Thus, it is possible that MnO_2 capable of re-oxidizing Cr(III) could still be present in the same area of the aquifer where Cr(VI) has been reductively precipitated.” This sentence was added to make the statement consistent with Section 5.2.6.
622	8.1/28	DTSC	As values for Alluvial Aquifer (Column #1) inappropriately changed. Mn also changed in #1? Not supposed to be changed based on RTCs. Change back to previous draft. Inappropriately including As from contaminated well MW-12. Average As concentrations (Columns #1 & #2) may be incorrect based on old draft. Mn #2: 2.4 lower range used to be 1. Block diagram wrong for fluvial deposits. Revise. Shows them to be everywhere and not restricted to the flood plain.	PG&E removed MW-12 from data set, checked data and updated figures as requested. The block diagram has been revised.
623	8.1/28	DTSC	Minor edit to the following sentence: “**Figures G6(a)-(d)** depict the range of naturally occurring arsenic and manganese concentrations observed in the floodplain adjacent to the compressor station, as well as ~~the~~ regional floodplain and alluvial locations.”	The sentence has been revised as requested.
624	8.1/28	DTSC	Minor edit to the following sentence: “**Figures G6(a)-(d)** depict the range of naturally occurring arsenic and manganese in the fluvial and alluvial groundwater including waters adjacent to the river.”	The sentence has been revised as requested.
625	8.1/28	DTSC	Minor edit to the following sentence: “The data depicted on these figures show that there are elevated naturally occurring concentrations of arsenic and manganese in fluvial ~~and alluvial~~ well samples”	The sentence has been revised as requested.

TABLE C-2 RESPONSES TO COMMENTS
Comments on the November 13, 2009 *Final Corrective Measures Study/Feasibility Study Report For SWMU 1/AOC 1 and AOC 10*
PG&E Topock Compressor Station, Needles, California

	Section/ Page	Commenter	Comment	Final Comment Resolution
626	8.1/29	DTSC	Minor edit to the following sentence: “It is noted that this well, along with some additional wells sampled in September 2009 (MW-32-20 [65 µg/L] and MW-32-35 [53 µg/L]) show elevated arsenic concentrations within the fluvial system wells. These wells in combination exhibit an average value of 14.3 µg/L (Figure G5, G6e).”	The sentence has been revised as requested.
627	8.1/29	DTSC	First paragraph on page 29, second to last sentence, related to Figures G5 and G6e: “These wells in combination exhibit an average value of 16.5 µg/L (Figure G5, G6e).” Remove MW-12 data and excluded background data from “Onsite Alluvial” box plots.	PG&E has removed MW-12 data and revised the average calculations. The averages were updated from 16.5 µg/L to 14.3 µg/L. The box plots were updated using the revised average calculations.
628	8.1/29	DTSC	Figure E5 (past draft) showed As fluvial avg at 10.1. Was this # wrong? 2 wells out of 287 can’t change 10.1 to 16.5. Double check averages.	The revised calculations include data for 2009 and the value has been updated to 14.3 µg/L.
629	8.1/29	DTSC	Inserted sentence: “Additional arsenic data is being collected to better evaluate arsenic distribution in the floodplain.”	The sentence has been revised as requested.
630	8.1/29	DTSC	Minor edit to the following sentence: “In May through June 2006 following the only injection into PTI-1S, tracer did not arrive at detectable levels and ~~iron,~~ manganese ~~and arsenic~~ concentrations did not increase at PT-6S (similar to downgradient well PT-1S), however, arsenic and iron did increase over baseline concentrations (similar to PT-1S) ~~located outside the radius of influence of PTI-1S~~.”	The sentence has been revised as requested.

TABLE C-2 RESPONSES TO COMMENTS
Comments on the November 13, 2009 *Final Corrective Measures Study/Feasibility Study Report For SWMU 1/AOC 1 and AOC 10*
PG&E Topock Compressor Station, Needles, California

	Section/ Page	Commenter	Comment	Final Comment Resolution
631	8.1/29	DTSC	Minor edit to the following sentence: “In contrast at PT-3S, tracer did arrive with increasing~~, and~~ TOC concentrations ~~increased at PT-3S~~ in May and June 2006, indicating that this location was within the radius of influence of PTI-1S	The sentence has been revised as requested.
632	8.1/29-30	DTSC	The following sentence was deleted. “~~PT-6S was not influenced by the injections in PTI-1S, because the hydraulic gradient is controlled by pumping at TW-2D and TW-3D in this area of the Floodplain, causing water to flow from the river, through PT-6D toward TW-2D and TW-3D.~~”	The sentence has been revised as requested.
633	8.1/30	DTSC	Like Figure G-5. Fix legend (“Fluvial Deposits of Colorado River“) /block diagram.	Figure G7 has been updated.
634	8.2/32	DTSC	Like Figure G-5. Fix legend (“Fluvial Deposits of Colorado River“) /block diagram. Avg As line may need to be changed if revised.	Figure G9 has been updated and average lines adjusted.
635	8.2/32-33	DTSC	Suggest deleting shaded text. Arsenic attenuation is about the same for two cited wells. “In the Floodplain pilot test (**Figure G9**) the rate of attenuation varied depending upon the carbon loading~~, with PT-3D returning to baseline arsenic concentrations rapidly about two years after organic carbon injections ceased, PT-1D, where more carbon was delivered at the very end of the operation of the IRZ was slower to show attenuation~~.”	The sentence has been revised as requested.

	Section/ Page	**Commenter**	**Comment**	**Final Comment Resolution**
636	8.2/33	DTSC	Minor edits to the following sentence: "Arsenic has returned to ~~baseline~~ pretest concentrations at both PT-1D and PT-3D locations, whereas manganese attenuation within the reducing zone has in general been slower (possibly due to a difference in the primary mechanisms of attenuation between arsenic and manganese [arsenic association with various reduced iron minerals that form in the IRZ]) but attenuation has been more rapid where carbon loading was lower (PT-3D).	The sentence has been revised as requested.
Table 5-5 - Individual Detailed Analysis of Remedial Alternatives against Seven Criteria				
637	Table 5-5, Alternative B	DTSC	Delete the phrase "…would be needed…" and insert "…will continue during remedial design." In the last sentence of the second paragraph under "Protect Human Health and the Environment"	In response to this comment the sentence has been updated at this location (and other locations where it had appeared throughout Table 5-5) as follows: "In addition, further studies to assess the effectiveness of long-term natural attenuation in the East Ravine will continue during remedial design."
638	Table 5-5, Alternative B	DTSC	Change the words "…AOC-10 investigations…" to "…further study of AOC 10 during remedy design…"	In response to this comment the sentence has been deleted as requested in comment 639 below.
639	Table 5-5, Alternative B	DTSC	Since it is one remedy for the plume, the time estimate to achieve RAOs will need to consider East Ravine bedrock and alluvial water as one system. Better to cite that estimate is based on 98% treatment and East Ravine represents the remaining one percent which can take much longer to attain, if ever.	In response to this comment the sentence "The estimated time to achieve the RAOs in bedrock has not yet been estimated, pending the results of further AOC-10 investigations." has been replaced with: "The estimated time to achieve the RAOs was based on the simulated time to remove 98 percent of the Cr(VI) mass within the plume. The amount of Cr(VI) mass within the East Ravine bedrock is estimated to be less than one percent of the total plume mass, and therefore does not significantly affect the simulated time to cleanup." This change has been made throughout Table 5-5.

	Section/ Page	Commenter	Comment	Final Comment Resolution
640	Table 5-5, Alternatives C through I	DTSC	The discussion in Table 5-5 on East Ravine did not seem to be consistently applied to all the alternatives. It can be reasoned that if East Ravine is discussed in Alt A and B for specific criteria, it should be discussed in all the other Alternatives because the same thought process is involved (in particular between Alt B - I). For Alternative B, East Ravine is discussed in the following criteria: • Protection of Human Health and the Environment • Attain Media Cleanup Goals • Control Sources of Releases • Chemical specific ARARs • Adequacy and Reliability of Controls • Amount of Plume Destroyed or Treated • Time Until RAOs are Achieved Additional discussion is added for Magnitude of Residual Risk in Alternative C which is appropriate and should be carried forward in all other Alternatives. Ensure that edits to Alternative C are carried through the remainder of alternatives in Table 5-5.	In response to this comment additional text has been added to Table 5-5 as requested to Alternatives C through H. The criteria that were modified as discussed and agreed to on December 15, 2009 include: • Protect Human Health and the Environment • Adequacy and Reliability of Controls • Amount of Plume Destroyed or Treated • Degree of Expected Reduction in Toxicity, Mobility, and Volume • Time Until RAOs are achieved
Appendix D – Remedial Alternative Cost Estimates				

	Section/ Page	Commenter	Comment	Final Comment Resolution
641	Appendix D	DTSC	DTSC noted that the Present Value cost estimates presented in the revised Table 5-5 have changed. Please explain why the numbers have changed	This comment was resolved with the following clarification: The present value cost estimates changed from the November 13 Final Redline Report for some of the alternatives as noted below: • Alternatives C, E, G, and H – Following receipt of DTSC's comments on "uptime" or dosing frequency and the amount of carbon added, the assumptions were re-evaluated. The uptime was adjusted to 50% for all alternatives and for some of the phases involving IRZ the flowrates were also adjusted upward. This increased the present value and nominal costs. • Alternatives F and G had slight adjustments in the capital costs due to rounding errors. None of these changes are significant in terms of how the alternatives rank in terms of cost effectiveness for either present value or nominal costs.
642	Appendix D	DTSC	We observed that the maximum number of wells cited in Table 19B is approximately twice that of the conceptual design Table 19A. There is a lack of rationale for this range. For EIR purposes, PG&E should provide some rationale in Appendix D for reference. DTSC acknowledges that PG&E did provide some discussion of uncertainties in conceptual design and potential changes from final design in the text of the CMS/FS, but no justification is cited in Appendix D If maximum numbers cited are simply for administrative flexibility, DTSC recommends using the acceptable range for cost estimates as the basis for infrastructure variations, which would be -30 to +50 percent.	The rationale for the difference between the number of wells used as a cost estimating assumption and the maximum number of wells for the CEQA analysis is included in the second paragraph of Section D.1. To address this comment the following sentence was added to this paragraph in order to further clarify the differences in well counts between Tables 19A and 19B: "To arrive at the maximum number or quantities, the maximum number for an alternative was multiplied by two and rounded up except for the treatment plant area (see Section D.2.1.3)."

	Section/ Page	**Commenter**	**Comment**	**Final Comment Resolution**
643	Appendix D	DTSC	None of the well numbers cited in Table 19A matches the number of wells in Table 5.5 (formerly Table 5.7).	Table 5-5 discusses the number of well locations for each alternative (in some cases there may be multiple wells per each location). In response to this comment, the footnote in Table 5-6A has been revised as follows: "Remediation Well Locations include extraction wells, injection wells, and wells for the IRZ system. There may be more than one well per location based on the conditions. For cost estimating purposes, the number of remediation wells (not well locations) is included in Appendix D, Table D-19A."
644	Appendix D, Section D.2.1.3	DTSC	For treatment plant size discussion in D.2.1.3. No justification was provided for the size of the treatment plant. Suggest adding language to compare current IM3 plant at 135 gpm flow rate with scale up factor to each alternative requiring ex-situ treatment plant.	In response to this comment the discussion for treatment plant size has been revised as follows: "The forthcoming CEQA analysis will evaluate the environmental ~~impacts~~ effects from an above-ground treatment plant. The treatment plant size for purposes of cost estimating is based on the conceptual layout for the assumed flow rate. For CEQA analysis, the maximum size was assumed as the cost estimate conceptual design area adjusted upwards by 50 percent for changes in flow rate and then by 100 percent for design changes, redundancy, etc. The treatment structure size (including covered and uncovered areas) for CEQA analysis of an above-ground treatment plant in Alternatives F, and G, ~~and H~~ is estimated to be a maximum of ~~range from 20,000 to 200,000~~ 90,000 square feet for the treatment plant with a maximum height of 45 feet. The plant may be constructed as several separate structures rather than one consolidated structure. Additional grading for the plant area will be required for vehicle access roads and temporary storage areas that could require as much as 100,000 square feet. For Alternative H, designed for a lower flow rate (325 gpm), the treatment structure size is estimated to be a maximum of 55,000 square feet with graded areas that could require as much as 65,000 square feet."

TABLE C-2 RESPONSES TO COMMENTS
Comments on the November 13, 2009 *Final Corrective Measures Study/Feasibility Study Report For SWMU 1/AOC 1 and AOC 10*
PG&E Topock Compressor Station, Needles, California

	Section/ Page	Commenter	Comment	Final Comment Resolution
645	Appendix D, Section D.2.1.4	DTSC	For pipe length discussion in D.2.1.4, EIR would need comparison of pipe length by alternative similar to wells. Current range cited is not consistent with cost summary for each alternative.	In response to this comment Table D-21 has been added to Appendix D to document both the pipe length assumptions for cost estimating as well as the maximum pipe length assumptions for the CEQA analysis for each alternative.
646	Appendix D	DTSC	For electrical and signal communication, please describe whether additional infrastructures would be needed for each alternative (power poles, electrical or phone line, etc.) and if these additional infrastructure will require new trenches or using pipeline trenches. If new trenches or overhead power lines, quantify how much disturbance (linear feet, number of poles, etc.). This number is nearly impossible to measure off figures in CMS/FS.	In response to this comment Table D-22 has been added to Appendix D to document both the electrical and signal communications length assumptions for cost estimating as well as the maximum electrical and signal communication length assumptions for the CEQA analysis for each alternative.
647	Appendix D	DTSC	Access roads: Are there differences in access roads between Alternatives C - H? Will the access roads be graveled, dirt (requiring dust suppressant) and need periodic maintenance? The cited access road lengths do not match cost estimate summaries for alternatives.	In response to this comment Table D-23 has been added ti Appendix D to document both the access road length assumptions for cost estimating as well as the maximum access road length assumptions for the CEQA analysis for each alternative.

Appendix D
Remedial Alternative Cost Estimates

Contents

Section **Page**

Tables

Acronyms and Abbreviations

CEQA	California Environmental Quality Act
gpm	gallons per minute
IM No. 3	Interim Measure Number 3
IRZ	*in-situ* reduction zone
O&M	operations and maintenance
PDI	pump-dose with carbon-inject
USEPA	United States Environmental Protection Agency

APPENDIX D

Remedial Alternative Cost Estimates

D.1 Introduction

This appendix describes the cost estimate basis for the conceptual remedial alternatives discussed in Section 5.0. The cost estimates were developed following United States Environmental Protection Agency (USEPA) guidance for a conceptual cost estimate and meets the prescribed level of accuracy of -30 percent to +50 percent (USEPA, 2000). This level of accuracy is appropriate given the preliminary nature of the design development (2 to 5 percent design development). The costs developed for this corrective measures study/feasibility study are for alternative comparison and do not represent bid- or construction-level engineering. It is fully expected that the quantities, layouts, and configuration of the implemented alternative will vary from that described herein. Costs in this appendix were estimated using unit rates appropriate for the size and scope of the alternatives. Costs were based on 2008 costs or for past costs escalated to 2008. Future costs were not escalated.

As stated in Section 5 of the CMS/FS, the remedial action alternatives were designed to a conceptual level of detail, sufficient to develop the remedial cost estimates consistent with USEPA guidance for developing cost estimates (USEPA, 2000). The specific numbers and locations of remedial facilities and described operational elements in the definitions of the alternatives are assumptions at this point and are used as a means to compare alternatives against each other. It is fully expected that changes to the numbers, locations, methods, configuration, and other assumptions made in developing the remedial costs will occur for the selected alternative as it moves through the design, construction, and operational phases. Changes to the conceptual design for the alternative ultimately selected will be made during design, construction, and implementation to optimize the remedy, to enhance performance in attaining the RAOs, to respond to contingency scenarios, to provide for adjustments due to field conditions, and comply with ARARs and agency, landowner and leaseholder requirements. Therefore, in addition to providing the cost estimate assumptions for each of the remedial alternatives, additional information about the potential ranges in number of wells, length of pipelines, and disturbance areas for above-ground remedial structures is provided herein for use in evaluating environmental impacts pursuant to the California Environmental Quality Act. To arrive at the maximum number or quantities, the maximum number for an alternative was multiplied by two and rounded up, except for the treatment plant area (see Section D.2.1.3).

The remainder of this appendix lists alternative components, assumptions, and cost estimating factors. Alternative components are shown on Table D-1. Tables D-2 through D-10 show the costs for each alternative. Assumptions and cost bases are summarized in Tables D-2 through D-10, their supporting tables (Tables D-11 through D-17), and in Section D.2 below.

TABLE D-1
Cost Components by Alternative
Groundwater Corrective Measures Study/Feasibility Study for SWMU 1/AOC 1 and AOC 10, PG&E Topock Compressor Station, Needles, California

	Wells		**In-situ Systems**	**Ex-situ Treatment**	**Infrastructure**		**Operation & Maintenance**					
Alternative	**Construct New Injection or Extraction Wells/Deconstruct New Injection or Extraction Wells Following Remedial Action**	**Construct New Monitoring Wells/ Deconstruct New Monitoring Wells Following Remedial Action**	**Construct New In-situ Systems (tanks, controls, etc.) /Deconstruct New In-situ Systems Following Remedial Action**	**Construct New Treatment Plant/Deconstruct New treatment Plant Following Remedial Action**	**Construct New Pipelines, Electrical Wiring and Conduit, or Access Roads**	**Construct Freshwater Supply Pipeline**	**Operate and Maintain In-situ Systems during Remediation Period**	**Operate and Maintain Ex-situ Treatment Plant during Remediation Period**	**Operate and Maintain Other Systems (pipelines, wells, etc.) during Remediation Period**	**Groundwater Monitoring during Remediation Period**	**Institutional Controls—Restriction on Groundwater Use within Plume Prior to Attaining RAOs during Remediation Period**	**Administrative Oversight (Surrounding Property Owner Agreements, Reports of System Performance, 5-year Reviews, etc.**
A. - No Action												
B. - Monitored Natural Attenuation		✓							✓	✓	✓	✓
C. - High Volume *In-situ* Treatment	✓	✓	✓		✓		✓		✓	✓	✓	✓
D. - Sequential *In-situ* Treatment	✓	✓	✓		✓		✓		✓	✓	✓	✓
E. - In-situ Treatment with Freshwater Flushing	✓	✓	✓		✓	✓	✓		✓	✓	✓	✓
F. - Pump and Treat	✓	✓		✓	✓			✓	✓	✓	✓	✓
G. - Combined Floodplain *In-situ/*Pump and Treat	✓	✓	✓	✓	✓		✓	✓	✓	✓	✓	✓
H. - Combined Upland *In-situ*/Pump and Treat	✓	✓	✓	✓	✓		✓	✓	✓	✓	✓	✓
I. - Continued Operation of Interim Measure								✓	✓	✓	✓	✓

TABLE D-2

Alternative A

Remedial Alternative Cost Summary - No Action

Site: Topock
Date: 12/13/2009

CAPITAL COSTS

DESCRIPTION	QTY	UNIT	UNIT COST	TOTAL	NOTES
Wells					
Injection & Extraction Wells	0			$0	
Monitoring	0	WELL	$60,800	$0	
SUBTOTAL				$0	
In Situ Systems					
IRZ	0.0	0	$0	$0	
SUBTOTAL				$0	
Ex Situ Treatment					
Treatment plant	0			$0	
SUBTOTAL				$0	
Infrastructure					
Pipelines & Conduit / Wire & Trench	0	See Note	$0	$0	
Access Roads	0.0	1,000 LF	$0	$0	
Fresh water					
Wells	0	WELLS	$0	$0	
Pipeline	0	1,000 LF	$0	$0	
SUBTOTAL				$0	
Remove IM3 Treatment Plant					
IM3 treatment - restoration and deconstruction	0	LS	$1,600,000	$0	
SUBTOTAL				$0	
SUBTOTAL				$0	
Prime Contractor Cost Factors[1]					
General Conditions (sub mob, sub GC)	10%			$0	
Field Construction Management and Engineer SDC	10%			$0	
Pre-construction (work plans, design, as-builts)	14%			$0	USEPA costing guidance EPA-540-R-00-002
Project Management	5%			$0	
Contractor Markup (G&A, fee)	21%			$0	
SUBTOTAL			75%	$0	
Miscellaneous					
Institutional Controls and other Administrative Approvals	0	CONSTR PHASES	$1,000,000	$0	Allowance
Biological Monitoring	0	CONSTR YRS	$330,000	$0	Allowance
Cultural Monitoring	0	CONSTR YRS	$330,000	$0	Allowance
Regulatory Oversight	0	CONSTR YRS	$300,000	$0	Allowance
Soil Cuttings	0	CONSTR PHASES	$200,000	$0	Allowance - see also Section D.2.1.7 for description of this line item.
SUBTOTAL				$0	
Contingency	25%			$0	
TOTAL CAPITAL COST				**$0**	
			Low Range		High Range
			$0		**$0**

Alternative A

Remedial Alternative Cost Summary - No Action

OPERATIONS AND MAINTENANCE COST

DESCRIPTION	UNITS	UNIT COST		NOTES
		Duration:		
Ex Situ Treatment Plant O&M	YR		$ -	
Freshwater well maintenance & pumping	100 gpm		$ -	
IRZ (dipolar)	1,000 LF		$ -	
IRZ (pump-C-inject)	1,000 LF		$ -	
IRZ Well Replacement	10%	Capital Cost of Wells	$ -	
Maintenance of Wells (Non IRZ)	See Note		$ -	Assume maintenance as percent of capital cost of wells. 10% for extraction and monitoring wells; 20% for injection wells.
Groundwater/Surface Water Monitoring	YR	See Note	$ -	$135,000/event for S&A, data mgmt. 6 events in first yr of a Phase, then 1 event/yr. Based on cost for recent similar activities at Topock.
Reporting - Site-wide Groundwater Monitoring	YR	See Note	$ -	$156,000 for first sampling event in a Phase, then $120,000/year. Based on cost for recent similar activities at Topock.
Reporting - Performance	YR	See Note	$ -	Allowance of $50,000/report in years remedy is operating. Assume once per two years during LTM.
Other Facilities - Road maintenance	0.0 x 1,000 LF	$ 700	$ -	
Other O&M Costs				
Permit Compliance	YR	See Note	$ -	$360,000/year based on IM3 compliance costs. 20% assumed during LTM.
Groundwater ICs	YR	$ 20,000	$ -	Allowance
Biological Surveys	YR	See Note	$ -	$100,000/yr from recent site costs for monitoring per PBA document. (Spring DETO and SWFL surveys).
Cultural Surveys	YR	See Note	$ -	Annual allowance $50,000/year. $0 in construction years.
Reg/stakeholder oversight	YR	See Note	$ -	Annual allowance $100,000/year. $0 in construction years.
Water rights	$/ac-ft	$ 27	$ -	Based on current invoices from the City of Needles
5-year reviews	YR	$ 15,000	$ -	$75,000/review based on cost at other sites; done once per 5 years.
SUBTOTAL			$ -	
Contingency	25%		$0	
SUBTOTAL			$ -	
TOTAL O&M COST			**$0**	

POST-REMEDIATION DECONSTRUCTION COSTS

DESCRIPTION	QTY	UNIT	UNIT COST	TOTAL	NOTES
Restoration of areas disturbed during construction.	0	LS	$1,000,000	$0	Allowance
Deconstruct roads and small structures	0	LS	$700,000	$0	$500K allowance for roads (including Rt 66), $200K for structures other than treatment plant
Deconstruct wells	0	WELL	$30,000	$0	Cost per well from experience at Topock
Deconstruct new treatment plant	0	LS	$4,731,825	$0	
SUBTOTAL				$0	
Contingency	25%			$0	
TOTAL POST-REMEDIATION DECONSTRUCTION COST				**$0**	

PRESENT VALUE ANALYSIS

PERIOD	COST TYPE	TOTAL COST	TOTAL COST PER YEAR	DISCOUNT FACTOR^2	PRESENT VALUE	NOMINAL VALUE	NOTES
							See Section D.2.4 for more information on Present Value calculations
0	CAPITAL COST, YEAR 0	$0		1.000	$0	$0	
0	ANNUAL O&M COST	$0	$0	1.000	$0	$0	
0	LONG TERM MONITORING	$0	$0	1.000	$0	$0	
0	POST-REMEDIATION DECONSTRUCTION, YEAR 0	$0		1.000	$0	$0	
	TOTAL PRESENT VALUE OF ALTERNATIVE				**$0**		
				Low Range		High Range	
				$0		**$0**	
Total Nominal Cost					**$0**		

Note:

Acronyms and abbreviations are defined in Table D-11. Total costs rounded to 3 significant figures.

Source Information:

1. Factors are applied cumulatively and based on United States Environmental Protection Agency. July 2000. A Guide to Developing and Documenting Cost Estimates During the Feasibility Study. EPA 540-R-00-002. (USEPA, 2000).
2. Discount factor of 3.17% per year is used

TABLE D-3

Alternative B

Remedial Alternative Cost Summary - Monitored Natural Attenuation

Site: Topock
Date: 12/13/2009

CAPITAL COSTS

DESCRIPTION	QTY	UNIT	UNIT COST	TOTAL	NOTES
Wells					
Injection & Extraction Wells	0			$0	
Monitoring	28	WELL	$60,800	$1,700,000	28 new wells assumed
				$1,700,000	
In Situ Systems					
IRZ	0			$0	
SUBTOTAL				$0	
Ex Situ Treatment					
Treatment plant	0			$0	
SUBTOTAL				$0	
Infrastructure					
Pipelines & Conduit / Wire & Trench	0			$0	
Access Roads	0	1,000 LF	$16,200	$0	
Fresh water					
Wells	0	WELLS	$333,900	$0	
Pipeline	0	1,000 LF	$160,000	$0	
SUBTOTAL				$0	
Remove IM3 Treatment Plant					
IM3 treatment - restoration and deconstruction	1	LS	$1,600,000	$1,600,000	See Table D-17
SUBTOTAL				$1,600,000	
SUBTOTAL				$3,300,000	
Prime Contractor Cost Factors[1]					
General Conditions (sub mob, sub GC)	10%			$330,000	USEPA costing guidance EPA-540-R-00-002
Field Construction Management and Engineer SDC	10%			$363,000	
Pre-construction (work plans, design, as-builts)	14%			$559,000	
Project Management	5%			$228,000	
Contractor Markup (G&A, fee)	21%			$1,000,000	
SUBTOTAL			75%	$2,480,000	
Miscellaneous					
Institutional Controls and other Administrative Approvals	0	CONSTR PHASES	$1,000,000	$0	Allowance
Biological Monitoring	0	CONSTR YRS	$330,000	$0	Allowance
Cultural Monitoring	0	CONSTR YRS	$330,000	$0	Allowance
Regulatory Oversight	0	CONSTR YRS	$300,000	$0	Allowance
Soil Cuttings	0	CONSTR PHASES	$200,000	$0	Allowance - see also Section D.2.1.7 for description of this line item.
SUBTOTAL				$5,780,000	
Contingency	25%			$1,450,000	
TOTAL CAPITAL COST				**$7,230,000**	
			Low Range		High Range
			$5,060,000		**$10,800,000**

Alternative B

Remedial Alternative Cost Summary - Monitored Natural Attenuation

OPERATIONS AND MAINTENANCE COST

DESCRIPTION	UNITS	UNIT COST		ANNUAL O&M COST MNA	NOTES
			Duration:	**540 years**	
Ex Situ Treatment Plant O&M	YR			$ -	
Freshwater well maintenance & pumping	100 gpm			$ -	
IRZ (dipolar)	1,000 LF				
IRZ (pump-C-inject)	1,000 LF				
IRZ Well Replacement	10%				
Maintenance of Wells (Non IRZ)	See Note			$ 393,000	Assume maintenance as percent of capital cost of wells. 10% for extraction and monitoring wells; 20% for injection wells.
Groundwater/Surface Water Monitoring	YR	See Note		$ 67,500	$135,000/event for S&A, data mgmt. Every two years during Alt. B or LTM. Based on cost for recent similar activities at Topock.
Reporting - Site-wide Groundwater Monitoring	YR	See Note		$ 120,000	$156,000 for first sampling event in a Phase, then $120,000/year. Assume once per two years during LTM. Based on cost for recent similar activities at Topock.
Reporting - Performance	YR	See Note		$ -	Does not apply to this Alternative.
Other Facilities - Road maintenance	0.0 x 1,000 LF	$ 700		$ -	
Other O&M Costs					
Permit Compliance	YR	See Note		$ 72,000	$360,000/year based on IM3 compliance costs. 20% assumed during LTM and MNA.
Groundwater ICs	YR	$ 20,000		$ 20,000	Allowance
Biological Surveys	YR	See Note		$ 20,000	$100,000/yr from recent site costs for monitoring per PBA document. (Spring DETO and SWFL surveys). Assumed decreases to 20% in MNA.
Cultural Surveys	YR	See Note		$ 10,000	Annual allowance. Assumed decreases to 20% in MNA.
Reg/stakeholder oversight	YR	See Note		$ 20,000	Annual allowance. Assumed decreases to 20% in MNA.
Water rights	$/ac-ft	$ 27		$ -	Based on current invoices from the City of Needles
5-year reviews	YR	$ 15,000		$ 15,000	$75,000/review based on cost at other sites; done once per 5 years.
SUBTOTAL				$ 738,000	
Contingency	25%			$185,000	
SUBTOTAL				$923,000	
TOTAL O&M COST				**$923,000**	

POST-REMEDIATION DECONSTRUCTION COSTS

DESCRIPTION	QTY	UNIT	UNIT COST	TOTAL	NOTES
Restoration of areas disturbed during construction.	1	LS	$1,000,000	$1,000,000	Allowance
Deconstruct roads and small structures	1	LS	$700,000	$700,000	$500K allowance for roads (including Rt 66), $200K for structures other than treatment plant
Deconstruct wells	138	WELL	$30,000	$4,140,000	Cost per well from experience at Topock
Deconstruct new treatment plant	0	LS			
SUBTOTAL				$5,840,000	
Contingency	25%			$1,460,000	
TOTAL POST-REMEDIATION DECONSTRUCTION COST				**$7,300,000**	

PRESENT VALUE ANALYSIS

PERIOD	COST TYPE	TOTAL COST	TOTAL COST PER YEAR	DISCOUNT FACTOR^2	PRESENT VALUE	NOMINAL VALUE	NOTES
							See Section D.2.4 for more information on Present Value calculations
0	CAPITAL COST, YEAR 0	$7,230,000		1.000	$7,230,000	$7,230,000	
540	ANNUAL O&M COST, YEAR 1-x	$923,000	$923,000	31.546	$29,116,718	$498,000,000	
541	POST-REMEDIATION DECONSTRUCTION, YEAR 541	$7,300,000	-	0.000	$0	$7,300,000	
	TOTAL PRESENT VALUE OF ALTERNATIVE				**$36,300,000**		
				Low Range		High Range	
				$25,000,000		**$54,000,000**	
Total Nominal Cost					**$513,000,000**		

Note:

Acronyms and abbreviations are defined in Table D-11. Total costs rounded to 3 significant figures.

Source Information:

1. Factors are applied cumulatively and based on United States Environmental Protection Agency. July 2000. A Guide to Developing and Documenting Cost Estimates During the Feasibility Study. EPA 540-R-00-002. (USEPA, 2000).
2. Discount factor of 3.17% per year is used

TABLE D-4

Alternative C

Remedial Alternative Cost Summary - High Volume In-Situ Treatment

Site: Topock
Date: 12/13/2009

CAPITAL COSTS

DESCRIPTION	QTY	UNIT	UNIT COST	TOTAL	NOTES
Wells					
Injection & Extraction Wells	1	See Note	$8,511,750	$8,510,000	See Table D-12
Monitoring	32	WELL	$60,800	$1,950,000	32 new wells assumed
SUBTOTAL				$10,460,000	
In Situ Systems					
IRZ	1	LS	$10,580,800	$10,600,000	See Table D-13a
SUBTOTAL				$10,600,000	
Ex Situ Treatment					
Treatment plant	0			$0	
SUBTOTAL				$0	
Infrastructure					
Pipelines & Conduit / Wire & Trench	1	See Note	$10,914,715	$10,900,000	See Table D-16
Access Roads	8	1,000 LF	$16,200	$124,000	
Fresh water					
Wells	0	WELLS	$333,900	$0	
Pipeline	0	1,000 LF	$160,000	$0	
SUBTOTAL				$11,000,000	
Remove IM3 Treatment Plant					
IM3 treatment - restoration and deconstruction	1	LS	$1,600,000	$1,600,000	See Table D-17
SUBTOTAL				$1,600,000	
SUBTOTAL				$33,700,000	
Prime Contractor Cost Factors[1]					
General Conditions (sub mob, sub GC)	10%			$3,370,000	
Field Construction Management and Engineer SDC	10%			$3,710,000	
Pre-construction (work plans, design, as-builts)	14%			$5,710,000	USEPA costing guidance EPA-540-R-00-002
Project Management	5%			$2,320,000	
Contractor Markup (G&A, fee)	21%			$10,300,000	
SUBTOTAL			75%	$25,400,000	
Miscellaneous					
Institutional Controls and other Administrative Approvals	2	CONSTR PHASES	$1,000,000	$2,000,000	Allowance
Biological Monitoring	2	CONSTR YRS	$330,000	$660,000	Allowance
Cultural Monitoring	2	CONSTR YRS	$330,000	$660,000	Allowance
Regulatory Oversight	2	CONSTR YRS	$300,000	$600,000	Allowance
Soil Cuttings	2	CONSTR PHASES	$200,000	$400,000	Allowance Allowance - see also Section D.2.1.7 for description of this line item.
SUBTOTAL				$63,420,000	
Contingency	25%			$15,900,000	
TOTAL CAPITAL COST				**$79,300,000**	
			Low Range		High Range
			$55,500,000		**$119,000,000**

Alternative C

Remedial Alternative Cost Summary - High Volume In-Situ Treatment

OPERATIONS AND MAINTENANCE COST

DESCRIPTION	UNITS	UNIT COST	Phase 1	Phase 2a	Phase 2b	Long-Term Mon.	NOTES
		Duration:	2 years	5 years	11 years	10 years	
Ex Situ Treatment Plant O&M	YR			$ -		$ -	
Freshwater well maintenance & pumping	100 gpm			$ -		$ -	
IRZ	YR	See Note	$ 1,450,000	$ 4,790,000	$ 2,290,000	$ -	Labor, materials, maintenance, well cleaning, reagents, reporting. Cost based on site experience in California and adjusted for flow and carbon demand. See Table D-14.
IRZ Well Replacement	10%	Capital Cost of Wells	$ -	$ 532,000	$ 532,000	$ -	Replace 10% of wells each year.
Maintenance of Wells (Non IRZ)	See Note		$ 418,000	$ 418,000	$ 418,000	$ 418,000	Assume maintenance as percent of capital cost of wells. 10% for extraction and monitoring wells; 20% for injection wells.
Groundwater/Surface Water Monitoring	YR	See Note	$ 472,500	$ 270,000	$ 196,000	$ 67,500	$135,000/event for S&A, data mgmt. 6 events in first yr of a Phase, then 1 event/yr. Based on cost for recent similar activities at Topock. Every two years during Alt. B or LTM.
Reporting - Site-wide Groundwater Monitoring	YR	See Note	$ 138,000	$ 127,200	$ 123,000	$ 60,000	$156,000 for first sampling event in a Phase, then $120,000/year. Assume once per two years during LTM. Based on cost for recent similar activities at Topock.
Reporting - Performance	YR	See Note	$ 50,000	$ 50,000	$ 50,000	$ 25,000	Allowance of $50,000/report in years remedy is operating. Assume once per two years during LTM.
Other Facilities - Road maintenance	7.7 x 1,000 LF	$ 700	$ 5,370	$ 5,370	$ 5,370	$ -	
Other O&M Costs							
Permit Compliance	YR	See Note	$ 360,000	$ 360,000	$ 360,000	$ 72,000	$360,000/year based on IM3 compliance costs. 20% assumed during LTM.
Groundwater ICs	YR	$ 20,000	$ 20,000	$ 20,000	$ 20,000	$ 20,000	Allowance
Biological Surveys	YR	See Note	$ 100,000	$ 100,000	$ 100,000	$ 20,000	$100,000/yr from recent site costs for monitoring per PBA document. Spring DETO and SWFL surveys). 20% assumed during LTM.
Cultural Surveys	YR	See Note	$ 50,000	$ 50,000	$ 50,000	$ 10,000	Annual allowance. 20% assumed during LTM.
Reg/stakeholder oversight	YR	$ 27	$ 100,000	$ 100,000	$ 100,000	$ 20,000	Annual allowance. 20% assumed during LTM.
Water rights	$/ac-ft	$ 27	$ 8,690	$ 8,690	$ 8,690	$ -	Based on current invoices from the City of Needles
5-year reviews	YR	$ 15,000	$ 15,000	$ 15,000	$ 15,000	$ 15,000	$75,000/review based on cost at other sites; done once per 5 years.
SUBTOTAL			$ 3,190,000	$ 6,850,000	$ 4,270,000	$ 728,000	
Contingency	25%		$798,000	$1,710,000	$1,070,000	$182,000	
SUBTOTAL		**0**	$3,990,000	$8,560,000	$5,340,000	$910,000	
TOTAL O&M COST			**$4,000,000**	**$8,600,000**	**$5,300,000**	**$900,000**	

POST-REMEDIATION DECONSTRUCTION COSTS

DESCRIPTION	QTY	UNIT	UNIT COST	TOTAL	NOTES
Restoration of areas disturbed during construction.	1	LS	$1,000,000	$1,000,000	Allowance
Deconstruct roads and small structures	1	LS	$700,000	$700,000	$500K allowance for roads (including Rt 66), $200K for structures other than treatment plant
Deconstruct wells	157	WELL	$30,000	$4,710,000	Cost per well from experience at Topock
Deconstruct new treatment plant	0	LS			
SUBTOTAL				$6,410,000	
Contingency	25%			$1,602,500	
TOTAL POST-REMEDIATION DECONSTRUCTION COST				**$8,010,000**	

PRESENT VALUE ANALYSIS

PERIOD	COST TYPE	TOTAL COST	TOTAL COST PER YEAR	DISCOUNT FACTOR[2]	PRESENT VALUE	NOMINAL VALUE	NOTES
							See Section D.2.4 for more information on Present Value calculations
0	CAPITAL COST, YEAR 0	$79,300,000	-	1.000	$79,300,000	$79,300,000	
2	PHASE 1 ANNUAL O&M COST, YEAR 1-2		$4,000,000	1.909	$7,635,065	$8,000,000	
5	PHASE 2 ANNUAL O&M COST, YEAR 3-7		$8,600,000	4.282	$36,823,426	$43,000,000	
11	PHASE 3 ANNUAL O&M COST, YEAR 8-18		$5,300,000	7.367	$39,046,916	$58,300,000	
10	LONG TERM MONITORING, YEAR 19-28		$900,000	4.822	$4,339,905	$9,000,000	
29	POST-REMEDIATION DECONSTRUCTION, YEAR 29	$8,010,000	-	0.405	$3,240,284	$8,010,000	
	TOTAL PRESENT VALUE OF ALTERNATIVE				**$170,000,000**		
				Low Range		High Range	
				$119,000,000		**$255,000,000**	
Total Nominal Cost					**$206,000,000**		

Note:

Acronyms and abbreviations are defined in Table D-11. Total costs rounded to 3 significant figures.

Source Information:

1. Factors are applied cumulatively and based on United States Environmental Protection Agency. July 2000. A Guide to Developing and Documenting Cost Estimates During the Feasibility Study. EPA 540-R-00-002. (USEPA, 2000).
2. Discount factor of 3.17% per year is used

TABLE D-5

Alternative D

Remedial Alternative Cost Summary - Sequential In-Situ Treatment

Site: Topock
Date: 12/13/2009

CAPITAL COSTS

DESCRIPTION	QTY	UNIT	UNIT COST	TOTAL		NOTES
Wells						
Injection & Extraction Wells	1	See Note	$9,030,300	$9,030,000		See Table D-12
Monitoring	40	WELL	$60,800	$2,400,000		40 new wells assumed
SUBTOTAL				$11,400,000		
In Situ Systems						
IRZ	1	LS	$7,239,400	$7,240,000		See Table D-13b
SUBTOTAL				$7,240,000		
Ex Situ Treatment						
Treatment plant	0			$0		
SUBTOTAL				$0		
Infrastructure						
Pipelines & Conduit / Wire & Trench	1	See Note	$21,964,225	$22,000,000		See Table D-16
Access Roads	8	1,000 LF	$16,200	$130,000		
Fresh water						
Wells	0	2 WELLS	$333,900	$0		
Pipeline	0	1,000 LF	$160,000	$0		
SUBTOTAL				$22,130,000		
Remove IM3 Treatment Plant						
IM3 treatment - restoration and deconstruction	1	LS	$1,600,000	$1,600,000		See Table D-17
SUBTOTAL				$1,600,000		
SUBTOTAL				$42,400,000		
Prime Contractor Cost Factors[1]						
General Conditions (sub mob, sub GC)	10%			$4,240,000		
Field Construction Management and Engineer SDC	10%			$4,660,000		
Pre-construction (work plans, design, as-builts)	14%			$7,180,000		USEPA cost estimating guidance (see Note 1)
Project Management	5%			$2,920,000		
Contractor Markup (G&A, fee)	21%			$12,900,000		
SUBTOTAL			75%	$31,900,000		
Miscellaneous						
Institutional Controls and other Administrative Approvals	5	CONSTR PHASES	$1,000,000	$5,000,000		Allowance, assumes all phases built at once.
Biological Monitoring	5	CONSTR YRS	$330,000	$1,650,000		Allowance
Cultural Monitoring	5	CONSTR YRS	$330,000	$1,650,000		Allowance
Regulatory Oversight	5	CONSTR YRS	$300,000	$1,500,000		Allowance
Soil Cuttings	5	CONSTR PHASES	$200,000	$1,000,000		Allowance - see also Section D.2.1.7 for description of this line iter
SUBTOTAL				$85,100,000		
Contingency	25%			$21,300,000		
TOTAL CAPITAL COST				**$106,000,000**		
			Low Range		High Range	
			$74,500,000		**$160,000,000**	

Alternative D

Remedial Alternative Cost Summary - Sequential In-Situ Treatment

OPERATIONS AND MAINTENANCE COST

DESCRIPTION	UNITS	UNIT COST	Phase 1	Phase 2	Phase 3	Phase 4	Phase 5	Phase 6	Phase 7	Phase 8	Phase 9	Phase 10	Long-Term Mon.	NOTES
		Duration:	**1.5 years**	**1.5 years**	**1.5 years**	**1.5 years**	**1.5 years**	**1.5 years**	**1.5 years**	**1.5 years**	**1.5 years**	**1.5 years**	**10 years**	
Ex Situ Treatment Plant O&M	YR													
Freshwater well maintenance & pumping	100 gpm													
IRZ	YR	See Note	$ 3,349,000	$ 2,016,500	$ 1,826,500	$ 1,826,500	$ 1,826,500	$ 1,826,500	$ 970,000	$ 970,000	$ 641,500	$ 532,000	$ -	Labor, materials, maintenance, well cleaning, reagents, reporting. Cost based on site experience in California and adjusted for flow and carbon demand. See Table D-14
IRZ Well Replacement	10%	Capital Cost of Wells	$ 70,100	$ 70,100	$ 70,100	$ 70,100	$ 70,100	$ 70,100	$ 70,100	$ 70,100	$ 70,100	$ 70,100	$ -	
Maintenance of Wells (Non IRZ)	See Note		$ 463,000	$ 463,000	$ 463,000	$ 463,000	$ 463,000	$ 463,000	$ 463,000	$ 463,000	$ 463,000	$ 463,000	$ 463,000	Assume maintenance as percent of capital cost of wells. 10% for extraction and monitoring wells; 20% for injection wells.
Groundwater/Surface Water Monitoring	YR	See Note	$ 585,000	$ 585,000	$ 585,000	$ 585,000	$ 585,000	$ 585,000	$ 585,000	$ 585,000	$ 585,000	$ 585,000	$ 67,500	$135,000/event for S&A, data mgmt. 6 events in first yr of a Phase, then 1 event/yr. Costs averaged over the active phase of the alternative Based on cost for recent similar activities at Topock.
Reporting - Site-wide Groundwater Monitoring	YR	See Note	$ 144,000	$ 144,000	$ 144,000	$ 144,000	$ 144,000	$ 144,000	$ 144,000	$ 144,000	$ 144,000	$ 144,000	$ 60,000	$156,000 for first sampling event in a Phase, then $120,000/year. Assume once per two years during LTM. Based on cost for recent similar activities at Topock.
Reporting - Performance	YR	See Note	$ 50,000	$ 50,000	$ 50,000	$ 50,000	$ 50,000	$ 50,000	$ 50,000	$ 50,000	$ 50,000	$ 50,000	$ 25,000	Allowance of $50,000/report in years remedy is operating. Assume once per two years during LTM.
Other Facilities - Road maintenance	8.0 x 1,000 LF	$ 700	$ 5,630	$ 5,630	$ 5,630	$ 5,630	$ 5,630	$ 5,630	$ 5,630	$ 5,630	$ 5,630	$ 5,630	$ -	
Other O&M Costs														
Permit Compliance	YR	See Note	$ 360,000	$ 360,000	$ 360,000	$ 360,000	$ 360,000	$ 360,000	$ 360,000	$ 360,000	$ 360,000	$ 360,000	$ 72,000	$360,000/year based on IM3 compliance costs. 20% assumed during LTM.
Groundwater ICs	YR	$ 20,000	$ 20,000	$ 20,000	$ 20,000	$ 20,000	$ 20,000	$ 20,000	$ 20,000	$ 20,000	$ 20,000	$ 20,000	$ 20,000	Allowance
Biological Surveys	YR	See Note	$ 100,000	$ 100,000	$ 100,000	$ 100,000	$ 100,000	$ 100,000	$ 100,000	$ 100,000	$ 100,000	$ 100,000	$ 20,000	$100,000/yr from recent site costs for monitoring per PBA document. Spring DETO and SWFL surveys). 20% assumed during LTM.
Cultural Surveys	YR	See Note	$ 50,000	$ 50,000	$ 50,000	$ 50,000	$ 50,000	$ 50,000	$ 50,000	$ 50,000	$ 50,000	$ 50,000	$ 10,000	Annual allowance. 20% assumed during LTM.
Reg/stakeholder oversight	YR	See Note	$ -	$ -	$ -	$ 100,000	$ 100,000	$ 100,000	$ 100,000	$ 100,000	$ 100,000	$ 100,000	$ 20,000	Annual allowance. 20% assumed during LTM.
Water rights	$/ac-ft	$ 27	$ 8,690	$ 8,694	$ 8,694	$ 8,694	$ 8,694	$ 8,694	$ 8,694	$ 8,694	$ 8,694	$ 8,694	$ -	Based on current invoices from the City of Needles
5-year reviews	YR	$ 15,000	$ 15,000	$ 15,000	$ 15,000	$ 15,000	$ 15,000	$ 15,000	$ 15,000	$ 15,000	$ 15,000	$ 15,000	$ 15,000	$75,000/review based on cost at other sites; done 1 per 5 years.
SUBTOTAL			$ 5,220,000	$ 3,890,000	$ 3,700,000	$ 3,800,000	$ 3,800,000	$ 3,800,000	$ 2,940,000	$ 2,940,000	$ 2,610,000	$ 2,500,000	$ 773,000	
Contingency	25%		$1,310,000	$973,000	$925,000	$950,000	$950,000	$950,000	$735,000	$735,000	$653,000	$625,000	$193,000	
SUBTOTAL			$ 6,530,000	$4,860,000	$4,630,000	$4,750,000	$4,750,000	$4,750,000	$3,680,000	$3,680,000	$3,260,000	$3,130,000	$966,000	
TOTAL O&M COST			**$6,500,000**	**$4,900,000**	**$4,600,000**	**$4,800,000**	**$4,800,000**	**$4,800,000**	**$3,700,000**	**$3,700,000**	**$3,300,000**	**$3,100,000**	**$1,000,000**	

POST-REMEDIATION DECONSTRUCTION COSTS

DESCRIPTION	QTY	UNIT	UNIT COST	TOTAL	NOTES
Restoration of areas disturbed during construction.	1	LS	$1,000,000	$1,000,000	Allowance
Deconstruct roads and small structures	1	LS	$700,000	$700,000	$500K allowance for roads (including Rt 66), $200K for structures other than treatment plant
Deconstruct wells	165	WELL	$30,000	$4,950,000	Cost per well from experience at Topock
Deconstruct new treatment plant	0	LS			
SUBTOTAL				$6,650,000	
Contingency	25%			$1,662,500	
TOTAL POST-REMEDIATION DECONSTRUCTION COST				**$8,310,000**	

PRESENT VALUE ANALYSIS

PERIOD	COST TYPE	TOTAL COST	TOTAL COST PER YEAR	DISCOUNT FACTOR[2]	PRESENT VALUE	NOMINAL VALUE	NOTES
							See Section D.2.4 for more information on Present Value calculations
0	CAPITAL COST, YEAR 0	$106,000,000		1.000	$106,000,000	$106,000,000	
1.5	PHASE 1 ANNUAL O&M COST, YEAR 0-1.5		$6,500,000	1.443	$9,377,452	$9,750,000	
1.5	PHASE 2 ANNUAL O&M COST, YEAR 1.5-3		$4,900,000	1.377	$6,745,862	$7,350,000	
1.5	PHASE 3 ANNUAL O&M COST, YEAR 3-4.5		$4,600,000	1.314	$6,043,229	$6,900,000	
1.5	PHASE 4 ANNUAL O&M COST, YEAR 4.5-6		$4,800,000	1.254	$6,017,586	$7,200,000	
1.5	PHASE 5 ANNUAL O&M COST, YEAR 6-7.5		$4,800,000	1.196	$5,742,383	$7,200,000	
1.5	PHASE 6 ANNUAL O&M COST, YEAR 7.5-9		$4,800,000	1.142	$5,479,766	$7,200,000	
1.5	PHASE 7 ANNUAL O&M COST, YEAR 9-10.5		$3,700,000	1.089	$4,030,810	$5,550,000	
1.5	PHASE 8 ANNUAL O&M COST, YEAR 10.5-12		$3,700,000	1.040	$3,846,469	$5,550,000	
1.5	PHASE 9 ANNUAL O&M COST, YEAR 12-13.5		$3,300,000	0.992	$3,273,741	$4,950,000	
1.5	PHASE 10 ANNUAL O&M COST, YEAR 13.5-15		$3,100,000	0.947	$2,934,688	$4,650,000	
10	LONG TERM MONITORING, YEAR 13-22		$1,000,000	5.815	$5,815,115	$10,000,000	
23	POST-REMEDIATION DECONSTRUCTION, YEAR 23	$8,310,000		0.488	$4,053,892	$8,310,000	
	TOTAL PRESENT VALUE OF ALTERNATIVE				**$169,000,000**		
				Low Range		High Range	
				$118,000,000		**$254,000,000**	
Total Nominal Cost					**$191,000,000**		

Note:

Acronyms and abbreviations are defined in Table D-11. Total costs rounded to 3 significant figures.

Source Information:

1. Factors are applied cumulatively and based on United States Environmental Protection Agency. July 2000. A Guide to Developing and Documenting Cost Estimates During the Feasibility Study. EPA 540-R-00-002. (USEPA, 2000).
2. Discount factor of 3.17% per year is used

TABLE D-6

Alternative E

Remedial Alternative Cost Summary - In-Situ Treatment with Freshwater Flushing

Site: Topock
Date: 12/13/2009

CAPITAL COSTS

DESCRIPTION	QTY	UNIT	UNIT COST	TOTAL	NOTES
Wells					
Injection & Extraction Wells	1	See Note	$5,701,860	$5,700,000	See Table D-12. Does not include freshwater extraction wells.
Monitoring	28	WELL	$60,800	$1,700,000	28 new wells assumed
SUBTOTAL				$7,400,000	
In Situ Systems					
IRZ	1	LS	$4,034,500	$4,030,000	See Table D-13c
SUBTOTAL				$4,030,000	
Ex Situ Treatment					
Treatment plant	0			$0	
SUBTOTAL				$0	
Infrastructure					
Pipelines & Conduit / Wire & Trench	1	See Note	$8,860,766	$8,860,000	See Table D-16
Access Roads	3	1,000 LF	$16,200	$50,000	
Fresh water					
Wells	1	LS	$158,700	$160,000	Assumed one 10" diameter well (shown on Table D-12)
Pipeline	1.6	1,000 LF	$100,000	$160,000	1,600 feet of 10" steel pipe running across existing pipe bridge and supports.
SUBTOTAL				$9,230,000	
Remove IM3 Treatment Plant					
IM3 treatment - restoration and deconstruction	1	LS	$1,600,000	$1,600,000	See Table D-17
SUBTOTAL				$1,600,000	
SUBTOTAL				$22,300,000	
Prime Contractor Cost Factors[1]					
General Conditions (sub mob, sub GC)	10%			$2,230,000	USEPA costing guidance EPA-540-R-00-002
Field Construction Management and Engineer SDC	10%			$2,450,000	
Pre-construction (work plans, design, as-builts)	14%			$3,780,000	
Project Management	5%			$1,540,000	
Contractor Markup (G&A, fee)	21%			$6,780,000	
SUBTOTAL			75%	$16,800,000	
Miscellaneous					
Institutional Controls and other Administrative Approvals	1	CONSTR PHASES	$1,000,000	$1,000,000	Allowance
Biological Monitoring	1	CONSTR YRS	$330,000	$330,000	Allowance
Cultural Monitoring	1	CONSTR YRS	$330,000	$330,000	Allowance
Regulatory Oversight	1	CONSTR YRS	$300,000	$300,000	Allowance
Soil Cuttings	1	CONSTR PHASES	$200,000	$200,000	Allowance - see also Section D.2.1.7 for description of this line item.
SUBTOTAL				$41,300,000	
Contingency	25%			$10,300,000	
TOTAL CAPITAL COST				**$51,600,000**	
			Low Range		High Range
			$36,100,000		**$77,400,000**

Alternative E

Remedial Alternative Cost Summary - In-Situ Treatment with Freshwater Flushing

OPERATIONS AND MAINTENANCE COST

DESCRIPTION	UNITS	UNIT COST	O&M	Long-Term Mon.	NOTES
		Duration:	29 years	10 years	
Ex Situ Treatment Plant O&M	YR				
Freshwater well maintenance & pumping	100 gpm	$ 11,108	$ 55,542	$ -	500 gpm of freshwater. Cost is for electricity for pumping, and maintaining well.
IRZ	YR	See Note	$ 1,031,500	$ -	Labor, materials, maintenance, well cleaning, reagents, reporting. Cost based on site experience in California and adjusted for flow and carbon demand. See Table D-14.
IRZ Well Replacement	10%	Capital Cost of Wells	$ 106,596	$ -	Replace 10% of wells each year.
Maintenance of Wells (Non IRZ)	See Note		$ 1,023,251	$ 393,341	Assume maintenance as percent of capital cost of wells. 10% for extraction and monitoring wells; 20% for injection wells.
Groundwater/Surface Water Monitoring	YR	See Note	$ 158,276	$ 67,500	$135,000/event for S&A, data mgmt. 6 events in first yr of a Phase, then 1 event/yr. Based on cost for recent similar activities at Topock. Every two years during Alt. B or LTM.
Reporting - Site-wide Groundwater Monitoring	YR	See Note	$ 121,241	$ 60,000	$156,000 for first sampling event in a Phase, then $120,000/year. Assume once per two years during LTM. Based on cost for recent similar activities at Topock.
Reporting - Performance	YR	See Note	$ 50,000	$ 25,000	Allowance of $50,000/report in years remedy is operating. Assume once per two years during LTM.
Other Facilities - Road maintenance	3.0 x 1,000 LF	$ 700	$ 2,126	$ -	
Other O&M Costs					
Permit Compliance	YR	See Note	$ 360,000	$ 72,000	$360,000/year based on IM3 compliance costs. 20% assumed during LTM.
Groundwater ICs	YR	$ 20,000	$ 20,000	$ 20,000	Allowance
Biological Surveys	YR	See Note	$ 100,000	$ 20,000	$100,000/yr from recent site costs for monitoring per PBA document. Spring DETO and SWFL surveys). 20% assumed during LTM.
Cultural Surveys	YR	See Note	$ 50,000	$ 10,000	Annual allowance. 20% assumed during LTM.
Reg/stakeholder oversight	YR	See Note	$ 100,000	$ 20,000	Annual allowance. 20% assumed during LTM.
Water rights	$/ac-ft	$ 27	$ 8,694	$ -	Based on current invoices from the City of Needles
5-year reviews	YR	$ 15,000	$ 15,000	$ 15,000	$75,000/review based on cost at other sites; done once per 5 years.
SUBTOTAL			$ 3,200,000	$ 703,000	
Contingency	25%		$800,000	$176,000	
SUBTOTAL			$4,000,000	$879,000	
TOTAL O&M COST			**$4,000,000**	**$900,000**	

POST-REMEDIATION DECONSTRUCTION COSTS

DESCRIPTION	QTY	UNIT	UNIT COST	TOTAL	NOTES
Restoration of areas disturbed during construction.	1	LS	$1,000,000	$1,000,000	Allowance
Deconstruct roads and small structures	1	LS	$700,000	$700,000	$500K allowance for roads (including Rt 66), $200K for structures other than treatment plant
Deconstruct wells	138	WELL	$30,000	$4,140,000	Cost per well from experience at Topock
Deconstruct new treatment plant	0	LS			
SUBTOTAL				$5,840,000	
Contingency	25%			$1,460,000	
TOTAL POST-REMEDIATION DECONSTRUCTION COST				**$7,300,000**	

PRESENT VALUE ANALYSIS

PERIOD	COST TYPE	TOTAL COST	TOTAL COST PER YEAR	DISCOUNT FACTOR[2]	PRESENT VALUE	NOMINAL VALUE	NOTES
							See Section D.2.4 for more information on Present Value calculations
0	CAPITAL COST, YEAR 0	$51,600,000	-	1.000	$51,600,000	$51,600,000	
29	ANNUAL O&M COST, YEAR 1-30		$4,000,000	18.785	$75,138,196	$116,000,000	
10	LONG TERM MONITORING, YEAR 31-40		$900,000	3.421	$3,078,878	$9,000,000	
41	POST-REMEDIATION DECONSTRUCTION, YEAR 41	$7,300,000	-	0.278	$2,030,637	$7,300,000	
	TOTAL PRESENT VALUE OF ALTERNATIVE				**$132,000,000**		
				Low Range		High Range	
				$92,000,000		**$198,000,000**	
Total Nominal Cost					**$184,000,000**		

Note:

Acronyms and abbreviations are defined in Table D-11. Total costs rounded to 3 significant figures.

Source Information:

1. Factors are applied cumulatively and based on United States Environmental Protection Agency. July 2000. A Guide to Developing and Documenting Cost Estimates During the Feasibility Study. EPA 540-R-00-002. (USEPA, 2000).
2. Discount factor of 3.17% per year is used

TABLE D-7

Alternative F

Remedial Alternative Cost Summary - Pump and Treat

Site: Topock
Date: 12/13/2009

CAPITAL COSTS

DESCRIPTION	QTY	UNIT	UNIT COST	TOTAL	NOTES
Wells					
Injection & Extraction Wells	1	See Note	$4,900,000	$4,900,000	See Table D-12
Monitoring	24	WELL	$60,800	$1,500,000	24 new wells assumed
SUBTOTAL				$6,400,000	
In Situ Systems					
IRZ	0	LS	$0	$0	
SUBTOTAL				$0	
Ex Situ Treatment					
Treatment plant	1	See Note	$18,100,000	$18,100,000	See Table D-15
SUBTOTAL				$18,100,000	
Infrastructure					
Pipelines & Conduit / Wire & Trench	1	See Note	$5,880,000	$5,880,000	See Table D-16
Access Roads	3.0	1,000 LF	$16,200	$50,000	
Fresh water					
Wells	0	2 WELLS	$333,900	$0	
Pipeline	0	1,000 LF	$160,000	$0	
SUBTOTAL				$5,930,000	
Remove IM3 Treatment Plant					
IM3 treatment - restoration and deconstruction	1	LS	$1,600,000	$1,600,000	See Table D-17
SUBTOTAL				$1,600,000	
SUBTOTAL				$32,000,000	
Prime Contractor Cost Factors[1]					
General Conditions (sub mob, sub GC)	10%			$3,200,000	USEPA costing guidance EPA-540-R-00-002
Field Construction Management and Engineer SDC	10%			$3,520,000	
Pre-construction (work plans, design, as-builts)	14%			$5,420,000	
Project Management	5%			$2,210,000	
Contractor Markup (G&A, fee)	21%			$9,730,000	
SUBTOTAL			75%	$24,100,000	
Miscellaneous					
Institutional Controls and other Administrative Approvals	1	CONSTR PHASES	$1,000,000	$1,000,000	Allowance
Biological Monitoring	1	CONSTR YRS	$330,000	$330,000	Allowance
Cultural Monitoring	1	CONSTR YRS	$330,000	$330,000	Allowance
Regulatory Oversight	1	CONSTR YRS	$300,000	$300,000	Allowance
Soil Cuttings	1	CONSTR PHASES	$200,000	$200,000	Allowance - see also Section D.2.1.7 for description of this line item.
SUBTOTAL				$58,300,000	
Contingency	25%			$14,600,000	
TOTAL CAPITAL COST				**$72,900,000**	
			Low Range		High Range
			$51,000,000		**$109,000,000**

Alternative F

Remedial Alternative Cost Summary - Pump and Treat

OPERATIONS AND MAINTENANCE COST

DESCRIPTION	UNITS	UNIT COST	ANNUAL O&M COST O&M	 Long-Term Mon.	NOTES
		Duration:	37 years	10 years	
Ex Situ Treatment Plant O&M	YR	$ 5,500,000	$ 5,500,000	$ -	Increased from IM3 cost per flow ratio as appropriate (IM3 treats 135 gpm)
Freshwater well maintenance & pumping	100 gpm	$ 11,108	$ -	$ -	
IRZ	YR	See Note	$ -	$ -	
IRZ Well Replacement	10% Capital Cost of Wells			$ -	
Maintenance of Wells (Non IRZ)	See Note		$ 875,000	$ 373,000	Assume maintenance as percent of capital cost of wells. 10% for extraction and monitoring wells; 20% for injection wells.
Groundwater/Surface Water Monitoring	YR	See Note	$ 153,000	$ 67,500	$135,000/event for S&A, data mgmt. 6 events in first yr of a Phase, then 1 event/yr. Based on cost for recent similar activities at Topock. Every two years during Alt. B or LTM.
Reporting - Site-wide Groundwater Monitoring	YR	See Note	$ 121,000	$ 60,000	$156,000 for first sampling event in a Phase, then $120,000/year. Assume once per two years during LTM. Based on cost for recent similar activities at Topock.
Reporting - Performance	YR	See Note	$ 50,000	$ 25,000	Allowance of $50,000/report in years remedy is operating. Assume once per two years during LTM.
Other Facilities - Road maintenance	3.0 x 1,000 LF	$ 700	$ 2,079	$ -	
Other O&M Costs					
Permit Compliance	YR	See Note	$ 360,000	$ 72,000	$360,000/year based on IM3 compliance costs. 20% assumed during LTM.
Groundwater ICs	YR	$ 20,000	$ 20,000	$ 20,000	Allowance
Biological Surveys	YR	See Note	$ 100,000	$ 20,000	$100,000/yr from recent site costs for monitoring per PBA document. Spring DETO and SWFL surveys). 20% assumed during LTM.
Cultural Surveys	YR	See Note	$ 50,000	$ 10,000	Annual allowance. 20% assumed during LTM.
Reg/stakeholder oversight	YR	See Note	$ 100,000	$ 20,000	Annual allowance. 20% assumed during LTM.
Water rights	$/ac-ft	$ 27	$ 8,694	$ -	Based on current invoices from the City of Needles
5-year reviews	YR	$ 15,000	$ 15,000	$ 15,000	$75,000/review based on cost at other sites; done once per 5 years.
SUBTOTAL			$ 7,350,000	$ 683,000	
Contingency	25%		$1,840,000	$171,000	
SUBTOTAL			$9,190,000	$854,000	
TOTAL O&M COST			**$9,200,000**	**$900,000**	

POST-REMEDIATION DECONSTRUCTION COSTS

DESCRIPTION	QTY	UNIT	UNIT COST	TOTAL	NOTES
Restoration of areas disturbed during construction.	1	LS	$1,000,000	$1,000,000	Allowance
Deconstruct roads and small structures	1	LS	$700,000	$700,000	$500K allowance for roads (including Rt 66), $200K for structures other than treatment plant
Deconstruct wells	167	WELL	$30,000	$5,010,000	Cost per well from experience at Topock
Deconstruct new treatment plant	1	LS	$10,339,913	$10,300,000	See Table D-17
SUBTOTAL				$17,010,000	
Contingency	25%			$4,252,500	
TOTAL POST-REMEDIATION DECONSTRUCTION COST				**$21,300,000**	

PRESENT VALUE ANALYSIS

PERIOD	COST TYPE	TOTAL COST	TOTAL COST PER YEAR	DISCOUNT FACTOR^2	PRESENT VALUE	NOMINAL VALUE	NOTES
							See Section D.2.4 for more information on Present Value calculations
0	CAPITAL COST, YEAR 0	$72,900,000	-	1.000	$72,900,000	$72,900,000	
37	ANNUAL O&M COST, YEAR 1-37		$9,200,000	20.297	$186,730,179	$340,000,000	
10	LONG TERM MONITORING, YEAR 38-47		$900,000	2.504	$2,253,503	$9,000,000	
48	POST-REMEDIATION DECONSTRUCTION, YEAR 48	$21,300,000	-	0.224	$4,762,280	$21,300,000	
	TOTAL PRESENT VALUE OF ALTERNATIVE				**$267,000,000**		
				Low Range **$187,000,000**		High Range **$401,000,000**	
Total Nominal Cost					**$443,000,000**		

Note:

Acronyms and abbreviations are defined in Table D-11. Total costs rounded to 3 significant figures.

Source Information:

1. Factors are applied cumulatively and based on United States Environmental Protection Agency. July 2000. A Guide to Developing and Documenting Cost Estimates During the Feasibility Study. EPA 540-R-00-002. (USEPA, 2000).
2. Discount factor of 3.17% per year is used

TABLE D-8

Alternative G

Remedial Alternative Cost Summary - Combined Floodplain In Situ/Pump and Treat

Site: Topock
Date: 12/13/2009

CAPITAL COSTS

DESCRIPTION	QTY	UNIT	UNIT COST	TOTAL	NOTES
Wells					
Injection & Extraction Wells	1	See Note	$5,900,000	$5,900,000	See Table D-12
Monitoring	30	WELL	$60,800	$1,800,000	30 new wells assumed
SUBTOTAL				$7,700,000	
In Situ Systems					
IRZ	1	LS	$4,944,500	$4,940,000	See Table D-13d
SUBTOTAL				$4,940,000	
Ex Situ Treatment					
Treatment plant	1	See Note	$18,100,000	$18,100,000	See Table D-15
SUBTOTAL				$18,100,000	
Infrastructure					
Pipelines & Conduit / Wire & Trench	1	See Note	$8,270,000	$8,270,000	See Table D-16
Access Roads	6.0	1,000 LF	$16,200	$100,000	
Fresh water					
Wells	0	2 WELLS	$333,900	$0	
Pipeline	0	1,000 LF	$160,000	$0	
SUBTOTAL				$8,370,000	
Remove IM3 Treatment Plant					
IM3 treatment - restoration and deconstruction	1	LS	$1,600,000	$1,600,000	See Table D-17
SUBTOTAL				$1,600,000	
SUBTOTAL				$40,700,000	
Prime Contractor Cost Factors[1]					
General Conditions (sub mob, sub GC)	10%			$4,070,000	
Field Construction Management and Engineer SDC	10%			$4,480,000	
Pre-construction (work plans, design, as-builts)	14%			$6,900,000	USEPA costing guidance EPA-540-R-00-002
Project Management	5%			$2,810,000	
Contractor Markup (G&A, fee)	21%			$12,400,000	
SUBTOTAL			75%	$30,600,000	
Miscellaneous					
Institutional Controls and other Administrative Approvals	2	CONSTR PHASES	$1,000,000	$2,000,000	Allowance
Biological Monitoring	2	CONSTR YRS	$330,000	$660,000	Allowance
Cultural Monitoring	2	CONSTR YRS	$330,000	$660,000	Allowance
Regulatory Oversight	2	CONSTR YRS	$300,000	$600,000	Allowance
Soil Cuttings	2	CONSTR PHASES	$200,000	$400,000	Allowance - see also Section D.2.1.7 for description of this line item.
SUBTOTAL				$75,600,000	
Contingency	25%			$18,900,000	
TOTAL CAPITAL COST				**$94,500,000**	
			Low Range		High Range
			$66,200,000		**$142,000,000**

Alternative G

Remedial Alternative Cost Summary - Combined Floodplain In Situ/Pump and Treat

Site: Topock
Date: 12/13/2009

OPERATIONS AND MAINTENANCE COST

DESCRIPTION	UNITS	UNIT COST	Phase 1	Phase 2	Long-Term Mon.	NOTES
		Duration:	**2 years**	**22 years**	**10 years**	
Ex Situ Treatment Plant O&M	YR	$ 5,500,000	$ -	$ 5,500,000	$ -	Increase from IM3 cost per flow ratio as appropriate (IM3 treats 135 gpm)
Freshwater well maintenance & pumping	100 gpm	$ 11,108	$ -	$ -	$ -	
IRZ	YR	See Note	$ 1,445,500	$ -	$ -	Labor, materials, maintenance, well cleaning, reagents, reporting. Cost based on site experience in California and adjusted for flow and carbon demand. See Table D-14.
IRZ Well Replacement	10% Capital Cost of Wells		$ -	$ -	$ -	
Maintenance of Wells (Non IRZ)	See Note	$ -	$ -	$ 867,000	$ 403,000	Assume maintenance as percent of capital cost of wells. 10% for extraction and monitoring wells; 20% for injection wells.
Groundwater/Surface Water Monitoring	YR	See Note	$ -	$ 166,000	$ 67,500	$135,000/event for S&A, data mgmt. 6 events in first yr of a Phase, then 1 event/yr. Based on cost for recent similar activities at Topock.
Reporting - Site-wide Groundwater Monitoring	YR	See Note	$ -	$ 122,000	$ 60,000	$135,000/event for S&A, data mgmt. 6 events in first yr of a Phase, then 1 event/yr. Based on cost for recent similar activities at Topock. Every two years during Alt. B or LTM.
Reporting - Performance	YR	See Note	$ -	$ 50,000	$ 25,000	Allowance of $50,000/report in years remedy is operating. Assume once per two years during LTM.
Other Facilities - Road maintenance	6.0 x 1,000 LF	$ 700	$ -	$ 4,200	$ -	
Other O&M Costs			$ -			
Permit Compliance	YR	See Note	$ -	$ 360,000	$ 72,000	$360,000/year based on IM3 compliance costs. 20% assumed during LTM.
Groundwater ICs	YR	$ 20,000	$ -	$ 20,000	$ 20,000	Allowance
Biological Surveys	YR	See Note	$ -	$ 100,000	$ 20,000	$100,000/yr from recent site costs for monitoring per PBA document. Spring DETO and SWFL surveys). 20% assumed during LTM.
Cultural Surveys	YR	See Note	$ -	$ 50,000	$ 10,000	Annual allowance. 20% assumed during LTM.
Reg/stakeholder oversight	YR	See Note	$ -	$ 100,000	$ 20,000	Annual allowance. 20% assumed during LTM.
Water rights	$/ac-ft	$ 27	$ 8,694	$ 8,694	$ -	Based on current invoices from the City of Needles
5-year reviews	YR	$ 27	$ -	$ 15,000	$ 15,000	$75,000/review based on cost at other sites; done once per 5 years.
SUBTOTAL			$ 1,450,000	$ 7,360,000	$ 713,000	
Contingency	25%		$363,000	$1,840,000	$178,000	
SUBTOTAL			$1,810,000	$9,200,000	$891,000	
TOTAL O&M COST			**$1,800,000**	**$9,200,000**	**$900,000**	

POST-REMEDIATION DECONSTRUCTION COSTS

DESCRIPTION	QTY	UNIT	UNIT COST	TOTAL	NOTES
Restoration of areas disturbed during construction.	1	LS	$1,000,000	$1,000,000	Allowance
Deconstruct roads and small structures	1	LS	$700,000	$700,000	$500K allowance for roads (including Rt 66), $200K for structures other than treatment plant
Deconstruct wells	142	WELL	$30,000	$4,260,000	Cost per well from experience at Topock
Deconstruct new treatment plant	1	LS	$10,339,913	$10,300,000	See Table D-17
SUBTOTAL				$16,260,000	
Contingency	25%			$4,065,000	
TOTAL POST-REMEDIATION DECONSTRUCTION COST				**$20,300,000**	

PRESENT VALUE ANALYSIS

PERIOD	COST TYPE	TOTAL COST	TOTAL COST PER YEAR	DISCOUNT FACTOR[2]	PRESENT VALUE	NOMINAL VALUE	NOTES
							See Section D.2.4 for more information on Present Value calculations
0	CAPITAL COST, YEAR 0	$94,500,000	-	1.000	$94,500,000	$94,500,000	
2	PHASE 1 ANNUAL O&M COST, YEAR 1-2		$1,800,000	1.909	$3,435,779	$3,600,000	
22	PHASE 2 ANNUAL O&M COST, YEAR 1-22		$9,200,000	15.669	$144,153,489	$202,000,000	
10	LONG TERM MONITORING, YEAR 23-32		$900,000	3.999	$3,598,816	$9,000,000	
33	POST-REMEDIATION DECONSTRUCTION, YEAR 33	$20,300,000	-	0.357	$7,248,244	$20,300,000	
	TOTAL PRESENT VALUE OF ALTERNATIVE				**$253,000,000**		
				Low Range		High Range	
				$177,000,000		**$380,000,000**	
Total Nominal Cost					**$329,000,000**		

Note:

Acronyms and abbreviations are defined in Table D-11. Total costs rounded to 3 significant figures.

Source Information:

1. Factors are applied cumulatively and based on United States Environmental Protection Agency. July 2000. A Guide to Developing and Documenting Cost Estimates During the Feasibility Study. EPA 540-R-00-002. (USEPA, 2000).
2. Discount factor of 3.17% per year is used

TABLE D-9

Alternative H

Remedial Alternative Cost Summary - Combined Upland In Situ/Pump and Treat

Site: Topock
Date: 12/13/2009

CAPITAL COSTS

DESCRIPTION	QTY	UNIT	UNIT COST	TOTAL	NOTES
Wells					
Injection & Extraction Wells	1	See Note	$6,200,000	$6,200,000	See Table D-12
Monitoring	32	WELL	$60,800	$1,900,000	32 new wells assumed
SUBTOTAL				$8,100,000	
In Situ Systems					
IRZ	1	LS	$6,119,100	$6,119,100	See Table D-13e
SUBTOTAL				$6,119,100	
Ex Situ Treatment					
Treatment plant	1	See Note	$11,400,000	$11,400,000	See Table D-15
SUBTOTAL				$11,400,000	
Infrastructure					
Pipelines & Conduit / Wire & Trench	1	See Note	$9,270,000	$9,270,000	See Table D-16
Access Roads	5.8	1,000 LF	$16,200	$90,000	
Fresh water					
Wells	0	2 WELLS	$333,900	$0	
Pipeline	0	1,000 LF	$160,000	$0	
SUBTOTAL				$9,360,000	
Remove IM3 Treatment Plant					
IM3 treatment - restoration and deconstruction	1	LS	$1,600,000	$1,600,000	See Table D-17
SUBTOTAL				$1,600,000	
SUBTOTAL				$36,600,000	
Prime Contractor Cost Factors[1]					
General Conditions (sub mob, sub GC)	10%			$3,660,000	USEPA costing guidance EPA-540-R-00-002
Field Construction Management and Engineer SDC	10%			$4,030,000	
Pre-construction (work plans, design, as-builts)	14%			$6,200,000	
Project Management	5%			$2,520,000	
Contractor Markup (G&A, fee)	21%			$11,100,000	
SUBTOTAL			75%	$27,500,000	
Miscellaneous					
Institutional Controls and other Administrative Approvals	1	CONSTR PHASES	$1,000,000	$1,000,000	Allowance
Biological Monitoring	1	CONSTR YRS	$330,000	$330,000	Allowance
Cultural Monitoring	1	CONSTR YRS	$330,000	$330,000	Allowance
Regulatory Oversight	1	CONSTR YRS	$300,000	$300,000	Allowance
Soil Cuttings	1	CONSTR PHASES	$200,000	$200,000	Allowance - see also Section D.2.1.7 for description of this line item.
SUBTOTAL				$66,300,000	
Contingency	25%			$16,600,000	
TOTAL CAPITAL COST				**$82,900,000**	
			Low Range		High Range
			$58,000,000		**$124,000,000**

Alternative H

Remedial Alternative Cost Summary - Combined Upland In Situ/Pump and Treat

OPERATIONS AND MAINTENANCE COST

DESCRIPTION	UNITS	UNIT COST	O&M	Long-Term Mon.	NOTES
		Duration:	18 years	10 years	
Ex Situ Treatment Plant O&M	YR	$ 2,700,000	$ 2,700,000	$ -	Increase from IM3 cost per flow ratio as appropriate (IM3 treats 135 gpm)
Freshwater well maintenance & pumping	100 gpm	$ 11,108	$ -	$ -	
IRZ	YR	See Note	$ 951,000	$ -	Labor, materials, maintenance, well cleaning, reagents, reporting. Cost based on site experience in California and adjusted for flow and carbon demand. See Table D-14.
IRZ Well Replacement	10%	Capital Cost of Wells	$ -	$ -	
Maintenance of Wells (Non IRZ)	See Note		$ 577,000	$ 413,000	Assume maintenance as percent of capital cost of wells. 10% for extraction and monitoring wells; 20% for injection wells.
Groundwater/Surface Water Monitoring	YR	See Note	$ 173,000	$ 67,500	$135,000/event for S&A, data mgmt. 6 events in first yr of a Phase, then 1 event/yr. Based on cost for recent similar activities at Topock. Every two years during Alt. B or LTM.
Reporting - Site-wide Groundwater Monitoring	YR	See Note	$ 122,000	$ 60,000	$156,000 for first sampling event in a Phase, then $120,000/year. Assume once per two years during LTM. Based on cost for recent similar activities at Topock.
Reporting - Performance	YR	See Note	$ 50,000	$ 25,000	Allowance of $50,000/report in years remedy is operating. Assume once per two years during LTM.
Other Facilities - Road maintenance	5.8 x 1,000 LF	$ 700	$ 4,026	$ -	
Other O&M Costs					
Permit Compliance	YR	See Note	$ 360,000	$ 72,000	$360,000/year based on IM3 compliance costs. 20% assumed during LTM.
Groundwater ICs	YR	$ 20,000	$ 20,000	$ 20,000	Allowance
Biological Surveys	YR	See Note	$ 100,000	$ 20,000	$100,000/yr from recent site costs for monitoring per PBA document. Spring DETO and SWFL surveys). 20% assumed during LTM.
Cultural Surveys	YR	See Note	$ 50,000	$ 10,000	Annual allowance. 20% assumed during LTM.
Reg/stakeholder oversight	YR	See Note	$ 100,000	$ 20,000	Annual allowance. 20% assumed during LTM.
Water rights	$/ac-ft	$ 27	$ 8,694	$ -	Based on current invoices from the City of Needles
5-year reviews	YR	$ 15,000	$ 15,000	$ 15,000	$75,000/review based on cost at other sites; done once per 5 years.
SUBTOTAL			$ 5,230,000	$ 723,000	
Contingency	25%		$1,310,000	$181,000	
SUBTOTAL			$6,540,000	$904,000	
TOTAL O&M COST			**$6,500,000**	**$900,000**	

POST-REMEDIATION DECONSTRUCTION COSTS

DESCRIPTION	QTY	UNIT	UNIT COST	TOTAL	NOTES
Restoration of areas disturbed during construction.	1	LS	$1,000,000	$1,000,000	Allowance
Deconstruct roads and small structures	1	LS	$700,000	$700,000	$500K allowance for roads (including Rt 66), $200K for structures other than treatment plant
Deconstruct wells	209	WELL	$30,000	$6,270,000	Cost per well from experience at Topock
Deconstruct new treatment plant	1	LS	$4,731,825	$4,730,000	See Table D-17
SUBTOTAL				$12,700,000	
Contingency	25%			$3,175,000	
TOTAL POST-REMEDIATION DECONSTRUCTION COST				**$15,900,000**	

PRESENT VALUE ANALYSIS

PERIOD	COST TYPE	TOTAL COST	TOTAL COST PER YEAR	DISCOUNT FACTOR[2]	PRESENT VALUE	NOMINAL VALUE	NOTES
							See Section D.2.4 for more information on Present Value calculations
0	CAPITAL COST, YEAR 0	$82,900,000	-	1.000	$82,900,000	$82,900,000	
18	ANNUAL O&M COST, YEAR 1-18		$6,500,000	13.558	$88,126,366	$117,000,000	
10	LONG TERM MONITORING, YEAR 19-28		$900,000	4.822	$4,339,905	$9,000,000	
29	POST-REMEDIATION DECONSTRUCTION, YEAR 29	$15,900,000	-	0.405	$6,432,024	$15,900,000	
	TOTAL PRESENT VALUE OF ALTERNATIVE				**$182,000,000**		
				Low Range		High Range	
				$127,000,000		**$273,000,000**	
Total Nominal Cost					**$225,000,000**		

Note:

Acronyms and abbreviations are defined in Table D-11. Total costs rounded to 3 significant figures.

Source Information:

1. Factors are applied cumulatively and based on United States Environmental Protection Agency. July 2000. A Guide to Developing and Documenting Cost Estimates During the Feasibility Study. EPA 540-R-00-002. (USEPA, 2000).
2. Discount factor of 3.17% per year is used

TABLE D-10

Alternative I

Remedial Alternative Cost Summary - Continued Operation of Interim Measure

Site: Topock
Date: 12/13/2009

CAPITAL COSTS

DESCRIPTION	QTY	UNIT	UNIT COST	TOTAL		NOTES
Wells						
Injection & Extraction Wells	0			$0		
Monitoring	0	WELL	$60,800	$0		0 new wells assumed
SUBTOTAL				$0		
In Situ Systems						
IRZ	0	LS	$460,000	$0		
SUBTOTAL				$0		
Ex Situ Treatment						
Treatment plant	0			$0		
SUBTOTAL				$0		
Infrastructure						
Pipelines & Conduit / Wire & Trench	0	See Note	$0	$0		
Access Roads	0	1,000 LF	$16,200	$0		
Fresh water						
Wells	0	2 WELLS	$333,900	$0		
Pipeline	0	1,000 LF	$160,000	$0		
SUBTOTAL				$0		
Remove IM3 Treatment Plant						
IM3 treatment - restoration and deconstruction	0	LS	$1,600,000	$0		Is included in POST-REMEDIATION DECONSTRUCTION COSTS for this Alternative
SUBTOTAL				$0		
SUBTOTAL				$0		
Prime Contractor Cost Factors[1]						
General Conditions (sub mob, sub GC)	10%			$0		USEPA costing guidance EPA-540-R-00-002
Field Construction Management and Engineer SDC	10%			$0		
Pre-construction (work plans, design, as-builts)	14%			$0		
Project Management	5%			$0		
Contractor Markup (G&A, fee)	21%			$0		
SUBTOTAL			75%	$0		
Miscellaneous						
Institutional Controls and other Administrative Approvals	0	CONSTR PHASES	$1,000,000	$0		Allowance
Biological Monitoring	0	CONSTR YRS	$330,000	$0		Allowance
Cultural Monitoring	0	CONSTR YRS	$330,000	$0		Allowance
Regulatory Oversight	0	CONSTR YRS	$300,000	$0		Allowance
Soil Cuttings	0	CONSTR PHASES	$200,000	$0		Allowance - see also Section D.2.1.7 for description of this line item.
SUBTOTAL				$0		
Contingency	25%			$0		
TOTAL CAPITAL COST				**$0**		
			Low Range		High Range	
			$0		**$0**	

Alternative I

Remedial Alternative Cost Summary - Continued Operation of Interim Measure

OPERATIONS AND MAINTENANCE COST

DESCRIPTION	UNITS	UNIT COST	O&M	Long-Term Mon.	NOTES
		Duration:	240 years	10 years	
Ex Situ Treatment Plant O&M	YR	$ 5,420,000	$ 5,420,000	$ -	IM3 costs (which includes disposal of brine)
Freshwater well maintenance & pumping	100 gpm	$ 11,108	$ -	$ -	
IRZ	YR		$ -	$ -	
IRZ Well Replacement	10%			$ -	
Maintenance of Wells (Non IRZ)	See Note		$ 294,000	$ 223,000	Assume maintenance as percent of capital cost of wells. 10% for extraction and monitoring wells; 20% for injection wells.
Groundwater/Surface Water Monitoring	YR	See Note	$ 138,000	$ 67,500	$135,000/event for S&A, data mgmt. 6 events in first yr of a Phase, then 1 event/yr. Based on cost for recent similar activities at Topock. Every two years during Alt. B or LTM.
Reporting - Site-wide Groundwater Monitoring	YR	See Note	$ 120,000	$ 60,000	$156,000 for first sampling event in a Phase, then $120,000/year. Assume once per two years during LTM. Based on cost for recent similar activities at Topock.
Reporting - Performance	YR	See Note	$ 50,000	$ 25,000	Allowance of $50,000/report in years remedy is operating. Assume once per two years during LTM.
Other Facilities - Road maintenance	0.0 x 1,000 LF	$ 700	$ -	$ -	
Other O&M Costs					
Permit Compliance	YR	See Note	$ 360,000	$ 72,000	$360,000/year based on IM3 compliance costs. 20% assumed during LTM.
Groundwater ICs	YR	$ 20,000	$ 20,000	$ 20,000	Allowance
Biological Surveys	YR	See Note	$ 100,000	$ 20,000	$100,000/yr from recent site costs for monitoring per PBA document. Spring DETO and SWFL surveys). 20% assumed during LTM.
Cultural Surveys	YR	See Note	$ 50,000	$ 10,000	Annual allowance. 20% assumed during LTM.
Reg/stakeholder oversight	YR	See Note	$ 100,000	$ 20,000	Annual allowance. 20% assumed during LTM.
Water rights	$/ac-ft	$ 27	$ 8,694	$ -	Based on current invoices from the City of Needles
5-year reviews	YR	$ 15,000	$ 15,000	$ 15,000	$75,000/review based on cost at other sites; done once per 5 years.
SUBTOTAL			$ 6,680,000	$ 533,000	
Contingency	25%		$1,670,000	$133,000	
SUBTOTAL			$8,350,000	$666,000	
TOTAL O&M COST			**$8,400,000**	**$700,000**	

POST-REMEDIATION DECONSTRUCTION COSTS

DESCRIPTION	QTY	UNIT	UNIT COST	TOTAL	NOTES
Restoration of areas disturbed during construction.	1	LS	$1,000,000	$1,000,000	Allowance
Deconstruct roads and small structures	1	LS	$700,000	$700,000	$500K allowance for roads (including Rt 66), $200K for structures other than treatment plant
Deconstruct wells	142	WELL	$30,000	$4,260,000	Cost per well from experience at Topock
Deconstruct IM3 treatment plant	1	LS	$2,804,044	$2,800,000	See Table D-17
SUBTOTAL				$8,760,000	
Contingency	25%			$2,190,000	
TOTAL POST-REMEDIATION DECONSTRUCTION COST				**$11,000,000**	

PRESENT VALUE ANALYSIS

PERIOD	COST TYPE	TOTAL COST	TOTAL COST PER YEAR	DISCOUNT FACTOR^2	PRESENT VALUE	NOMINAL VALUE	NOTES
							See Section D.2.4 for more information on Present Value calculations
0	CAPITAL COST, YEAR 0	$0	-	1.000	$0	$0	
240	ANNUAL O&M COST, YEAR 1-240		$8,400,000	31.528	$264,836,181	$2,020,000,000	
10	LONG TERM MONITORING, YEAR 241-250		$700,000	0.005	$3,307	$7,000,000	
251	POST-REMEDIATION DECONSTRUCTION, YEAR 251	$11,000,000		0.013	$141,842	$11,000,000	
	TOTAL PRESENT VALUE OF ALTERNATIVE				**$265,000,000**		
				Low Range		High Range	
				$186,000,000		**$398,000,000**	

Total Nominal Cost **$2,030,000,000**

Note:

Acronyms and abbreviations are defined in Table D-11. Total costs rounded to 3 significant figures.

Source Information:

1. Factors are applied cumulatively and based on United States Environmental Protection Agency. July 2000. A Guide to Developing and Documenting Cost Estimates During the Feasibility Study. EPA 540-R-00-002. (USEPA, 2000).
2. Discount factor of 3.17% per year is used

TABLE D-11

Acronyms and Abbreviations Used in Cost Summaries

Corrective Measures Study/Feasibility Study Report for Chromium in Groundwater

1000 LF	1000 linear feet
$K	Thousands of dollars
5 Yr Rev	Five Year Review
ac-ft	acre-feet
Bio/Cult	Biological/Cultural Resources Monitoring
C	Carbon
CONSTR	Construction
DETO	Desert Tortoise
G&A	General and Administrative
GC	General Conditions
gpm	Gallons per minute
HR	Hour
ICs	Institutional Controls
IM3	Interim Measures Number 3
IRZ	In situ Reduction Zone
LF	Linear feet
LS	Lump Sum
LTM	Long-Term Monitoring
O&M	Operations and Maintenance
PBA	Programmatic Biological Assessment
QTY	Quantity
Reg	Regulatory
Rt 66	Route 66
S&A	Sampling and Analysis
SDC	Services During Construction
Sub GC	Subcontractor General Conditions
Sub Mob	Subcontractor Mobilization
SWFL	Southwestern Willow Flycatcher
USEPA	United States Environmental Protection Agency
YRS	Years

TABLE D-12

Well Installation Costs

Corrective Measures Study/ Feasibility Study Report for Chromium in Groundwater

						Alt. C - Phase 1		**Alt. C - Phase 2**		**Alt. D**		**Alt. E**		**Alt. F**		**Alt. G - Phase 1**		**Alt. G - Phase 2**		**Alt. H**	
	/well	**wells**	**$**	**wells**	**$**	**wells**	**$**	**wells**	**$**	**wells**	**$**	**wells**	**$**	**wells**	**$**	**wells**	**$**	**wells**	**$**	**wells**	**$**
EXTRACTION																					
Mud drilling / upland		0	$ -																		
4" PVC	$ 112,500	0	$ -	0	$ -	0	$ -	0	$ -		$ -		$ -		$ -		$ -		$ -	0	$ -
4" SS	$ 119,100	0	$ -	0	$ -	0	$ -	0	$ -		$ -	2	$ 238,200		$ -		$ -		$ -	0	$ -
6" SS	$ 125,700	0	$ -	0	$ -	0	$ -	0	$ -		$ -	2	$ 251,400		$ -		$ -	1	$ 125,700	0	$ -
8" SS	$ 142,200	0	$ -	0	$ -	0	$ -	0	$ -		$ -		$ -		$ -		$ -	2	$ 284,400	0	$ -
10" SS	$ 158,700	0	$ -	0	$ -	0	$ -	0	$ -		$ -	1	$ 158,700	5	$ 793,500		$ -		$ -	0	$ -
12" SS	$ 175,200	0	$ -		$ -	0	$ -	0	$ -		$ -		$ -		$ -		$ -	2	$ 350,400	0	$ -
Sonic drilling / floodplain																					
4" PVC	$ 85,250	0	$ -	0	$ -	0	$ -	0	$ -		$ -		$ -		$ -		$ -		$ -	0	$ -
4" SS	$ 90,450	0	$ -	0	$ -	0	$ -	0	$ -		$ -		$ -		$ -		$ -		$ -	1	$ 90,450
6" SS	$ 102,800	0	$ -	0	$ -	0	$ -	0	$ -		$ -	6	$ 616,800		$ -		$ -		$ -	4	$ 411,200
Total		**0**	**$ -**	**0**	**$ -**	**0**	**$ -**	**0**	**$ -**	**0**	**$ -**	**11**	**$ 1,265,100**	**5**	**$ 793,500**		**$ -**	**5**	**$ 760,500**	**5**	**$ 501,650**
Bedrock		0	$ -																		
4" PVC	$ 135,000	0	$ -	0	$ -		$ -	15	$ 2,025,000	15	$ 2,025,000	15	$ 2,025,000	15	$ 2,025,000	0	$ -	15	$ 2,025,000	15	$ 2,025,000
4" SS	$ 142,920	0	$ -	0	$ -		$ -	0	$ -		$ -		$ -		$ -		$ -		$ -	0	$ -
6" SS	$ 150,840	0	$ -	0	$ -		$ -	0	$ -		$ -		$ -		$ -		$ -		$ -	0	$ -
8" SS	$ 170,640	0	$ -	0	$ -		$ -	0	$ -		$ -		$ -		$ -		$ -		$ -	0	$ -
10" SS	$ 190,440	0	$ -	0	$ -		$ -	0	$ -		$ -		$ -		$ -		$ -		$ -	0	$ -
12" SS	$ 210,240	0	$ -		$ -		$ -		$ -		$ -		$ -		$ -		$ -		$ -	0	$ -
INJECTION		**wells**	**$**	**wells**	**$**																
Mud drilling / upland		0	$ -																		
4" PVC	$ 112,500	0	$ -	0	$ -	0	$ -	0	$ -		$ -		$ -		$ -		$ -		$ -	0	$ -
4" SS	$ 119,100	0	$ -	0	$ -	0	$ -	0	$ -		$ -		$ -		$ -		$ -		$ -	0	$ -
6" SS	$ 125,700	0	$ -	0	$ -	0	$ -	0	$ -		$ -		$ -	2	$ 251,400		$ -	2	$ 251,400	0	$ -
8" SS	$ 142,200	0	$ -	0	$ -	0	$ -	0	$ -		$ -	5	$ 711,000	1	$ 142,200		$ -	1	$ 142,200	4	$ 568,800
10" SS	$ 158,700	0	$ -	0	$ -	0	$ -	0	$ -		$ -	5	$ 793,500	2	$ 317,400		$ -	2	$ 317,400	0	$ -
12" SS	$ 175,200	0	$ -		$ -	0	$ -	0	$ -		$ -	0	$ -	8	$ 1,401,600		$ -	7	$ 1,226,400	0	$ -
Sonic drilling / floodplain																					
4" PVC	$ 85,250	0	$ -	0	$ -	0	$ -	0	$ -		$ -		$ -		$ -		$ -		$ -	0	$ -
4" SS	$ 90,450	0	$ -	0	$ -	0	$ -	0	$ -		$ -		$ -		$ -		$ -		$ -	0	$ -
6" SS	$ 102,800	0	$ -	0	$ -	0	$ -	0	$ -		$ -		$ -		$ -		$ -		$ -	0	$ -
Total		**0**	**$ -**	**0**	**$0**	**0**	**$0**	**0**	**$ -**	**0**	**$0**	**10**	**$ 1,504,500**	**13**	**$ 2,112,600**	**0**	**$0**	**12**	**$ 1,937,400**	**4**	**$ 568,800**
IRZ		**wells**	**$**	**wells**	**$**																
Mud drilling / upland			$ -																		
4" PVC	$ 62,500	0	$ -	0	$ -	0	$ -	0	$ -	0	$ -		$ -		$ -	0	$ -		$ -		$ -
4" SS	$ 69,100	0	$ -	0	$ -	0	$ -	0	$ -	0	$ -		$ -		$ -	0	$ -		$ -	39	$ 2,694,900
6" SS	$ 75,700	0	$ -	0	$ -	0	$ -	42	$ 3,179,400	7	$ 529,900		$ -		$ -	0	$ -		$ -		$ -
8" SS	$ 92,200	0	$ -	0	$ -	0	$ -	2	$ 184,400	48	$ 4,425,600		$ -		$ -	0	$ -		$ -	4	$ 368,800
10" SS	$ 108,700	0	$ -	0	$ -	0	$ -	8	$ 869,600	14	$ 1,521,800		$ -		$ -	0	$ -		$ -		$ -
12" SS	$ 125,200	0	$ -		$ -	0	$ -	3	$ 375,600	0	$ -		$ -		$ -	0	$ -		$ -		$ -
Sonic drilling / floodplain																					
4" PVC (Note 2)	$ 35,250	0	$ -	0	$ -	33	$ 1,163,250	0	$ -	0	$ -	18	$ 1,065,960		$ -	33	$ 1,163,250		$ -	0	$ -
4" SS	$ 40,450	0	$ -	0	$ -	0	$ -	2	$ 80,900	0	$ -		$ -		$ -		$ -		$ -	0	$ -
6" SS	$ 52,800	0	$ -	0	$ -	0	$ -	12	$ 633,600	10	$ 528,000		$ -		$ -		$ -		$ -	0	$ -
Total		**0**	**$ -**	**0**	**$0**	**33**	**$1,163,250**	**69**	**$ 5,323,500**	**79**	**$ 7,005,300**	**18**	**$1,065,960**	**0**	**$ -**	**33**	**$ 1,163,250**	**0**	**$ -**	**43**	**$ 3,063,700**
Grand Total			**$ -**		**$0**		**$1,163,250**		**$ 7,348,500**		**$9,030,300**		**$5,860,560**		**$4,931,100**		**$1,163,250**		**$4,722,900**		**$6,159,150**

Notes:

1. Cost of well is based on site specific project experience
2. For Alternative E, a higher unit cost for the IRZ wells was assumed to accommodate dual nested wells screens including the larger borehole and additional casing.

TABLE D-13a

Alternative C IRZ System Estimate, Topock, California

Corrective Measures Study/Feasibility Study Report for Chromium in Groundwater

Purchased Equipment Costs	**QTY**	**Unit**	**Unit Cost**	**Extension**	**Notes**
Main Node System Equipment (Three Nodes Total)					
Carbon Storage Tank	3	Each	$110,000	$330,000	12,000 Gallon Double Wall Steel Tank
Building(s) (Modified Shipping Containers)	3	LS	$45,000	$135,000	40' and 20' Modified Shipping Containers (1 of each)
Chemical Feed Pumps	6	Each	$5,000	$30,000	Feed Pump for Injecting Carbon
Mechanical Components	3	LS	$85,000	$255,000	Pipe, Valves, and Appurtanances
Electrical, Instrumentation, and Controls Components	3	LS	$200,000	$600,000	Panels, Switches, Flow Meters, Etc.
			Equipment Subtotal (EQ):	***$1,350,000***	
Taxes (9% of EQ)	1	Lump	$121,500	$121,500	
Freight (5% of EQ)	1	Lump	$67,500	$67,500	
			Total Purchased Equipment Cost (PEC):	***$1,539,000***	

Direct Installation Costs	**QTY**	**Unit**	**Unit Cost**	**Extension**	
General Requirements					
Equipment Installation (20% of PEC)				$307,800	
Mechanical Installation (20% of PEC)				$307,800	
Electrical Installation (25% of PEC)				$384,800	
Reinforced Concrete	1	LS	$250,000	$250,000	Tank/Building Pads and Tanker Offloading
IRZ Well Head Completion	102	Each	$50,000	$5,100,000	Average Extraction/Injection Well Vault Cost
Trenching, Subgrade Piping, and Electrical Duct Bank	5,300	LF	$410	$2,191,379	Including Electrical Handholes, Cleanouts, Etc.
Miscellaneous Equipment/Materials	1	LS	$500,000	$500,000	Remote Panels, Wireless, Etc.
			Total Direct Installation Cost (DI):	**$9,041,800**	
			TOTAL DIRECT COST (DC) [PEC + DI]:	**$10,580,800**	

TABLE D-13b

Alternative D IRZ System Estimate, Topock, California

Corrective Measures Study/Feasibility Study Report for Chromium in Groundwater

Purchased Equipment Costs	**QTY**	**Unit**	**Unit Cost**	**Extension**	**Notes**
Main Node System Equipment (Three Nodes Total)					
Carbon Storage Tank	3	Each	$110,000	$330,000	12,000 Gallon Double Wall Steel Tank
Building(s) (Modified Shipping Containers)	3	LS	$45,000	$135,000	40' and 20' Modified Shipping Containers (1 of each)
Chemical Feed Pumps	6	Each	$5,000	$30,000	Feed Pump for Injecting Carbon
Mechanical Components	3	LS	$85,000	$255,000	Pipe, Valves, and Appurtanances
Electrical, Instrumentation, and Controls Components	3	LS	$200,000	$600,000	Panels, Switches, Flow Meters, Etc.
			Equipment Subtotal (EQ):	***$1,350,000***	
Taxes (9% of EQ)	1	Lump	$121,500	$121,500	
Freight (5% of EQ)	1	Lump	$67,500	$67,500	
			Total Purchased Equipment Cost (PEC):	***$1,539,000***	

Direct Installation Costs	**QTY**	**Unit**	**Unit Cost**	**Extension**	
General Requirements					
Equipment Installation (20% of PEC)				$307,800	
Mechanical Installation (20% of PEC)				$307,800	
Electrical Installation (25% of PEC)				$384,800	
Reinforced Concrete	1	LS	$250,000	$250,000	Tank/Building Pads and Tanker Offloading
IRZ Well Head Completion	79	Each	$50,000	$3,950,000	Average Extraction/Injection Well Vault Cost
Trenching, Subgrade Piping, and Electrical Duct Bank	0	LF	$0	$0	Costs accounted for on Table D-16
Miscellaneous Equipment/Materials	1	LS	$500,000	$500,000	Remote Panels, Wireless, Etc.
			Total Direct Installation Cost (DI):	**$5,700,400**	
			TOTAL DIRECT COST (DC) [PEC + DI]:	**$7,239,400**	

TABLE D-13c

Alternative E IRZ System Estimate, Topock, California

Corrective Measures Study/Feasibility Study Report for Chromium in Groundwater

Purchased Equipment Costs	**QTY**	**Unit**	**Unit Cost**	**Extension**	**Notes**
Main Node System Equipment (One Node Only)					
Carbon Storage Tank	1	Each	$110,000	$110,000	12,000 Gallon Double Wall Steel Tank
Building(s) (Modified Shipping Containers)	1	LS	$45,000	$45,000	40' and 20' Modified Shipping Containers (1 of each)
Chemical Feed Pumps	2	Each	$5,000	$10,000	Feed Pump for Injecting Carbon
Mechanical Components	1	LS	$85,000	$85,000	Pipe, Valves, and Appurtanances
Electrical, Instrumentation, and Controls Components	1	LS	$200,000	$200,000	Panels, Switches, Flow Meters, Etc.
			Equipment Subtotal (EQ):	***$450,000***	
Taxes (9% of EQ)	1	Lump	$40,500	$40,500	
Freight (5% of EQ)	1	Lump	$22,500	$22,500	
			Total Purchased Equipment Cost (PEC):	***$513,000***	

Direct Installation Costs	**QTY**	**Unit**	**Unit Cost**	**Extension**	
General Requirements					
Equipment Installation (20% of PEC)				$102,600	
Mechanical Installation (20% of PEC)				$102,600	
Electrical Installation (25% of PEC)				$128,300	
Reinforced Concrete	1	LS	$125,000	$125,000	Tank/Building Pads and Tanker Offloading
IRZ Well Head Completion	18	Each	$70,000	$1,260,000	Extraction/Injection Well Vault Cost for dual screens
Trenching, Subgrade Piping, and Electrical Duct Bank	2,900	LF	$570	$1,653,000	Including Electrical Handholes, Cleanouts, Etc.
Miscellaneous Equipment/Materials	1	LS	$150,000	$150,000	Remote Panels, Wireless, Etc.
			Total Direct Installation Cost (DI):	**$3,521,500**	
			TOTAL DIRECT COST (DC) [PEC + DI]:	**$4,034,500**	

TABLE D-13d

Alternative G IRZ System Estimate, Topock, California

Corrective Measures Study/Feasibility Study Report for Chromium in Groundwater

Purchased Equipment Costs	**QTY**	**Unit**	**Unit Cost**	**Extension**	**Notes**
Main Node System Equipment (One Node Only)					
Carbon Storage Tank	1	Each	$110,000	$110,000	12,000 Gallon Double Wall Steel Tank
Building(s) (Modified Shipping Containers)	1	LS	$45,000	$45,000	40' and 20' Modified Shipping Containers (1 of each)
Chemical Feed Pumps	2	Each	$5,000	$10,000	Feed Pump for Injecting Carbon
Mechanical Components	1	LS	$85,000	$85,000	Pipe, Valves, and Appurtanances
Electrical, Instrumentation, and Controls Components	1	LS	$200,000	$200,000	Panels, Switches, Flow Meters, Etc.
			Equipment Subtotal (EQ):	***$450,000***	
Taxes (9% of EQ)	1	Lump	$40,500	$40,500	
Freight (5% of EQ)	1	Lump	$22,500	$22,500	
			Total Purchased Equipment Cost (PEC):	***$513,000***	

Direct Installation Costs	**QTY**	**Unit**	**Unit Cost**	**Extension**	
General Requirements					
Equipment Installation (20% of PEC)				$102,600	
Mechanical Installation (20% of PEC)				$102,600	
Electrical Installation (25% of PEC)				$128,300	
Reinforced Concrete	1	LS	$125,000	$125,000	Tank/Building Pads and Tanker Offloading
IRZ Well Head Completion	33	Each	$50,000	$1,650,000	Average Extraction/Injection Well Vault Cost
Trenching, Subgrade Piping, and Electrical Duct Bank	5,300	LF	$410	$2,173,000	Including Electrical Handholes, Cleanouts, Etc.
Miscellaneous Equipment/Materials	1	LS	$150,000	$150,000	Remote Panels, Wireless, Etc.
			Total Direct Installation Cost (DI):	**$4,431,500**	
			TOTAL DIRECT COST (DC) [PEC + DI]:	**$4,944,500**	

TABLE D-13e

Alternative H IRZ System Estimate, Topock, California

Corrective Measures Study/Feasibility Study Report for Chromium in Groundwater

Purchased Equipment Costs	**QTY**	**Unit**	**Unit Cost**	**Extension**	**Notes**
Main Node System Equipment (One Node Only)					
Carbon Storage Tank	1	Each	$80,000	$80,000	8,000 Gallon Double Wall Steel Tank
Building(s) (Modified Shipping Containers)	1	LS	$45,000	$45,000	40' and 20' Modified Shipping Containers (1 of each)
Chemical Feed Pumps	2	Each	$5,000	$10,000	Feed Pump for Injecting Carbon
Mechanical Components	1	LS	$85,000	$85,000	Pipe, Valves, and Appurtanances
Electrical, Instrumentation, and Controls Components	1	LS	$200,000	$200,000	Panels, Switches, Flow Meters, Etc.
			Equipment Subtotal (EQ):	***$420,000***	
Taxes (9% of EQ)	1	Lump	$37,800	$37,800	
Freight (5% of EQ)	1	Lump	$21,000	$21,000	
			Total Purchased Equipment Cost (PEC):	***$478,800***	

Direct Installation Costs	**QTY**	**Unit**	**Unit Cost**	**Extension**	
General Requirements					
Equipment Installation (20% of PEC)				$95,800	
Mechanical Installation (20% of PEC)				$95,800	
Electrical Installation (25% of PEC)				$119,700	
Reinforced Concrete	1	LS	$125,000	$125,000	Tank/Building Pads and Tanker Offloading
IRZ Well Head/Downhole Completion	43	Each	$50,000	$2,150,000	Average Extraction/Injection Well Vault Cost
Trenching, Subgrade Piping, and Electrical Duct Bank	6,600	LF	$440	$2,904,000	Including Electrical Handholes, Cleanouts, Etc.
Miscellaneous Equipment/Materials	1	LS	$150,000	$150,000	Remote Panels, Wireless, Etc.
			Total Direct Installation Cost (DI):	**$5,640,300**	
			TOTAL DIRECT COST (DC) [PEC + DI]:	**$6,119,100**	

Table D-14

Summary of IRZ Alternatives Annual O&M Estimates

Corrective Measures Study/Feasibility Study Report for Chromium in Groundwater

IRZ Alternative	Estimated Annual O&M Cost	Operational Uptime	Estimated Annual O&M Cost (w/Uptime Factored In)
Alternative C - IRZ			
Phase 1	$ 2,891,000	50%	$ 1,445,500
Phase 2	$ 9,575,000	50%	$ 4,787,500
Phase 3	$ 4,589,000	50%	$ 2,294,500
Alternative D - IRZ			
Phase 1	$ 6,698,000	50%	$ 3,349,000
Phase 2	$ 4,033,000	50%	$ 2,016,500
Phase 3	$ 3,653,000	50%	$ 1,826,500
Phase 4	$ 3,653,000	50%	$ 1,826,500
Phase 5	$ 3,653,000	50%	$ 1,826,500
Phase 6	$ 3,653,000	50%	$ 1,826,500
Phase 7	$ 1,940,000	50%	$ 970,000
Phase 8	$ 1,940,000	50%	$ 970,000
Phase 9	$ 1,283,000	50%	$ 641,500
Phase 10	$ 1,064,000	50%	$ 532,000
Alternative E - IRZ			
NTH Wells	$ 1,399,000	50%	$ 699,500
Upland Wells	$ 664,000	50%	$ 332,000
Alternative G - IRZ	$ 2,891,000	50%	$ 1,445,500
Alternative H - IRZ	$ 1,902,000	50%	$ 951,000

Table D-14a

Alternative C IRZ System Annual O&M Estimate

Corrective Measures Study/Feasibility Study Report for Chromium in Groundwater

Phase 1 Annual O&M Costs	QTY	Unit	Unit Cost	Extension	Notes
Labor	52	WK	$10,500	$546,000	Operations and support.
Carbon	1	LS	$1,903,322	$1,903,322	Ethanol @ $6/gal
Miscellaneous Materials/Equipment and Subs	52	WK	$8,500	$442,000	Spare parts, maintenance, cleaning
Phase 1 Annual O&M Subtotal (P1O&M):				***$2,891,300***	

Phase 2 Annual O&M Costs	QTY	Unit	Unit Cost	Extension	Notes
Labor	52	WK	$20,000	$1,040,000	Operations and support.
Carbon	1	LS	$7,651,356	$7,651,356	Ethanol @ $6/gal
Miscellaneous Materials/Equipment and Subs	52	WK	$17,000	$884,000	Spare parts, maintenance, cleaning
Phase 2 Annual O&M Subtotal (P2O&M):				***$9,575,400.00***	

Phase 3 Annual O&M Costs	QTY	Unit	Unit Cost	Extension	Notes
Labor	52	WK	$20,000	$1,040,000	Operations and support.
Carbon	1	LS	$2,664,651	$2,664,651	Ethanol @ $6/gal
Miscellaneous Materials/Equipment and Subs	52	WK	$17,000	$884,000	Spare parts, maintenance, cleaning
Phase 2 Annual O&M Subtotal (P2O&M):				***$4,588,700.00***	

Costs shown are annual costs for years the IRZ systems are operational. See summary on Table D-14 that shows assumed frequency of operations, and average annual O&M costs

Table D-14b

Alternative D IRZ System Annual O&M Estimate

Corrective Measures Study/Feasibility Study Report for Chromium in Groundwater

Phase 1 Annual O&M Costs	QTY	Unit	Unit Cost	Extension	Notes
Labor	52	WK	$10,500	$546,000	
Carbon	1	LS	$5,709,967	$5,709,967	Ethanol @ $6/gal
Miscellaneous Materials/Equipment and Subs	52	WK	$8,500	$442,000	Spare parts, maintenance, cleaning

Phase 1 Annual O&M Subtotal (P1O&M): $6,698,000.00

Phase 2 Annual O&M Costs	QTY	Unit	Unit Cost	Extension	Notes
Labor	52	WK	$10,500	$546,000	
Carbon	1	LS	$3,045,316	$3,045,316	Ethanol @ $6/gal
Miscellaneous Materials/Equipment and Subs	52	WK	$8,500	$442,000	Spare parts, maintenance, cleaning

Phase 2 Annual O&M Subtotal (P2O&M): $4,033,300.00

Phase 3 Annual O&M Costs	QTY	Unit	Unit Cost	Extension	Notes
Labor	52	WK	$10,500	$546,000	Operations and support.
Carbon	1	LS	$2,664,651	$2,664,651	Ethanol @ $6/gal
Miscellaneous Materials/Equipment and Subs	52	WK	$8,500	$442,000	Spare parts, maintenance, cleaning

Phase 3 Annual O&M Subtotal (P3O&M): $3,652,700.00

Phase 4 Annual O&M Costs	QTY	Unit	Unit Cost	Extension	Notes
Labor	52	WK	$10,500	$546,000	Operations and support.
Carbon	1	LS	$2,664,651	$2,664,651	Ethanol @ $6/gal
Miscellaneous Materials/Equipment and Subs	52	WK	$8,500	$442,000	Spare parts, maintenance, cleaning

Phase 4 Annual O&M Subtotal (P4O&M): $3,652,700.00

Phase 5 Annual O&M Costs	QTY	Unit	Unit Cost	Extension	Notes
Labor	52	WK	$10,500	$546,000	Operations and support.
Carbon	1	LS	$2,664,651	$2,664,651	Ethanol @ $6/gal
Miscellaneous Materials/Equipment and Subs	52	WK	$8,500	$442,000	Spare parts, maintenance, cleaning

Phase 5 Annual O&M Subtotal (P5O&M): $3,652,700.00

Table D-14b

Alternative D IRZ System Annual O&M Estimate

Corrective Measures Study/Feasibility Study Report for Chromium in Groundwater

Phase 6 Annual O&M Costs	QTY	Unit	Unit Cost	Extension	Notes
Labor	52	WK	$10,500	$546,000	Operations and support.
Carbon	1	LS	$2,664,651	$2,664,651	Ethanol @ $6/gal
Miscellaneous Materials/Equipment and Subs	52	WK	$8,500	$442,000	Spare parts, maintenance, cleaning

Phase 6 Annual O&M Subtotal (P6O&M): $3,652,700.00

Phase 7 Annual O&M Costs	QTY	Unit	Unit Cost	Extension	Notes
Labor	52	WK	$10,500	$546,000	Operations and support.
Carbon	1	LS	$951,661	$951,661	Ethanol @ $6/gal
Miscellaneous Materials/Equipment and Subs	52	WK	$8,500	$442,000	Spare parts, maintenance, cleaning

Phase 7 Annual O&M Subtotal (P7O&M): $1,939,700.00

Phase 8 Annual O&M Costs	QTY	Unit	Unit Cost	Extension	Notes
Labor	52	WK	$10,500	$546,000	Operations and support.
Carbon	1	LS	$951,661	$951,661	Ethanol @ $6/gal
Miscellaneous Materials/Equipment and Subs	52	WK	$8,500	$442,000	Spare parts, maintenance, cleaning

Phase 8 Annual O&M Subtotal (P8O&M): $1,939,700.00

Phase 9 Annual O&M Costs	QTY	Unit	Unit Cost	Extension	Notes
Labor	52	WK	$10,500	$546,000	Operations and support.
Carbon	1	LS	$295,015	$295,015	Ethanol @ $6/gal
Miscellaneous Materials/Equipment and Subs	52	WK	$8,500	$442,000	Spare parts, maintenance, cleaning

Phase 9 Annual O&M Subtotal (P9O&M): $1,283,000.00

Phase 10 Annual O&M Costs	QTY	Unit	Unit Cost	Extension	Notes
Labor	52	WK	$10,500	$546,000	Operations and support.
Carbon	1	LS	$76,133	$76,133	Ethanol @ $6/gal
Miscellaneous Materials/Equipment and Subs	52	WK	$8,500	$442,000	Spare parts, maintenance, cleaning

Phase 10 Annual O&M Subtotal (P10O&M): $1,064,100.00

Costs shown are annual costs for years the IRZ systems are operational. See summary on Table D-14 that shows assumed frequency of operations, and average annual O&M costs

Table D-14c

Alternative E IRZ System Annual O&M Estimate

Corrective Measures Study/Feasibility Study Report for Chromium in Groundwater

Annual National Trails Highway O&M Costs	QTY	Unit	Unit Cost	Extension	Notes
Labor	52	WK	$10,500	$546,000	Operations and support.
Carbon	1	LS	$411,118	$411,118	Ethanol @ $6/gal
Miscellaneous Materials/Equipment and Subs	52	WK	$8,500	$442,000	Spare parts, maintenance, cleaning
			Annual O&M Subtotal (O&M):	***$1,399,100.00***	

Annual Upland Wells O&M Costs	QTY	Unit	Unit Cost	Extension	Notes
Labor	52	WK	$5,500	$286,000	Operations and support.
Carbon	1	LS	$143,891	$143,891	Ethanol @ $6/gal
Miscellaneous Materials/Equipment and Subs	52	WK	$4,500	$234,000	Spare parts, maintenance, cleaning
			Annual O&M Subtotal (O&M):	***$663,900.00***	

Costs shown are annual costs for years the IRZ systems are operational. See summary on Table D-14 that shows assumed frequency of operations, and average annual O&M costs

Table D-14d

Alternative G IRZ System Annual O&M Estimate

Corrective Measures Study/Feasibility Study Report for Chromium in Groundwater

Annual O&M Costs	QTY	Unit	Unit Cost	Extension	Notes
Labor	52	WK	$10,500	$546,000	Operations and support.
Carbon	1	LS	$1,903,322	$1,903,322	Ethanol @ $6/gal
Miscellaneous Materials/Equipment and Subs	52	WK	$8,500	$442,000	Spare parts, maintenance, cleaning
			Annual O&M Subtotal (O&M):	***$2,891,300.00***	

Costs shown are annual costs for years the IRZ systems are operational. See summary on Table D-14 that shows assumed frequency of operations, and average annual O&M costs

Table D-14e

Alternative H IRZ System Annual O&M Estimate

Corrective Measures Study/Feasibility Study Report for Chromium in Groundwater

Annual O&M Costs	QTY	Unit	Unit Cost	Extension	Notes
Labor	52	WK	$10,500	$546,000	Operations and support.
Carbon	1	LS	$913,595	$913,595	Ethanol @ $6/gal
Miscellaneous Materials/Equipment and Subs	52	WK	$8,500	$442,000	Spare parts, maintenance, cleaning
Annual O&M Subtotal (O&M):				***$1,901,600.00***	

Costs shown are annual costs for years the IRZ systems are operational. See summary on Table D-14 that shows assumed frequency of operations, and average annual O&M costs

TABLE D-15
Cost Worksheet - Ex Situ Treatment Plant Capital Cost (1,200-1,300 gpm plant)
Corrective Measures Study/Feasibility Study Report for Chromium in Groundwater

Item	**Design Criteria**	**Quantity**	**Basis**	**Cost per Unit**	**Estimated Cost**
Raw EQ Tank	40 foot diameter, 285,000 gallon	1	Recent vendor quote for similar equipment	$ 375,000	$ 375,000
Raw Water Feed Pump	1500 gpm @ 50' TDH (15 hp)	2	Recent vendor quote for similar equipment	$ 33,591	$ 67,183
Chromium reduction tank	8,500 gallon chrome reduction tank (15' dia x 8' sidewater)	2	Recent vendor quote for similar equipment	$ 69,194	$ 138,387
Iron Oxidation Reactor Tank w/ sparger ring	30,000 gal 15 ft diameter, 23 ft side water depth, 30 ft total ht.	2	Recent vendor quote for similar equipment	$ 32,517	$ 65,033
Iron Oxidation Tank Mixers	30 hp mixers	2	Recent vendor quote for similar equipment	$ 35,000	$ 70,000
Clarifier	275000 gallon Concrete 56 ft diameter 20 ft total height	1	Recent vendor quote for similar equipment	$ 550,000	$ 550,000
Rapid Mixers	for clarifier	1	Rough estimate	$ 7,500	$ 7,500
Pre-Treated Water (MF Feed) Transfer Pump	750 gpm @ 35' TDH (5 hp)	2	Recent vendor quote for similar equipment	$ 44,596	$ 89,191
Treated Water Transfer Pump	1000 gpm @ 250'TDH (40 hp)	2	Recent vendor quote for similar equipment	$ 51,585	$ 103,170
FeCl Tank (~12,000 gal)	12000 gallon FeCl tank, 12 ft diameter, 20 ft total height	2	Recent vendor quote for similar equipment	$ 76,810	$ 153,620
NaOH Tank (~8,500 gal)	8500 gallon NaOH tank, 12 ft diameter, 20 ft total height	1	Recent vendor quote for similar equipment	$ 40,000	$ 40,000
HCl Tank (~8,000 gal)	8500 gallon HCl tank, 12 ft diameter, 20 ft total height	1	Recent vendor quote for similar equipment	$ 40,000	$ 40,000
HCl Feed System		1	Scaled up from IM3 cost	$ 15,000	$ 15,000
NaOH Feed System		1	Scaled up from IM3 cost	$ 25,000	$ 25,000
FeCl Feed System		1	Scaled up from IM3 cost	$ 15,000	$ 15,000
Sulfuric Acid Feed System		1	Scaled up from IM3 cost	$ 25,000	$ 25,000
Polymer Skid		1	Scaled up from IM3 cost	$ 50,000	$ 50,000
New MCC	Original Capacity 750kVA	1	Recent vendor quote for similar equipment	$ 261,471	$ 261,471
On-line Cr analyzer	Redundant pair for on-line chromium analysis	2	Recent vendor quote for similar equipment	$ 120,000	$ 240,000
Iron Oxidation Blower	2700 scfm @ 12 psig	4	Recent vendor quote for similar equipment	$ 135,000	$ 540,000
Microfiltration Unit	350 gpm unit	5	Recent vendor quote for similar equipment	$ 427,680	$ 2,138,400
Plate and Frame Filter Press	2700 pounds per day wet sludge for dewatering	2	Based on similar type equipment	$ 185,000	$ 370,000
Sludge Holding Tank	7500 gallon storage tank	2	Recent vendor quote for similar equipment	$ 30,000	$ 60,000
Treated Water Storage Tank	200,000 gallon storage tank	1	Recent vendor quote for similar equipment	$ 305,000	$ 305,000
Process Drain Tank	20,000 gallon storage tank	2	Recent vendor quote for similar equipment	$ 31,750	$ 63,500
Total Equipment Cost (EQ)					$5,807,456
Freight and Taxes		10%	of EQ		581,000
Equipment Delivery Adjustment: Schedule		0%	of EQ		0
Equipment Delivery Adjustment: Location		0%	of EQ		0
Purchased Equipment Cost - Delivered (PEC-D)					$6,388,456
Equipment Installation (a)		20%	of PEC-D		1,278,000
Piping		20%	of PEC-D		1,278,000
Instrumentation and Controls		15%	of PEC-D		958,000
Electrical		20%	of PEC-D		1,278,000
Buildings			$250/sf * 18,000 sf		4,500,000
Yard Improvements (b)		35%	of PEC-D		2,236,000
Service Facilities (c)		2%	of PEC-D		128,000
Subtotal					**$18,044,456**

Note: Construction Adders not included

(a) Includes costs for labor, foundations, supports, platforms, construction expenses, and other factors

Item	Design Criteria	Quantity	Basis	Cost per Unit	Estimated Cost

directly related to the erection of purchased equipment.

(b) Includes fencing, grading, roads, sidewalks, and similar items.

(c) Includes required improvements to steam, water, compressed air, waste disposal, fire protection, and other plant services.

(d) This cost estimate has been prepared for guidance in project evaluation and implementation and was based on information available at the time that the estimate was prepared. Final costs for the project, and the project's resulting feasibility will depend on actual labor and material costs, competitive market conditions, actual site conditions, final project scope, implementation schedule, and other variable factors. As a result, the final project cost will vary from the estimate prepared. Because of these factors, project feasibility, benefit/cost ratios, risks, and funding needs must be carefully reviewed before making specific financial decisions or establishing project budgets in order to help ensure proper project evaluation and adequate funding.

Note: Installation factors from Plant Design and Economics for Chemical Engineers, Fourth Edition, M.S. Peters

TABLE D-16

Pipe, Trench, and Electrical Installation Costs

Corrective Measures Study/Feasibility Study Report for Chromium in Groundwater

			C-P1		**C-P2**		**D-P1**			**E**	**F-PT**		**G-P1**		**G-PT**		**H**	
	Trench, inches	**$ per 1,000 ft (Note 1)**	**Alt. C - Phase 1**		**Alt. C - Phase 2**		**Alt. D - Phase 1**				**Alt. F**		**Alt. G - Phase 1**		**Alt. G - Phase 2**		**Alt. H**	
			000s ft	**$**	**000s ft**	**$**	**000s ft**	**$**	**000s ft**	**$**	**000s ft**	**$**	**000s ft**	**$**	**000s ft**	**$**	**000s ft**	**$**
Pipe, 2" HDPE SDR 11	12	$ 5,490		$ -		$ -		$ -		$ -	1.718	$ 9,432		$ -	1.718	$ 9,432		$ -
Pipe, 4" HDPE SDR 11	12	$ 21,320		$ -		$ -		$ -	5.05	$ 107,666	0.045	$ 959		$ -	0.045	$ 959	7.75	$ 165,230
Pipe, 6" HDPE SDR 11	18	$ 33,590		$ -		$ -		$ -	1.849	$ 62,108	2.87	$ 96,403		$ -	1.13	$ 37,957	2.332	$ 78,332
Pipe, 8" HDPE SDR 11	20	$ 41,810	0	$ -		$ -		$ -	5.652	$ 236,310	4.43	$ 185,218		$ -	5.971	$ 249,648	3.831	$ 160,174
Pipe, 10" HDPE SDR 11	22	$ 60,170		$ -		$ -		$ -		$ -	0.395	$ 23,767		$ -	1.1	$ 66,187		$ -
Pipe, 12" HDPE SDR 11	24	$ 82,820		$ -		$ -		$ -		$ -	1.565	$ 129,613		$ -	1.565	$ 129,613		$ -
Double Wall Pipe, 2" 4"	16	$ 92,450		$ -	6.1953	$ 572,755	0.9	$ 83,205	0.9	$ 83,205	2.429	$ 224,561		$ -	2.429	$ 224,561	2.714	$ 250,909
Double Wall Pipe, 4" 8"	20	$ 146,800		$ -	4.81928	$ 707,470	10.283	$ 1,509,544	4.345	$ 637,846		$ -		$ -	0.199	$ 29,213	1.277	$ 187,464
Double Wall Pipe, 6" 10"	22	$ 221,720		$ -	4.61705	$ 1,023,692	3.472	$ 769,812	0.976	$ 216,399	0.48	$ 106,426		$ -		$ -	0.685	$ 151,878
Double Wall, Pipe, 8" 12"	24	$ 315,160	0	$ -	0.90415	$ 284,952	3.581	$ 1,128,588	4.998	$ 1,575,170	0.325	$ 102,427		$ -	0.72	$ 226,915	5.43	$ 1,711,319
Double Wall Pipe, 10" 14"	26	$ 387,740	0	$ -	0.2996	$ 116,167	5.153	$ 1,998,024		$ -	0.725	$ 281,112		$ -	1.205	$ 467,227		$ -
Double Wall Pipe, 12" 16"	28	$ 410,680	0	$ -	1.58681	$ 651,671	2.802	$ 1,150,725		$ -	1.96	$ 804,933		$ -	1.96	$ 804,933		$ -
Double Wall Pipe, 14" 20"	38	$ 474,900	0	$ -		$ -		$ -		$ -		$ -		$ -		$ -		$ -
Small Trench / Backfill, Normal	12"	$ 37,240	0	$ -		$ -		$ -		$ -	0.46	$ 17,130		$ -	0.165	$ 6,145		$ -
Small Trench / Backfill, Difficult	12"	$ 66,140	0	$ -		$ -	0	$ -		$ -		$ -		$ -		$ -	1.13	$ 74,738
Medium Trench / Backfill, Normal	36"	$ 51,920	2.925	$ 151,866	7.46432	$ 387,547	14.138	$ 734,045	14.778	$ 767,274	10.44	$ 542,045	0.16	$ 8,307	7.939	$ 412,193	17.95	$ 931,964
Medium Trench / Backfill, Difficult	36"	$ 68,120	0	$ -	6.53877	$ 445,421	8.107	$ 552,249	1.775	$ 120,913	2.07	$ 141,008		$ -	1.13	$ 76,976		$ -
Large Trench / Backfill, Normal	60"	$ 91,900	0	$ -	7.43436	$ 683,218	8.979	$ 825,170	4.458	$ 409,690		$ -	2.734	$ 251,255	2.6	$ 238,940	3.009	$ 276,527
Large Trench / Backfill, Difficult	60"	$ 107,780		$ -		$ -		$ -		$ -		$ -	0.94	$ 101,313	0.94	$ 101,313		$ -
Wiring, Conduit Large (15) - 6 ext wells / 12 inj wells	30	$ 274,385	0	$ -	8.65523	$ 2,374,865	32.502	$ 8,918,061	7.091	$ 1,945,664	4.969	$ 1,363,419		$ -	5.206	$ 1,428,448	7.859	$ 2,156,392
Wiring, Conduit Medium (10) - 4 ext wells / 8 inj wells	24	$ 212,135	2.925	$ 620,495	3.83381	$ 813,285	8.089	$ 1,715,960	8.16	$ 1,731,022	0.88	$ 186,679	7.137	$ 1,514,007	0.875	$ 185,618	7.463	$ 1,583,164
Wiring, Conduit Small (5) - 2 ext wells / 4 inj wells	18	$ 115,481		$ -	14.2128	$ 1,641,310	14.711	$ 1,698,841	8.378	$ 967,500	6.805	$ 785,848		$ -	7.076	$ 817,144	9.533	$ 1,100,880
Fiber Optic	12	$ 38,109		$ -		$ -		$ -		$ -		$ -		$ -		$ -		$ -
Number of underpasses (Note 2)		$ 440,000	0	$ -	1	$ 440,000	2	$ 880,000		$ -	2	$ 880,000		$ -	2	$ 880,000	1	$ 440,000
	2																	
Total				**$772,361**		**$10,142,354**		**$21,964,225**		**$8,860,766**		**$5,880,981**		**$1,874,882**		**$6,393,421**		**$9,268,971**

Notes:

1 - Cost includes materials and 19.5% markup by the contractor. Does not include GC's costs.

Trenches assume 3' cover over pipes

2 - Cost is from quote for underpass (by jack-and-bore) at nearby site.

2 - Have divided cost elements into smaller pieces then in 2006 exercise. Example: a 5' wide trench with one 4" single-wall pipe, one double-wall pipe 4"x8", and 15 conduits would be for 1000 ft:

$ 21,320
$ 146,800
$ 91,900
$ 274,385
$ 534,405

3 - Wire, conduit includes: 15 conduits. 6 I&C wire pairs; 3 power lines, assume sufficient for up to a 20 HP load; 6 conduits are empty spare

4 - Small Trenches were used for single pipes up to 4" dia. Medium for up to 6". Medium trenches for electrical. Difficult trenches were selected for overland runs and normal for trenches along existing roads.

TABLE D-17

Cost Worksheet - Cost to Deconstruct New Treatment Plant

Corrective Measures Study/Feasibility Study Report for Chromium in Groundwater

Costs were first estimated for the existing IM3 plant.

Costs for larger plants in CMS were estimated using flow ratio raised to 0.6 power.

Initial Estimate (IM3 = 135 gpm)		
Cost Element		**Cost ($)**
Remove Trailer Control Room to Storage	$	23,533
Salvage / Store Electronic Items	$	23,533
Strip building skin and haul to dump	$	28,028
Salvage / Store Building Steel Members	$	28,240
Remove Piping - Haul to Dump	$	133,858
Salvage / Store Tanks/Pumps	$	331,639
Remove Electrical	$	77,887
Remove Foundations - Haul to Dump	$	145,753
Backfill Foundation with Bought Fill	$	20,302
Remove Paving	$	37,551
Grade and Seed with Native Vegetation	$	8,066
Misc Waste	$	40,696
Supervision During Demo	$	395,319
Other	$	160,043
Demolish Existing Plant Sub-Total	**$**	**1,294,405**
Decon Contaminated Equipment	**$**	**195,726**
Restore Site	**$**	**88,864**
Total	**$**	**1,600,000**
Estimate for Larger Plant - 1200 gpm		
Flow ratio to 0.6 power at 1200 gpm		3.7
	$	**5,900,000**
Estimate for Larger Plant - 325 gpm		
Flow ratio to 0.6 power at 325 gpm		1.7
	$	**2,700,000**

Components and Assumptions

This section provides detail on cost estimating approach and assumptions to supplement the cost notes in Tables D-2 through D-10.

D.2.1 Capital Costs

D.2.1.1 Wells

Three types of wells are components for the alternatives under consideration: monitoring, extraction, and injection. *In-situ* reduction zone (IRZ) wells are a subcategory, as they can be vertical circulation wells that incorporate both injection and extraction in separate screened intervals within a single well, or they can be conventional wells that operate in either injection or extraction mode. For estimating the cost of well installation, there is little difference between any of these well types. Well construction costs are primarily dependent upon the well diameter and depth. Generally, two drilling methods have been used at Topock to install wells: mud-rotary and roto-sonic (or sonic). The methods are different, but the overall footprint is similar. Generally larger-diameter wells will require mud rotary drilling methods, while either method may be used for smaller-diameter wells. Regardless of the drilling method, after completion, the well is developed to remove any foreign materials introduced during drilling. Water recovered during development is disposed of or treated in accordance with regulations. The drilling methods for installing injection, extraction, and IRZ and the areas in which they were assumed to apply are shown in Table D-18.

TABLE D-18
Drilling Methods Assumed for Installing Injection, Extraction, and *In-situ* Reduction Zone
Groundwater Corrective Measures Study/Feasibility Study for SWMU 1/AOC 1 and AOC 10,
PG&E Topock Compressor Station, Needles, California

	Drilling Method (Area Used)	
Diameter and Casing Material	**Mud Rotary (Upland Area)**	**Rotosonic (Floodplain Area and East Ravine Area)**
4-inch polyvinyl chloride	X	X
4-inch stainless steel	X	X
6-inch stainless steel	X	X
8-inch stainless steel	X	
10-inch stainless steel	X	
12-inch stainless steel	x	

Note: Wells drilled in upland areas were assumed to be drilled to 220 feet, and wells drilled in the floodplain were assumed to be drilled to 130 feet.

Alternatives B through H all include construction of new wells at the site. Alternatives C through H include construction of new wells at the start of the remedial action, and these costs are included on Table D-12. Alternatives B, C, D, E, F, G, and H also include periodic well installation during the remedial action period for optimization of the treatment and monitoring. Table D-19A lists the approximate number and type of wells assumed for the alternatives for cost estimating purposes.

TABLE D-19A
Number of Wells Assumed for the Cost Estimate
Groundwater Corrective Measures Study/Feasibility Study for SWMU 1/AOC 1 and AOC 10, PG&E Topock Compressor Station, Needles, California

	Alternatives								
Wells by Type	**A**	**B**	**C**	**D**	**E**	**F**	**G**	**H**	**I**
Remediation Wells[b]	0	0	117	94	54	33	65	67	0
Additional Monitoring	0	28	32	40	28	24	30	32	0
Total	0	28	149	134	82	57	95	99	0

Notes:

[a] This table lists only new wells and does not include replacement wells. See section under Operations and Maintenance. Cluster or co-located wells are counted individually for the purposes of this table.

[b] Remediation wells include extraction, injection, and IRZ wells.

Although the remedial alternatives described in this document included an assumed number of wells for the conceptual design cost estimates, the number of wells actually installed will depend on circumstances that will be addressed in the design, construction, and operation of the remedial alternative selected. Accordingly, the forthcoming California Environmental Quality Act (CEQA) analysis will evaluate the environmental effects that could result from implementation of additional wells, as listed in Table D-19B.

TABLE D-19B
Maximum Number of Wells Assumed for the CEQA Analysis[a]
Groundwater Corrective Measures Study/Feasibility Study for SWMU 1/AOC 1 and AOC 10, PG&E Topock Compressor Station, Needles, California

	Alternatives								
Wells by Type	**A**	**B**	**C**	**D**	**E**	**F**	**G**	**H**	**I**
Remediation Wells[b]	0	0	240	200	110	70	140	140	0
Monitoring Wells	0	60	70	80	60	50	60	70	0
Total	0	60	310	280	170	120	200	210	0

Notes;

[a] This table lists only new wells and does not include replacement wells. See section under Operations and Maintenance. Cluster or co-located wells are counted individually for the purposes of this table.

[b] Remediation wells include extraction, injection, and IRZ wells.

Past well installations at the site provide evidence of the pumping or injection capacity of wells. For the CMS/FS, extraction wells were assumed to have a maximum design flow rate of 620 gallons per minute (gpm) for a 12-inch well. Injection well design capacity was assumed to be 150 gpm for wells receiving water with carbon substrate. This rate accounts for the biofouling that typically occurs in these wells. Injection wells receiving water with no carbon substrate had an assumed design capacity of 250 gpm. These rates are based on operational experience and driller reports of testing at the Interim Measure Number 3 (IM No. 3) injection wells and the former PGE-1 and -2 production wells and are assumed to be applicable to portions of the Alluvial Aquifer where saturated thickness is at least 50 feet. It is not possible to accurately determine pumping or injection rates of any individual well until it is installed and tested, as local hydrogeologic conditions and variations in methods of well construction and development can have large effects on well performance.

The groundwater model used to design the alternatives simulates the response of the aquifer but does not account for well efficiency. Injection wells typically have low efficiency, which limits the amount of water that can be injected. Therefore, the model is able to simulate injection rates at a given location that may be more than a single well could accommodate. Where this occurred, additional wells were added into the cost estimate in recognition that multiple wells would be needed at locations where the model simulated injection or pumping rate exceeded the capacity of a single well. Table D-20 lists the number of wells by size for the Alternatives C through H.

TABLE D-20
Assumptions Regarding Number of Wells by Size[a]
Groundwater Corrective Measures Study/Feasibility Study for SWMU 1/AOC 1 and AOC 10, PG&E Topock Compressor Station, Needles, California

Well Type	**Alternative C**	**Alternative D**	**Alternative E**	**Alternative F**	**Alternative G**	**Alternative H**
4-inch PVC	48	15	33	15	48	15
4-inch stainless steel	2	0	2	0	0	40
6-inch stainless steel	54	17	8	2	3	4
8-inch SS	2	48	5	1	3	8
10-inch stainless steel	8	14	5	7	2	0
12-inch stainless steel	3	0	1	8	9	0

Note:
[a] No new wells are installed as part of Alternative I.

D.2.1.2 *In-situ* Systems

Alternatives C, D, E, G, and H include *in-situ* systems for treatment of hexavalent chromium. *In-situ* reduction is applied in two configurations to create reduction zones: dipolar and pump-dose with carbon-inject (PDI).

- The dipolar configuration is one or more lines of dual function injection/extraction wells designed to create a linear IRZ through which groundwater flow would pass. Carbon (lactate and ethanol have been tested at Topock) is injected at prescribed rates and is re-circulated between dipolar well pairs. The wells create a circulation zone along the axis of the well lines.
- The PDI configuration relies on extraction wells to produce water, carbon injection systems to dose the extracted water with carbon, and injection wells to receive the amended water thus creating a reductive zone to treat the chromium plume. The objective of the PDI approach is to cover the bulk of the plume with injected organic carbon. The flow is not directed along a line of wells to create a linear IRZ but rather between wells spaced over wider distances to obtain maximum coverage of the plume area with carbon.

Costs for the construction of the *in-situ* systems in Alternatives C, D, E, G, and H include equipment, buildings, pads, double-contained piping, trenching, electrical, controls, instrumentation, vaults, valves, and tanks and are based on recent projects completed in

Southern California. Costs were adjusted based on the modeled flowrates. Individual estimates for these five alternatives were developed as shown on Tables D-13a through D-13e. Well installation costs were estimated separately based on an assumed spacing of six wells minimum per 1,000 feet, and the number of wells was adjusted based on the groundwater modeling results.

The forthcoming CEQA analysis will evaluate the environmental effects from structures associated with *in situ* systems. The maximum footprint of the areas in which the *in situ* tanks and associated equipment would be located for Alternatives C, D, E, G and H is estimated to be 100,000 square feet, which may consist of facilities at multiple locations.

D.2.1.3 *Ex-situ* Treatment

Alternatives F and G include construction of an approximately 1,200- to 1,300-gpm aboveground treatment plant to treat extracted groundwater prior to injection. Alternative H includes construction of a 300-gpm aboveground treatment plant (for part of the flow; see Section 5.0 of the main report) prior to injection. Alternative I includes operation of the existing IM No. 3 treatment plant with no modification, hence there is no capital cost. For cost estimating purposes, the *ex-situ* treatment process is assumed to include chemical reduction of hexavalent chromium to trivalent chromium, precipitation and settling, and filtration. The treatment process details are not described here but would be similar to the plant built for IM No. 3. For cost estimating, design parameters from IM No. 3 were used for sizing treatment process equipment.

Metals precipitation involves the conversion of soluble heavy metal salts to insoluble salts that will precipitate. The precipitate can then be removed from the treated water by physical methods such as clarification (settling) and/or filtration. The process usually uses pH adjustment, addition of a chemical precipitant, and flocculation. Typically, metals precipitate from the solution as hydroxides, sulfides, or carbonates. The solubilities of the specific metal contaminants and the required cleanup standards will dictate the process used.

The treated groundwater flows through one or more tanks in series. After the hexavalent chromium has been reduced to trivalent chromium by soluble ferrous iron during a chemical reduction step, air is bubbled through the downstream oxidation tanks to oxidize soluble ferrous iron to the very insoluble ferric form. The resulting ferric hydroxide precipitate will co-precipitate trivalent chromium hydroxide to remove it from the groundwater. Sodium hydroxide is added to raise the pH of the groundwater to the range of 7.5 to 8.2 to further promote precipitation of iron and trivalent chromium.

Treated groundwater from the ferrous oxidation step flows into a clarifier. Solids drop to the bottom, from which they are transferred into a filter press or gravity separation device to separate the water from the sludge. Water removed from the sludge is pumped to the head of the plant for treatment. The sludge is stored in bins. The bins would be either hauled directly or emptied into a waste hauling vehicle for offsite disposal. Treated groundwater exiting the clarifier is further treated by membrane microfiltration. Microfilter systems will include membrane housings, pumps, piping, and controls to automatically divert water for membrane backwashing. Backwash water is returned to the treatment process.

For cost estimating purposes, the treatment plant is assumed to be constructed in available space at the Topock Compressor Station. Selection of an alternate location for the plant would result in a change to the cost estimate that would likely be within the -30 percent/+50 percent range of costs being developed at this stage. Electrical power is assumed to be supplied by the generators at the compressor station. Costs for construction of the *ex-situ* treatment plant include the foundation, exterior structure, tanks, piping, pumps, equipment, controls, and instrumentation. Polishing with reverse osmosis as in the current IM No. 3 plant is not included in the cost estimate for Alternatives F, G, and H. Costs were calculated by estimating costs for purchasing process equipment, as shown in Table D-15, and then applying factors to include installation costs, electrical, plant area piping, instrumentation and controls, buildings, and other necessary work for constructing the complete plant.

The forthcoming CEQA analysis will evaluate the environmental effects from an above-ground treatment plant. The treatment plant size for purposes of cost estimating is based on conceptual layout for the assumed flow rate. For CEQA analysis, the maximum size was assumed as the cost estimate conceptual design area adjusted upwards by 50 percent for changes in flow rate and then by 100 percent for design changes, redundancy, etc. The treatment structure size (including covered and uncovered areas) for CEQA analysis of an above-ground treatment plant in Alternatives F, and G, is estimated to be a maximum of 90,000 square feet for the treatment plant, with a maximum height of 45 feet. The plant may be constructed as several separate structures rather than one consolidated structure. Additional grading for the plant area will be required for vehicle access roads and temporary storage areas that could require as much as 100,000 square feet. For Alternative H, designed for a lower flow rate (325 gpm), the treatment structure size is estimated to be a maximum of 55,000 square feet, with graded areas that could require as much as 65,000 square feet.

D.2.1.4 Infrastructure

Piping. Alternatives C through H include piping to convey water between locations such as between wells or to/from an *ex-situ* treatment plant. For cost estimating purposes, piping is assumed to be installed underground for protection from the elements and from physical damage and is assumed to be made of non-metallic materials like polyvinyl chloride or high-density polyethylene since these materials are corrosion-resistant. Double-contained (high-density polyethylene) pipe is assumed to be used for all untreated water. Pipelines were laid out to convey water to the desired locations, and sizes were selected such that velocities at the given flow rates were less than or equal to 5 feet per second. Costs for piping were estimated for different pipe sizes ranging from 2 to 14 inches in diameter for both double- and single-contained piping based on estimated flow rates of the remedial alternatives. Maximum flowrates for different pipe sizes are listed below.

- Two-inch diameter – 45 gpm
- Four-inch diameter – 175 gpm
- Six-inch diameter – 400 gpm
- Eight-inch diameter – 700 gpm
- Ten-inch diameter – 1,100 gpm
- Twelve-inch diameter – 1,560 gpm
- Fourteen-inch diameter – 1,880 gpm

The piping manufacturer's information was reviewed to select the combinations of piping wall thicknesses for double containment. For cost estimating, lengths for piping were measured from maps (shown in Figures 5-4 through 5-11 of the main report) that illustrated the alternative configurations. The forthcoming CEQA analysis will evaluate the environmental effects from piping with lengths ranging from 10,000 to 60,000 linear feet for Alternatives C, D, E, F, G, and H. It may be necessary to replace existing pipelines during the operational period of the remedial alternatives, especially those with longer time durations, for example Alternative I with approximately 15,000 linear feet of existing pipeline associated with this alternative. Pipeline lengths are tabulated by alternative for cost estimating and CEQA analysis in Table D-21.

TABLE D-21
Pipeline Lengths
Groundwater Corrective Measures Study/Feasibility Study for SWMU 1/AOC 1 and AOC 10, PG&E Topock Compressor Station, Needles, California

	Alternatives								
Wells by Type	**A**	**B**	**C**	**D**	**E**	**F**	**G**	**H**	**I**
Pipeline length for cost estimate [a], (1,000s feet)	0	0	18.4	26.2	23.8	16.9	18	24	0
Maximum pipeline length assumed for the CEQA analysis [b], (1,000s feet)	0	0	40	60	50	40	40	50	0

Notes;
[a] This only includes initial construction. Piping will be repaired and replaced as needed during O&M period
[b] The maximum amount was calculated by doubling the cost estimate assumption, rounded up to the nearest 10,000 feet.

Electrical and Signal Communications (Conduit and Wire). Alternatives C through H include electrical power and signal (for instrumentation and control) communications conveyed through copper wire or optical cable. Copper wire is generally bundled wires coated individually and collectively (referred to as cable) with a synthetic outer covering. Optical cable is used for communications wiring, although copper can be used effectively over shorter distances. Either form of cable is generally installed in metal or plastic conduit similar to a pipe; the conduit is placed underground for protection from the elements and from physical damage. Costs for electrical wiring were estimated for three different combinations representing large (15-conduit), medium (10-conduit), and small (5-conduit). The sizes used in the alternatives were adjusted based on the number of wells supplied. Generally two conduits are required per well, with one conduit holding power cable and one conduit holding signal communications cable. Spares are assumed to be installed during construction to accommodate future changes or expansion. Lengths for electrical and signal communications were measured from maps (shown in Figures 5-4 to 5-11 in the main report) that illustrated the alternative configurations. Lengths are tabulated for cost estimating purposes and CEQA analysis in Table D-22.

Trenches. To construct the piping and electrical for Alternatives C through H, trenches were assumed to be used to place subsurface infrastructure for protection from vandalism and adverse effects from heat. For cost estimating, trenches are assumed to be excavated with heavy equipment such as backhoes or excavators to depths of 3 to 4 feet. The pipe and conduit are assumed to be placed with a sand bedding layer or, in the case of conduit, protected with concrete. Then backfill is placed (in 6-inch layers or lifts) and compacted. The top of the trench is restored to match the surrounding area, whether it be pavement or soil.

TABLE D-22
Electrical and Signal Communications Lengths
Groundwater Corrective Measures Study/Feasibility Study for SWMU 1/AOC 1 and AOC 10, PG&E Topock Compressor Station, Needles, California

	Alternatives								
Wells by Type	**A**	**B**	**C**	**D**	**E**	**F**	**G**	**H**	**I**
Electrical and Signal Communications length for cost estimate [a], (1,000s feet)	0	0	29.6	55.3	23.6	12.7	20.3	24.9	0
Maximum Electrical and Signal Communications length assumed for the CEQA analysis [b], (1,000s feet)	0	0	60	110	50	30	40	50	0

Notes;
[a] This only includes initial construction. Electrical and signal communications lengths will be repaired and replaced as needed during O&M period

[b] The maximum amount was calculated by doubling the cost estimate assumption, rounded up to the nearest 10,000 feet.

Costs for constructing trenches were estimated based on three widths: 5 feet, 3 feet, and 1 foot. Assignment of trench sizes for electrical and piping are:

- One-foot-wide trench: 2- to 4-inch-diameter single-contained piping.
- Three-foot-wide trench: All combinations of electrical wiring, 6- to 12-inch-diameter single-contained piping and 2- to 12-inch-diameter double-contained piping.
- Five-foot-wide trench: 14-inch-diameter double-contained piping.

Trench widths for combinations of piping and electrical conduit are evaluated on a case-by-case basis. The normal approach for electrical conduit and piping is to install the conduit above the pipe (except for double-contained pipe).

For cost estimating, trench lengths were measured from maps (shown in Figures 5-4 to 5-11 in the main report) that illustrated the alternative configurations. The forthcoming CEQA analysis will evaluate the environmental effects from trenches of up to 60,000 linear feet for Alternatives C, D, E, F, G, and H. It may be necessary to replace or repair utilities within trenches during the long operational period of remedial alternatives, especially those with longer time durations, for example Alternative I with approximately 4,000 linear feet of existing subsurface utilities.

Access Roads. Alternatives C through H include construction of access roads to allow for well installation and for operation and maintenance of the remediation systems. Access roads would be graded to create a smooth surface and proper drainage and would be routed to take advantage of topography and to avoid utilities or other sensitive features. For cost estimating purposes, the road surfaces are assumed to be finished with gravel.

For cost estimating, access road routes in the cost estimates were assumed. Roads were routed to areas with wells but where there are no existing roads. The forthcoming CEQA analysis will evaluate the environmental effects from access roads for remediation and monitoring as follows:

- Alternative B: up to 10,000 linear feet
- Alternatives C through H: up to 15,000 linear feet
- Alternative I: the existing approximately 10,000 linear feet may need replacing during the operational period.

Table 23 lists the lengths of access roads assumed for the cost estimate and the maximum length for CEQA analysis.

TABLE D-23
Access Road Lengths
Groundwater Corrective Measures Study/Feasibility Study for SWMU 1/AOC 1 and AOC 10, PG&E Topock Compressor Station, Needles, California

	Alternatives								
Wells by Type	**A**	**B**	**C**	**D**	**E**	**F**	**G**	**H**	**I**
Access Road length for cost estimate [a], (1,000s feet)	0	0	7.7	8	3	3	6	5.8	0
Maximum Access Road length assumed for the CEQA analysis [b], (1,000s feet)	0	0	16	16	6	6	12	12	0

Notes;
[a] This only includes initial construction. Access road will be repaired and replaced as needed during O&M period
[b] The maximum amount was calculated by doubling the cost estimate assumption, rounded up to the nearest 1,000 feet.

Both unit costs and total infrastructure costs are shown in Table D-16 as well as the corresponding quantities for each of the alternatives.

Freshwater Source. For Alternative E, 500 gpm of freshwater is injected to flush the aquifer. For cost estimating purposes, the freshwater supply is assumed to be provided by an extraction well drilled in Arizona near the existing Topock-2 and Topock-3 supply wells. Costs were based on installing a 10-inch-diameter well to extract the required amount of water. There is an existing 8-inch-diameter pipeline crossing the Colorado River, but that pipeline is assumed to not have sufficient capacity, and a new 10-inch-diameter steel pipe would have to be constructed across the river using the existing pipe bridge as support. Depending upon the water quality of the freshwater and the quality of the receiving aquifer zone, water treatment may be required as described in Section 5.0 of the main report. However, if needed, this cost is likely to be within the contingency factor used and was therefore not estimated for Alternative E. The forthcoming CEQA analysis will evaluate the environmental effects from installation of structures associated with treatment of freshwater. The maximum footprint of the areas in which the treatment equipment would be located for Alternative E is estimated to be up to 30,000 square feet, which may consist of facilities at multiple locations. Other potential freshwater supply locations include wells located in California or supplied from the Colorado River (see Section 5.3 of the main text). Regardless of the source location, pipelines would be constructed to convey the water to the freshwater injection wells.

D.2.1.5 Remove IM No. 3 Treatment Plant

The cost to remove the IM No. 3 Treatment Plant is included for Alternatives B through H as an up-front capital cost. Costs include decontaminating piping and treatment equipment, removing the building, disposing of building materials, cost to transport re-usable equipment to storage, and re-grading and re-vegetating with native vegetation.

D.2.1.6 Prime Contractor Cost Factors

Cost estimates were first developed at the subcontractor level. Several factors were then applied to the summation of these costs to develop a total alternative cost. Using factors simplifies the estimating process and is commonly used in feasibility-type estimates. As most construction projects involve several types of subcontractors, such as electrical, drilling, piping, or mechanical contractors, the prime or general contractor will normally apply factors to cover administrative costs, mobilization, and for project profit. There are two factors in this category: General Conditions and (prime) Contractor Markup. Other factors falling into this category include:

- Field Construction Management and Engineering Services During Construction.
- Pre-construction including work plans, surveying, engineering design, and post-construction as-built drawings.
- Project Management.

Table D-24 lists the factors applied and their values. These factors are based on middle-range values listed in *A Guide to Developing and Documenting Cost Estimates during the Feasibility Study* (USEPA, 2000). These factors are cumulative so they add to more than the sum of list (i.e., 75 percent rather than 60 percent in this case).

TABLE D-24
Applied Factors and Values
Groundwater Corrective Measures Study/Feasibility Study for SWMU 1/AOC 1 and AOC 10,
PG&E Topock Compressor Station, Needles, California

Factor	Percentage
General Conditions	10%
Field Construction Management and Engineering Services During Construction	10%
Pre-construction	14%
Project Management	5%
Contractor Markup (overhead and profit)	21%

D.2.1.7 Miscellaneous

Other capital costs associated with Alternatives B through I include:

- **Institutional Controls and Other Administrative Approvals.** Administrative approvals required for construction, including agreements with surrounding property owners (Havasu National Wildlife Refuge, Caltrans, Burlington Northern-Santa Fe, United States Bureau of Reclamation, and the United States Bureau of Land Management), San

Bernardino County, agreements with local potable water and electrical suppliers, and establishment of an institutional control to prohibit groundwater use within the plume.

- **Biological Monitoring.** Biological surveys and oversight during construction.
- **Cultural Monitoring.** Cultural surveys and oversight during construction.
- **Regulatory Oversight.** Includes regulatory interactions during construction. This would include such events as meetings and site-specific documentation to meet regulatory requirements.
- **Soil Cuttings Management.** Soil and mud (drill cuttings) from installation of monitoring, extraction, and injection wells is assumed to be characterized and managed appropriately. For cost estimating purposes, the soil cuttings are assumed to be sampled and, if contaminated, managed at an offsite disposal facility. Past experience has shown that most drill cuttings are not contaminated and can be managed onsite as general fill material; therefore, an allowance of $200,000 per alternative phase is set aside for managing drill cuttings.

D.2.1.8 Contingency

Cost estimates for these miscellaneous capital costs were estimated based on IM costs. In addition, a 25 percent contingency was added to total of the annual and capital costs. Contingency is a reserve for unknown events or scope changes that experience has shown will likely occur. The contingency amount varies with the accuracy level of the estimate.

D.2.1.9 Capital or Fixed or Ancillary Costs Not Included in Cost Estimate

Costs not included in the alternative estimates are environmental impact report mitigation measures for other resources, legal costs, taxes (other than sales tax on equipment), internal PG&E costs, right-of-way-related costs and fees, land transfer or purchase costs, remediation completion or oversight, and obtaining and maintaining a land use control to prohibit development of water supply wells within plume during the remediation period.

D.2.2 Operations and Maintenance

Operations and maintenance (O&M) is a broad grouping for costs completed during the operational (as opposed to construction or post-remediation deconstruction) period of the project.

For cost estimating purposes, the O&M periods for the remedial alternatives are summarized in Table D-25.

TABLE D-25
Operation and Maintenance Periods for Remedial Alternatives
Groundwater Corrective Measures Study/Feasibility Study for SWMU 1/AOC 1 and AOC 10, PG&E Topock Compressor Station, Needles, California

Alternative	Active Remediation	Long-term Monitoring following Active Remediation
A. - No Action	NA	NA
B. - Monitored Natural Attenuation	540 years	NA
C. - High Volume *In-situ* Treatment	18 years	10 years
D. - Sequential *In-situ* Treatment	15 years	10 years

TABLE D-25
Operation and Maintenance Periods for Remedial Alternatives
Groundwater Corrective Measures Study/Feasibility Study for SWMU 1/AOC 1 and AOC 10, PG&E Topock Compressor Station, Needles, California

Alternative	**Active Remediation**	**Long-term Monitoring following Active Remediation**
E. - *In-situ* Treatment with Fresh Water Flushing	29 years	10 years
F. - Pump and Treat	37 years	10 years
G. - Combined Floodplain *In-situ*/Pump and Treat	22 years	10 years
H. - Combined Upland *In-situ*/Pump and Treat	18 years	10 years
I. - Continued Operation of Interim Measure	240 years	10 years

Note: NA = not applicable.

D.2.2.1 *Ex-situ* Treatment Plant O&M

Alternatives F, G, and I include O&M of an *ex-situ* treatment plant (existing treatment plant in the case of Alternative I). This is assumed to include periodic performance sampling and analysis, equipment maintenance and inspection, and process chemical and waste management. For cost estimating purposes, the *ex-situ* treatment plant is assumed to require staffing 24 hours each day, 7 days each week. *Ex-situ* treatment plant O&M costs are assumed to include offsite transportation of sludge, quarterly during the operational period, to a permitted disposal facility in Kettleman City, California. Costs include technical support for plant operations and for optimizing plant performance.

Costs for *ex-situ* treatment plant O&M are based on experience operating the IM No. 3 treatment plant and were adjusted for a larger flow rate as appropriate. Alternative I includes operation of the reverse osmosis equipment and, as such, brine would be hauled to an offsite disposal system during the life of the project. Alternative I includes an allowance for replacement of the equipment and the wells. This was based on escalating costs for their assumed life (20 years for the plant and 10 years for the wells) and annualizing that cost so it is part of the O&M cost.

D.2.2.2 Freshwater Supply O&M

Alternative E includes freshwater supply at a rate of approximately 500 gpm. Costs for the freshwater supply were estimated based on estimated electrical usage for pumping. As described in Section 5.0, water treatment may be required to make the freshwater compatible with the receiving aquifer, but this cost is not included in this estimate as it is unknown and, if needed, is likely to be within the contingency applied.

D.2.2.3 *In-situ* System O&M

Alternatives C, D, E, G, and H include O&M of the *in-situ* systems. This is assumed to include periodic equipment inspection and maintenance and management of the substrate storage and delivery systems. Costs for *in-situ* system O&M are based on experience with O&M of the *in-situ* pilot studies and other full-scale projects in Southern California. It is assumed that when acid treatment is needed for redevelopment of injection wells; once swabbing is complete, clean water will be employed to push low-pH water into the formation. Thus, no redevelopment waste disposal costs are included in estimate. A summary of the O&M costs is included in Table D-14, and cost estimates for the Alternatives are in Tables D-14a through D-14E. These costs include routine well and pipeline cleaning for biofouling and scaling for the IRZ components.

D.2.2.4 Well Maintenance

Alternatives B through H, and I include well maintenance. Groundwater monitoring wells and extraction wells require the least maintenance, and O&M costs are for periodic repair and replacement of pumps. A monitoring well replacement allowance was added based on a 40-year life. The existing monitoring well replacement cost was amortized over that 40-year period. This allowance includes abandonment and replacement costs. Injection well maintenance includes periodic inspection, testing, re-development, rehabilitation measures such as chemical and physical treatment methods, and periodic replacement due to clogging. Cost estimates for injection wells associated with *in-situ* systems in Alternatives C, D, E, G, and H are assumed to require regular maintenance throughout the active remediation period. Cost estimates for injection wells associated with potable water or treated water in Alternatives E, F, G, and H are assumed to require annual maintenance throughout the active remediation period. An allowance of 10 percent of the total well installation cost was included in the O&M costs for future well replacements.

In the case of IRZ wells, cleaning well maintenance is included in the O&M costs. For Alternatives C and E, the IRZ wells will be used for an extended period and replacement may be necessary. For those cases, an allowance equal to 10 percent of the installation cost was added to the annual O&M costs.

D.2.2.5 Groundwater and Surface Water Monitoring

Alternatives B through I include a corrective action monitoring program to evaluate the progress toward attaining the remedial action objectives. The corrective action monitoring program is assumed to include periodic sampling and analysis of groundwater and surface water, both during the active remediation period as well as following the active remediation period. For cost estimating purposes, the monitoring program is assumed to be quarterly for Alternatives C and D during the active remediation period; annually for Alternatives E, F, and G during the active remediation period; and annually for Alternatives B through I during the long-term monitoring. Costs for the corrective action monitoring program were based on current site monitoring costs and include data validation and data management. A few of the important analytes assumed to be in the program besides chromium are arsenic, molybdenum, selenium, manganese, and nitrate.

D.2.2.6 Monitoring Reporting and Performance Reporting

Alternatives B through I include periodic reporting of remedial action performance. For cost estimating purposes, Alternatives B through I include an annual report of the corrective action monitoring program to evaluate the progress in attaining the remedial action goals. This report summarizes the results of the groundwater and surface water monitoring. In addition, Alternative C through I include quarterly performance reports of the active treatment systems. This report would summarize treatment system performance and modifications to system over the quarter to enhance system performance.

D.2.2.7 Other Facilities – Road Maintenance

Alternatives C through I include periodic inspection and repair of access roads for access to the remediation systems. For cost estimating purposes, the inspection and repair is assumed to include annual inspection and annual grading with onsite borrow material due to erosion.

D.2.2.8 Other O&M Costs

Other O&M costs included in the cost estimates are permits and administrative oversight of agreements with regulatory agencies and surrounding property owners, administration of the institutional control restricting groundwater use within the plume, biological surveys, cultural resource surveys, water rights, and 5-year reviews of the performance of the remedial action to attain the remedial action objectives.

D.2.2.9 O&M Costs Not Included in Cost Estimate

Costs not included in the alternative estimates are optimization of the remedy over time and site security expenses.

D.2.3 Post-remedy Deconstruction Costs

Alternatives B through I include deconstruction of remedial and monitoring facilities following completion of the remedial action. All alternatives (except Alternative A) would include deconstruction of the 110 existing monitoring wells at the site, as well as the additional monitoring wells to be constructed for the corrective action monitoring program, following the determination that additional information from the wells would not be needed to evaluate attainment of the cleanup goals. Costs for Alternatives C through G would also include deconstruction of the extraction, injection, IRZ recirculation wells installed for the remedial action, as well as the above-grade tanks, concrete foundations, instrumentation, piping, and other equipment associated with the *in-situ* and *ex-situ* systems. For the estimate, underground pipelines and electrical conduits were assumed to be left in place. After deconstruction and decommissioning of facilities, the areas would be restored using decompaction and grading techniques designed to decrease erosion and accelerate revegetation of native species or other method as directed by the land manager.

Costs for deconstructing the IM No. 3 treatment plant are included for Alternative I because it would remain for the life of remediation. Costs for deconstructing the IM No. 3 plant are counted as up-front capital costs in Alternatives B through H.

D.2.4 Present-value Analysis Calculations

Present-value analysis is a method to evaluate expenditures, either capital or O&M, that occur over different time periods. This standard methodology allows for cost comparisons of different remedial alternatives on the basis of a single cost figure for each alternative. This single number, referred to as the present value, is the amount needed to be set aside at the initial point in time (base year) to assure that funds will be available in the future as they are needed, assuming certain economic conditions

The present value (PV) is

$$PV = \frac{x_t}{(1+i)^t} \tag{1}$$

where x_t is the payment in year t (t = 0 for present or base year) and i is the discount rate.

For steady or constant expenditures, the present value is

$$PV = \sum_{t=1}^{t=n} x_t \frac{1}{(1+i)^n} = \frac{(1+i)^n - 1}{i(1+i)^n} \qquad (2)$$

where x_t is the payment in year t (t = 0 for present or base year), i is the discount rate and n is the number of years.

For a steady stream of costs in the future, such as a situation where a future phase lasts for more than a few years, the constant expenditures calculated in Equation (2) above will be discounted using Equation (1).

For the corrective measures study/feasibility study, a discount rate of 3.17 percent was selected. Since many of the alternatives have long durations, a nominal cost or undiscounted summation of all project costs is more useful for comparing the alternatives. The reason being is that the change in the present value between years diminishes greatly once the number of years exceeds 30 years.

D.3 References

United States Environmental Protection Agency (USEPA).2000. *A Guide to Developing and Documenting Cost Estimates During the Feasibility Study*. EPA 540-R-00-002. July.

Appendix E
Demonstration of Groundwater Flow Model Accuracy

Contents

Figures

APPENDIX E

Demonstration of Groundwater Flow Model Accuracy

E.1 Introduction

This appendix presents three different model simulations used to demonstrate the accuracy of the groundwater model. The groundwater model version used in this Corrective Measures Study/Feasibility Study (CMS/FS), the five-layer model, is the most recent fully-calibrated model, originally documented in the *Groundwater Model Update Report, Topock Compressor Station, Needles California* (CH2M HILL, 2005). The model was calibrated against observed data through early 2005. At a meeting of the Technical Work Group in August 2008, the agencies directed that CH2M HILL should further demonstrate that the five-layer model is appropriate for analysis of alternatives to the level needed in the CMS/FS.

The California Environmental Protection Agency, Department of Toxic Substances Control requested that demonstration of model accuracy be performed by using the model to forecast the hydraulic data collected after the calibration period (between 2005 and 2008). Specifically, the Technical Work Group agreed that the validation should consist of comparing simulated data to: (1) the monthly average groundwater levels in monitoring wells in response to changing monthly average river levels, and (2) the response of Arizona wells in the MW-54 cluster to the May 2008 Interim Measure No. 3 (IM No. 3) pumping shutdown event. However, due to anomalous river levels during the deconvolution fitting period of the May 2008 IM No. 3 shutdown, detection of well response in the MW-54 cluster (located across the river in Arizona) was incomplete. As a result, a second IM No. 3 shutdown event was simulated with the model in September 2008, and improved results were obtained. The September 2008 evaluation was conducted in response to a United States Department of the Interior (DOI) comment on Appendix C of the Draft CMS/FS Report (DOI-154) requesting that more work be conducted fitting the MW-54 well response data.

In addition, during the East Ravine groundwater investigation in winter/spring 2009 (Appendix A of the CMS/FS Report), chromium was also found within the bedrock aquifer in the East Ravine. This required that the groundwater model also have the capability to simulate water levels in the greater East Ravine area. To accomplish this, updates to the groundwater model included:

- Adjusting the bedrock-alluvial contact to match boring log data.
- Adjusting model layer thicknesses in the East Ravine area to reflect the screen interval distribution.
- Changing the area of bedrock recharge to 800 feet above mean sea level and higher (the total amount of precipitation recharge remained the same).

- Adjusting the hydraulic conductivity in bedrock from 0.00001 centimeters per second (cm/s) to 0.0001 cm/s in areas where no saturated alluvium is present.
- Adjusting bedrock hydraulic conductivity in model layer one to 0.0003 cm/s in the East Ravine area.
- Reducing the hydraulic conductivity in the area around well MW-59-100 by a factor of four to better match observed water levels.

It should be noted that the model was adjusted to reasonably replicate conditions in the East Ravine area but was not recalibrated, which would involve a much more extensive effort. The hydraulic conductivity of the bedrock incorporated into the groundwater model was estimated from the various types of aquifer testing at East Ravine bedrock wells. The model was used to simulate hydraulic control measures for the East Ravine bedrock area. The current model, which does not simulate flow in discrete fractures, was not used to simulate flushing times for the bedrock in East Ravine.

E.2 Description of Model Simulations to Demonstrate Accuracy

The following sections briefly describe the methods used to demonstrate groundwater flow model accuracy including: (1) simulating monthly water level fluctuations, (2) simulating the September 2008 IM No. 3 shutdown, and (3) simulating average groundwater contours of the greater East Ravine area during June and July 2009 and comparing them to observed water levels over the same period. These data are presented in Figures E-1 through E-3.

E.2.1 Simulating Monthly Water-level Fluctuations

Figures E-1a through E-1p present plots of observed monthly average water-level fluctuations with monthly fluctuations simulated with the groundwater model. In simulating monthly water-level fluctuations, the model was run on monthly time steps. For each step, the average river water elevations at all river nodes were calculated using the measured average at monitoring station I-3 and the estimated river slopes used in the 2005 calibration. Simulated water levels were downloaded from the model and were compared to measured averages. Wells with greater than 10 months' of measured average data were selected for the comparisons. The monthly average data are plotted in the same manner as those plotted in the July 2005 model report. Each data set (observed data, simulated data, and Colorado River data) is plotted relative to that data set's average for the period January 2005 through July 2008. This was done to highlight the monthly fluctuations and to demonstrate that simulated data respond to changes in river level in a similar manner as the observed data.

E.2.2 September 2008 Interim Measures No. 3 Shutdown

The IM No. 3 extraction and treatment system was shut down for routine maintenance for 2 days in mid-September 2008. The TW-3D and PE-1 pumping wells were shut down at 8:12 a.m. on September 15, 2008 and were restarted at 9:09 a.m. on September 17, 2008. Water-level data collected from pressure transducers with data loggers were analyzed to estimate aquifer response associated with this shutdown. The data were analyzed using the deconvolution method of Halford (USGS, 2006) to screen out the hydraulic effects of fluctuations in river stage, which will obscure aquifer response in wells hydraulically connected to the river. As detailed in the *Summary Report for Hydraulic Testing in Bedrock Wells, Topock Compressor Station, Needles, California*. (CH2M HILL, 2008), this analytical method has been applied for previous hydraulic evaluations at the site. For this evaluation, the deconvolution fitting period was from September 9, 2008 at 1:00 a.m. through September 15, 2008 at 8:00 a.m. and from September 19, 2008 at 8:00 a.m. through September 23, 2008 at 11:55 p.m., incorporating time both before and after the test.

Using the deconvolution analysis, the magnitude of aquifer response (water-level recovery/drawdown) at seven observation wells was evaluated. Figures E-2a and E-2b show the deconvolution analysis in two representative wells on the California side of the river. Well MW-34-100 is within 100 feet of the pumping well PE-1 and responds most dramatically to the shutdown and restart with a response of about 0.6 foot. Well MW-49-135 is a deep zone well approximately 1,100 feet from TW-3D and 1,300 feet from PE-1. Water level response at MW-49-135 was muted but still observable at about 0.13 foot. Figures E-2c through E-2g show the deconvolution analyses for the MW-54 and MW-55 wells in Arizona. In general, the detection limit for observable water-level fluctuation was estimated to be 0.1 foot; however, the detection limit for water level change in the MW-55 well cluster was estimated to be 0.05 foot due to a less noisy baseline in this well. Measurable water-level recovery of 0.1 foot was observed in the deep well at MW-54 (MW-54-195). Water-level recovery in the other Arizona wells was below the estimated detection limits.

Model simulated response is also plotted for each well in Figures E-2a through E-2g. These plots demonstrate that the model reasonably duplicates the observed responses in wells on both sides of the Colorado River.

E.2.3 Simulated Groundwater Model Contours

Groundwater elevation contour maps were prepared to compare these contours to averages calculated from observed data over the period June 1 through July 15, 2009 for all five model layers. The objective at this stage was not to recalibrate the model, but to configure the model to incorporate the East Ravine bedrock and simulate a direction and magnitude of groundwater gradient within the East Ravine bedrock that reasonably approaches that of observed data. The simulated contours and observed heads presented in Figures E-3a through E-3e demonstrate that, although absolute head values in East Ravine wells were not always closely matched, the simulated groundwater gradient is similar to that inferred by observed data. No changes were made to Alluvial Aquifer parameters in order to preserve the calibration in the original model configuration.

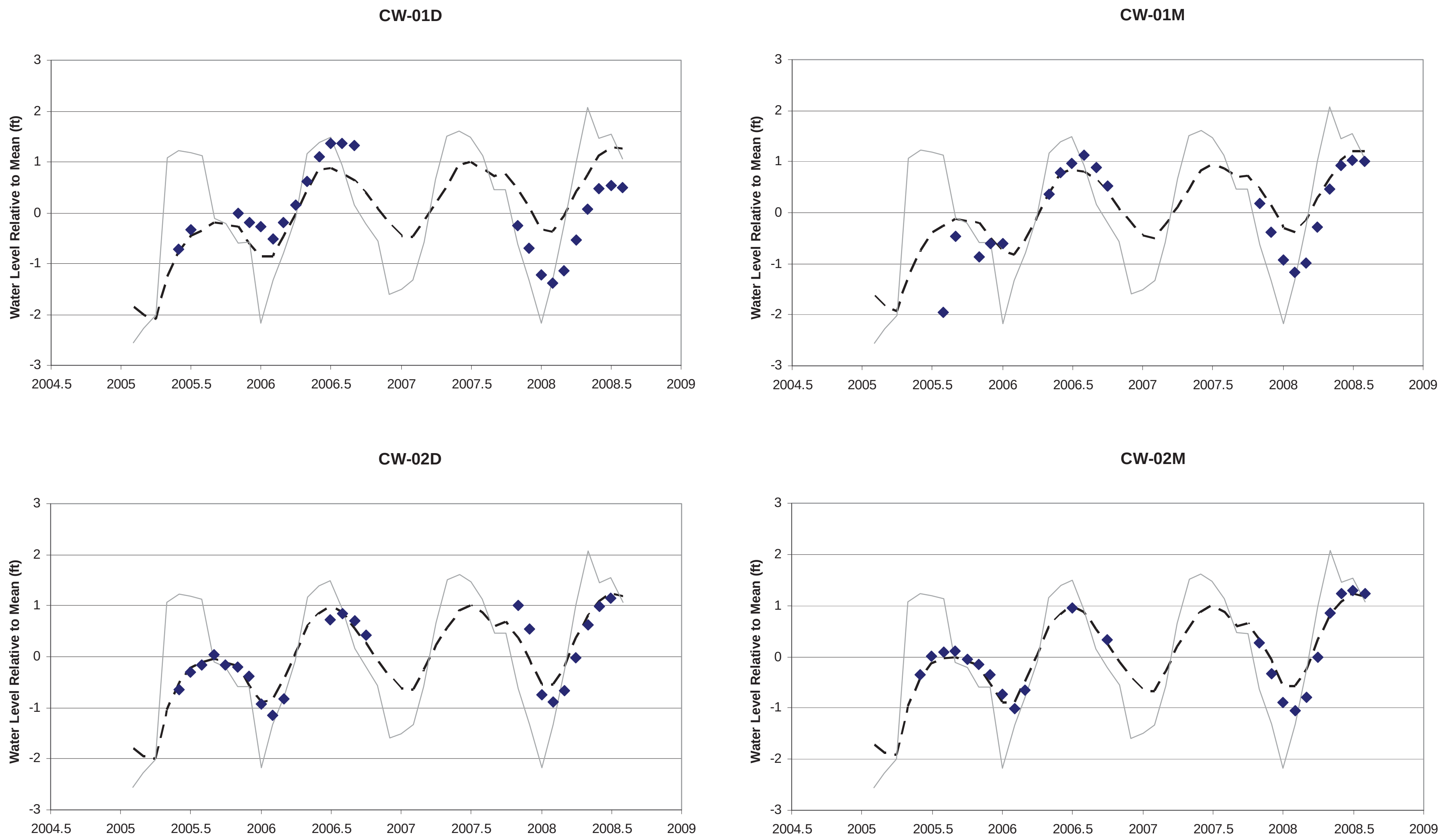
The groundwater model is, like all models, only an approximation of the real system. This model was calibrated in 2005, based on pre-pumping conditions. The model was developed and calibrated prior to the installation of PE-1, and the model grid does not include a node at the exact location of PE-1. Therefore, CH2M HILL has simulated pumping from PE-1 from a location that is a few feet away from the true location of the well. This inaccuracy of location of PE-1, in addition to the fact that the model was not calibrated to match the observed water level response from PE-1 pumping, results in larger-than-average differences between observed and simulated heads under the influence of PE-1. In the CMS/FS, the model is being used to simulate future groundwater flow patterns under complex distributions of pumping and injection for the ultimate purpose of comparing alternatives.

E.3 References

CH2M HILL. 2005. *Groundwater Model Update Report, Topock Compressor Station, Needles, California*. July.

__________. 2008. *Summary Report for Hydraulic Testing in Bedrock Wells, Topock Compressor Station, Needles, California*. January.

United States Geological Survey (USGS). 2006. *Documentation of a Spreadsheet for Time-Series Analysis and Drawdown Estimation.* USGS Scientific Investigations Report 2006-5024.

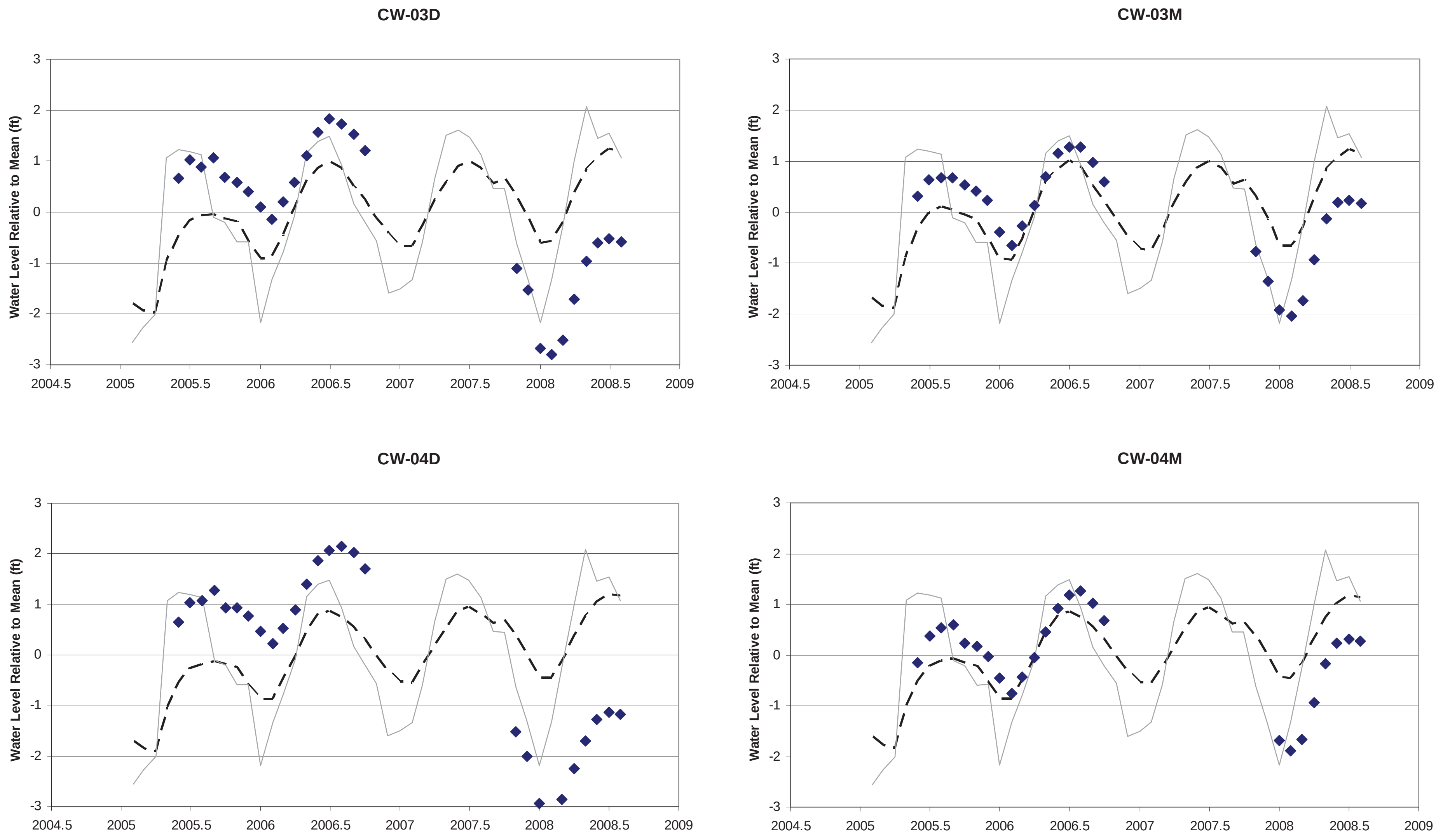


Note:
Water levels shown are relative to the average of each data group over the period January 2005 through July 2008; for example, I-3 river data represent each month's average minus the average of all monthly I-3 averages over the specified period.

FIGURE E-1a
MONTHLY AVERAGE WATER LEVEL FLUCTUATIONS: SIMULATED VERSUS OBSERVED

FINAL GROUNDWATER CORRECTIVE MEASURES STUDY/
FEASIBILITY STUDY REPORT FOR SWMU 1/AOC 1 AND AOC 10
PG&E TOPOCK COMPRESSOR STATION
NEEDLES, CALIFORNIA

CH2MHILL



Legend

◆ observed

▬ ▬ simulated

── I-3 (Colorado River)

Note:
Water levels shown are relative to the average of each data group over the period January 2005 through July 2008; for example, I-3 river data represent each month's average minus the average of all monthly I-3 averages over the specified period.

FIGURE E-1b
MONTHLY AVERAGE WATER LEVEL FLUCTUATIONS: SIMULATED VERSUS OBSERVED

FINAL GROUNDWATER CORRECTIVE MEASURES STUDY/
FEASIBILITY STUDY REPORT FOR SWMU 1/AOC 1 AND AOC 10
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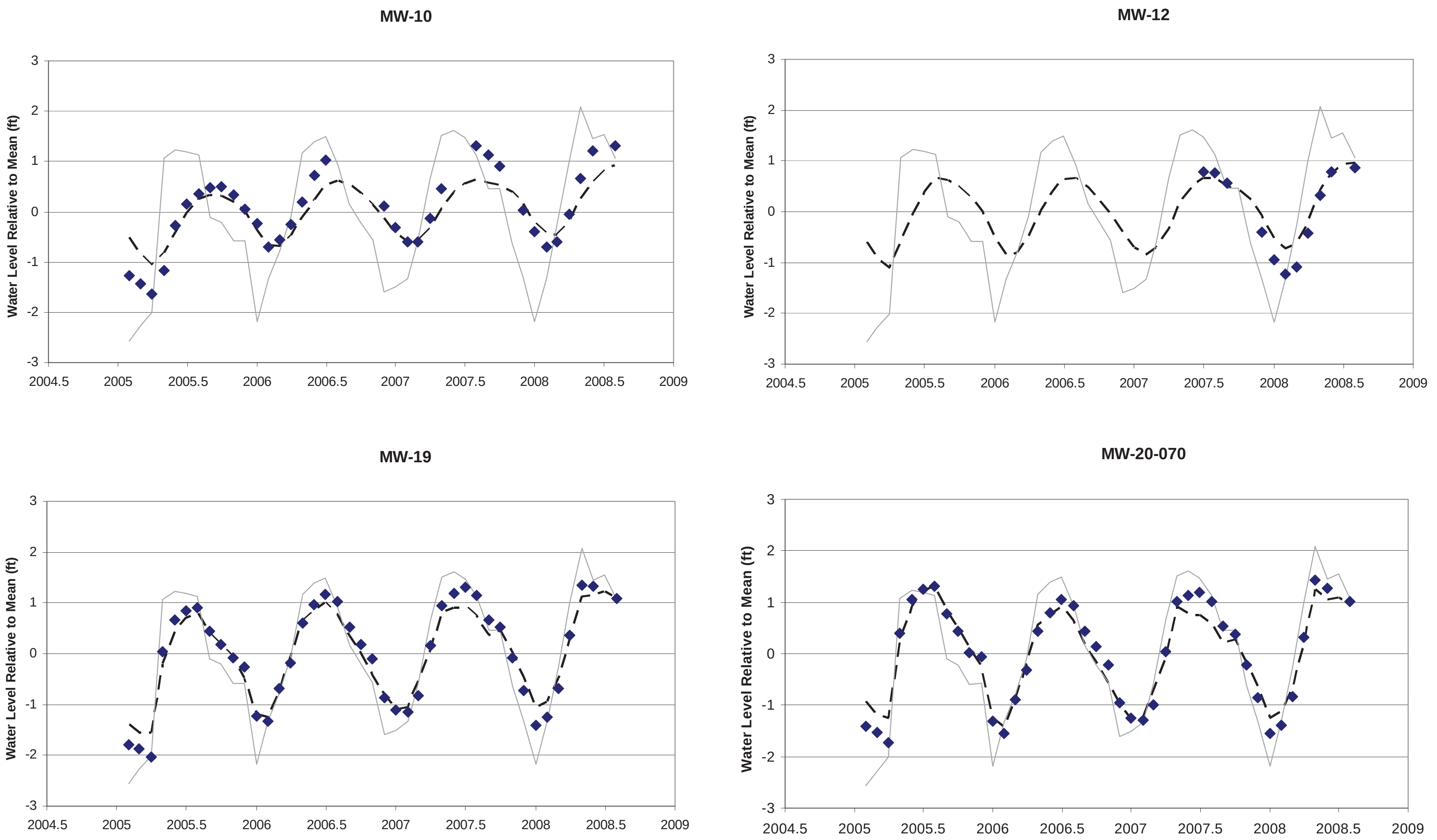
CH2MHILL



Legend

◆ observed

— — simulated

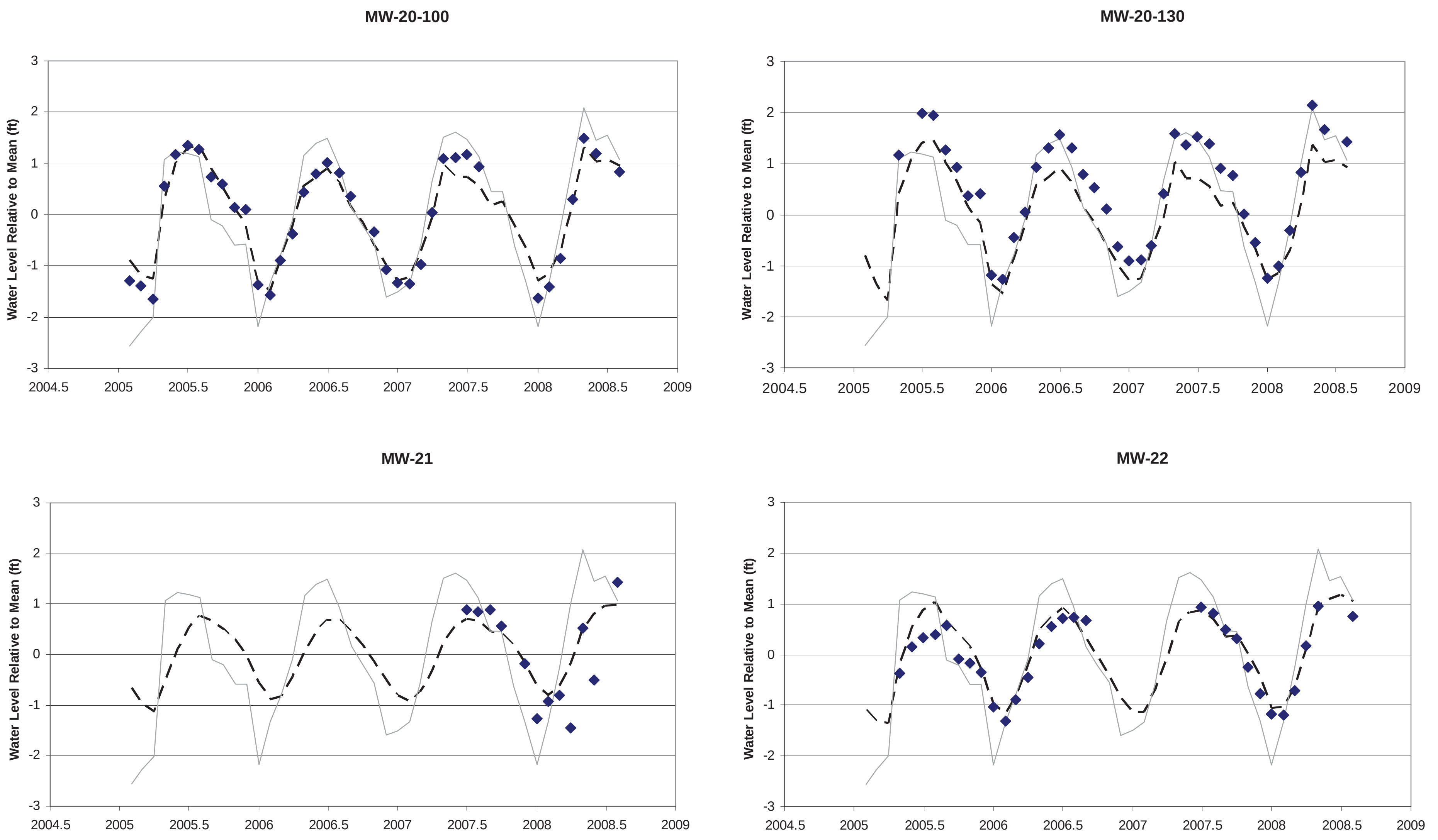
—— I-3 (Colorado River)

Note:
Water levels shown are relative to the average of each data group over the period January 2005 through July 2008; for example, I-3 river data represent each month's average minus the average of all monthly I-3 averages over the specified period.

FIGURE E-1c
MONTHLY AVERAGE WATER LEVEL FLUCTUATIONS: SIMULATED VERSUS OBSERVED

FINAL GROUNDWATER CORRECTIVE MEASURES STUDY/
FEASIBILITY STUDY REPORT FOR SWMU 1/AOC 1 AND AOC 10
PG&E TOPOCK COMPRESSOR STATION
NEEDLES, CALIFORNIA

CH2MHILL



Legend

◆ observed

▬ ▬ simulated

─── I-3 (Colorado River)

Note:
Water levels shown are relative to the average of each data group over the period January 2005 through July 2008; for example, I-3 river data represent each month's average minus the average of all monthly I-3 averages over the specified period.

FIGURE E-1d
MONTHLY AVERAGE WATER LEVEL FLUCTUATIONS: SIMULATED VERSUS OBSERVED

FINAL GROUNDWATER CORRECTIVE MEASURES STUDY/
FEASIBILITY STUDY REPORT FOR SWMU 1/AOC 1 AND AOC 10
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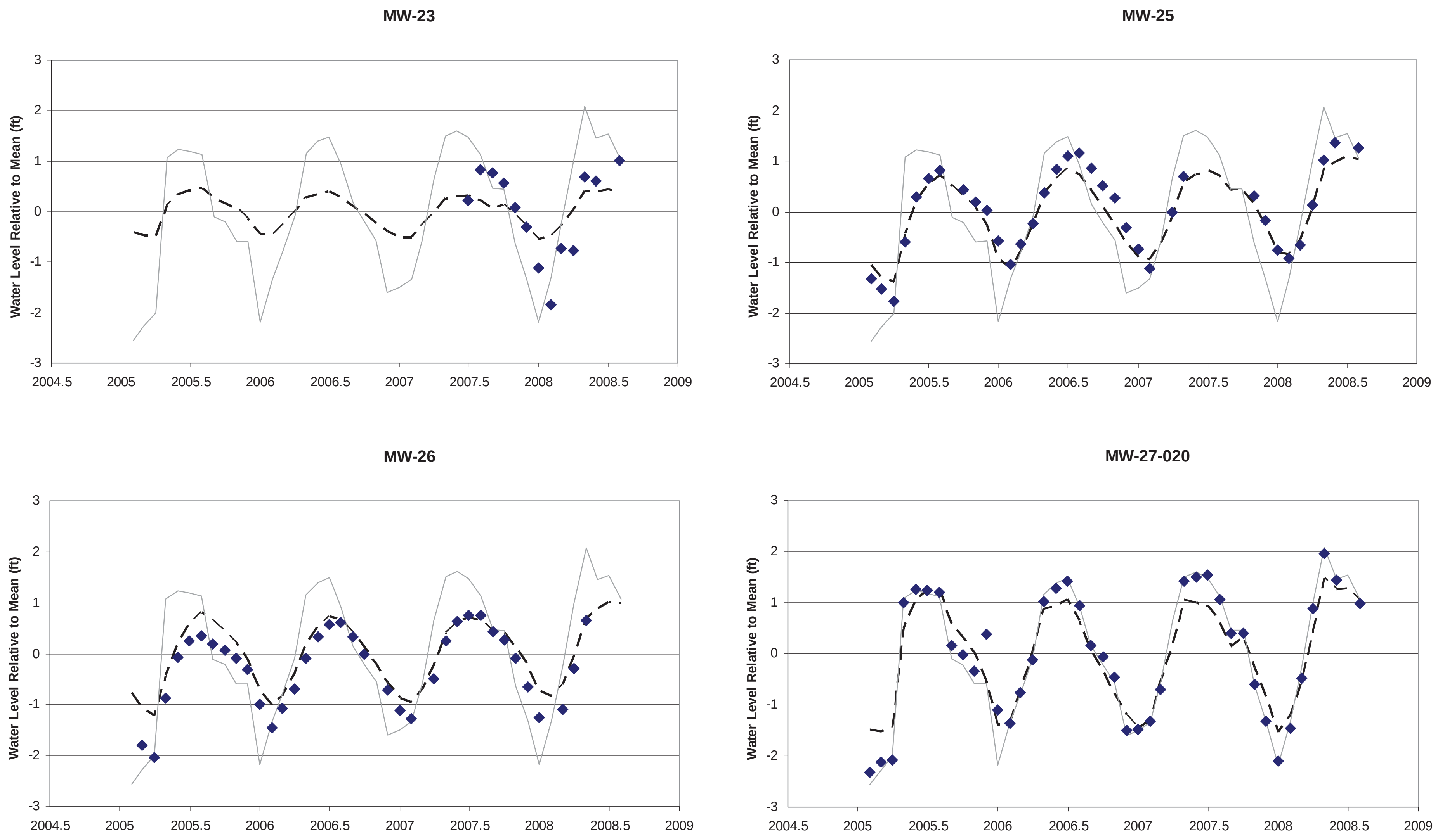
NEEDLES, CALIFORNIA



Note:
Water levels shown are relative to the average of each data group over the period January 2005 through July 2008; for example, I-3 river data represent each month's average minus the average of all monthly I-3 averages over the specified period.

FIGURE E-1e
MONTHLY AVERAGE WATER LEVEL FLUCTUATIONS: SIMULATED VERSUS OBSERVED

FINAL GROUNDWATER CORRECTIVE MEASURES STUDY/
FEASIBILITY STUDY REPORT FOR SWMU 1/AOC 1 AND AOC 10
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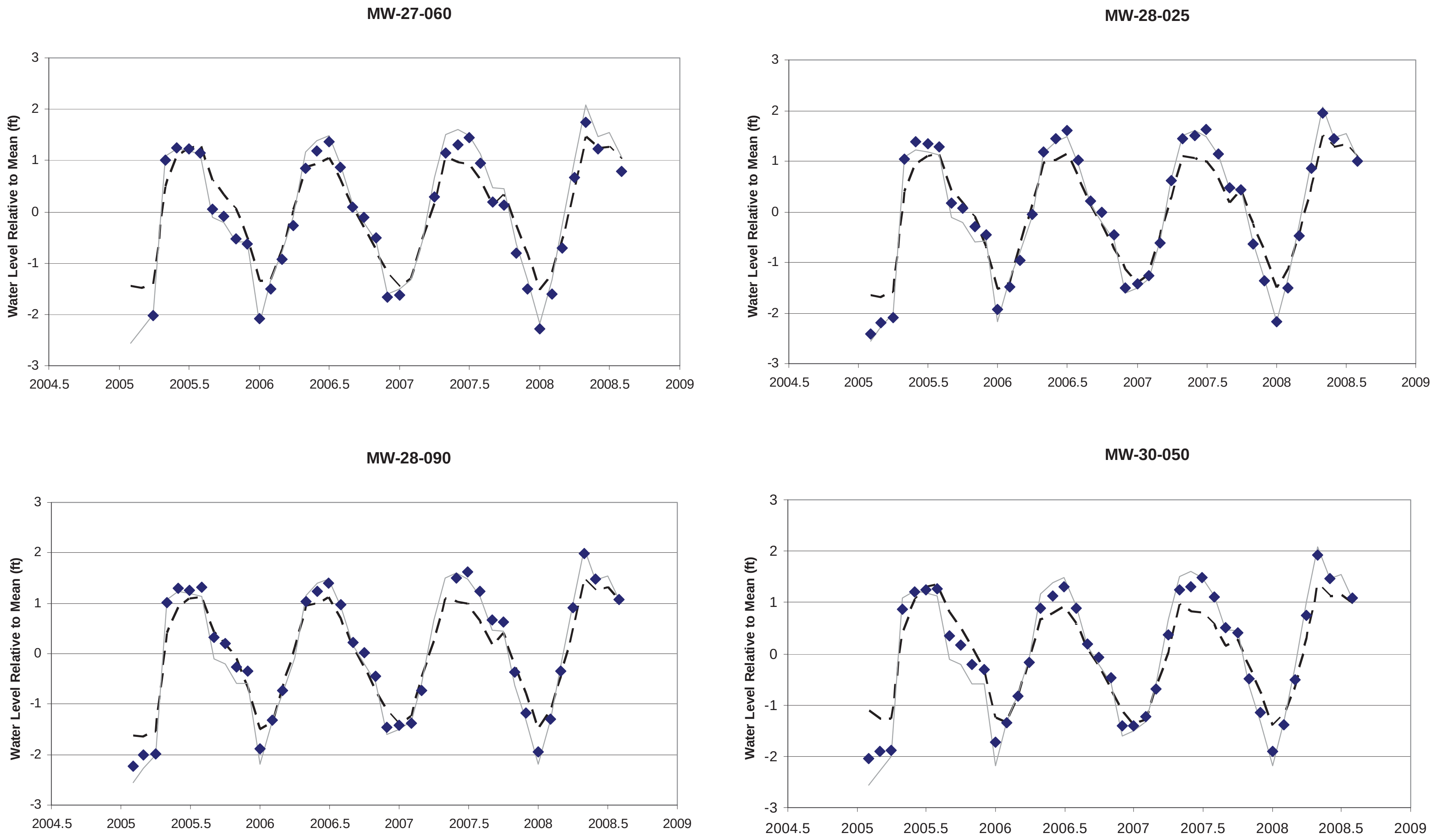

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◆ observed

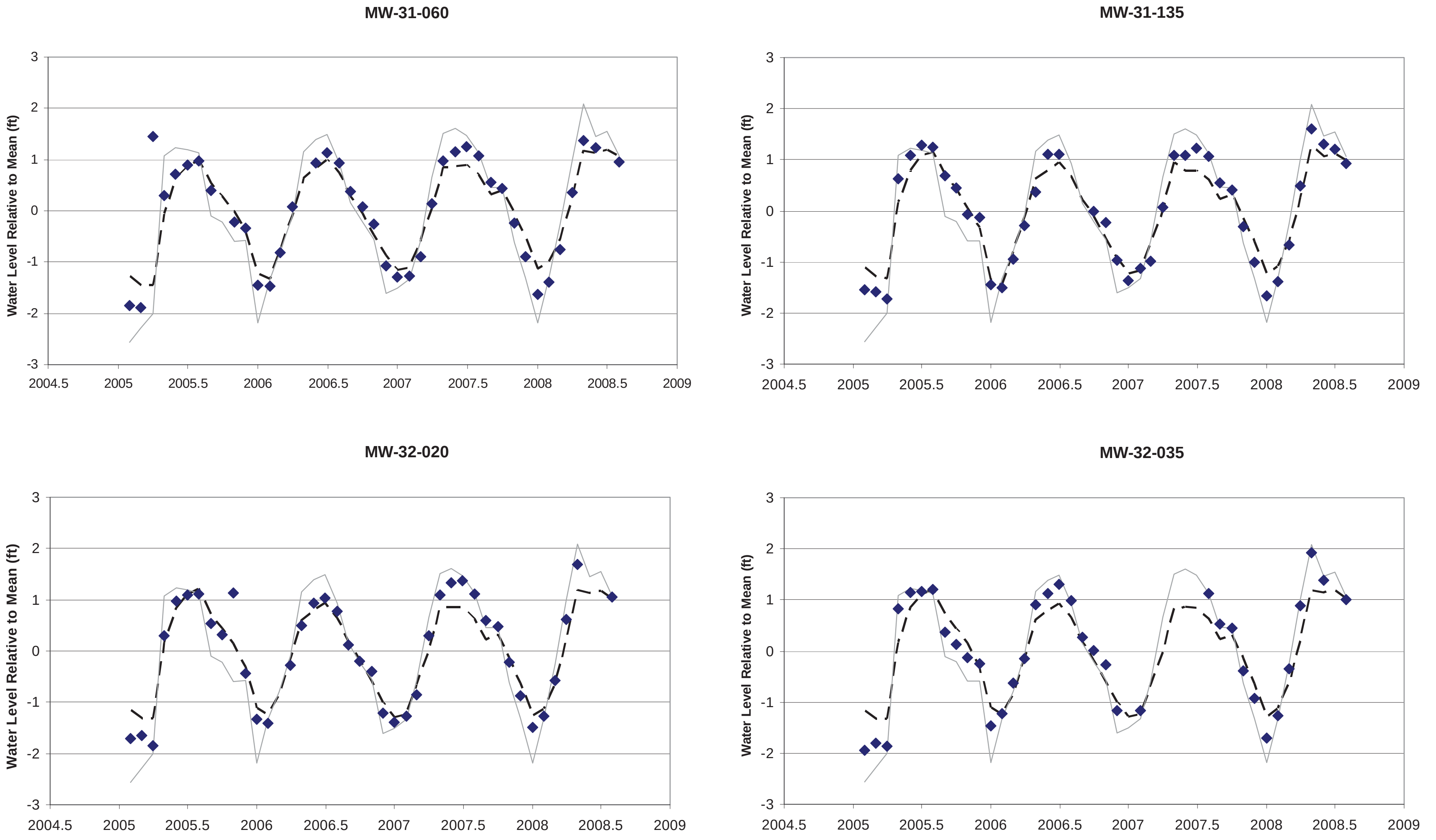
— — simulated

— I-3 (Colorado River)

Note:
Water levels shown are relative to the average of each data group over the period January 2005 through July 2008; for example, I-3 river data represent each month's average minus the average of all monthly I-3 averages over the specified period.

FIGURE E-1f
MONTHLY AVERAGE WATER LEVEL FLUCTUATIONS: SIMULATED VERSUS OBSERVED

FINAL GROUNDWATER CORRECTIVE MEASURES STUDY/
FEASIBILITY STUDY REPORT FOR SWMU 1/AOC 1 AND AOC 10
PG&E TOPOCK COMPRESSOR STATION
NEEDLES, CALIFORNIA



Legend

◆ observed

— — simulated

— I-3 (Colorado River)

Note:
Water levels shown are relative to the average of each data group over the period January 2005 through July 2008; for example, I-3 river data represent each month's average minus the average of all monthly I-3 averages over the specified period.

FIGURE E-1g
MONTHLY AVERAGE WATER LEVEL FLUCTUATIONS: SIMULATED VERSUS OBSERVED

FINAL GROUNDWATER CORRECTIVE MEASURES STUDY/
FEASIBILITY STUDY REPORT FOR SWMU 1/AOC 1 AND AOC 10
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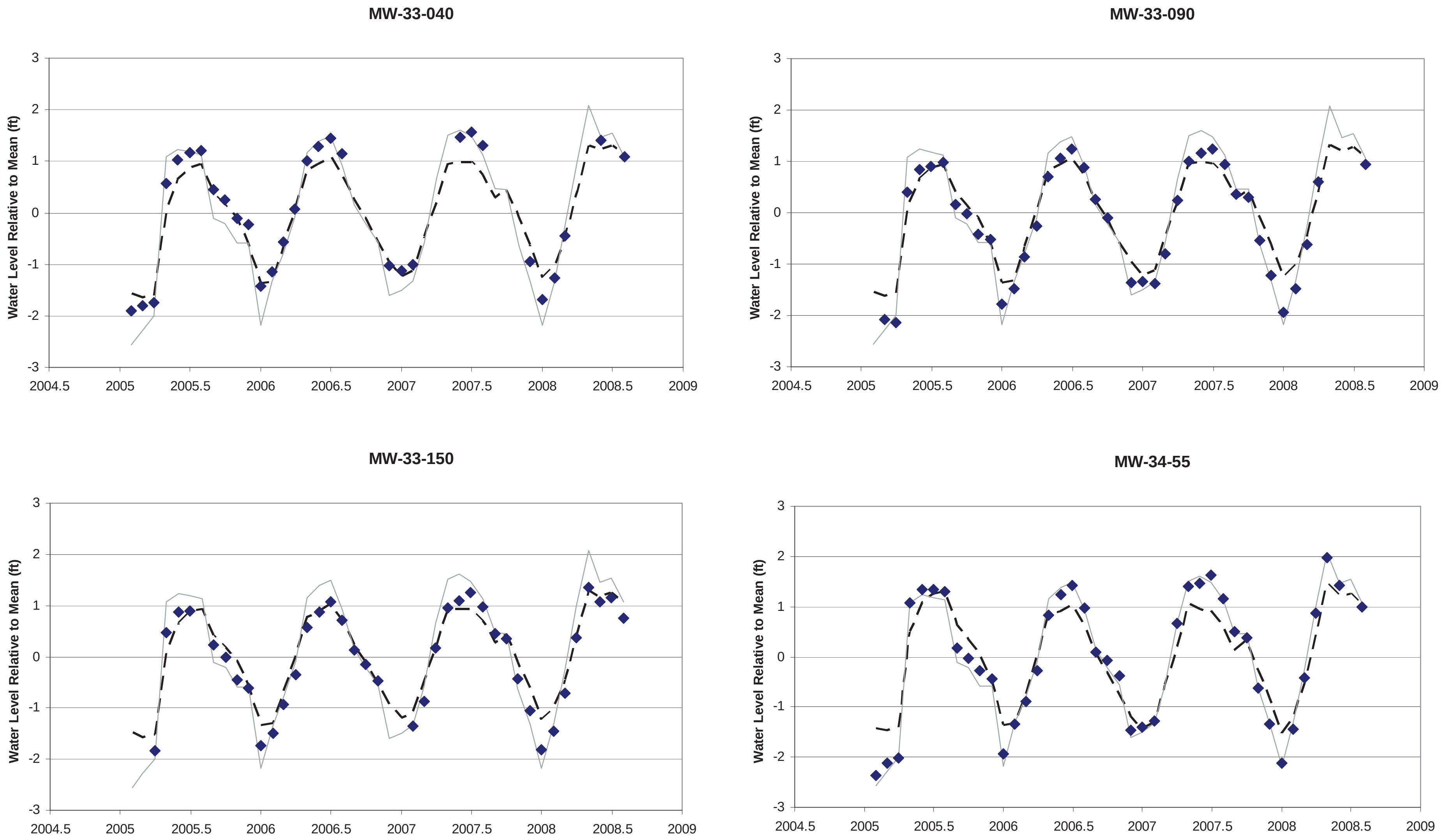
NEEDLES, CALIFORNIA



Legend

◆ observed

— — simulated

— I-3 (Colorado River)

Note:
Water levels shown are relative to the average of each data group over the period January 2005 through July 2008; for example, I-3 river data represent each month's average minus the average of all monthly I-3 averages over the specified period.

FIGURE E-1h
MONTHLY AVERAGE WATER LEVEL FLUCTUATIONS: SIMULATED VERSUS OBSERVED

FINAL GROUNDWATER CORRECTIVE MEASURES STUDY/
FEASIBILITY STUDY REPORT FOR SWMU 1/AOC 1 AND AOC 10
PG&E TOPOCK COMPRESSOR STATION
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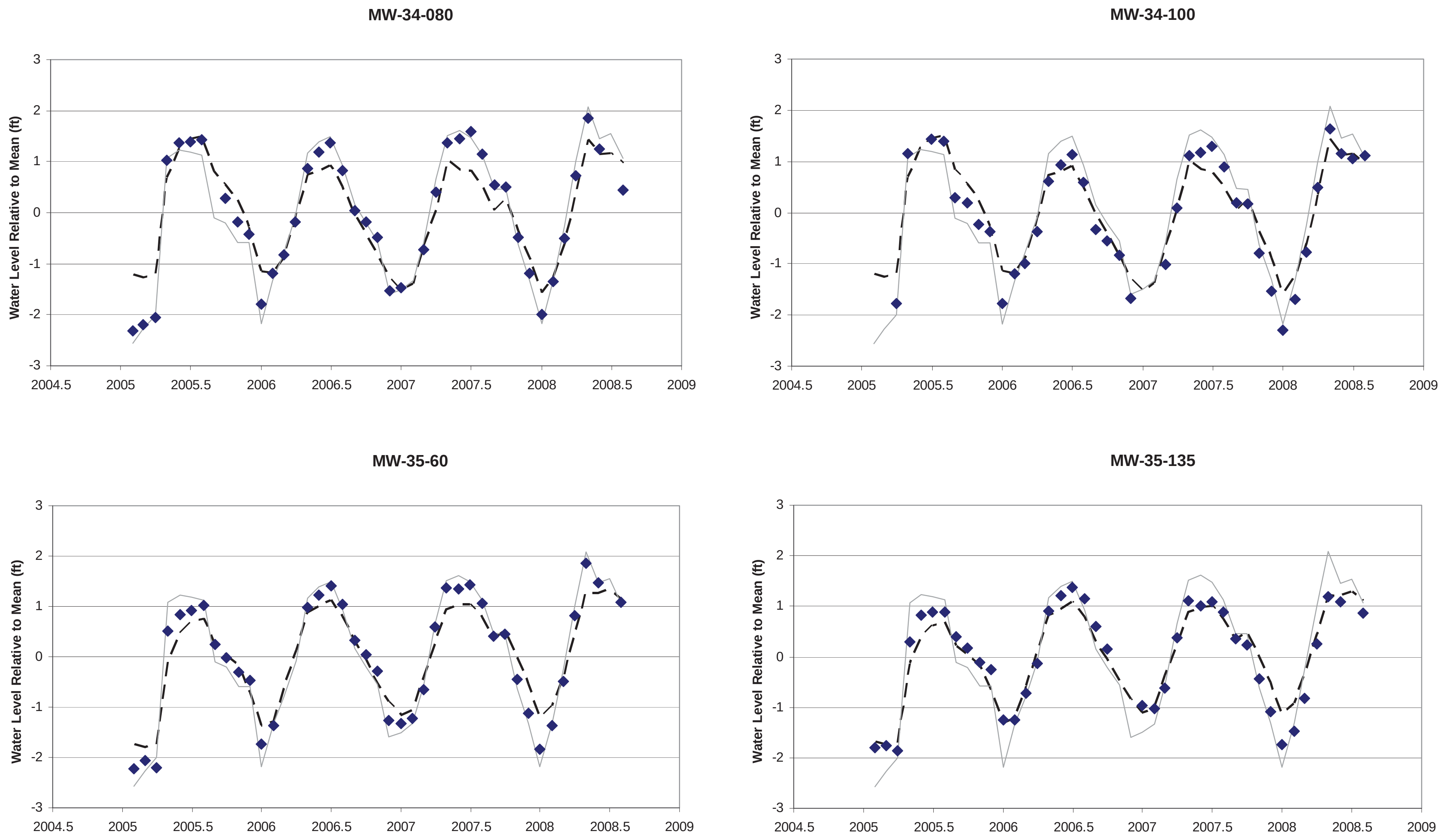

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◆ observed

— — simulated

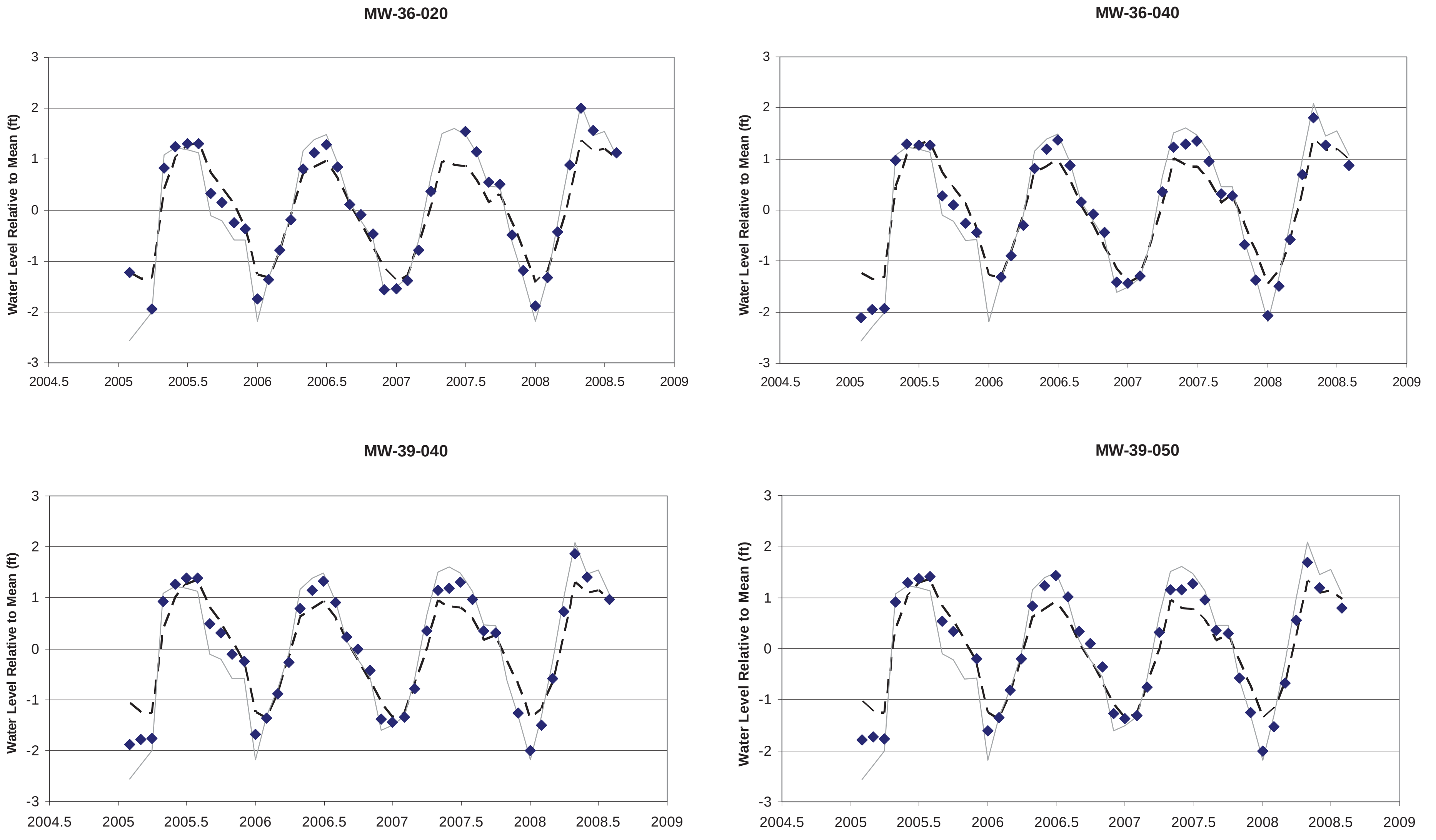
—— I-3 (Colorado River)

Note:
Water levels shown are relative to the average of each data group over the period January 2005 through July 2008; for example, I-3 river data represent each month's average minus the average of all monthly I-3 averages over the specified period.

FIGURE E-1i
MONTHLY AVERAGE WATER LEVEL FLUCTUATIONS: SIMULATED VERSUS OBSERVED

FINAL GROUNDWATER CORRECTIVE MEASURES STUDY/
FEASIBILITY STUDY REPORT FOR SWMU 1/AOC 1 AND AOC 10
PG&E TOPOCK COMPRESSOR STATION
NEEDLES, CALIFORNIA

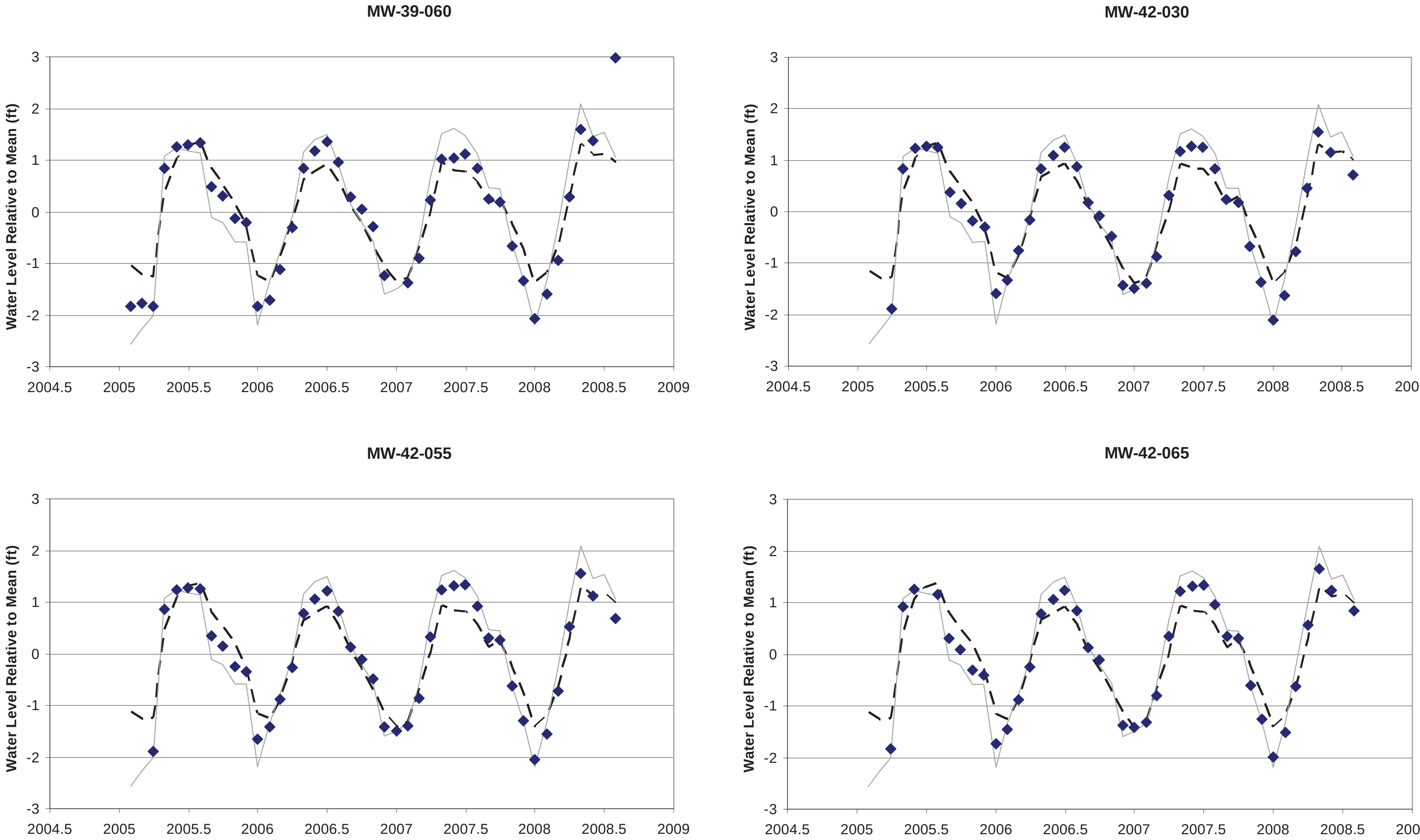
CH2MHILL



Note:
Water levels shown are relative to the average of each data group over the period January 2005 through July 2008; for example, I-3 river data represent each month's average minus the average of all monthly I-3 averages over the specified period.

FIGURE E-1j
MONTHLY AVERAGE WATER LEVEL FLUCTUATIONS: SIMULATED VERSUS OBSERVED

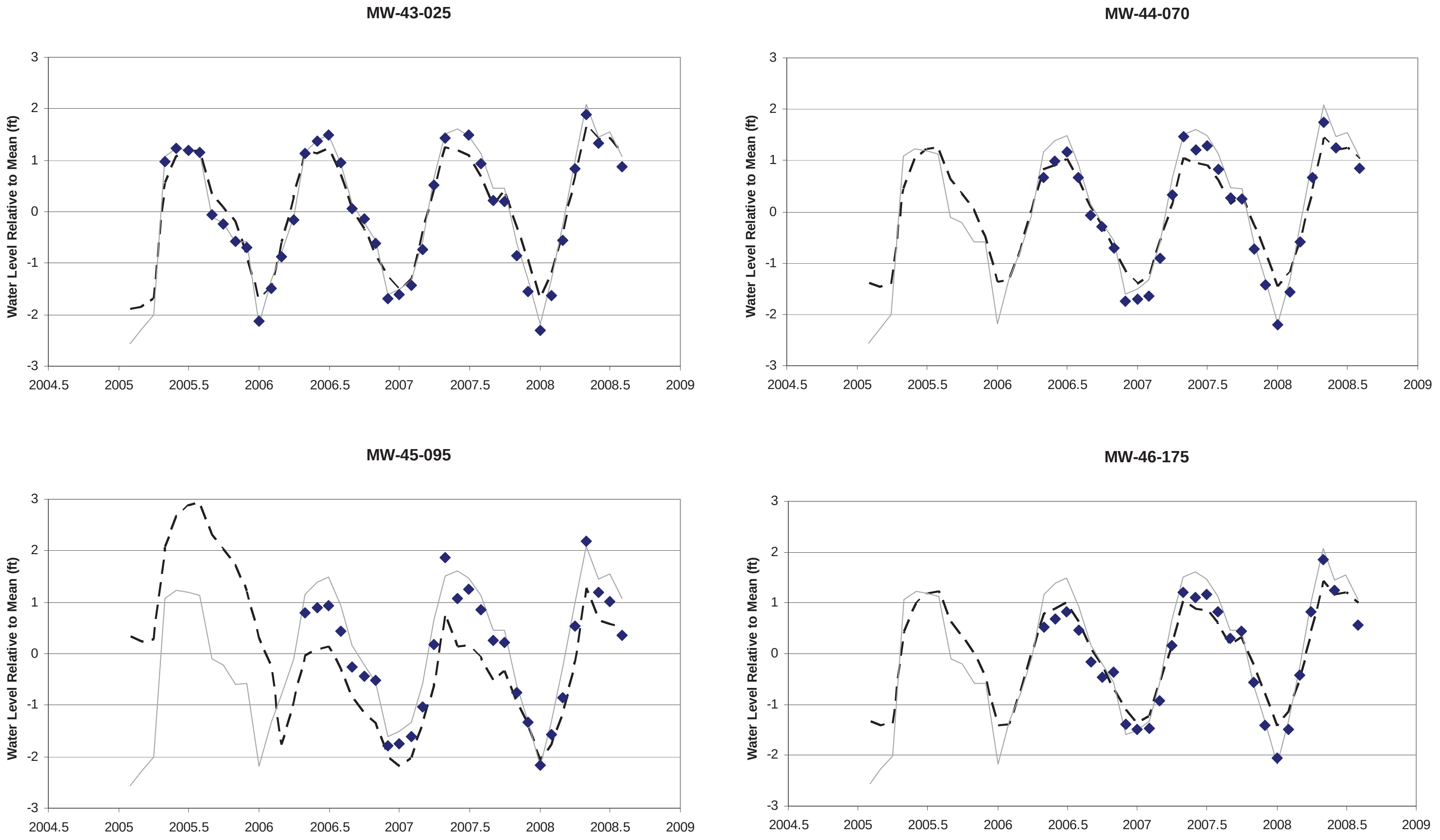
FINAL GROUNDWATER CORRECTIVE MEASURES STUDY/
FEASIBILITY STUDY REPORT FOR SWMU 1/AOC 1 AND AOC 10
PG&E TOPOCK COMPRESSOR STATION
NEEDLES, CALIFORNIA



Note:
Water levels shown are relative to the average of each data group over the period January 2005 through July 2008; for example, I-3 river data represent each month's average minus the average of all monthly I-3 averages over the specified period.

FIGURE E-1k
MONTHLY AVERAGE WATER LEVEL FLUCTUATIONS: SIMULATED VERSUS OBSERVED

FINAL GROUNDWATER CORRECTIVE MEASURES STUDY/
FEASIBILITY STUDY REPORT FOR SWMU 1/AOC 1 AND AOC 10
PG&E TOPOCK COMPRESSOR STATION
NEEDLES, CALIFORNIA



Legend

◆ observed

— — simulated

— I-3 (Colorado River)

Note:
Water levels shown are relative to the average of each data group over the period January 2005 through July 2008; for example, I-3 river data represent each month's average minus the average of all monthly I-3 averages over the specified period.

FIGURE E-1l
MONTHLY AVERAGE WATER LEVEL FLUCTUATIONS: SIMULATED VERSUS OBSERVED

FINAL GROUNDWATER CORRECTIVE MEASURES STUDY/
FEASIBILITY STUDY REPORT FOR SWMU 1/AOC 1 AND AOC 10
PG&E TOPOCK COMPRESSOR STATION
NEEDLES, CALIFORNIA

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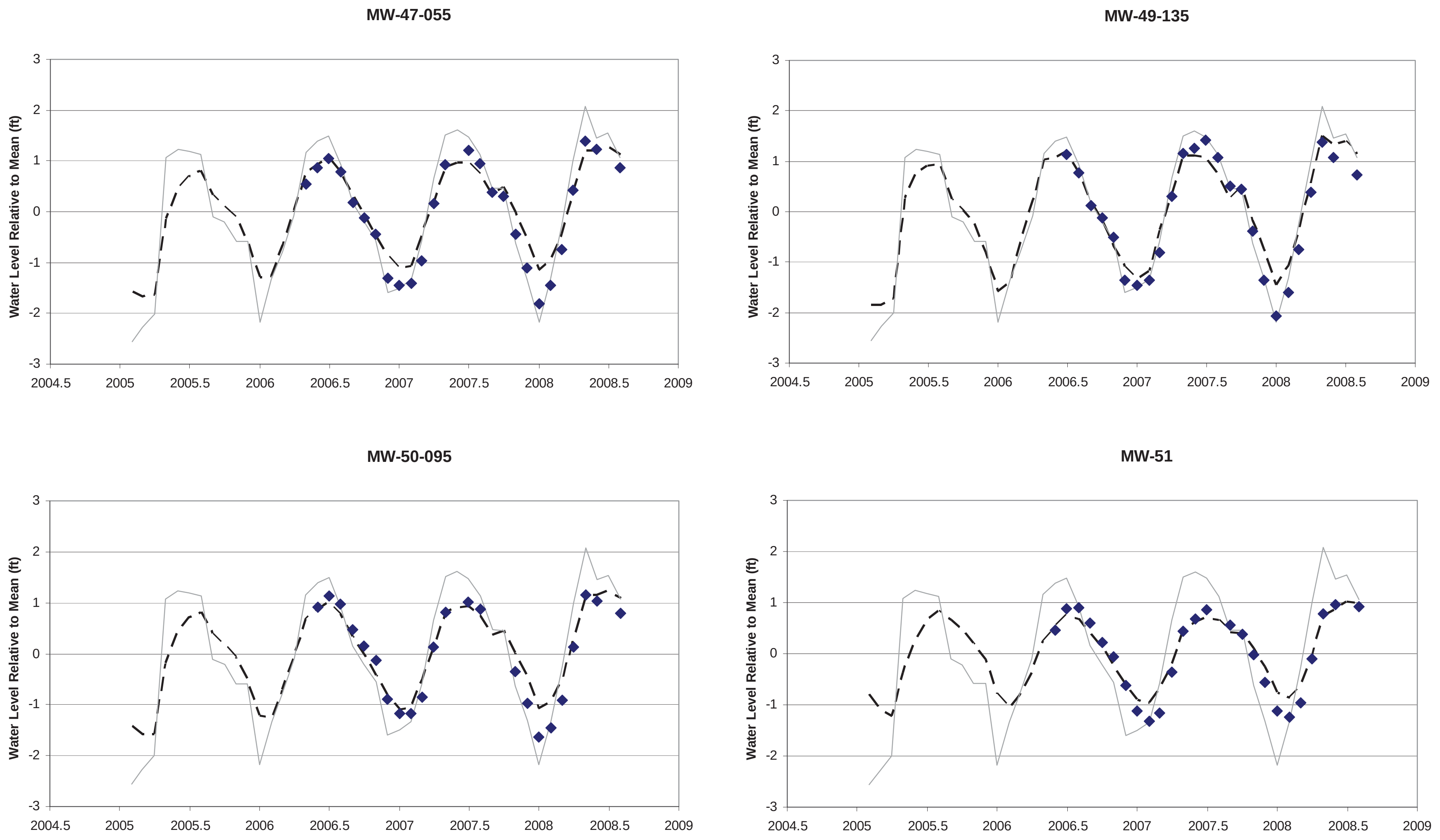


Legend

◆ observed

— — simulated

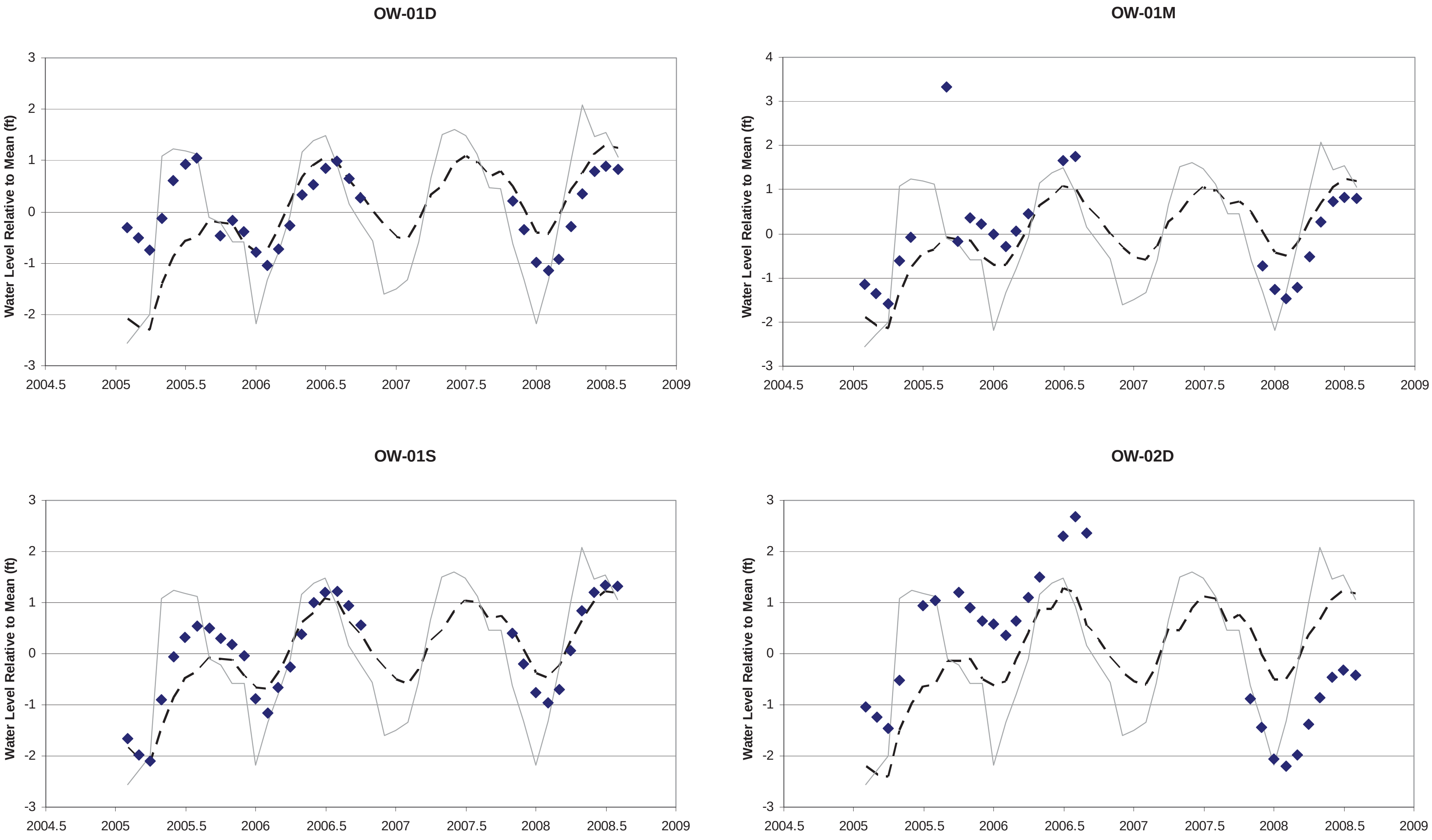
— I-3 (Colorado River)

Note:
Water levels shown are relative to the average of each data group over the period January 2005 through July 2008; for example, I-3 river data represent each month's average minus the average of all monthly I-3 averages over the specified period.

FIGURE E-1m
MONTHLY AVERAGE WATER LEVEL FLUCTUATIONS: SIMULATED VERSUS OBSERVED

FINAL GROUNDWATER CORRECTIVE MEASURES STUDY/
FEASIBILITY STUDY REPORT FOR SWMU 1/AOC 1 AND AOC 10
PG&E TOPOCK COMPRESSOR STATION
NEEDLES, CALIFORNIA

CH2MHILL



Legend

◆ observed

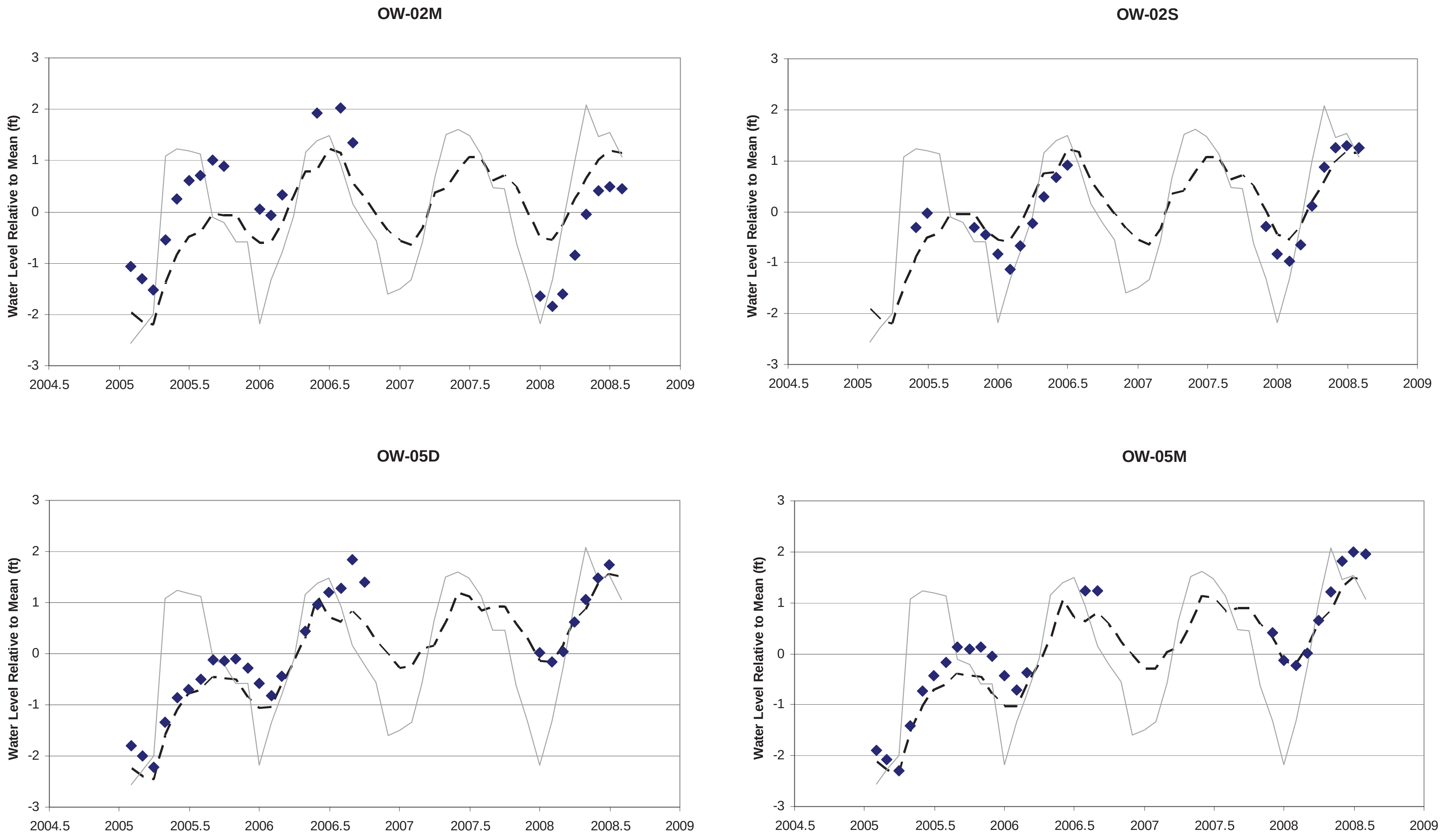
— — simulated

─ I-3 (Colorado River)

Note:
Water levels shown are relative to the average of each data group over the period January 2005 through July 2008; for example, I-3 river data represent each month's average minus the average of all monthly I-3 averages over the specified period.

FIGURE E-1n
MONTHLY AVERAGE WATER LEVEL FLUCTUATIONS: SIMULATED VERSUS OBSERVED

FINAL GROUNDWATER CORRECTIVE MEASURES STUDY/
FEASIBILITY STUDY REPORT FOR SWMU 1/AOC 1 AND AOC 10
PG&E TOPOCK COMPRESSOR STATION
NEEDLES, CALIFORNIA



Legend

◆ observed

— — simulated

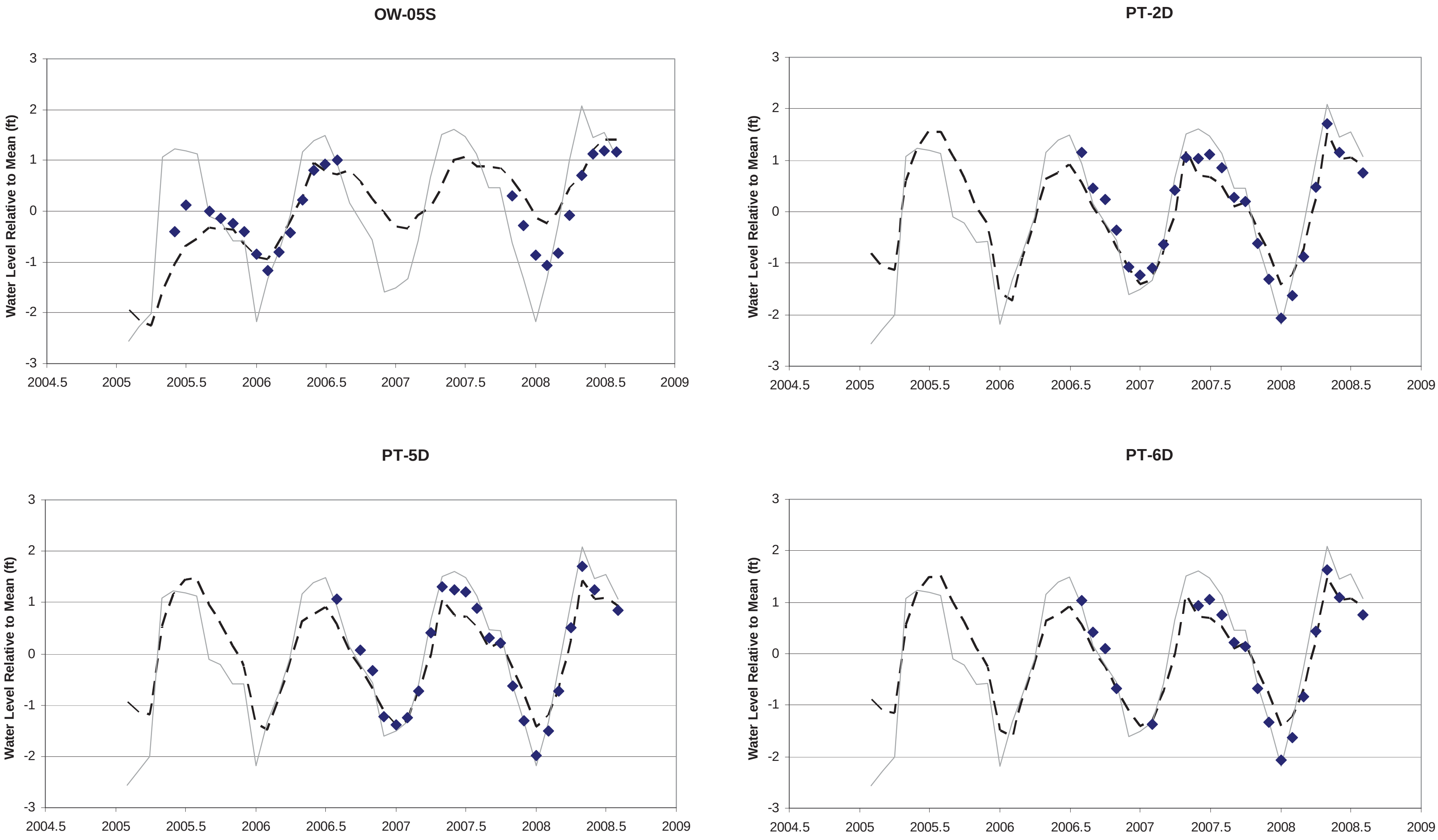
—— I-3 (Colorado River)

Note:
Water levels shown are relative to the average of each data group over the period January 2005 through July 2008; for example, I-3 river data represent each month's average minus the average of all monthly I-3 averages over the specified period.

FIGURE E-1o
MONTHLY AVERAGE WATER LEVEL FLUCTUATIONS: SIMULATED VERSUS OBSERVED

FINAL GROUNDWATER CORRECTIVE MEASURES STUDY/
FEASIBILITY STUDY REPORT FOR SWMU 1/AOC 1 AND AOC 10
PG&E TOPOCK COMPRESSOR STATION
NEEDLES, CALIFORNIA

CH2MHILL



Legend

◆ observed

— — simulated

— I-3 (Colorado River)

Note:
Water levels shown are relative to the average of each data group over the period January 2005 through July 2008; for example, I-3 river data represent each month's average minus the average of all monthly I-3 averages over the specified period.

FIGURE E-1p
MONTHLY AVERAGE WATER LEVEL FLUCTUATIONS: SIMULATED VERSUS OBSERVED

FINAL GROUNDWATER CORRECTIVE MEASURES STUDY/
FEASIBILITY STUDY REPORT FOR SWMU 1/AOC 1 AND AOC 10
PG&E TOPOCK COMPRESSOR STATION
NEEDLES, CALIFORNIA

CH2MHILL

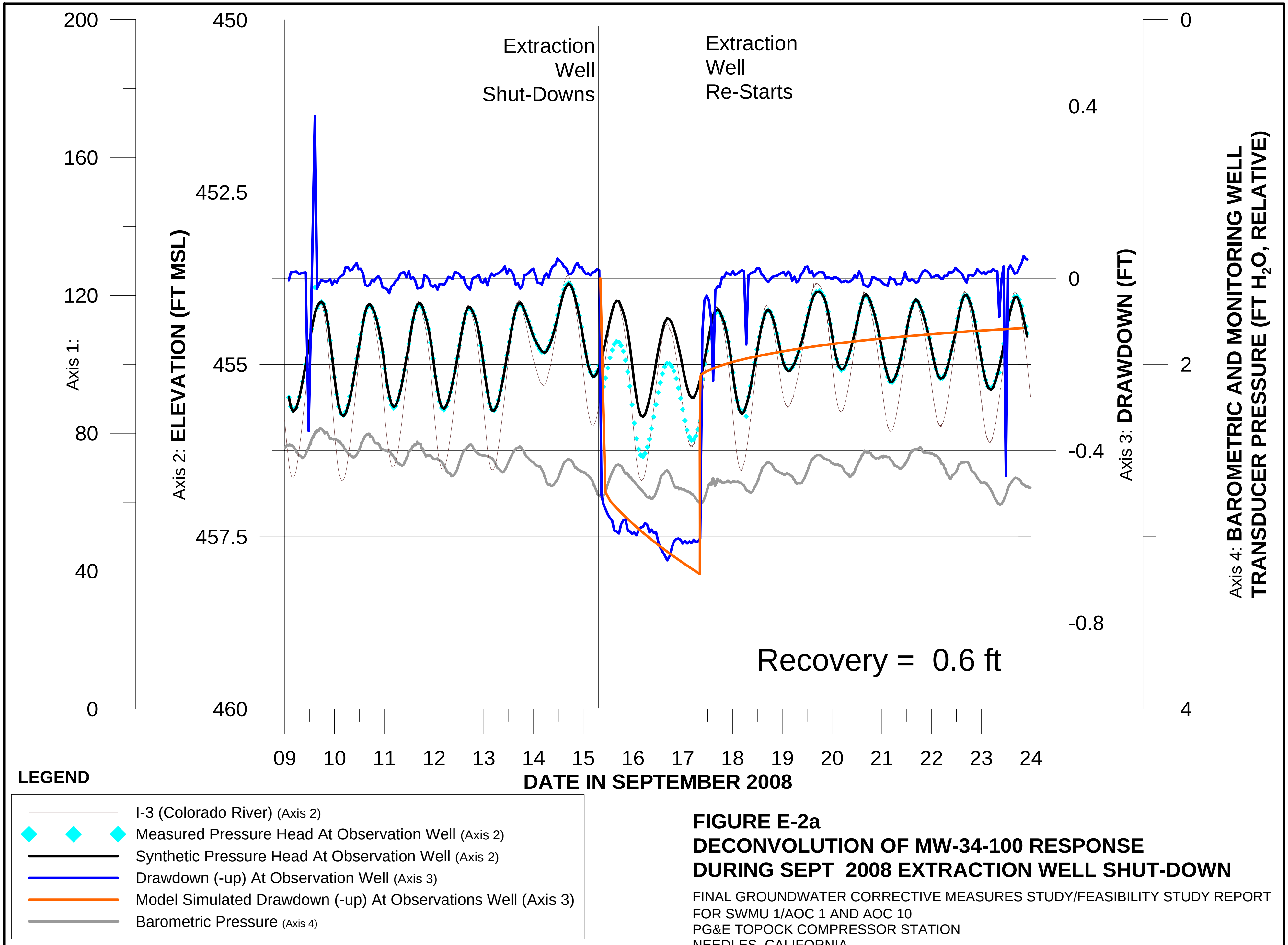


FIGURE E-2a
DECONVOLUTION OF MW-34-100 RESPONSE DURING SEPT 2008 EXTRACTION WELL SHUT-DOWN

FINAL GROUNDWATER CORRECTIVE MEASURES STUDY/FEASIBILITY STUDY REPORT
FOR SWMU 1/AOC 1 AND AOC 10
PG&E TOPOCK COMPRESSOR STATION
NEEDLES, CALIFORNIA

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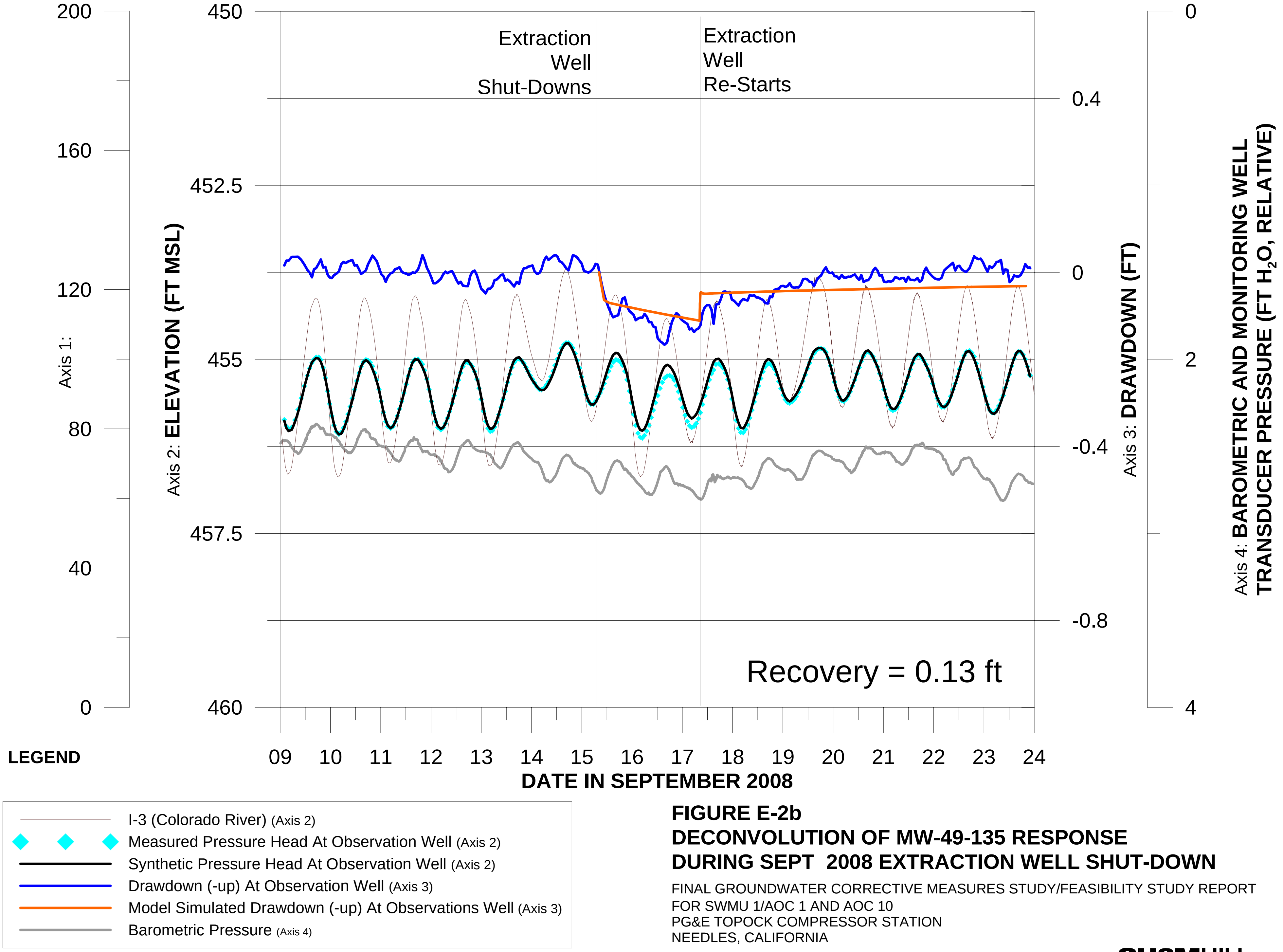

FIGURE E-2b
DECONVOLUTION OF MW-49-135 RESPONSE DURING SEPT 2008 EXTRACTION WELL SHUT-DOWN

FINAL GROUNDWATER CORRECTIVE MEASURES STUDY/FEASIBILITY STUDY REPORT
FOR SWMU 1/AOC 1 AND AOC 10
PG&E TOPOCK COMPRESSOR STATION
NEEDLES, CALIFORNIA

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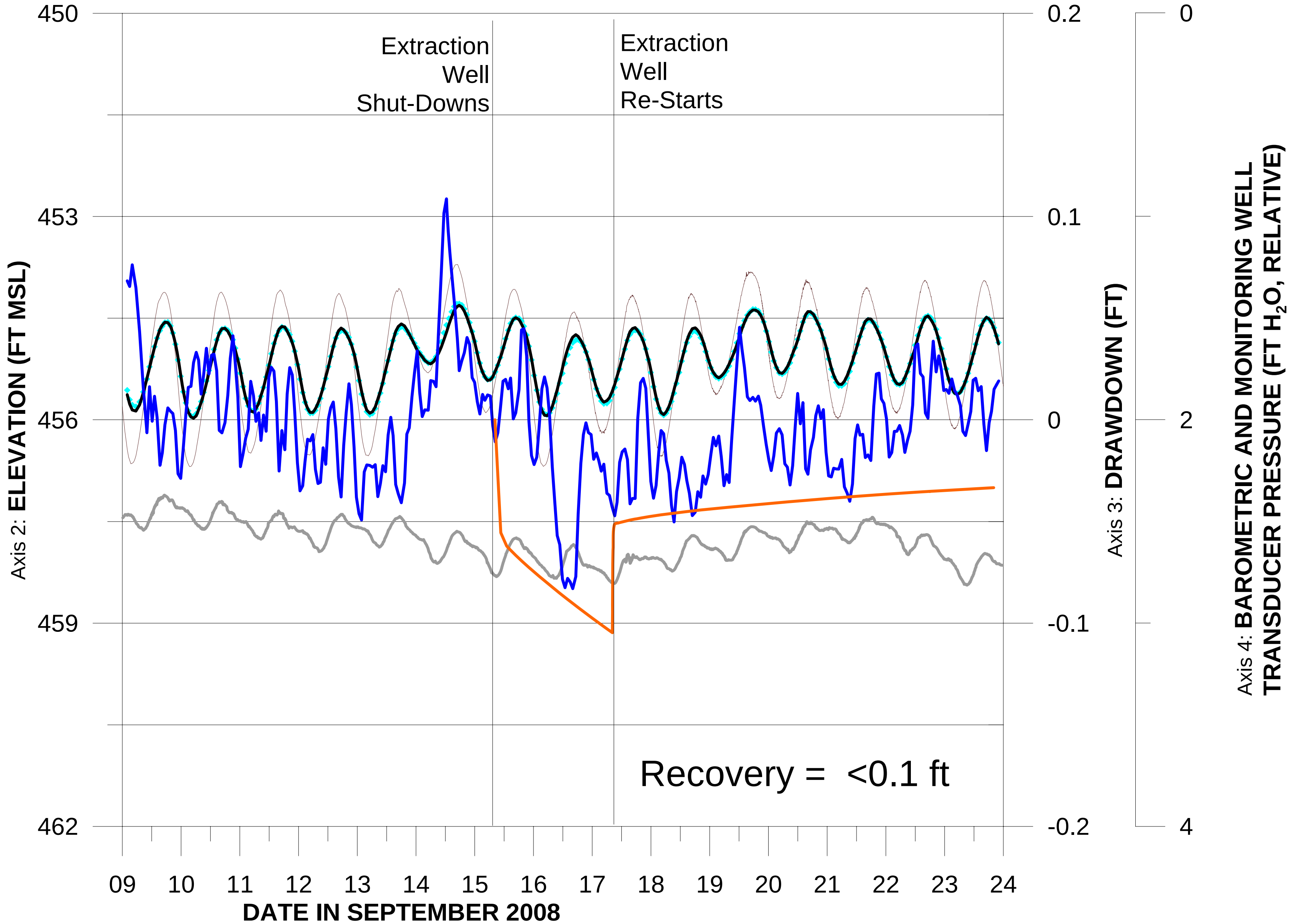
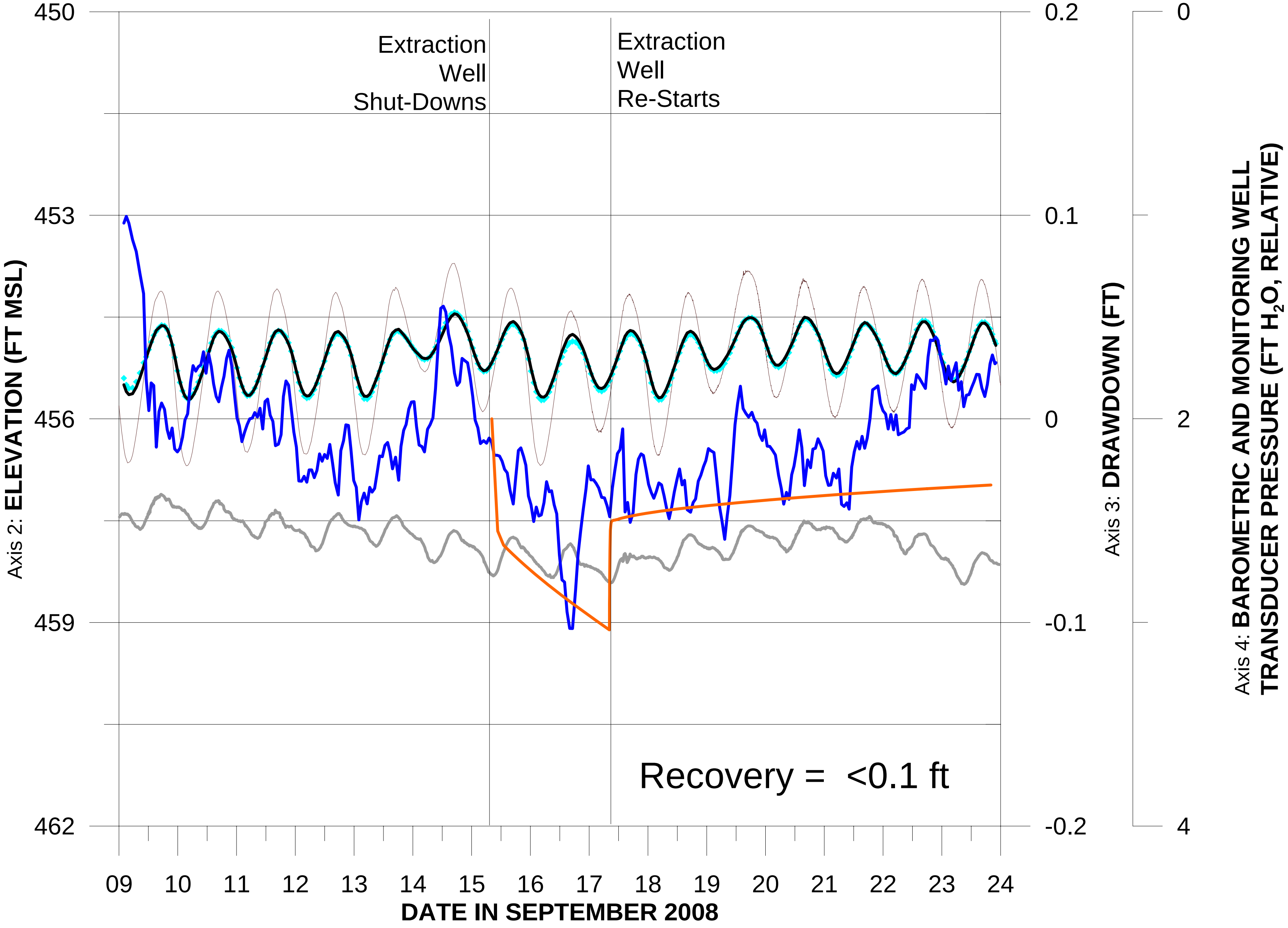


FIGURE E-2c
DECONVOLUTION OF MW-54-085
RESPONSE DURING SEPTEMBER 2008
EXTRACTION WELL SHUT-DOWN

FINAL GROUNDWATER CORRECTIVE MEASURES STUDY/FEASIBILITY STUDY REPORT
FOR SWMU 1/AOC 1 AND AOC 10
PG&E TOPOCK COMPRESSOR STATION
NEEDLES, CALIFORNIA



LEGEND

- I-3 (Colorado River) (Axis 2)
- ◆ ◆ ◆ Measured Pressure Head At Observation Well (Axis 2)
- Synthetic Pressure Head At Observation Well (Axis 2)
- Drawdown (-up) At Observation Well (Axis 3)
- Model Simulated Drawdown (-up) At Observations Well (Axis 3)
- Barometric Pressure (Axis 4)

FIGURE E-2d
DECONVOLUTION OF MW-54-140 RESPONSE DURING SEPTEMBER 2008 EXTRACTION WELL SHUT-DOWN

FINAL GROUNDWATER CORRECTIVE MEASURES STUDY/FEASIBILITY STUDY REPORT
FOR SWMU 1/AOC 1 AND AOC 10
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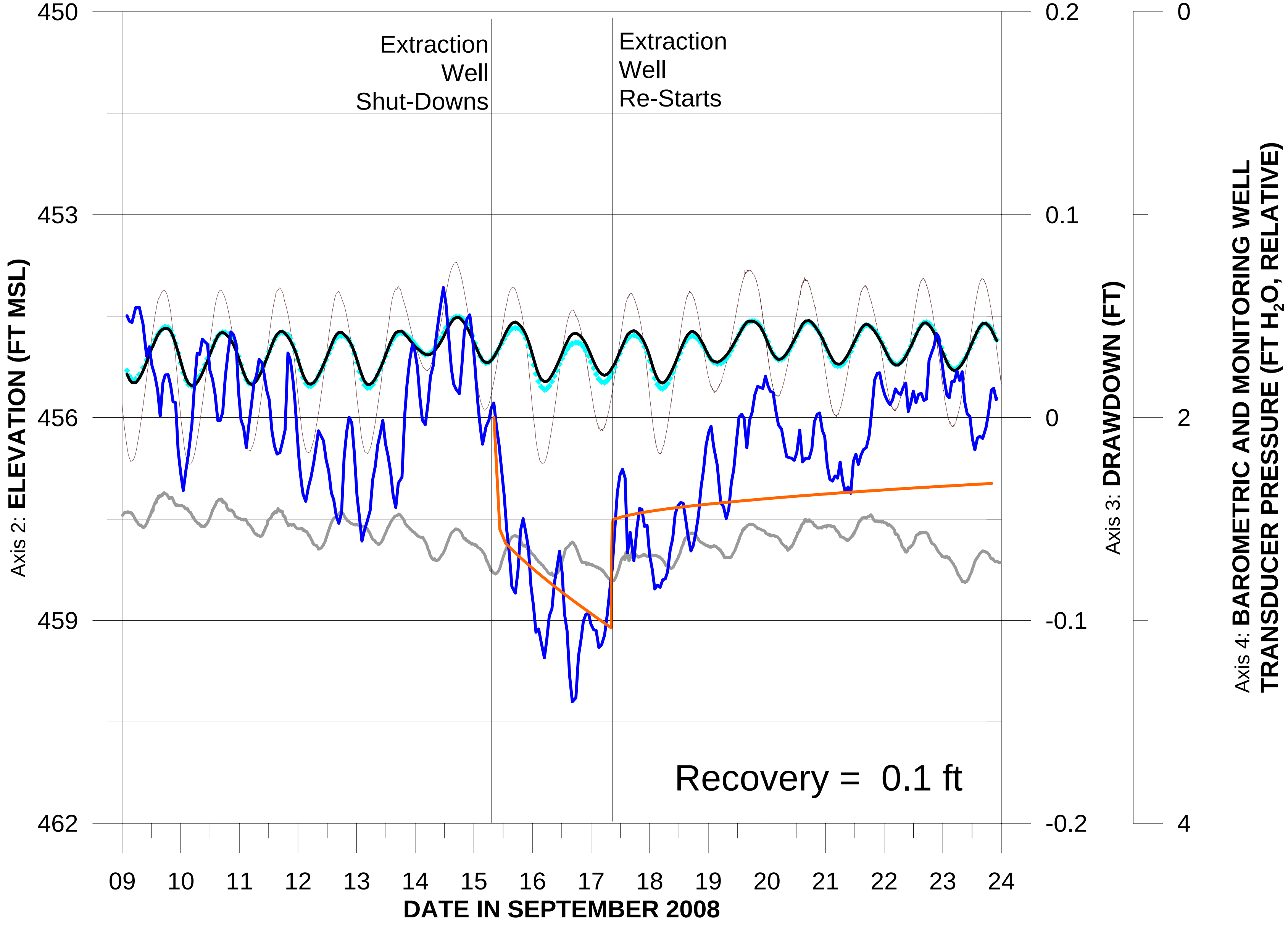

LEGEND

―	I-3 (Colorado River) (Axis 2)
◆ ◆ ◆	Measured Pressure Head At Observation Well (Axis 2)
―	Synthetic Pressure Head At Observation Well (Axis 2)
―	Drawdown (-up) At Observation Well (Axis 3)
―	Model Simulated Drawdown (-up) At Observations Well (Axis 3)
―	Barometric Pressure (Axis 4)

FIGURE E-2e
DECONVOLUTION OF MW-54-195 RESPONSE DURING SEPTEMBER 2008 EXTRACTION WELL SHUT-DOWN

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FOR SWMU 1/AOC 1 AND AOC 10
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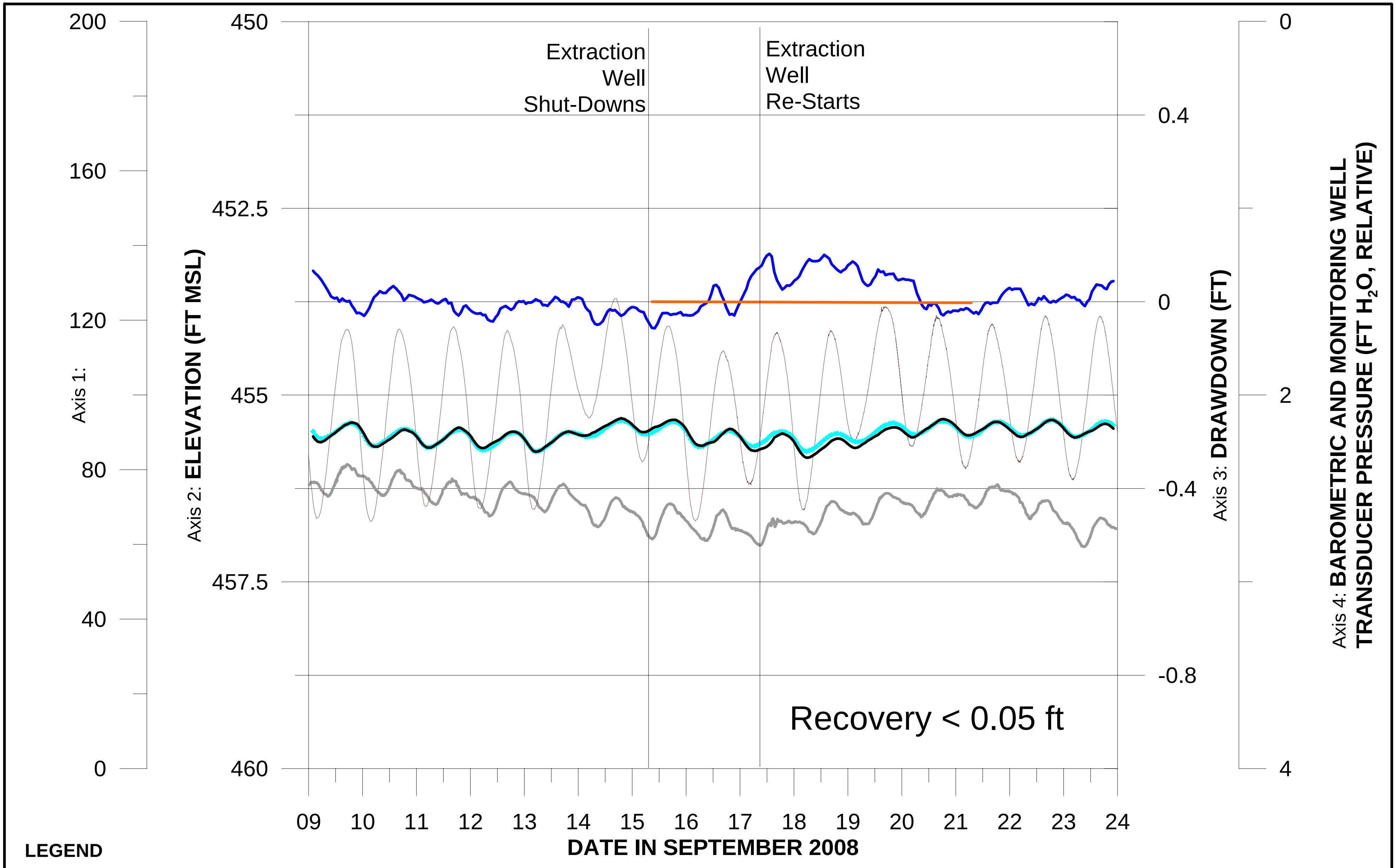

LEGEND

—	I-3 (Colorado River) (Axis 2)
◆ ◆ ◆	Measured Pressure Head At Observation Well (Axis 2)
—	Synthetic Pressure Head At Observation Well (Axis 2)
—	Drawdown (-up) At Observation Well (Axis 3)
—	Model Simulated Drawdown (-up) At Observations Well (Axis 3)
—	Barometric Pressure (Axis 4)

FIGURE E-2f
DECONVOLUTION OF MW-55-045 RESPONSE
DURING SEPT 2008 EXTRACTION WELLSHUT-DOWN

FINAL GROUNDWATER CORRECTIVE MEASURES STUDY/FEASIBILITY STUDY REPORT
FOR SWMU 1/AOC 1 AND AOC 10
PG&E TOPOCK COMPRESSOR STATION
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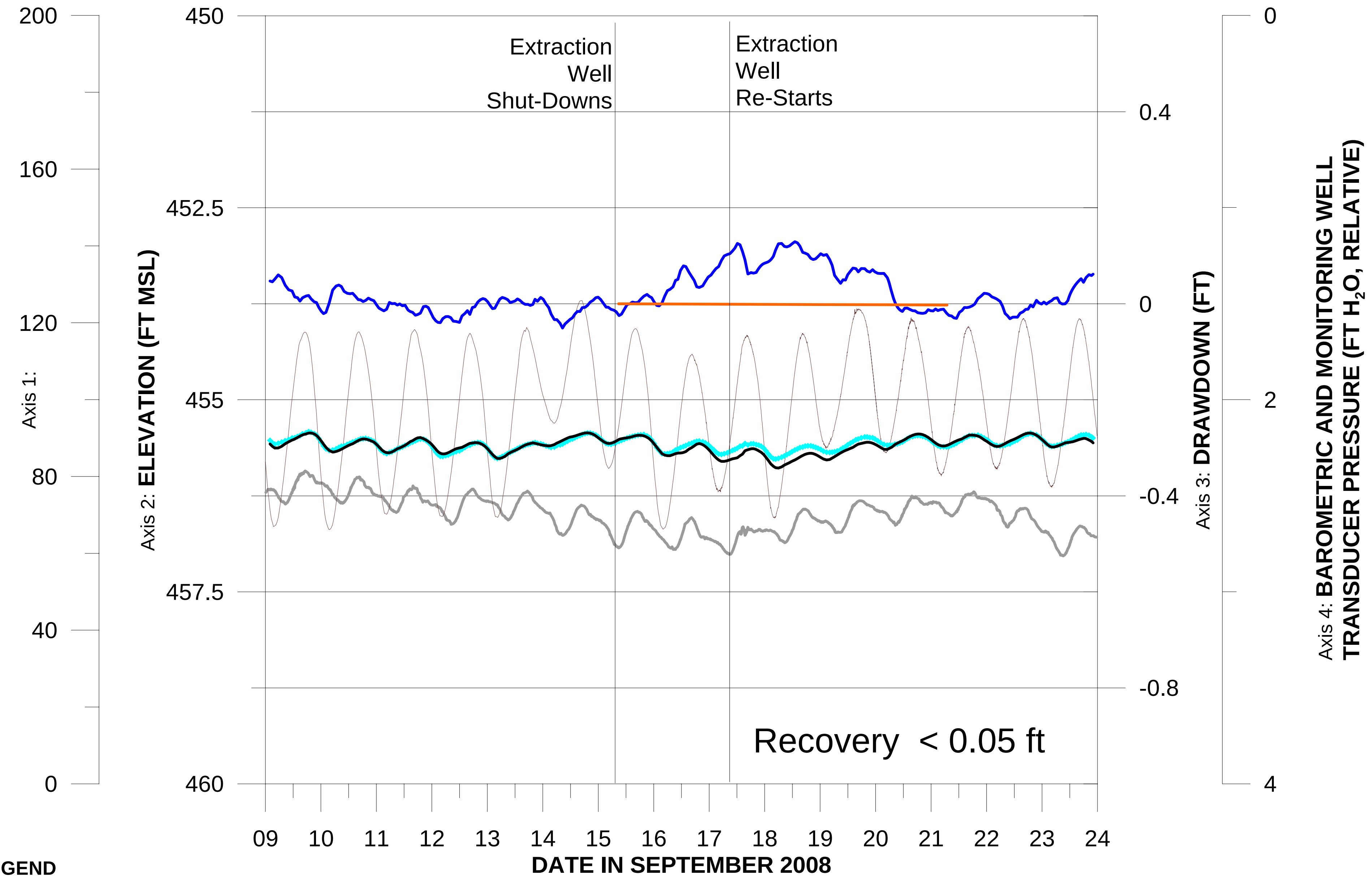

LEGEND

—	I-3 (Colorado River) (Axis 2)
◆ ◆ ◆	Measured Pressure Head At Observation Well (Axis 2)
—	Synthetic Pressure Head At Observation Well (Axis 2)
—	Drawdown (-up) At Observation Well (Axis 3)
—	Model Simulated Drawdown (-up) At Observations Well (Axis 3)
—	Barometric Pressure (Axis 4)

FIGURE E-2g
DECONVOLUTION OF MW-55-120 RESPONSE DURING SEPT 2008 EXTRACTION WELL SHUT-DOWN

FINAL GROUNDWATER CORRECTIVE MEASURES STUDY/FEASIBILITY STUDY REPORT
FOR SWMU 1/AOC 1 AND AOC 10
PG&E TOPOCK COMPRESSOR STATION
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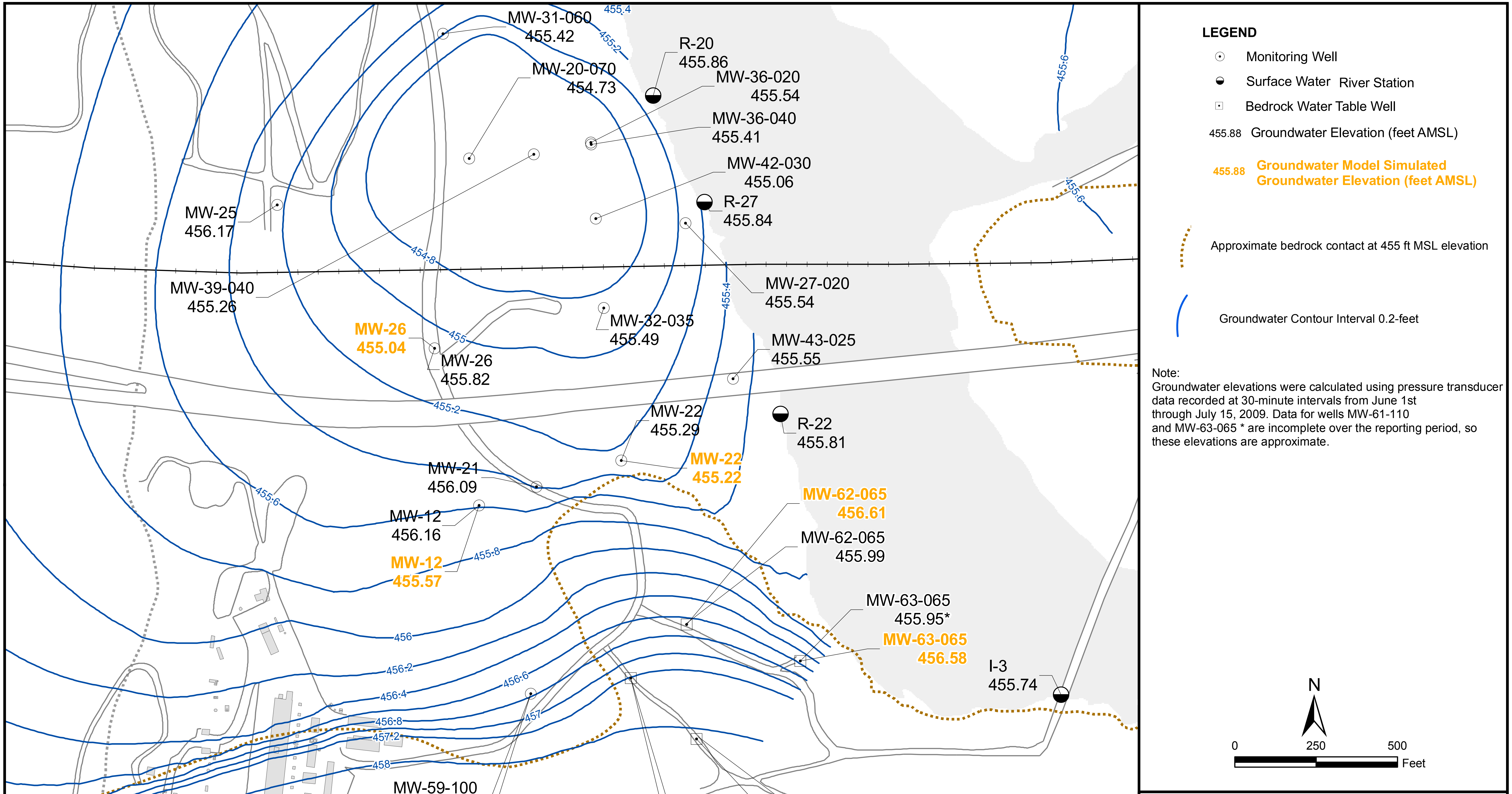

Note:
Groundwater elevations were calculated using pressure transducer data recorded at 30-minute intervals from June 1st through July 15, 2009. Data for wells MW-61-110 and MW-63-065 * are incomplete over the reporting period, so these elevations are approximate.

FIGURE E-3a
AVERAGE GROUNDWATER ELEVATIONS IN EAST RAVINE AREA WELLS WITH MODEL SIMULATED CONTOURS LAYER 1, JUNE 1st THROUGH JULY15th, 2009

FINAL GROUNDWATER CORRECTIVE MEASURES
STUDY/FEASIBILITY STUDY REPORT
FOR SWMU 1/AOC 1 AND AOC 10
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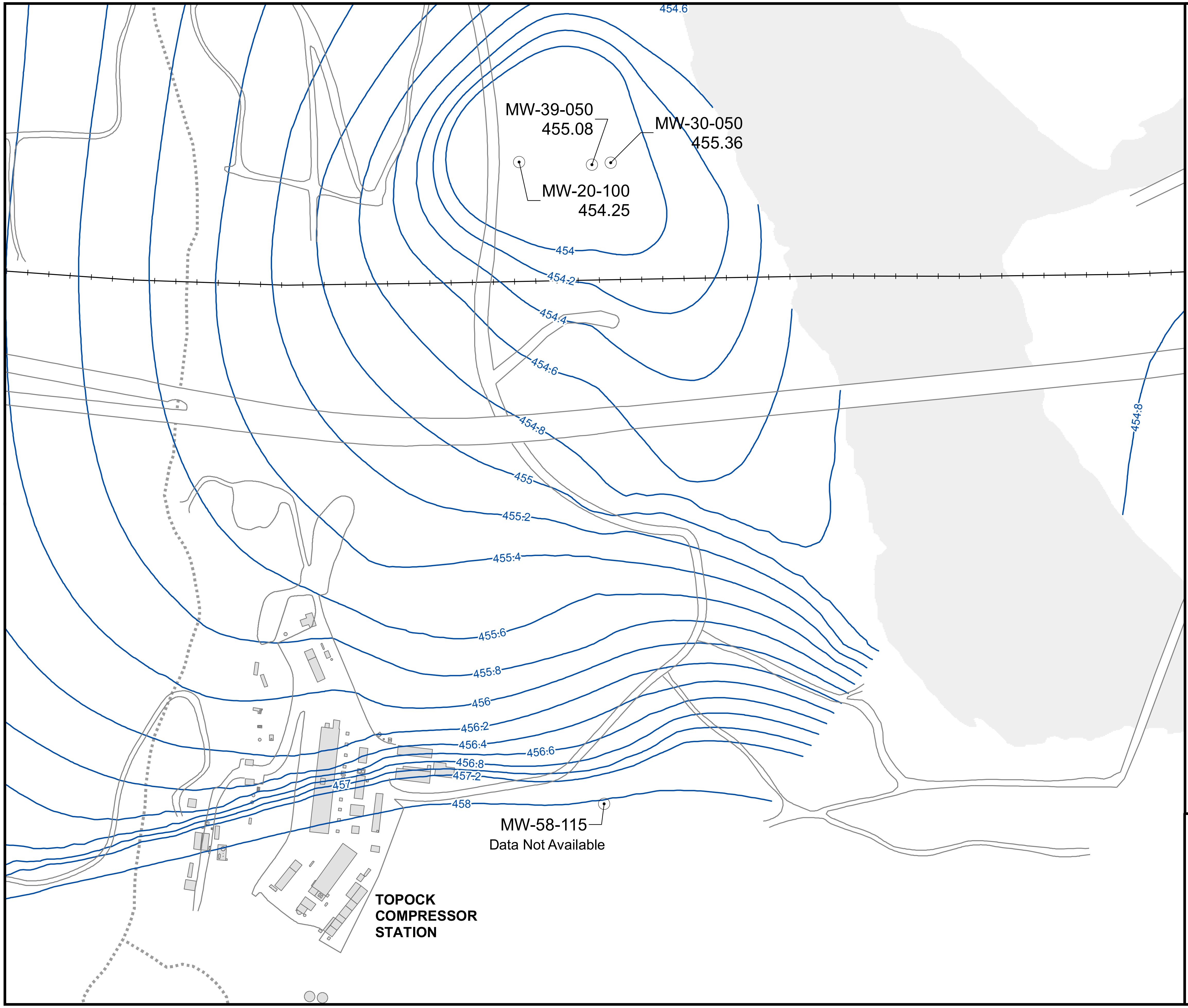

Note:
Groundwater elevations were calculated using pressure transducer data recorded at 30-minute intervals from June 1st through July 15, 2009.

FIGURE E-3b
AVERAGE GROUNDWATER ELEVATIONS IN EAST RAVINE AREA WELLS WITH MODEL SIMULATED CONTOURS LAYER 2, JUNE 1st THROUGH JULY15th, 2009

FINAL GROUNDWATER CORRECTIVE MEASURES
STUDY/FEASIBILITY STUDY REPORT
FOR SWMU 1/AOC 1 AND AOC 10
PG&E TOPOCK COMPRESSOR STATION
NEEDLES, CALIFORNIA

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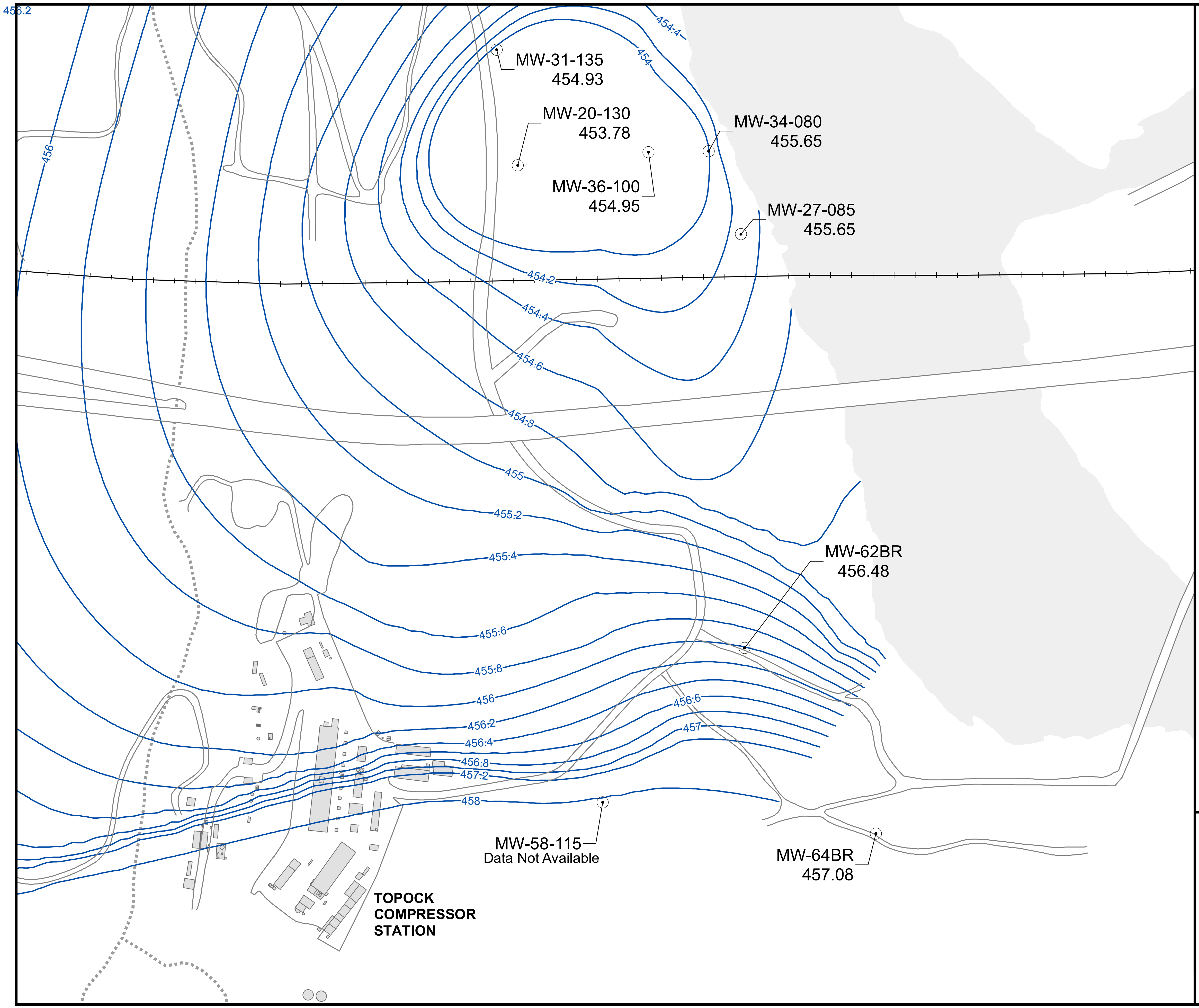

LEGEND

⊙ Monitoring Well

455.88 Groundwater Elevation (feet AMSL)

Groundwater Contour Interval 0.2-feet

Note:
Groundwater elevations were calculated using pressure transducer data recorded at 30-minute intervals from June 1st through July 15, 2009.

N

0 250 500 Feet

FIGURE E-3c
AVERAGE GROUNDWATER ELEVATIONS IN EAST RAVINE AREA WELLS WITH MODEL SIMULATED CONTOURS LAYER 3, JUNE 1st THROUGH JULY15th, 2009

FINAL GROUNDWATER CORRECTIVE MEASURES
STUDY/FEASIBILITY STUDY REPORT
FOR SWMU 1/AOC 1 AND AOC 10
PG&E TOPOCK COMPRESSOR STATION
NEEDLES, CALIFORNIA

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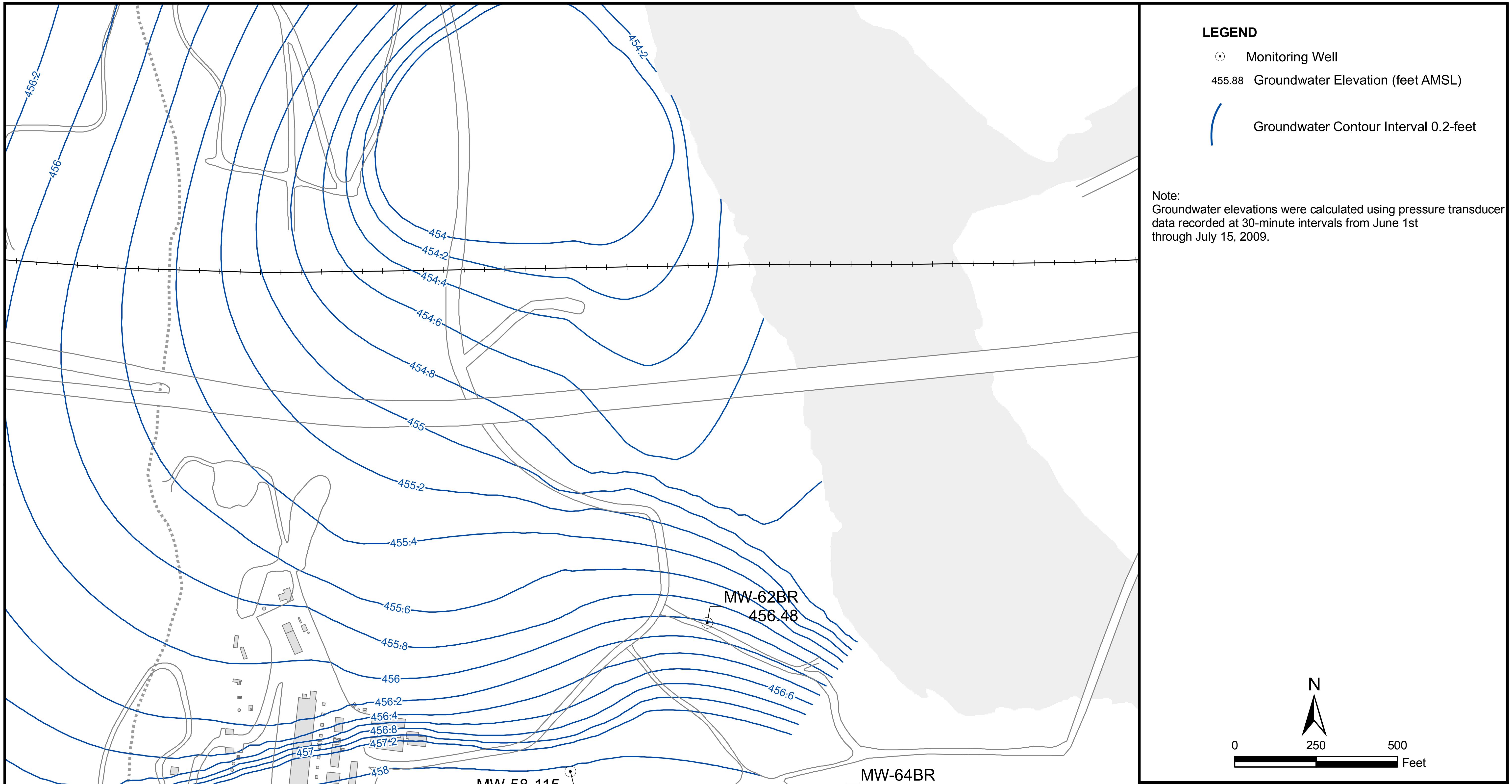

Note:
Groundwater elevations were calculated using pressure transducer data recorded at 30-minute intervals from June 1st through July 15, 2009.

FIGURE E-3d
AVERAGE GROUNDWATER ELEVATIONS IN EAST RAVINE AREA WELLS WITH MODEL SIMULATED CONTOURS LAYER 4, JUNE 1st THROUGH JULY15th, 2009

FINAL GROUNDWATER CORRECTIVE MEASURES
STUDY/FEASIBILITY STUDY REPORT
FOR SWMU 1/AOC 1 AND AOC 10
PG&E TOPOCK COMPRESSOR STATION
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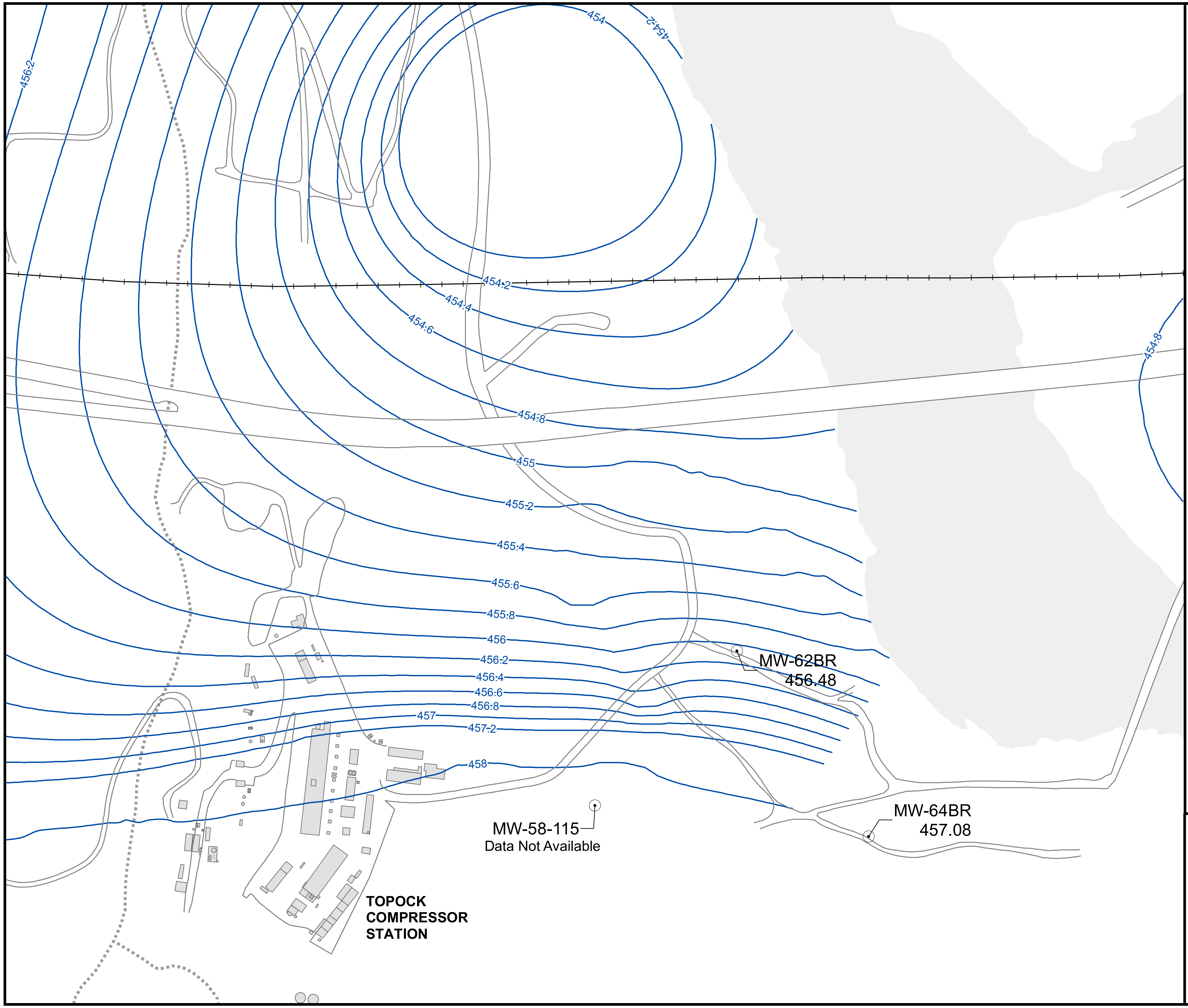

LEGEND

⊙ Monitoring Well

455.88 Groundwater Elevation (feet AMSL)

(Groundwater Contour Interval 0.2-feet

Note:
Groundwater elevations were calculated using pressure transducer data recorded at 30-minute intervals from June 1st through July 15, 2009.

N

0 250 500
Feet

FIGURE E-3e
AVERAGE GROUNDWATER ELEVATIONS IN EAST RAVINE AREA WELLS WITH MODEL SIMULATED CONTOURS LAYER 5, JUNE 1st THROUGH JULY15th, 2009

FINAL GROUNDWATER CORRECTIVE MEASURES
STUDY/FEASIBILITY STUDY REPORT
FOR SWMU 1/AOC 1 AND AOC 10
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Appendix F

Groundwater Flow Model Simulation Procedures for Remedial Alternative Development and Comparison and Modeled Flowlines

Contents

Section **Page**

Figures

Acronyms and Abbreviations

µg/L	micrograms per liter
CMS/FS	corrective measures study/feasibility study
Cr(VI)	hexavalent chromium
gpm	gallons per minute
IM	Interim Measure
IRZ	*in-situ* reactive zone

APPENDIX F

Groundwater Flow Model Simulation Procedures for Remedial Alternative Development and Comparison and Modeled Flowlines

F.1 Groundwater Model Description and Applicability

The Topock site groundwater flow model was used for developing remedial alternatives and comparing relative cleanup times between various alternatives. A detailed description of model structure, parameters, and assumptions is provided in the *Groundwater Model Update Report for the Pacific Gas and Electric Company Topock site* (CH2M HILL, 2005). The model code used to simulate groundwater flow was MicroFEM (Hemker, 1999, 2009). Although the model cannot simulate solute transport explicitly, it includes the capability to conduct particle tracking simulations and represent explicit solute pathways and travel times. Prior to using the model in the corrective measures study/feasibility study (CMS/FS), test simulations were conducted to confirm the model's ability to predict groundwater elevations and aquifer test data observed since calibration and to demonstrate the model's accuracy. The results of these test simulations (provided in Appendix E, Demonstration of Groundwater Flow Model Accuracy) confirm that the model reliably represents the groundwater system and is an appropriate tool for developing and evaluating alternatives.

F.2 Methods for Developing Remedial Alternatives, Evaluating Effectiveness, and Estimating Cleanup Time

Prior to conducting the model simulations for design of the remedial alternatives, it was necessary to identify the target volume of the aquifer for hexavalent chromium [Cr(VI)] remediation. Hexavalent chromium concentrations were contoured for model layers 1 through 4, which cover the shallow, medium, and deep Alluvial Aquifer groundwater zones, based on average hexavalent chromium [Cr(VI)] concentrations for all site monitoring wells. The contours were digitized, and a concentration grid was produced for each model layer by interpolation. These grids were used to estimate the mass of Cr(VI) in the volume surrounding each model node of the plume and to define the extent of the target volume where Cr(VI) concentrations are above 32 micrograms per liter (µg/L). Using this method, the total mass of Cr(VI) estimated to be present in the plume is 30,800 pounds.

The bedrock groundwater of the East Ravine area was not included in the target volume. Based on data collected through the summer of 2009, it is estimated that less than 1 percent of the mass of Cr(VI) in the plume is contained in the fractured bedrock of the East Ravine. The model was not used to estimate remediation time in the fractured bedrock medium.

Based on current data for the East Ravine area, the alternatives were designed to minimize Alluvial Aquifer plume groundwater from entering the bedrock groundwater of East Ravine and to provide hydraulic control for contaminated groundwater in this area. It is planned that the remedy for East Ravine bedrock groundwater will be further developed during the design phase.

Model simulation of each alternative involved choosing initial locations for extraction wells and injection wells and assigning flow rates for each well. For each alternative, the well configuration and flow rates were adjusted repeatedly to achieve "capture" of the target volume, as defined by the 32 µg/L contour in each model layer. Capture was evaluated based on particle tracking simulations where particles were started from each model node in each model layer within the plume. Capture was defined in two ways. Hydraulic capture was achieved when all downstream particle tracks from all nodes in the plume terminated in one of the extraction wells. For remedies that included *in-situ* reactive zones (IRZs), capture was achieved when all particles originating in the plume terminated in either in a simulated IRZ or an extraction well. Only configurations of wells that achieved capture of the entire alluvial and bedrock plume were retained. Water injected outside the plume area was not evaluated in this capture analysis.

Care was taken during design of each alternative to minimize the number of particle tracks that extended beyond the plume area on the way to an extraction well. This was done to minimize the effect of injection wells "pushing" the plume groundwater into non-plume areas.

The model was used in combination with external data processing programs to evaluate the effectiveness and relative cleanup time for various remedial configurations. The alternatives were designed with the target of simulated cleanup time between 20 and 40 years. More precise estimates are not meaningful given the present data set and inherent model uncertainty. Cleanup time computations were made by applying the following basic assumptions to the flow model:

- Groundwater to be remediated was defined as that with average Cr(VI) concentrations above the Topock groundwater background study upper tolerance limit of 32 µg/L (CH2M HILL, 2008). Groundwater outside of the estimated 32 µg/L Cr(VI) contours for the shallow, medium, and deep groundwater zones was considered to be non-plume or "clean" groundwater.
- Simulated extraction and injection wells were assumed to be screened over the entire saturated thickness of the Alluvial Aquifer.
- For estimation of plume cleanup times, it was assumed that five pore volumes of "clean" groundwater would need to be flushed through the entire flowpath leading to each model node within the plume to achieve cleanup goals (as explained below).
- For remedies that include *in-situ* treatment, nodes within IRZ areas where carbon substrate is distributed were considered clean as soon as the carbon substrate reached that node.

Injection of carbon substrate in injection wells was simulated using forward particle tracking from the injection wells to allow for an understanding of the flow field. Based on estimates of the anticipated amendment strength, the effective half-life, and mobility of the substrate provided in Appendix G to the CMS/FS Report, it was assumed that substrate would persist for up to 210 days after leaving an amended-water injection well. However, the substrate would move slower than groundwater with a retardation factor of 1.1, so the model was used to define 210/1.1=190-day travel envelopes surrounding an amended water injection well. Forward particle tracks radiating from the amended water injection wells were used to define the 190-day travel time zones (i.e., the IRZ footprint). The area covered by the IRZ footprint was considered to be "clean" non-plume groundwater for the remainder of the alternative simulation. Although 210 days was assumed to be the maximum life of the substrate in the aquifer, it was assumed that the amended water injection wells might operate for as much as one year to achieve complete coverage of the IRZ areas. This additional injection time beyond the 210-day substrate life is needed to account for imperfect distribution due to heterogeneity in the aquifer. The one-year assumption is used in the time estimates for all alternatives as an approximation. Assumptions such as half-life and injection concentration, made in Appendix G, may change during final design, which would in turn increase or decrease the travel time. Adjustments would be made to compensate for these changes should they occur. For example, if the half-life were found to be shorter, flow rates may be increased in the IRZ to compensate. Also, the well spacing may be adjusted during design or implementation, depending on the concentration of carbon to be used, with closer well spacing corresponding to lower concentrations.

Injection of amended water outside the plume for Alternative E was simulated using forward particle tracking from the injection wells to allow for an understanding of the flow field. The water is considered treated; an understanding of the flow field was developed to assist with designing an appropriate monitoring network for verification of treatment and management of secondary byproducts.

For remedial configurations that successfully captured the plume, a second simulation was performed to determine the flowpath flushing times. One flowpath flushing time for each node is defined as the simulated time for clean groundwater to arrive at each plume node. In this simulation, reverse particle tracks were run from each plume node in each layer to the nearest source of clean water, defined as either the edge of the plume or an IRZ area. Clean water travel time was simulated by advective flow with an assigned effective porosity of 0.12 (independently estimated from Interim Measure [IM] injection breakthrough at observation wells and from *in-situ* pilot testing tracer studies). Using this method, nodes remote from the plume edge or from an IRZ have a longer flushing time, and nodes close to the plume edge or IRZ have a shorter flushing time. Therefore, this approach approximates the commonly observed behavior of the core of a plume taking considerably longer to clean up than the edges.

For each node, the one-flow-path flushing time was multiplied by five to calculate the estimated time required for groundwater at each plume node to become "clean" (less than 32 µg/L) or non-plume. It is recognized that this assumption of five flowpath volumes is somewhat arbitrary. Some parts of the plume may clean up with less than five flowpath volumes of flushing, and some parts may require considerably more. The assumption of five flowpath flushing is considered a reasonable estimate for the purposes of comparing remedial alternatives against one another. It correlates approximately with observed floodplain stable isotope data changes during IM extraction and with tracer test data in the floodplain *in-situ* pilot study. The stable hydrogen isotope deuterium, ^2H, has been measured in floodplain wells since early 2004 and is regularly reported in the performance monitoring reports (CH2M HILL, 2009). IM extraction has caused river-influenced groundwater to replace plume groundwater in several floodplain wells, resulting in a distinctly different isotopic signature. The evolution of ^2H in these wells was combined with model-estimated flowpath flushing associated with IM pumping to estimate the rate at which water is replaced, or flushed, at each well location. Pore volume flushing was also estimated with specific conductance data from observation wells in the injection well field. In addition, data from short-term tracer tests performed at the floodplain *in-situ* pilot test area of the western floodplain and in the uplands pilot test area were used to estimate flowpath flushing requirements. The range in the 12 flushing estimates using all sets of data described above was 0.7 to 17 flowpath volumes. Besides those two extremes, the rest of the estimates ranged from 1.5 to 5 flowpath volumes. Overall, both data sets suggested that approximately five flowpath volumes were required to flush 95 percent of the initial concentration out of groundwater at a monitoring well location. However, because the data scatter was significant for each estimate, the estimate of five flowpath volumes is considered a reasonably good comparison tool between alternatives and not an accurate measure of cleanup time for any given alternative. In order to provide a more reasonable range of cleanup time estimates, all simulations were also run using two flowpath volumes and 20 flowpath volumes for node mass cleanup.

For each model node within the plume and in each model layer, the initial Cr(VI) mass associated with the volume represented by that node (described above) was assumed to be removed after the five flowpath flushing time for that node had passed. The simulation did not account for incremental decrease in mass at each node volume over time, but rather assumed that all the mass was present in the node volume up until the five flowpath flush had been achieved, at which time the mass in that node volume was set to zero. This is a rough approximation for each model node, but it is computationally more efficient and has a built-in conservative approach of not removing plume mass before it is completely gone. Because there are so many flowpaths in the modeled plume (approximately 13,000), the mass reduction associated with each flowpath is small. This results in a smooth curve for plume mass reduction over time and provides an adequate method for comparing alternatives at the conceptual design level required for a CMS/FS. For each year of simulated time, the total mass of Cr(VI) remaining in the plume was summed for all nodes and at each model layer. The resulting set of data was plotted as fraction of total Cr(VI) mass remaining vs. time for each alternative. In order to account for the uncertainty inherent in the five flowpath volume estimate, mass reduction curves were also constructed for two- and 20-flowpath volume flushing to provide a range of cleanup time estimates.

Due to the uncertainty and variability in simulated mass removal past 98 percent of the total, the active remediation alternatives were designed to achieve 98 percent mass removal within approximately 40 years based on the simulated mass removal curves.

F.2.1 Assumptions and Limitations

The following table provides a summary of the major assumptions upon which the evaluation of remedial alternatives and the limitations inherent in the methods and the data sets used in these evaluations.

Assumption	Limitation
The groundwater model adequately simulates the complexity of groundwater flow in the highly heterogeneous aquifer at Topock for the purposes of a CMS/FS analysis.	The number of wells and degree of characterization at the Topock site is typical for a site of this size; however, there are many areas of the site where no monitoring wells exist. Hydraulic properties in these areas may be different than assumed in the model. As additional data are collected, these assumptions will be reviewed, and adjustments made, as necessary, and in the configuration or operation of the final remedy to account for these differences.
Cleanup goals could be achieved by flushing between two and 20 pore volumes of “clean” groundwater through the contaminated portion of the aquifer.	Zones of fine-grained material in the aquifer will not be flushed as efficiently as coarse-grained zones. If these zones are numerous enough and contain high enough concentrations of Cr(VI), flushing 20 pore volumes may not be adequate to reach remedial action objectives, and/or rebound in concentrations may occur after the flushing stops. This would affect all remedies that rely on flushing and could result in longer cleanup times than currently projected.
In IRZ areas where carbon substrate is distributed at an effective concentration, Cr(VI) reduction will occur as soon as the plume water encounters the carbon substrate.	Available data from the pilot tests show that the reduction of Cr(VI) to trivalent chromium occurs very quickly after the reducing conditions are established. Reducing conditions may be more difficult to establish in areas where fine-grained materials dominate. If aquifer materials are less permeable than assumed, the model may over-predict the extent of the reducing conditions around each *in-situ* injection well, and additional wells may need to be installed to ensure adequate distribution of *in-situ* amendments.
The groundwater flow regime in the southern portion of the Mohave Basin will remain relatively stable throughout the period of time that the final remedy will operate	Some of the remedies being considered may need to operate for hundreds of years or longer. Over this time frame, major changes could occur in the flow regime of the Colorado river as a result of climate change, river flow management by the Bureau of Reclamation, or the siltation of upstream reservoirs. There is therefore more confidence in projections that extend out for a few decades than for projections that extend out for hundreds of years.
Target cleanup volume and contaminant mass appropriately defined for the purpose of a CMS/FS analysis.	The number of wells and degree of characterization at the Topock site is typical for a site of this size; however, there are many areas of the site where no monitoring wells exist. The target cleanup volume and contaminant mass may be different than assumed in the model. As additional data are collected, these assumptions will be reviewed and adjustments made, as necessary, in the configuration or operation of the final remedy to account for these differences.
Extraction wells were assumed to have a maximum design flow rate of 620 gallons per minute (gpm) for a 12-inch well. Injection well design capacity was assumed to be 150 gpm for wells receiving water with carbon substrate. This rate accounts for the biofouling that typically	Past well installations at the site provide evidence of the pumping or injection capacity of wells. These rates are based on operational experience and testing at the IM No. 3 injection wells and driller reports of testing at the former PGE-1 and -2 production wells and are assumed to be applicable to portions of the Alluvial Aquifer where

Assumption	Limitation
occurs in these wells. Injection wells receiving water with no carbon substrate had an assumed design capacity of 250 gpm.	saturated thickness is at least 50 feet. It is not possible to accurately determine pumping or injection rates of any individual well until it is installed and tested, as local hydrogeologic conditions and variations in methods of well construction and development can have large effects on well performance.

F.3 Simulated Flowline Maps for Remedial Alternatives

For each alternative, the model was used to simulate flow from all model nodes within the plume area for each of the four model layers that constitute the Alluvial Aquifer. This was done to demonstrate that flow from the plume either (1) is captured by an extraction well or (2) passes through an *in-situ* zone of enhanced reducing conditions. Some alternatives required flowline maps at various stages of the alternative.

Plume nodes were marked in the model and correspond to the area within the 32 μg/L Cr(VI) concentration contour for the model Layers 1 through 4. The concentration contours of the chromium plume in each of the three depth zones are shown in Figures 2-10, 2-11, and 2-12 of the CMS/FS Report, respectively. The upper and middle depth zones are mostly equivalent to model Layers 1 and 2, respectively. Figure 2-12 (lower depth zone) represents a composite of the concentration distribution in model Layers 3 and 4; the wells corresponding to each of these layers were contoured separately for the model. As explained below, the depth zone contour maps differ from the model layer contour maps in the area where the aquifer becomes very thin.

For each stage of a given alternative, simulated flowlines were run forward (downstream), starting from each node within the plume in each model layer. The viability of the alternative simulation was checked by ensuring that none of the flowlines strayed substantially from the plume area and ended in either an extraction well or an *in-situ* reactive zone. There are four flowline figures representing each of the four model layers for each stage of each alternative. Flowline figures are provided at the end of this appendix.

The following assumptions and strategies were followed in constructing flowline figures:

- Each flowline was started in the vertical midpoint of the model layer.
- A transport porosity of 0.12 was assigned to the entire model grid. This value is consistent with the observed movement of treated water from the IM No. 3 injection wells and with tracer breakthrough data from *in-situ* pilot test tracer studies. The porosity is directly proportionate to the time of travel of each flowline so that it affects cleanup time estimates but not the simulated flowpath.
- For alternatives in which an *in-situ* phase was included, flowlines were run from *in-situ* injection wells for a period of 190 days and stopped. The 190 days was estimated as the time of travel during which the injected carbon substrate would produce effective reducing conditions (see Appendix G of the CMS/FS Report). The ends of the 190-day flowlines emanating from each injection well were connected to form an *in-situ* "halo"

around the well. During estimation of cleanup time, any flowline from a subsequent phase of the alternative entering this "halo" was considered "clean," and its Cr(VI) mass was removed.

- Consideration was given to accessibility when choosing the locations of wells and utility corridors. Many areas of the site have irregular topography that prevents access by drilling or other construction equipment.
- The injection or extraction rate within each model layer at a given well was apportioned on the basis of the relative transmissivity of each layer. For example, if the total rate for a given well was 100 gpm and model layers 1 through 4 had transmissivities of 250, 1,000, 250, and 500 square feet per day, then the assigned gpm for each layer would be 12.5, 50, 12.5, and 25 gpm, respectively.
- All simulated containment will require verification monitoring during implementation of the chosen alternative. Monitoring networks will be designed for the chosen alternative during final design phase. Once new wells are installed, model parameters will be adjusted based on newly acquired hydraulic data from those wells.
- The bedrock contact shown on each figure in Section 5.0 of the CMS/FS Report (Figures 5-4 through 5-11) represents the point at which the saturated thickness of the Alluvial Aquifer becomes zero. In the plume maps of the CMS/FS Report (Figures 2-10, 2-11, and 2-12), the bedrock contact was different for each depth zone, reflecting areas where a given depth zone thickness becomes zero. However, model layers cannot "pinch out" like depth zones can so that as the aquifer thins, so do all of the top four model layers. Where all of the saturated groundwater thickness is within bedrock, the properties of the top four model layers change to those of bedrock, and their thicknesses increase to either a default value or those that reflect the screened intervals of East Ravine wells.
- A line of closely spaced wells pumping from bedrock along National Trails Highway at the eastern edge of the East Ravine was required to achieve capture in some but not all alternatives. This line of wells was included as a common element for all alternatives in the alternative descriptions in Section 5.0 and the cost estimates. It was assumed that, even though some alternatives did not require bedrock wells to achieve capture in East Ravine in this groundwater modeling analysis, the line of pumping wells would be needed as a component of a more robust East Ravine final remedy.

The following points that apply to the individual alternatives are listed below:

F.3.1 Alternative C (High-volume *In-situ* Treatment)

Alternative C consists of two phases: floodplain cleanup and interior plume cleanup (Figure 5-5 of the CMS/FS Report).

The first phase of Alternative C is floodplain cleanup. Floodplain cleanup would be accomplished through establishing IRZ lines using recirculating flow either within each well or between pairs of wells along the IRZ line. No flowlines were run for the recirculation wells, as they are designed to have zero net effect on groundwater flow.

In the second phase, injection of carbon substrate requires simulation of 190-day flowline "halos" that represent the *in-situ* reactive zones associated with each well, as described in Section F.2. These are provided in Figures F3-1 through F3-4, corresponding to the four model layers.

F.3.2 Alternative D (Sequential *In-situ* Treatment)

Alternative D was designed as a sequential cleanup involving one pair of extraction/injection transects for each phase of cleanup, with 10 phases in all. Figure 5-6 in the CMS/FS Report illustrates the conceptual remedial approach for Alternative D. With the exception of the easternmost and westernmost transects, each transect is used for injection in one phase and extraction in the next phase, working from the floodplain westward and finishing at the southern end of Bat Cave Wash. The 190-day "halos" (described above) are shown for each of the four model layers in each of the 10 phases, for a total of 40 figures (F3-5 through D3-44). Composites of the phases for each layer are provided in Figures F3-45 through F3-48.

Simulated extraction wells flush the injected water across the treatment zone for each phase.

F.3.3 Alternative E (*In-situ* Treatment with Fresh Water Flushing)

Figure 5-7 in the CMS/FS Report illustrates the conceptual remedial approach for Alternative E. The assumed configuration of Alternative E consists of nine extraction well locations; four injection locations on the western margin of the plume for injection of carbon-amended water extracted from within and near the plume; and four injection locations further out from the plume boundary for injection of fresh water from an offsite source. Flowlines emanating from all plume nodes are shown for each model layer in Figures F3-49 through F3-52.

Flowpaths emanating from the four carbon-amended water injection wells and the clean water injection wells are shown for each model layer in Figures F3-53 through F3-56. As discussed in Appendix G, the potential for *in-situ* byproducts to be mobile in groundwater is believed to be limited to the immediate area of influence of carbon-amendment, with an estimated soluble residence time similar to that estimated for the organic carbon (190 days). With this assumption, flowpaths for 1-year travel time are shown in green to represent the maximum expected travel of *in-situ* byproducts. The flowpaths extending from one year to 30 years are shown in blue, and represent clean water with no byproducts.

F.3.4 Alternative F (Pump and Treat)

Figure 5-8 in the CMS/FS Report illustrates the conceptual remedial approach for Alternative F. The assumed configuration of Alternative F consists of five extraction well locations located along the main axis of the plume, along with six treated water injection well locations within and outside of the plume boundary. The flowline maps for the four model layers are shown in Figures F3-57 through F3-60.

F.3.5 Alternative G (Combined Floodplain *In-situ*/Pump and Treat)

Figure 5-9 in the CMS/FS Report illustrates the conceptual remedial approach for Alternative G. Floodplain cleanup would be accomplished through establishing IRZ lines using recirculating flow either within each well or between pairs of wells along the IRZ line. No flowlines were run for the recirculation wells, as they are designed to have zero net effect on groundwater flow.

Concurrent with floodplain cleanup, the assumed configuration of Alternative G for the interior plume treatment consists of five extraction well locations located along the main axis of the plume, along with six treated water injection well locations within and outside of the plume boundary. Flowlines were run from all plume nodes in each layer, and the resulting maps are provided in Figures F3-61 through F3-64.

F.3.6 Alternative H (Combined Upland *In-situ*/Pump and Treat)

Figure 5-10 in the CMS/FS Report illustrates the conceptual remedial approach for Alternative H. Alternative H involves construction of a series of IRZ lines in the upland area. These IRZ lines would be constructed using recirculating flow either within each well or between pairs of wells along the IRZ line. No flowlines were run for the recirculation wells, as they are designed to have zero net effect on groundwater flow. In addition to the IRZ lines, the assumed configuration of Alternative H includes a line of five extraction well locations along National Trails Highway, four injection well locations for carbon-amended water along the northwest boundary of the plume, and four treated water injection well locations within and outside of the plume boundary.

Flowlines originating at all plume nodes are shown in Figures F3-65 through F3-68. In calculating cleanup time, flowlines passing through or emanating from the IRZ lines were considered to be “clean.”

F.3.7 Alternative I (Continued Operation of the Interim Measure)

Alternative I assumes continued operation of the existing IM extraction, treatment, and injection systems. Plume flowline maps are provided in Figures F3-69 through F3-72.

F.4 Comparative Estimated Cleanup Times for Remedial Alternatives

A description of each remedial alternative for evaluation in the CMS/FS is provided in Section 5.3 of the CMS/FS Report. Based on the methods discussed above, Figures F4-1 through F4-8 show the simulated plume mass fraction remaining vs. time for each alternative. In each plot, the five-flowpath volume curve is shown in bold line, with the two- and 20-flowpath volume curves as dashed curves on the left and right, respectively. The range between all curves is shaded in light blue. The selection of two, five, and 20 flowpath volume curves was based on observed site data and is described in Section F.2. Specific modeling assumptions and techniques are described below for each alternative.

A similar accounting for uncertainty was applied to alternatives involving *in-situ* treatment (recirculation IRZ and amended water injection wells). Effective delivery of carbon substrate will vary due to a variety of factors, including hydraulic properties surrounding the injection well, unforeseen design changes during field operations, conditions requiring a change in injection rates, and repairs and maintenance requirements. In an attempt to account for these variables, the *in-situ* phase time estimates were bracketed with shorter and longer time frames, as described more specifically below.

F.4.1 Alternatives A and B: No Action and Monitored Natural Attenuation

For each of these alternatives, there would be no extraction or injection or induced treatment, and groundwater would be allowed to flow under natural gradients towards and through the fluvial sediments near the Colorado River. The cleanup time method described above was run with no alterations, except that no initial check was made for plume capture. The projected cleanup times for Alternatives A and B are shown in Figure F4-1. This projection is based on flushing of the aquifer through natural groundwater flow.

F.4.2 Alternative C: High-Volume *In-situ* Treatment

Alternative C consists of two phases. Phase 1 (floodplain cleanup) involves construction of an IRZ line across the width of the plume along National Trails Highway and construction of IRZ lines between National Trails Highway and the Colorado River. Organic carbon would be injected and recirculated in the IRZ lines to treat the existing Cr(VI) in the alluvial zone of the floodplain aquifer. It was estimated that the floodplain cleanup would require between 1 and 5 years, with the baseline estimate at 2 years. This estimate is based on the expected time for construction of the IRZ wells and distribution of carbon substrate to establish the IRZ. Construction activities in the floodplain may have to be sequenced to avoid nesting season of endangered birds, which could delay completion of the wells. If it is determined that additional wells are needed to achieve adequate distribution of carbon substrates, additional construction and implementation time would ensue. Thus, it is assumed that it could require up to 5 years to fully complete and confirm the effectiveness of the floodplain cleanup.

Phase 2 (active uplands *in-situ* cleanup) involves construction of extraction wells around the perimeter of the plume and injection wells through the core of the plume. Water is pumped from the extraction wells at a rate of approximately 2,000 gpm, organic carbon is added, and the carbon-amended water is injected into the core of the plume. To account for inefficiencies in operation, extra time was assumed beyond the 190-day travel time for cleanup to occur around the injection wells in Phase 2. Simulations were run with assigned Phase 2 operational times of 3, 5, and 10 years, as shown in Figure F4-2. The mass removal is assumed to be linear over the assigned Phase 2 cleanup time.

With the relatively wide well spacing in Alternative C, there are some areas of the plume that the model projected would not be treated by direct reaction with injected carbon reagent as part of the *in-situ* injection. Because of this, Phase 2 was split into two subphases: Phase 2a, during which the full carbon dose is used in the injection wells, and Phase 2b, which uses a lower dose. Phase 2b involves continued pumping of groundwater after the carbon substrate of Phase 2a has been distributed to flush the plume from the areas where the substrate does not reach. Phase 2b uses the same wells and the same flow rate as Phase 2a (2,000 gpm) but would require less carbon to be added to the injected water. Flushing time for the untreated area was simulated with the standard assumptions of two-, five-, and 20-flowpath volumes described above.

The range of projected cleanup time for this alternative is shown in Figure F4-2. The faster projected cleanup time assumes a 1-year Phase 1, 3-year carbon injection Phase 2a, and two-flowpath-volume flushing for Phase 2b. The slower projected cleanup time assumes a 5-year Phase 1, 10-year Phase 2a, and 20-flowpath-volume flushing for Phase 2b.

F.4.3 Alternative D: Sequential *In-situ* Treatment

Alternative D is designed to provide the most aggressive application of IRZs; it does not rely on any flushing of the aquifer for cleanup. Approximately 12 lines of injection and extraction wells would be constructed and operated in phases to distribute an organic carbon substrate over the entire plume. Wells would be switched from extraction to injection as the phases progress. Lines of wells would be constructed with piping and power to allow each line to be operated in either an injection or extraction mode. Water would be pumped from one line of wells and injected into the adjacent line of wells. Estimated flow rates would vary from about 1,500 gpm to less than 30 gpm, depending on which lines of wells were being operated. Carbon substrate would be added to extracted water prior to injection. The carbon would be distributed throughout the aquifer in the area between the active injection and extraction well lines. Operating the wells in this way would result in 10 recirculation phases in the areas between the 12 lines of wells. For the baseline case, it was estimated that 1.5 years would be required to fully distribute carbon between each line of injection and extraction wells. For the simulations, each zone was assigned a bracketed range of 1.0, 1.5, and 2.0 years for each phase. It was assumed that each phase would remove one-tenth of the plume mass, resulting in a linear decrease in plume mass over the 10-, 15-, and 20-year durations, as shown in Figure F4-3. Due to the short-term nature of operation in this alternative, the application of temporary or mobile distribution system elements such as piping, conduit, and mechanical equipment may prove beneficial; however, to provide a more conservative estimate for this alternative cost analysis, such considerations are not included.

F.4.4 Alternative E: *In-situ* Treatment with Fresh Water Flushing

Alternative E consists of a combination of *in-situ* treatment, downgradient extraction, and upgradient injection to maximize plume flushing without the use of a treatment plant. .

Extraction would occur both in the floodplain and in the area immediately northeast of the compressor station at approximately nine extraction locations. The assumed pumping rate from the extraction wells would be approximately 640 gpm. This extracted water would be amended with carbon substrate and reinjected in injection wells at approximately four locations near the western edge of the plume. In addition, fresh water from an offsite source would be injected at an assumed rate of 500 gpm into injection wells at approximately four locations within and outside the plume boundary. The injection of clean water would accelerate the flushing of the aquifer. The IRZ barrier across the width of the plume along National Trails Highway would remove the Cr(VI) from the groundwater as it passed through the barrier. The projected cleanup times for this alternative, shown in Figure F4-4, were calculated based on the range of two- to 20-flowpath flushing times, with the baseline cleanup time based on five-flowpath flushing time.

F.4.5 Alternative F – Pump and Treat

Alternative F relies on pump-and-treat technology, with extraction wells located in the core of the Cr(VI) plume and injection wells located to the west of the plume and within the southern portion of the plume. Groundwater would be pumped from the extraction wells at an assumed combined rate of approximately 1,280 gpm and treated to remove Cr(VI) before being reinjected through the injection wells. There is no *in-situ* component to this remedy. The pumping of the extraction wells will provide landward gradients to hydraulically prevent movement of the Cr(VI) toward the river. The injection of treated water around the upgradient margins of the plume helps to accelerate the flushing process. The projected cleanup times for this alternative, shown in Figure F4-5, were calculated based on the range of two- to 20-flowpath flushing times, with the baseline cleanup time based on a five-flowpath flushing time.

F.4.6 Alternative G – Combined Floodplain *In-situ*/Pump and Treat

Alternative G combines pump-and-treat remediation for the upland portion of the plume with *in-situ* treatment in floodplain. The pump-and-treat remediation would be very similar to Alternative F. Groundwater would be pumped from the extraction wells at an assumed combined rate of approximately 1,230 gpm and treated to remove Cr(VI) before being reinjected through the injection wells. A few extraction wells in Alternative G were moved to locations further from the floodplain to optimize the projected cleanup times. The floodplain IRZ implementation for Alternative G would be very similar to the first phase of Alternative C. Because landward gradients would be maintained by the pump-and-treat system, the floodplain IRZ implementation for Alternative G would not need to be a separate phase. As for Alternative C, it was estimated that the floodplain cleanup would require between 1 and 5 years, with the baseline estimate at 2 years. This estimate is based on the expected time for construction of the IRZ wells and distribution of carbon substrate to establish the IRZ. Construction activities in the floodplain may have to be sequenced to avoid nesting season of endangered birds, which could delay completion of the wells. If it is determined that additional wells are needed to achieve adequate distribution of carbon substrates, additional construction and implementation time would ensue. Thus, it is assumed it could require up to 5 years to fully complete and confirm the effectiveness of the floodplain IRZs. The projected cleanup times for this alternative, shown in Figure F4-6, were calculated based on the range of two- to 20-flowpath flushing times, with the baseline cleanup time based on a five-flowpath flushing time.

F.4.7 Alternative H – Combined Upland *In-situ*/Pump and Treat

Alternative H combines pump-and-treat remediation and *in-situ* treatment in a different manner than Alternative G. Alternative H would combine *in-situ* treatment in the upland portions of the plume, with pump-and-treat technology in the floodplain. Groundwater would be pumped from extraction wells along National Trails Highway at an assumed combined rate of approximately 500 gpm. Extracted water from these wells would be split and managed in two ways: approximately 300 gpm of the extracted water would be treated by an *ex-situ* treatment plant and reinjected at locations within and outside the plume boundary; the remaining approximately 200 gpm of the extracted water would be reinjected near the western edge of the plume in injection wells after being amended with a carbon source. Chromium in the upland areas of the plume would be addressed by construction of several IRZ lines. The projected cleanup times for this alternative, shown in Figure F4-7, were calculated based on the range of two- to 20-flowpath flushing times, with the baseline cleanup time based on a five-flowpath flushing time.

F.4.8 Alternative I – Continued Operation of Interim Measure

Alternative I assumes continued operation of the existing IM extraction, treatment, and injection systems, assuming 135 gpm extraction rate and 120 gpm injection rate. The projected cleanup times for this alternative, shown in Figure F4-8, were calculated based on the range of two- to 20-flowpath flushing times, with the baseline cleanup time based on a five-flowpath flushing time.

F.4.9 *In-situ* vs. *Ex-situ* Mass Reduction

A comparison of Cr(VI) mass reduction via *in-situ* treatment with reduction via *ex-situ* treatment for the alternatives is provided in Figures F4-9 through F4-16. Using these figures, a comparison of alternatives may be made by the comparative amount of Cr(VI) that would be removed by each process.

F.5 References

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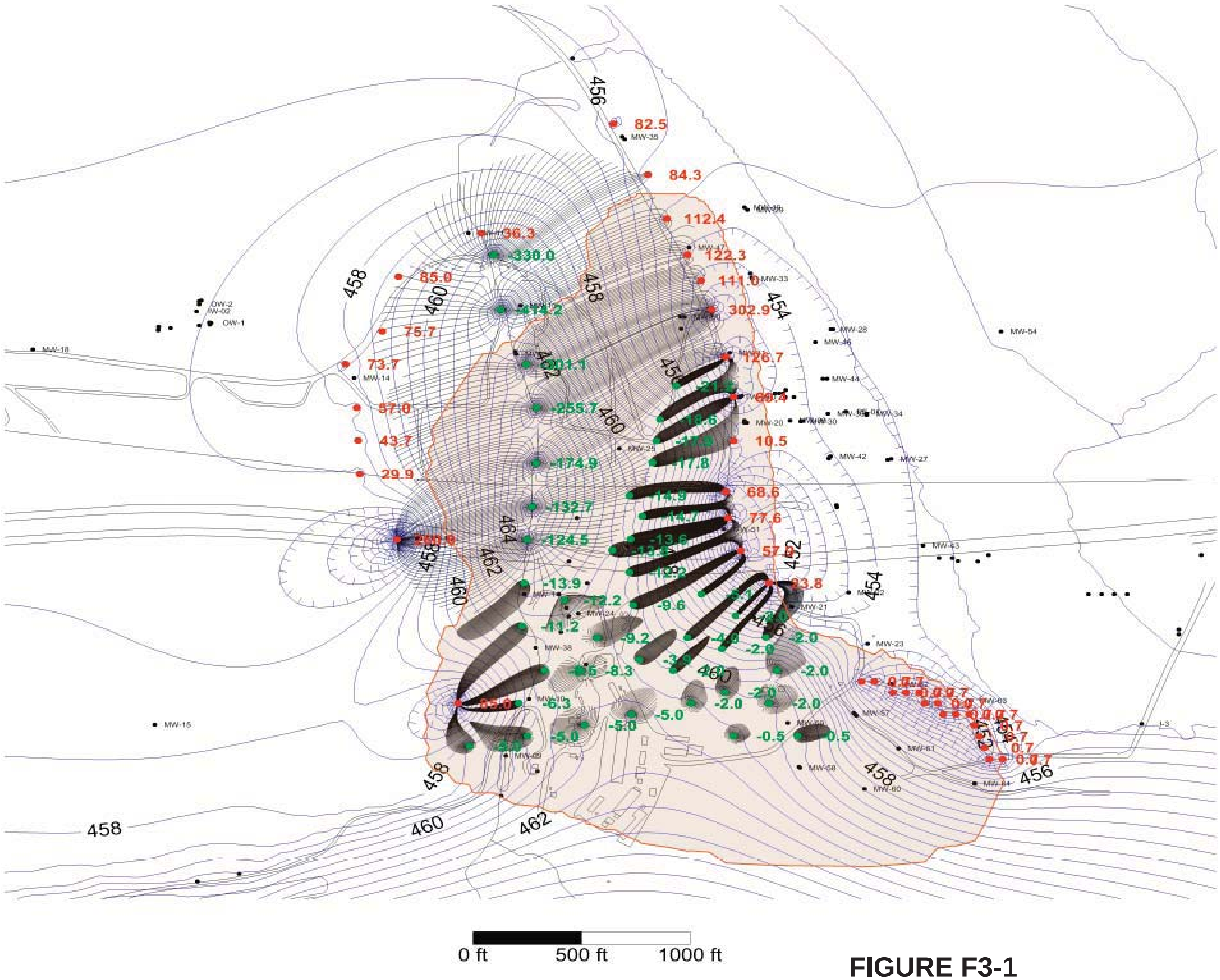

▨ = Plume capture target area for this model layer

Red = Extraction Well Rate (gpm)

Green = Injection Well Rate (gpm)

gpm = gallons per minute

N

FIGURE F3-1
ALTERNATIVE C:
190 DAY HALOES STARTING IN MODEL LAYER 1

FINAL GROUNDWATER CORRECTIVE MEASURES STUDY/
FEASIBILITY STUDY REPORT FOR SWMU 1/AOC 1 and AOC 10
PG&E TOPOCK COMPRESSOR STATION
NEEDLES, CALIFORNIA

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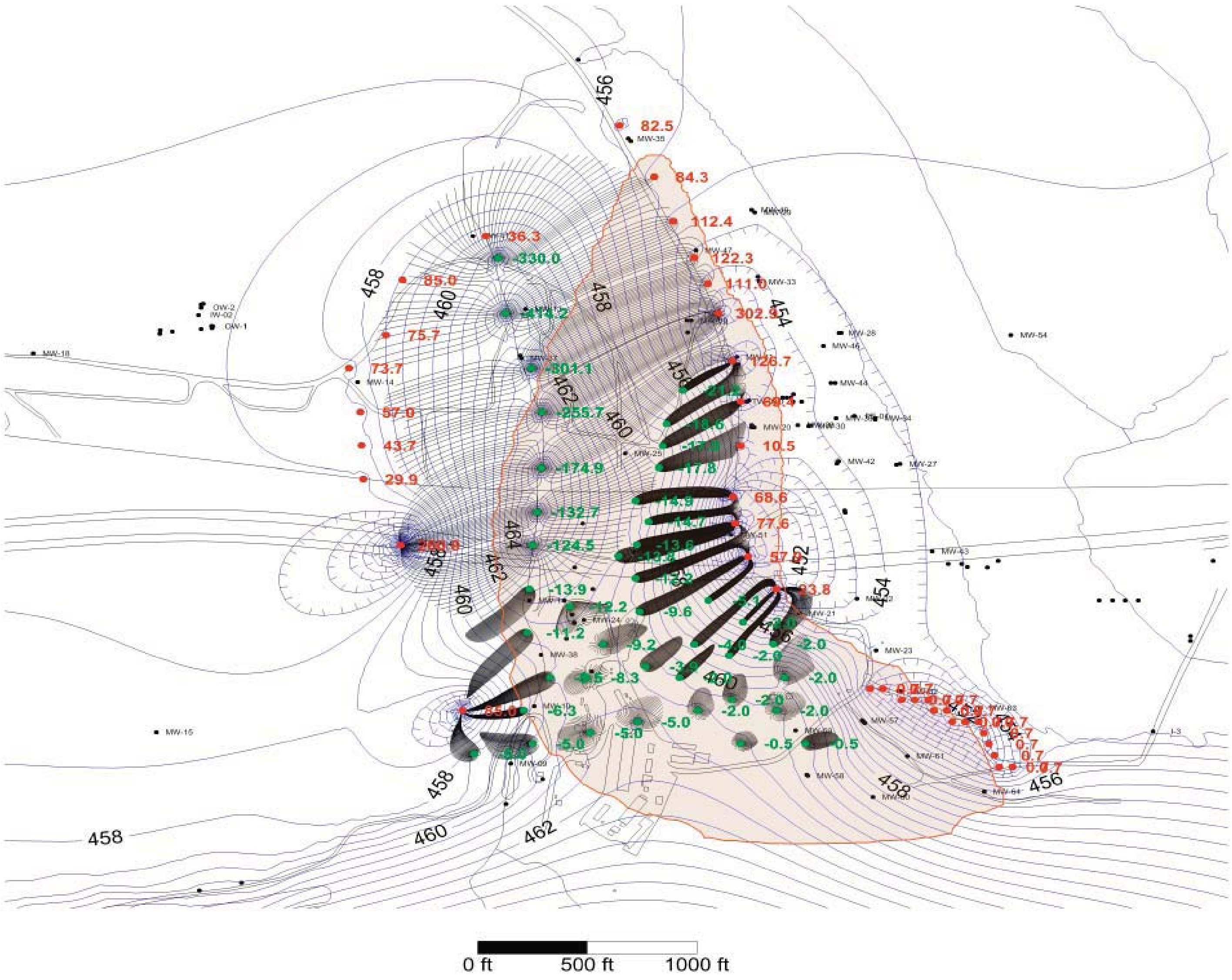

▨ = Plume capture target area for this model layer

Red = Extraction Well Rate (gpm)

Green = Injection Well Rate (gpm)

gpm = gallons per minute

FIGURE F3-2
ALTERNATIVE C:
190 DAY HALOES STARTING IN MODEL LAYER 2

FINAL GROUNDWATER CORRECTIVE MEASURES STUDY/
FEASIBILITY STUDY REPORT FOR SWMU 1/AOC 1 and AOC 10
PG&E TOPOCK COMPRESSOR STATION
NEEDLES, CALIFORNIA

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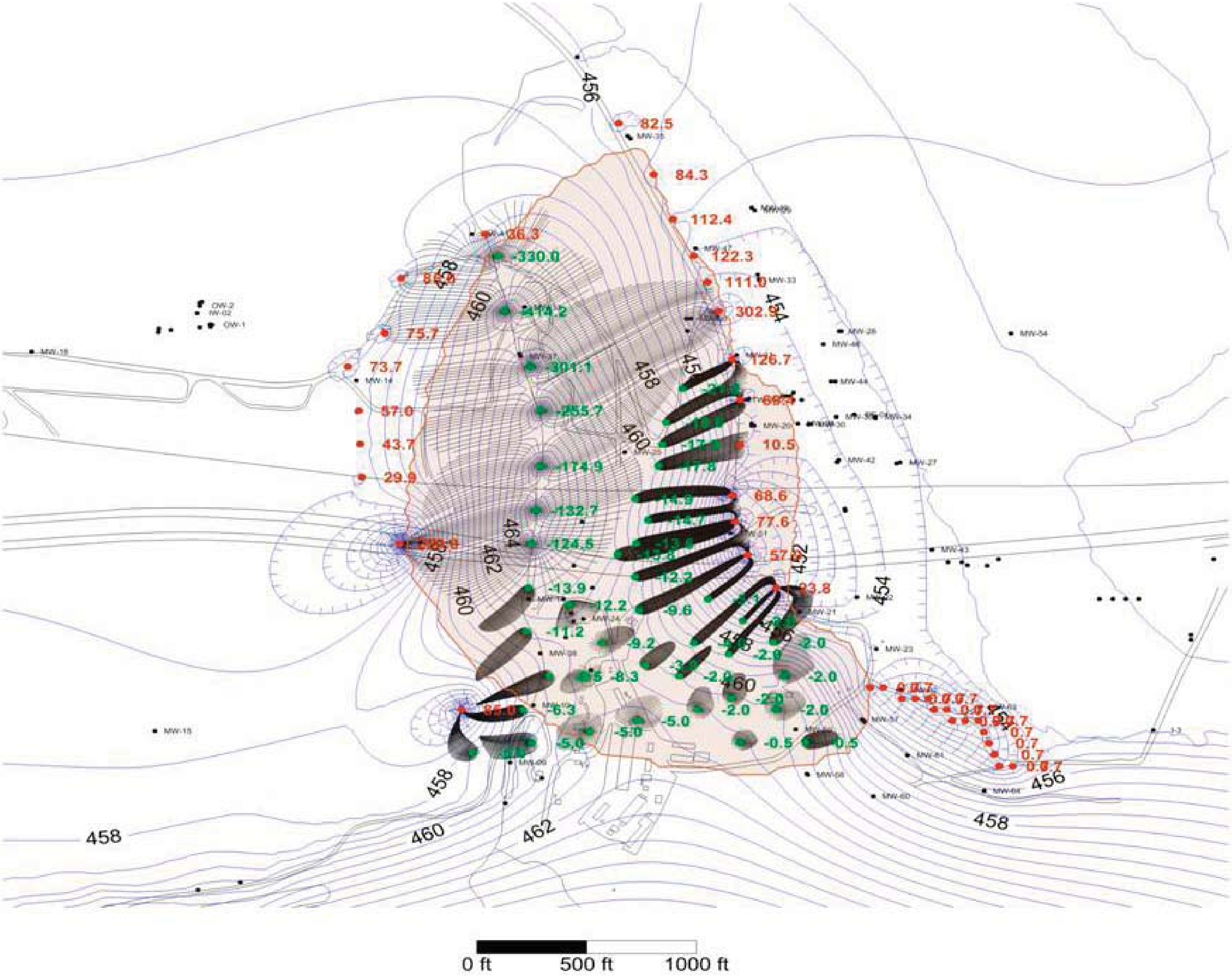


▨ = Plume capture target area for this model layer

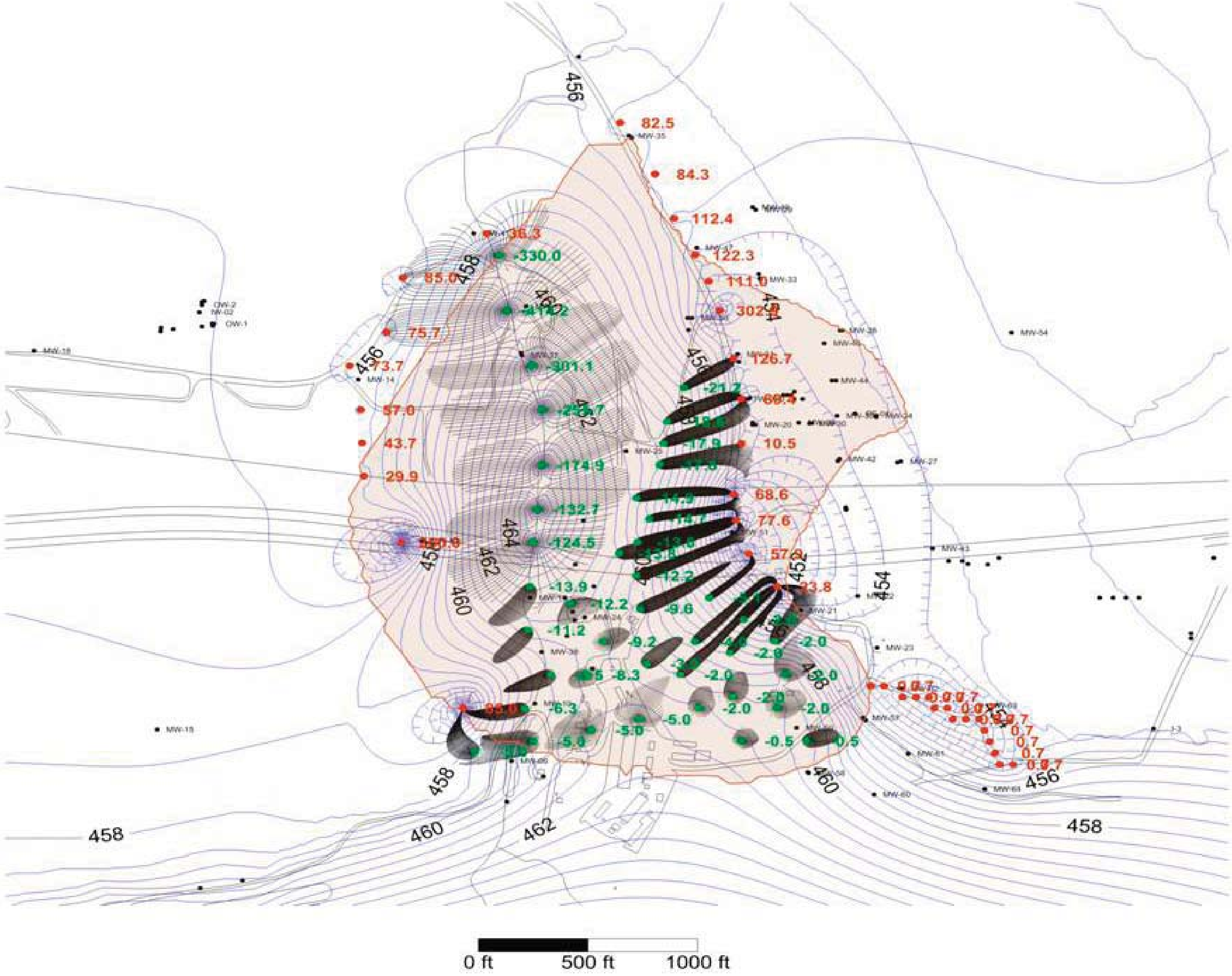
Red = Extraction Well Rate (gpm)

Green = Injection Well Rate (gpm)

gpm = gallons per minute

FIGURE F3-3
ALTERNATIVE C:
190 DAY HALOES STARTING IN MODEL LAYER 3

FINAL GROUNDWATER CORRECTIVE MEASURES STUDY/
FEASIBILITY STUDY REPORT FOR SWMU 1/AOC 1 and AOC 10
PG&E TOPOCK COMPRESSOR STATION
NEEDLES, CALIFORNIA



▨ = Plume capture target area for this model layer

Red = Extraction Well Rate (gpm)

Green = Injection Well Rate (gpm)

gpm = gallons per minute

N

FIGURE F3-4
ALTERNATIVE C:
190 DAY HALOES STARTING IN MODEL LAYER 4

FINAL GROUNDWATER CORRECTIVE MEASURES STUDY/
FEASIBILITY STUDY REPORT FOR SWMU 1/AOC 1 and AOC 10
PG&E TOPOCK COMPRESSOR STATION
NEEDLES, CALIFORNIA

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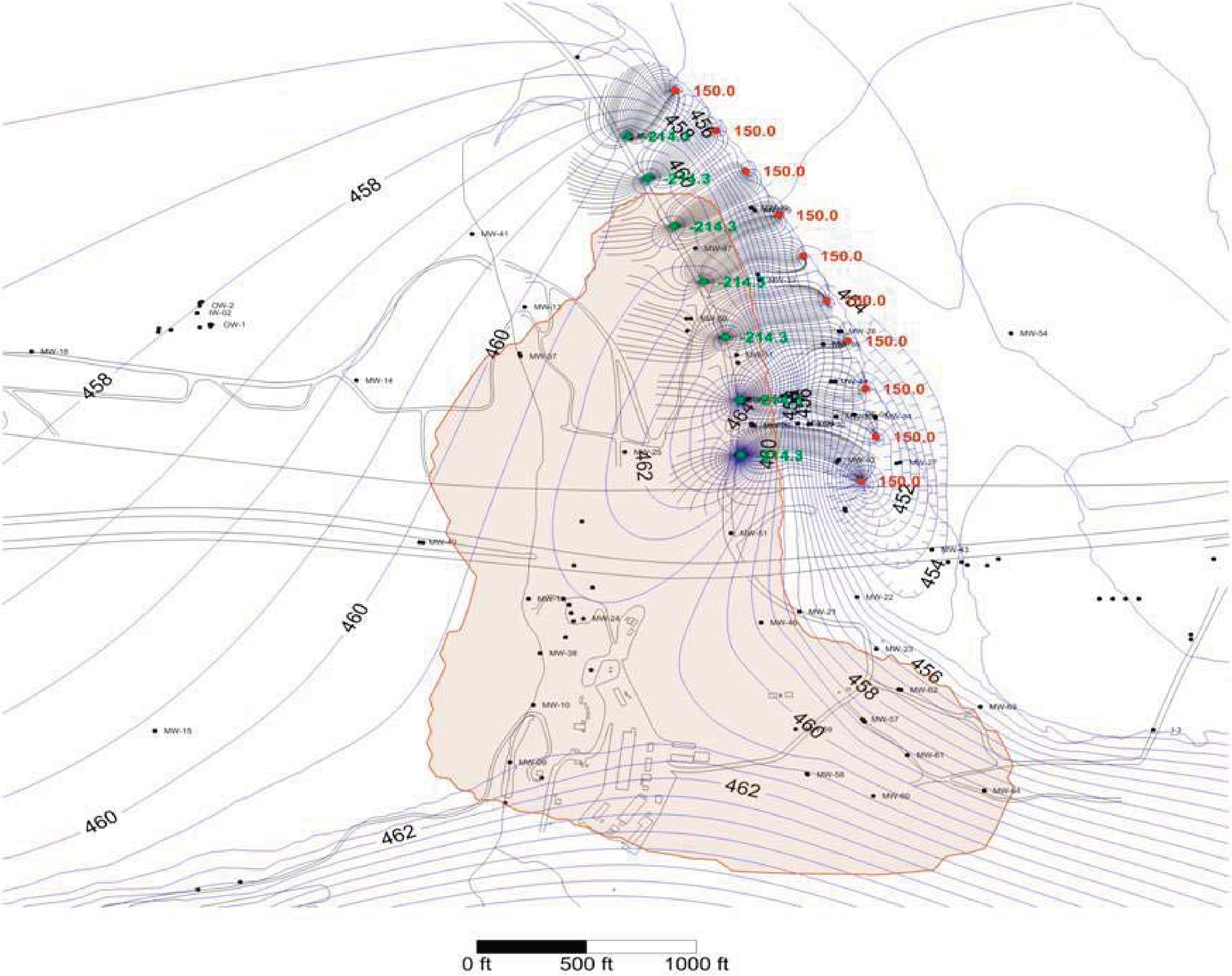


▨ = Plume capture target area for this model layer

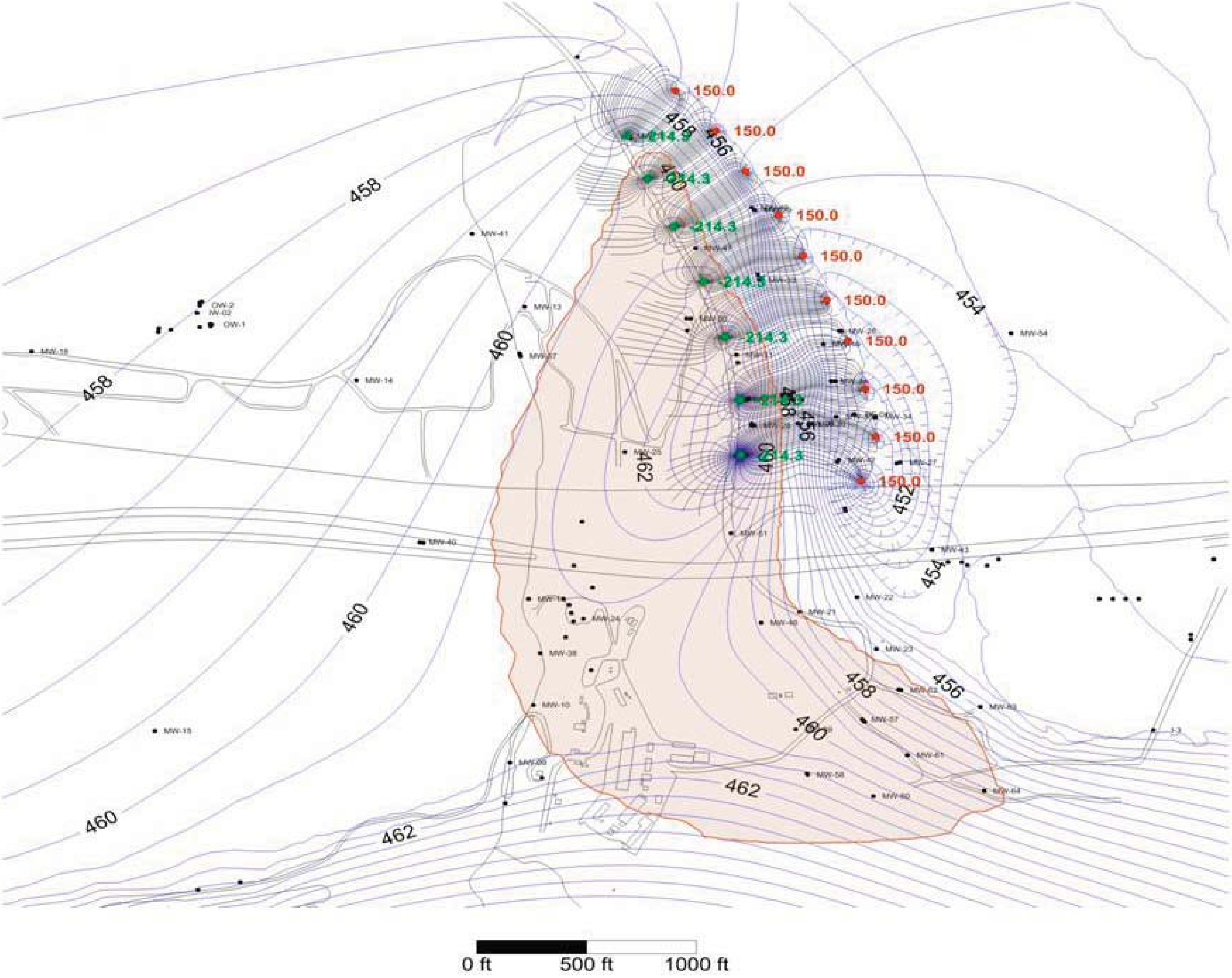
Red = Extraction Well Rate (gpm)

Green = Injection Well Rate (gpm)

gpm = gallons per minute

FIGURE F3-5
ALTERNATIVE D PHASE 1: 190 DAY FLOWLINE STARTING IN MODEL LAYER 1

FINAL GROUNDWATER CORRECTIVE MEASURES STUDY/
FEASIBILITY STUDY REPORT FOR SWMU 1/AOC 1 and AOC 10
PG&E TOPOCK COMPRESSOR STATION
NEEDLES, CALIFORNIA



▨ = Plume capture target area for this model layer

Red = Extraction Well Rate (gpm)

Green = Injection Well Rate (gpm)

gpm = gallons per minute

FIGURE F3-6
ALTERNATIVE D PHASE 1: 190 DAY FLOWLINE STARTING IN MODEL LAYER 2

FINAL GROUNDWATER CORRECTIVE MEASURES STUDY/
FEASIBILITY STUDY REPORT FOR SWMU 1/AOC 1 and AOC 10
PG&E TOPOCK COMPRESSOR STATION
NEEDLES, CALIFORNIA

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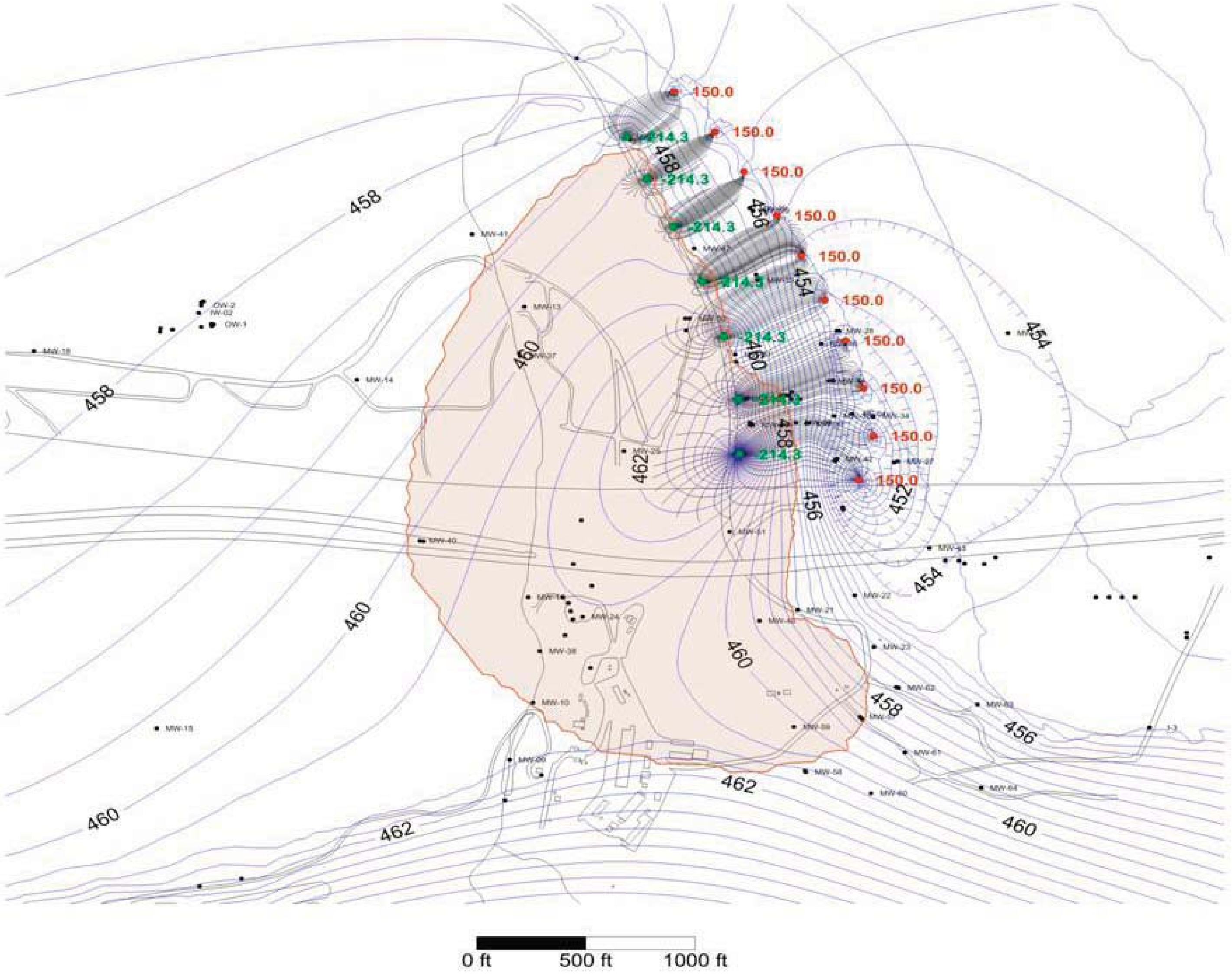

▨ = Plume capture target area for this model layer

Red = Extraction Well Rate (gpm)

Green = Injection Well Rate (gpm)

gpm = gallons per minute

N

FIGURE F3-7
ALTERNATIVE D PHASE 1:
190 DAY FLOWLINE STARTING IN MODEL LAYER 3

FINAL GROUNDWATER CORRECTIVE MEASURES STUDY/
FEASIBILITY STUDY REPORT FOR SWMU 1/AOC 1 and AOC 10
PG&E TOPOCK COMPRESSOR STATION
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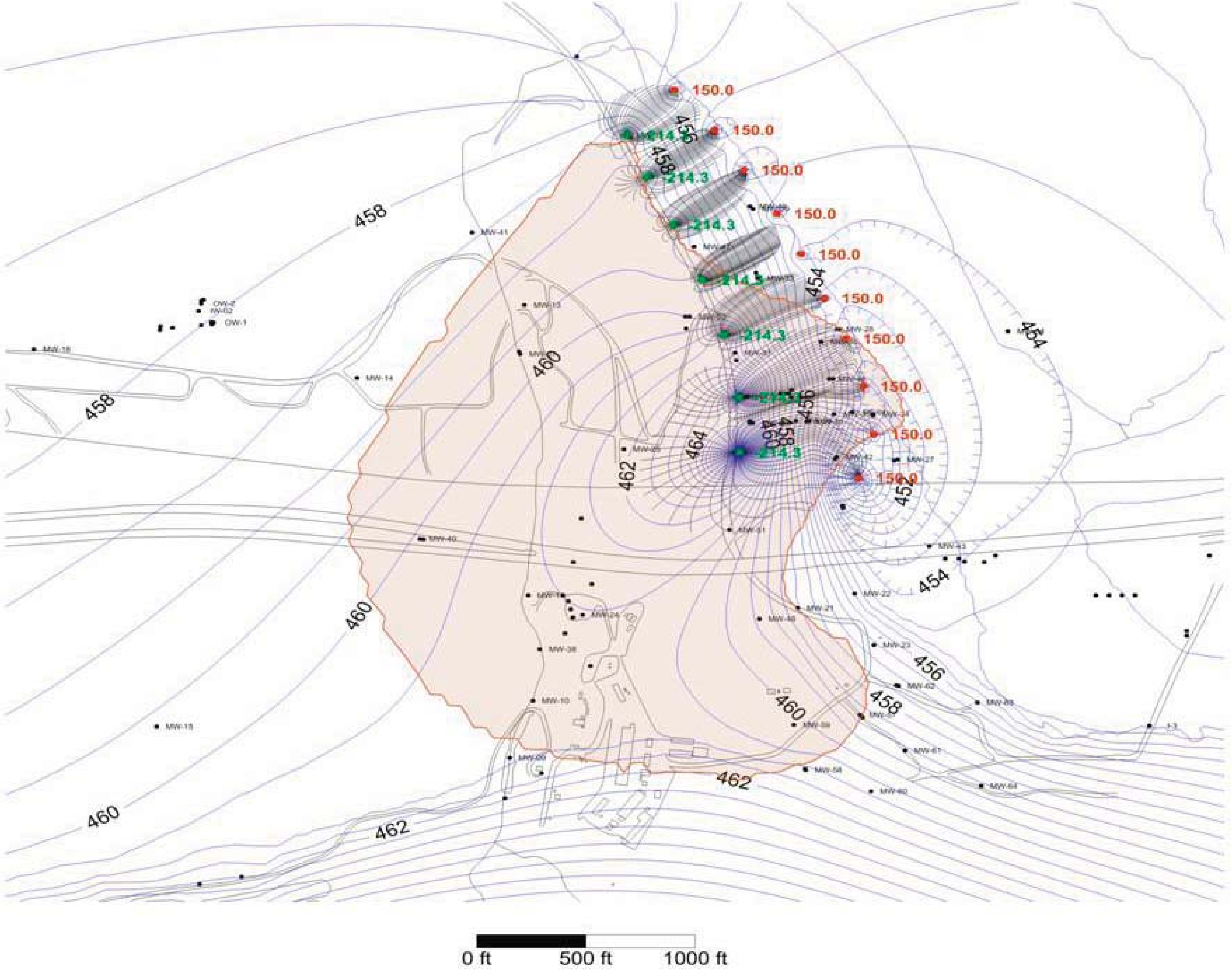


▨ = Plume capture target area for this model layer

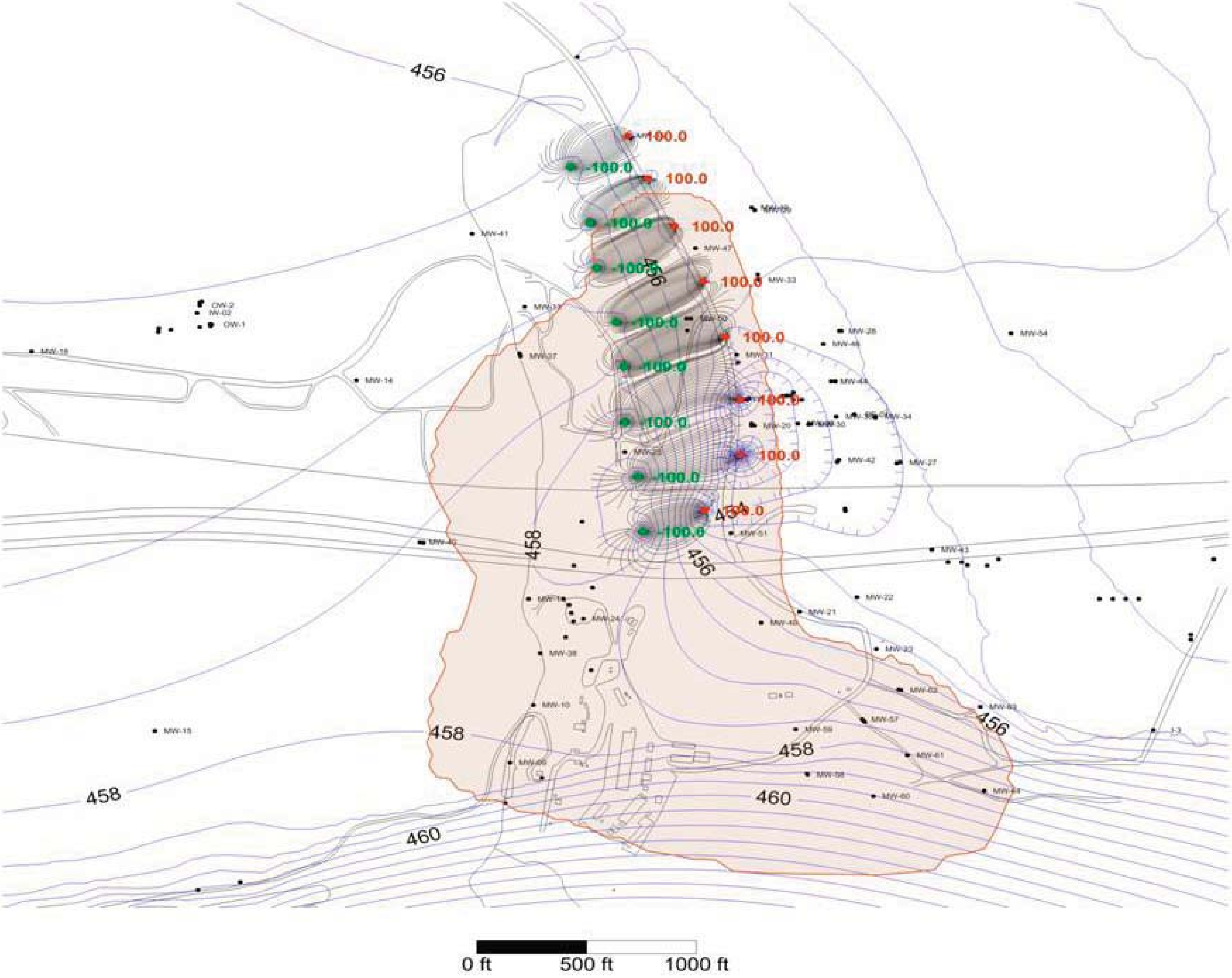
Red = Extraction Well Rate (gpm)

Green = Injection Well Rate (gpm)

gpm = gallons per minute

FIGURE F3-8
ALTERNATIVE D PHASE 1: 190 DAY FLOWLINE STARTING IN MODEL LAYER 4

FINAL GROUNDWATER CORRECTIVE MEASURES STUDY/
FEASIBILITY STUDY REPORT FOR SWMU 1/AOC 1 and AOC 10
PG&E TOPOCK COMPRESSOR STATION
NEEDLES, CALIFORNIA



▨ = Plume capture target area for this model layer

Red = Extraction Well Rate (gpm)

Green = Injection Well Rate (gpm)

gpm = gallons per minute

FIGURE F3-9
ALTERNATIVE D PHASE 2: 190 DAY FLOWLINE STARTING IN MODEL LAYER 1

FINAL GROUNDWATER CORRECTIVE MEASURES STUDY/
FEASIBILITY STUDY REPORT FOR SWMU 1/AOC 1 and AOC 10
PG&E TOPOCK COMPRESSOR STATION
NEEDLES, CALIFORNIA

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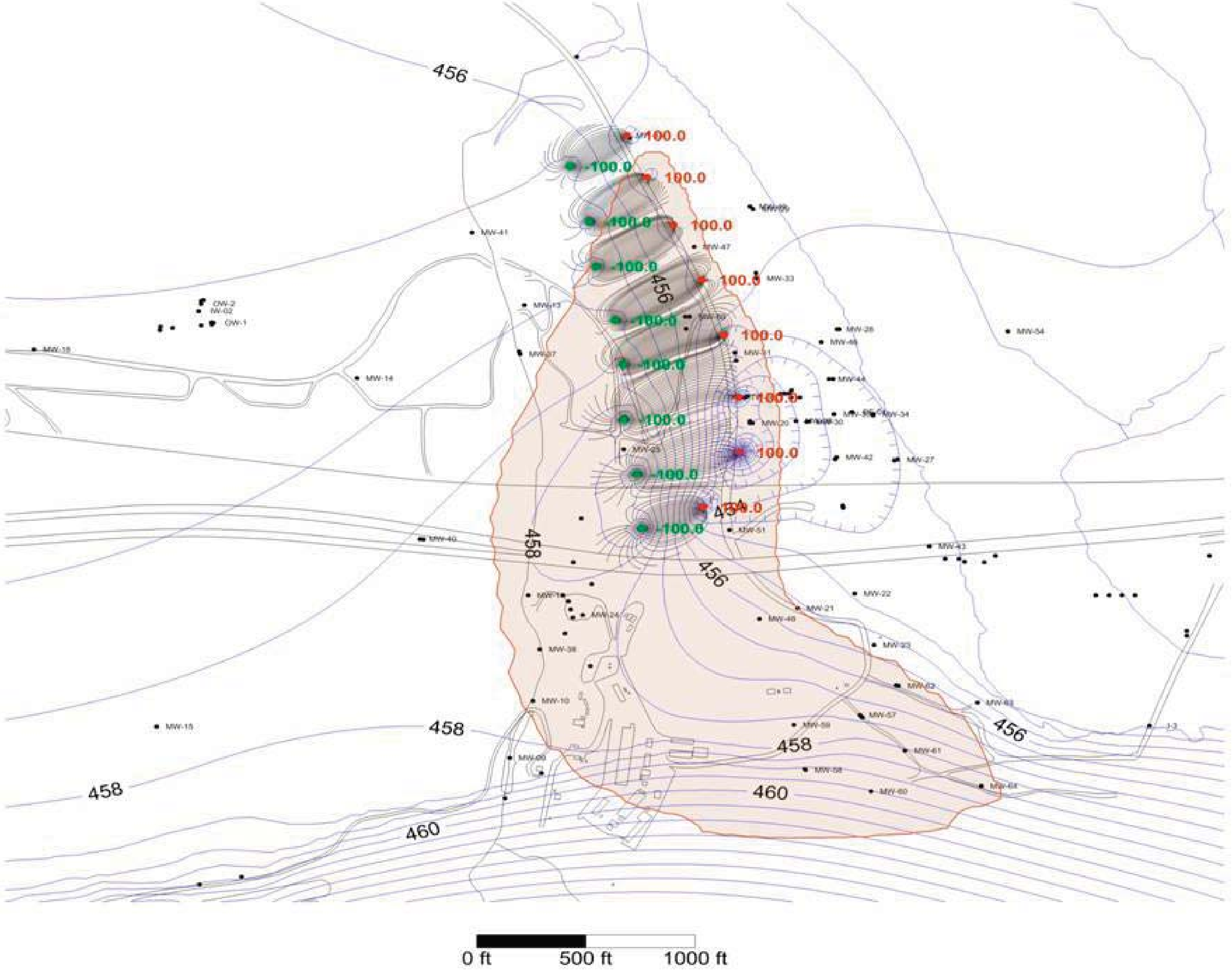

▨ = Plume capture target area for this model layer

Red = Extraction Well Rate (gpm)
Green = Injection Well Rate (gpm)
gpm = gallons per minute

N

FIGURE F3-10
ALTERNATIVE D PHASE 2:
190 DAY FLOWLINE STARTING IN
MODEL LAYER 2

FINAL GROUNDWATER CORRECTIVE MEASURES STUDY/
FEASIBILITY STUDY REPORT FOR SWMU 1/AOC 1 and AOC 10
PG&E TOPOCK COMPRESSOR STATION
NEEDLES, CALIFORNIA

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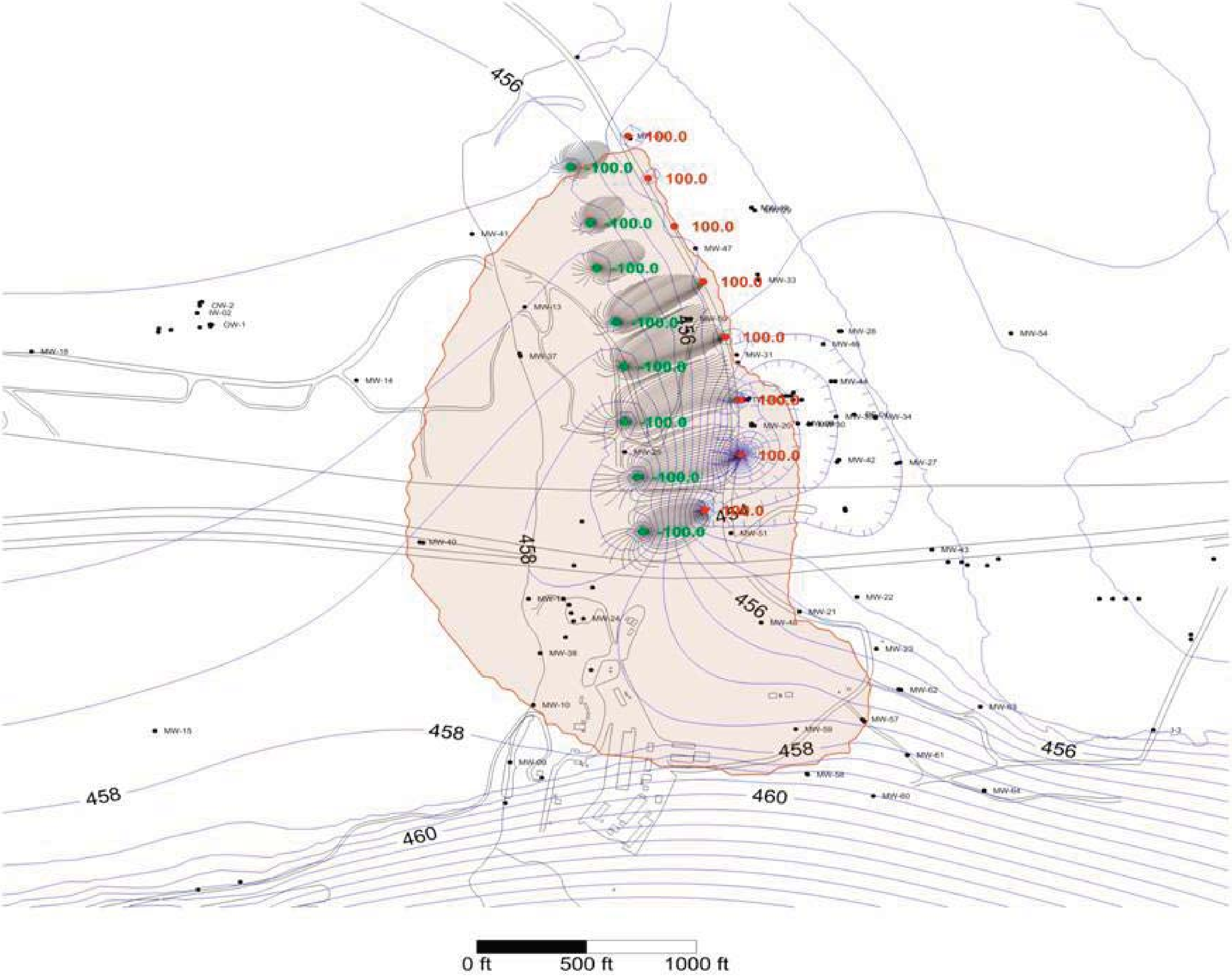
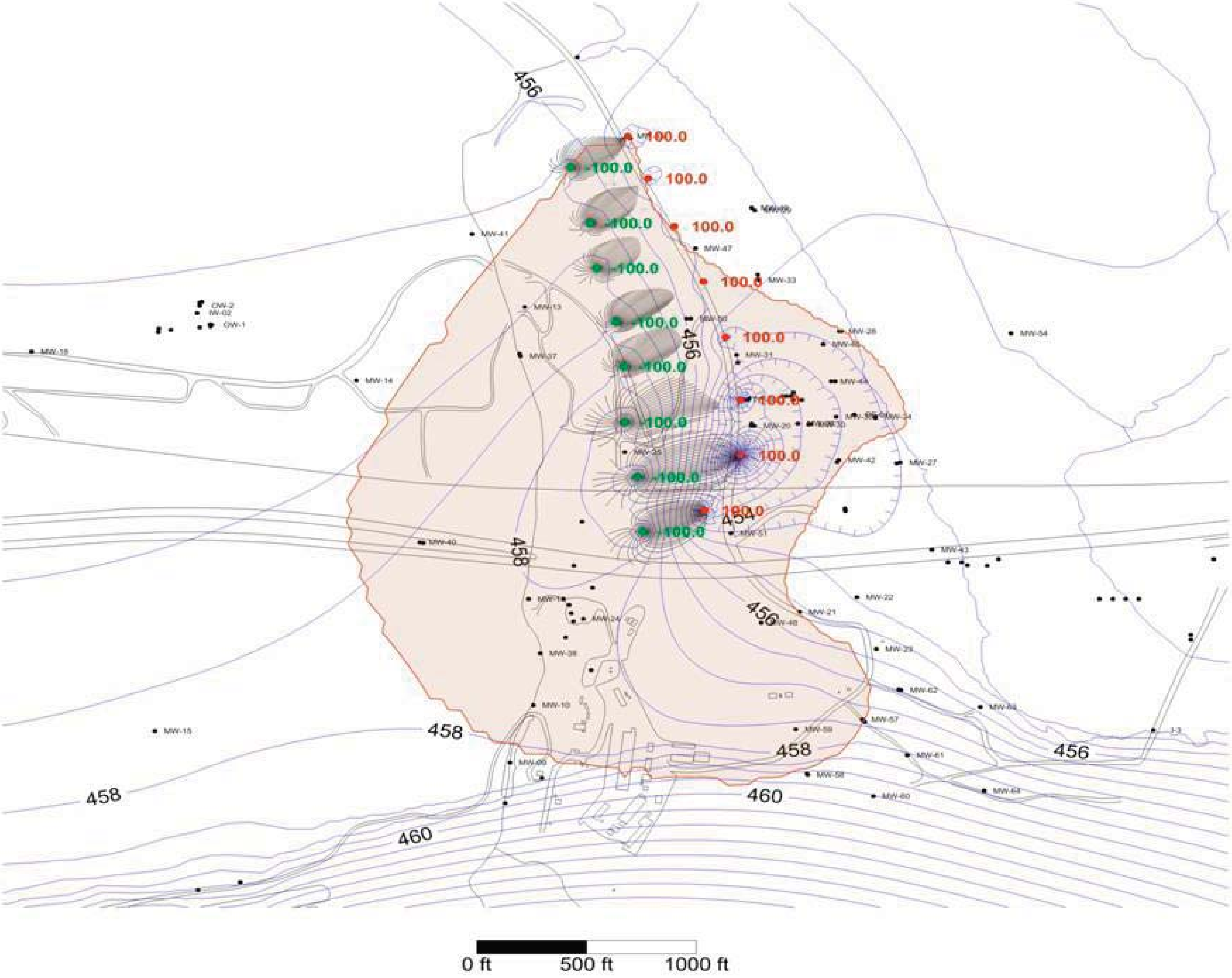


FIGURE F3-11
ALTERNATIVE D PHASE 2:
190 DAY FLOWLINE STARTING IN
MODEL LAYER 3
FINAL GROUNDWATER CORRECTIVE MEASURES STUDY/
FEASIBILITY STUDY REPORT FOR SWMU 1/AOC 1 and AOC 10
PG&E TOPOCK COMPRESSOR STATION
NEEDLES, CALIFORNIA

▨ = Plume capture target area for this model layer

Red = Extraction Well Rate (gpm)
Green = Injection Well Rate (gpm)
gpm = gallons per minute



▨ = Plume capture target area for this model layer

Red = Extraction Well Rate (gpm)

Green = Injection Well Rate (gpm)

gpm = gallons per minute

N

FIGURE F3-12
ALTERNATIVE D PHASE 2:
190 DAY FLOWLINE STARTING IN
MODEL LAYER 4
FINAL GROUNDWATER CORRECTIVE MEASURES STUDY/
FEASIBILITY STUDY REPORT FOR SWMU 1/AOC 1 and AOC 10
PG&E TOPOCK COMPRESSOR STATION
NEEDLES, CALIFORNIA

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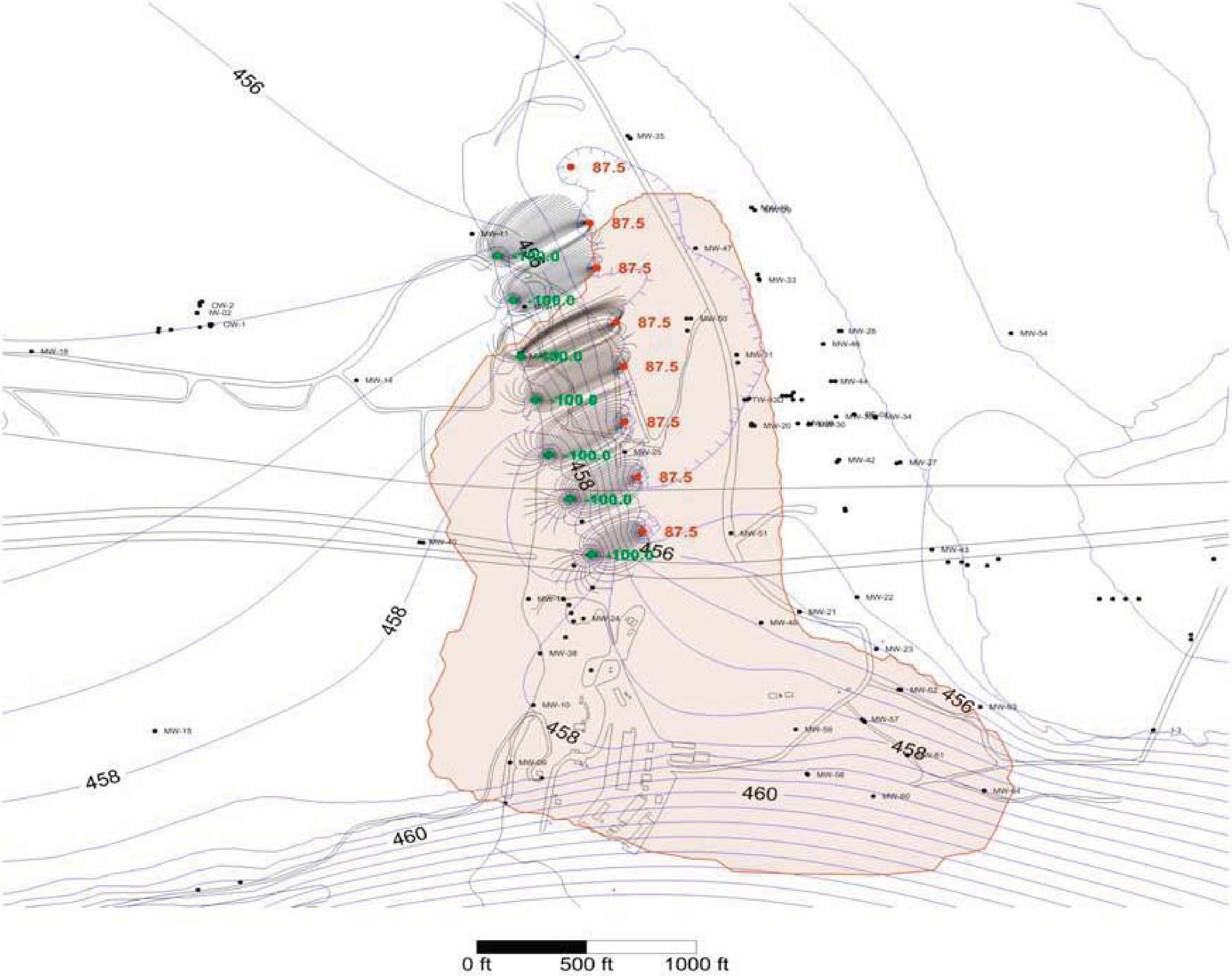

▨ = Plume capture target area for this model layer

Red = Extraction Well Rate (gpm)

Green = Injection Well Rate (gpm)

gpm = gallons per minute

FIGURE F3-13
ALTERNATIVE D PHASE 3: 190 DAY FLOWLINE STARTING IN MODEL LAYER 1

FINAL GROUNDWATER CORRECTIVE MEASURES STUDY/
FEASIBILITY STUDY REPORT FOR SWMU 1/AOC 1 and AOC 10
PG&E TOPOCK COMPRESSOR STATION
NEEDLES, CALIFORNIA

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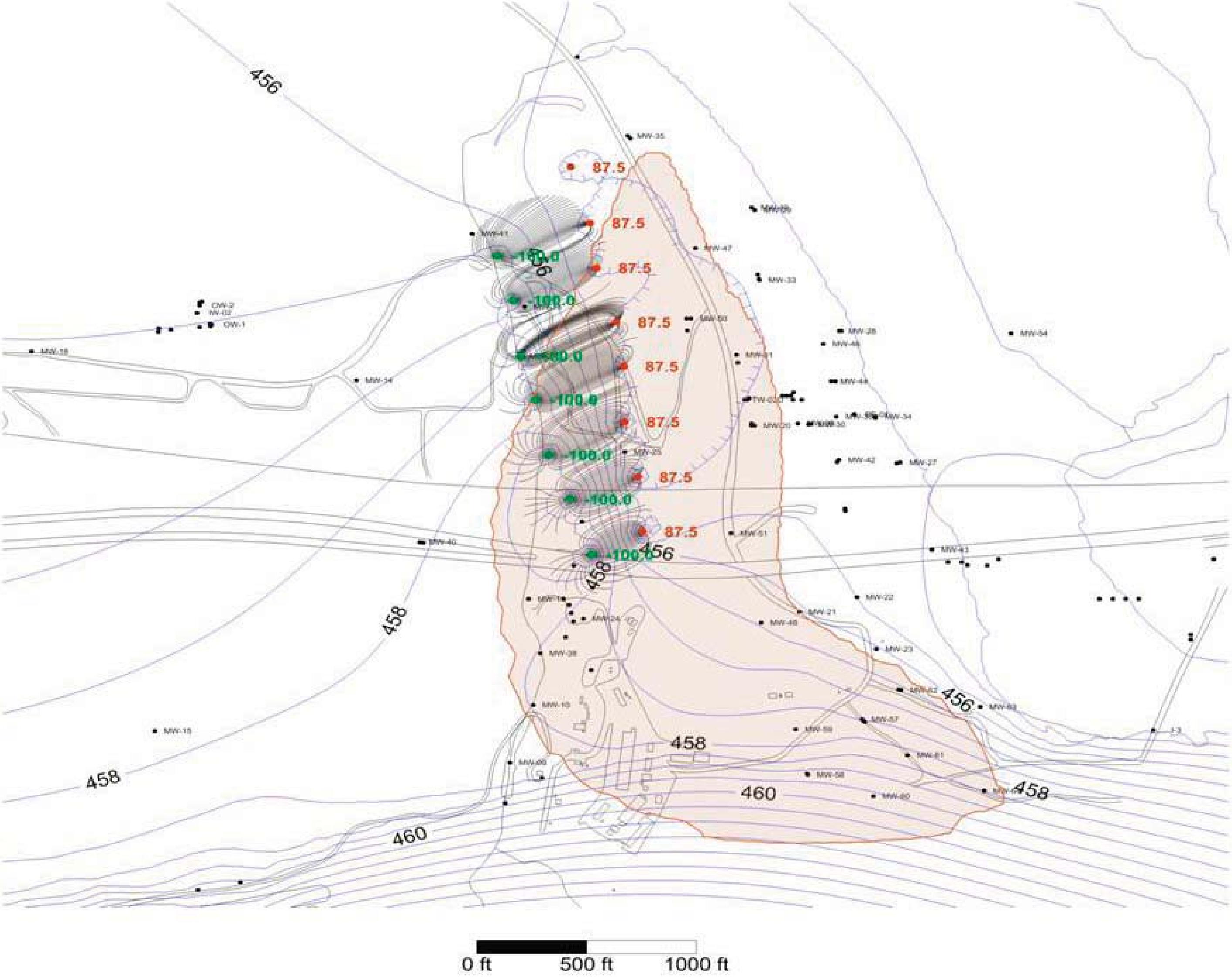


▨ = Plume capture target area for this model layer

Red = Extraction Well Rate (gpm)

Green = Injection Well Rate (gpm)

gpm = gallons per minute

FIGURE F3-14
ALTERNATIVE D PHASE 3: 190 DAY FLOWLINE STARTING IN MODEL LAYER 2

FINAL GROUNDWATER CORRECTIVE MEASURES STUDY/
FEASIBILITY STUDY REPORT FOR SWMU 1/AOC 1 and AOC 10
PG&E TOPOCK COMPRESSOR STATION
NEEDLES, CALIFORNIA

CH2MHILL

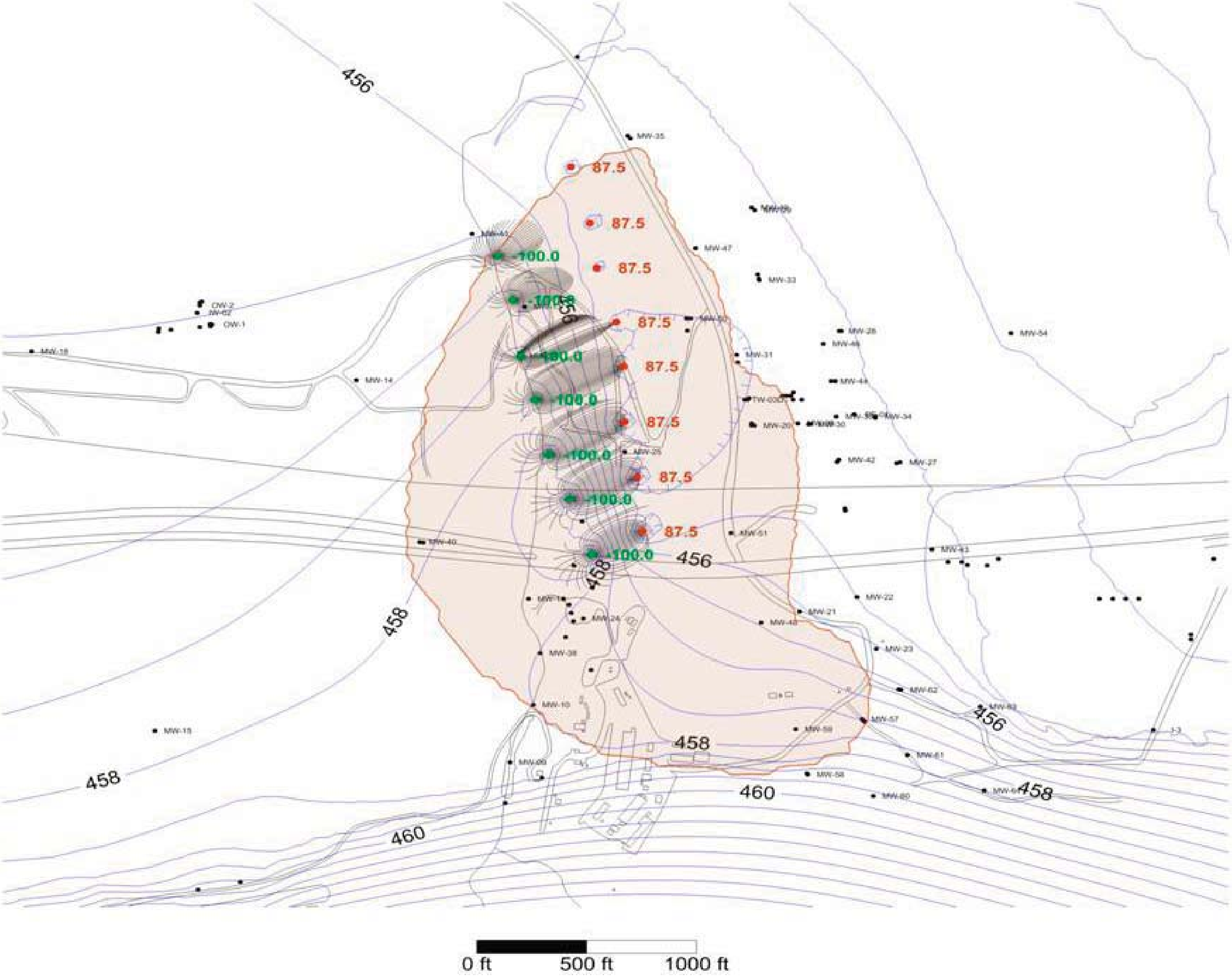


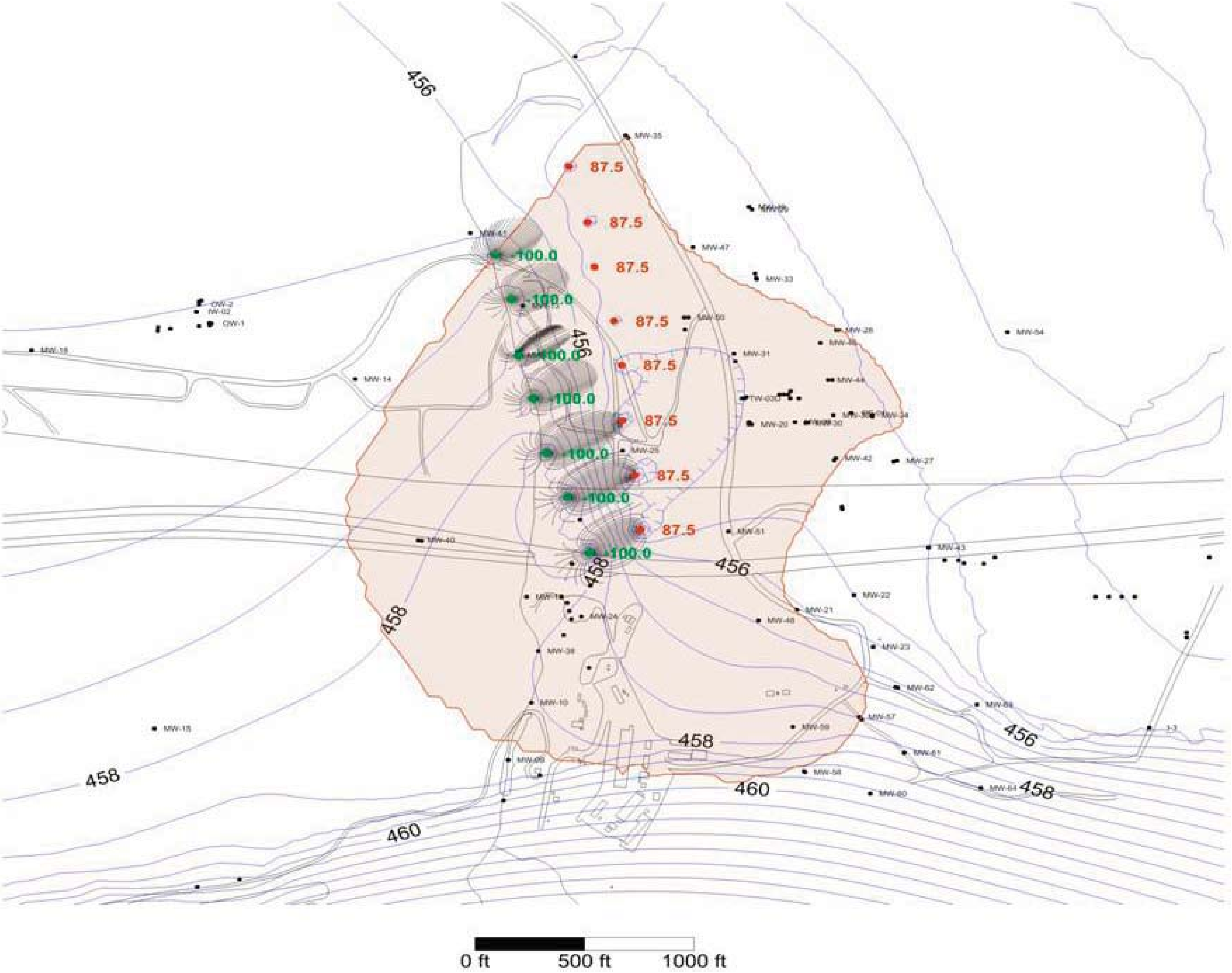
FIGURE F3-15
ALTERNATIVE D PHASE 3:
190 DAY FLOWLINE STARTING IN MODEL LAYER 3

FINAL GROUNDWATER CORRECTIVE MEASURES STUDY/
FEASIBILITY STUDY REPORT FOR SWMU 1/AOC 1 and AOC 10
PG&E TOPOCK COMPRESSOR STATION
NEEDLES, CALIFORNIA

▨ = Plume capture target area for this model layer

Red = Extraction Well Rate (gpm)
Green = Injection Well Rate (gpm)
gpm = gallons per minute

CH2MHILL



▨ = Plume capture target area for this model layer

Red = Extraction Well Rate (gpm)

Green = Injection Well Rate (gpm)

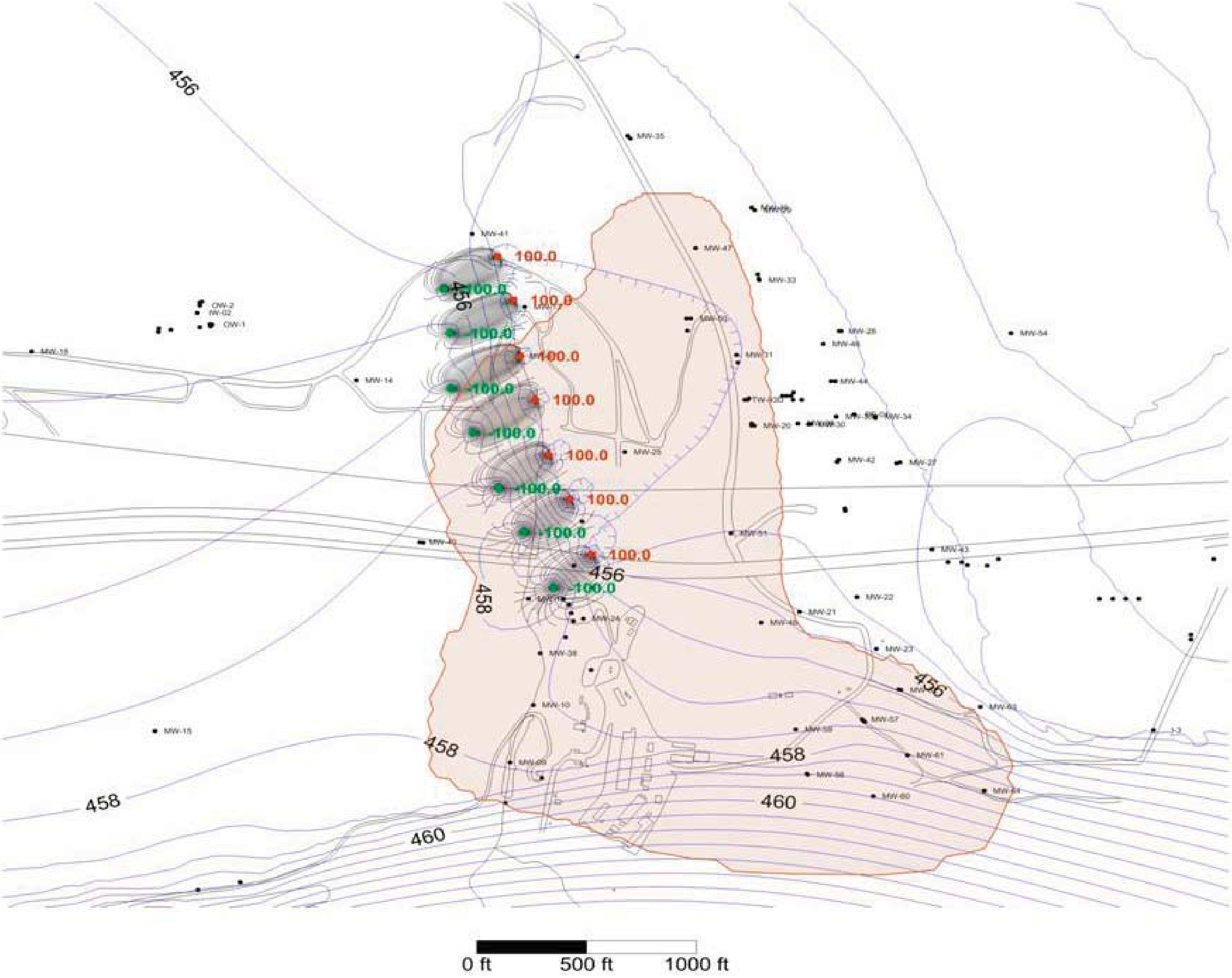
gpm = gallons per minute

N

FIGURE F3-16
ALTERNATIVE D PHASE 3: 190 DAY FLOWLINE STARTING IN MODEL LAYER 4

FINAL GROUNDWATER CORRECTIVE MEASURES STUDY/
FEASIBILITY STUDY REPORT FOR SWMU 1/AOC 1 and AOC 10
PG&E TOPOCK COMPRESSOR STATION
NEEDLES, CALIFORNIA

CH2MHILL

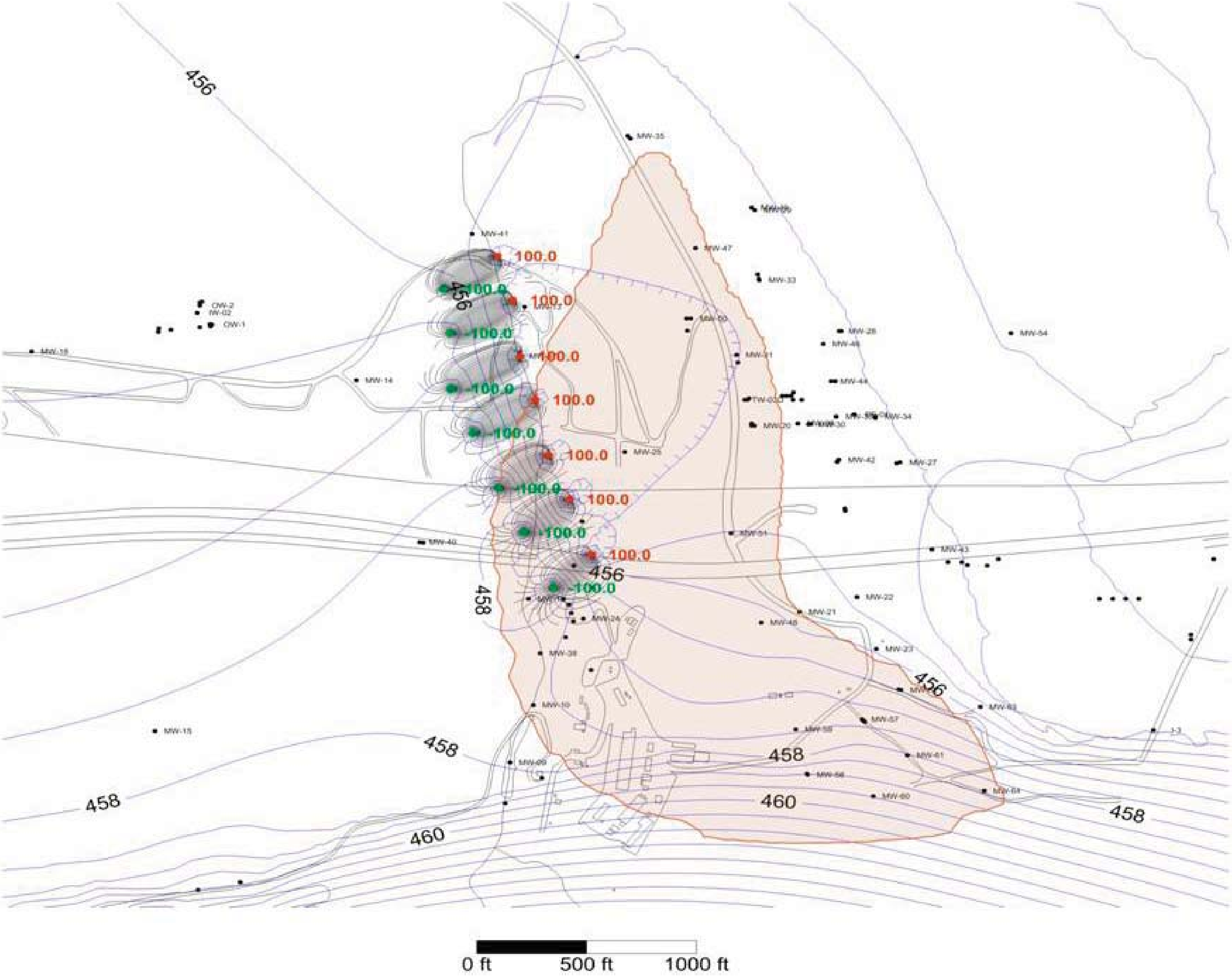


▨ = Plume capture target area for this model layer

Red = Extraction Well Rate (gpm)
Green = Injection Well Rate (gpm)
gpm = gallons per minute

FIGURE F3-17
ALTERNATIVE D PHASE 4: 190 DAY FLOWLINE STARTING IN MODEL LAYER 1

FINAL GROUNDWATER CORRECTIVE MEASURES STUDY/
FEASIBILITY STUDY REPORT FOR SWMU 1/AOC 1 and AOC 10
PG&E TOPOCK COMPRESSOR STATION
NEEDLES, CALIFORNIA



▨ = Plume capture target area for
this model layer

Red = Extraction Well Rate (gpm)

Green = Injection Well Rate (gpm)

gpm = gallons per minute

FIGURE F3-18
ALTERNATIVE D PHASE 4: 190 DAY FLOWLINE STARTING IN MODEL LAYER 2

FINAL GROUNDWATER CORRECTIVE MEASURES STUDY/
FEASIBILITY STUDY REPORT FOR SWMU 1/AOC 1 and AOC 10
PG&E TOPOCK COMPRESSOR STATION
NEEDLES, CALIFORNIA

CH2MHILL

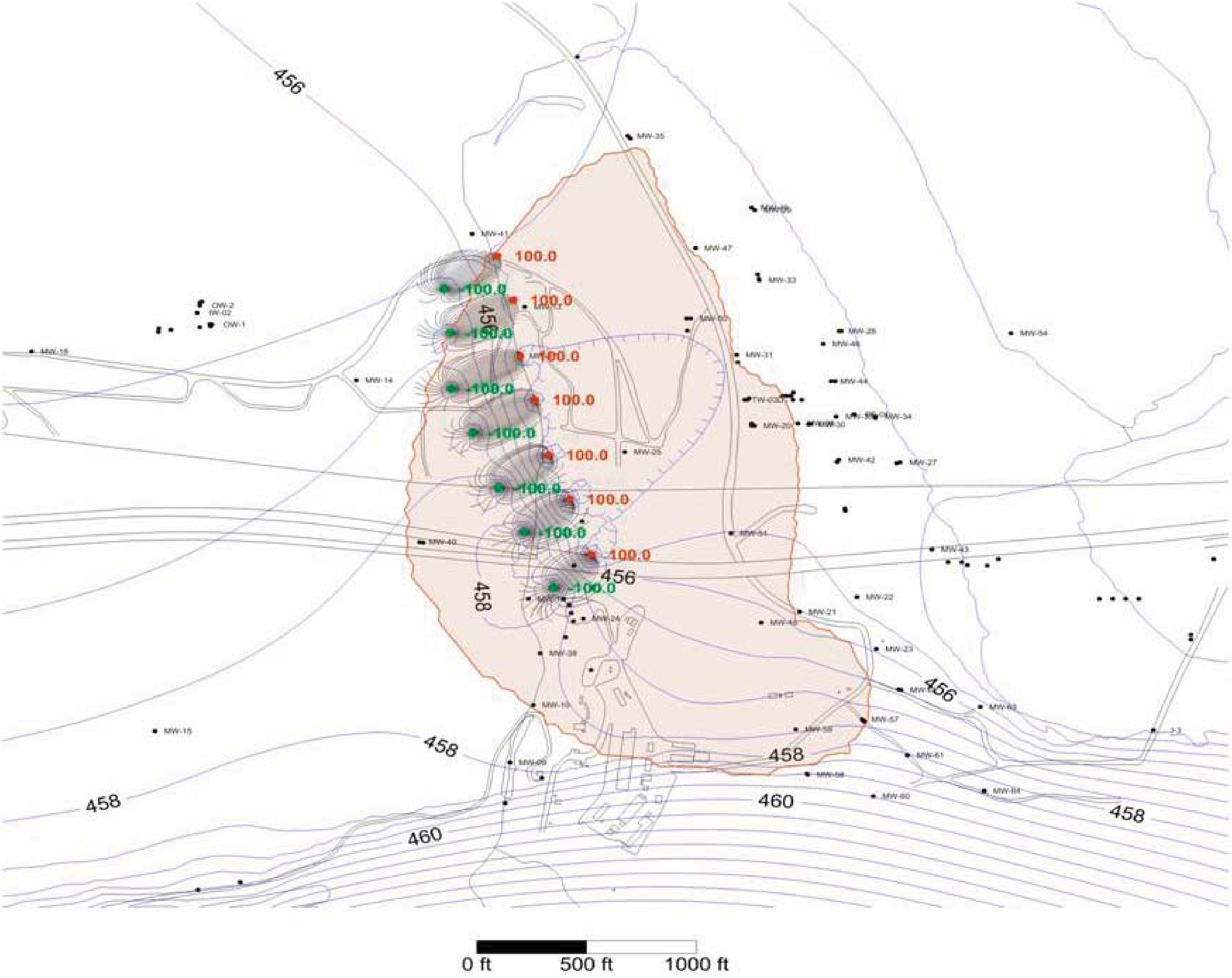


FIGURE F3-19
ALTERNATIVE D PHASE 4:
190 DAY FLOWLINE STARTING IN MODEL LAYER 3

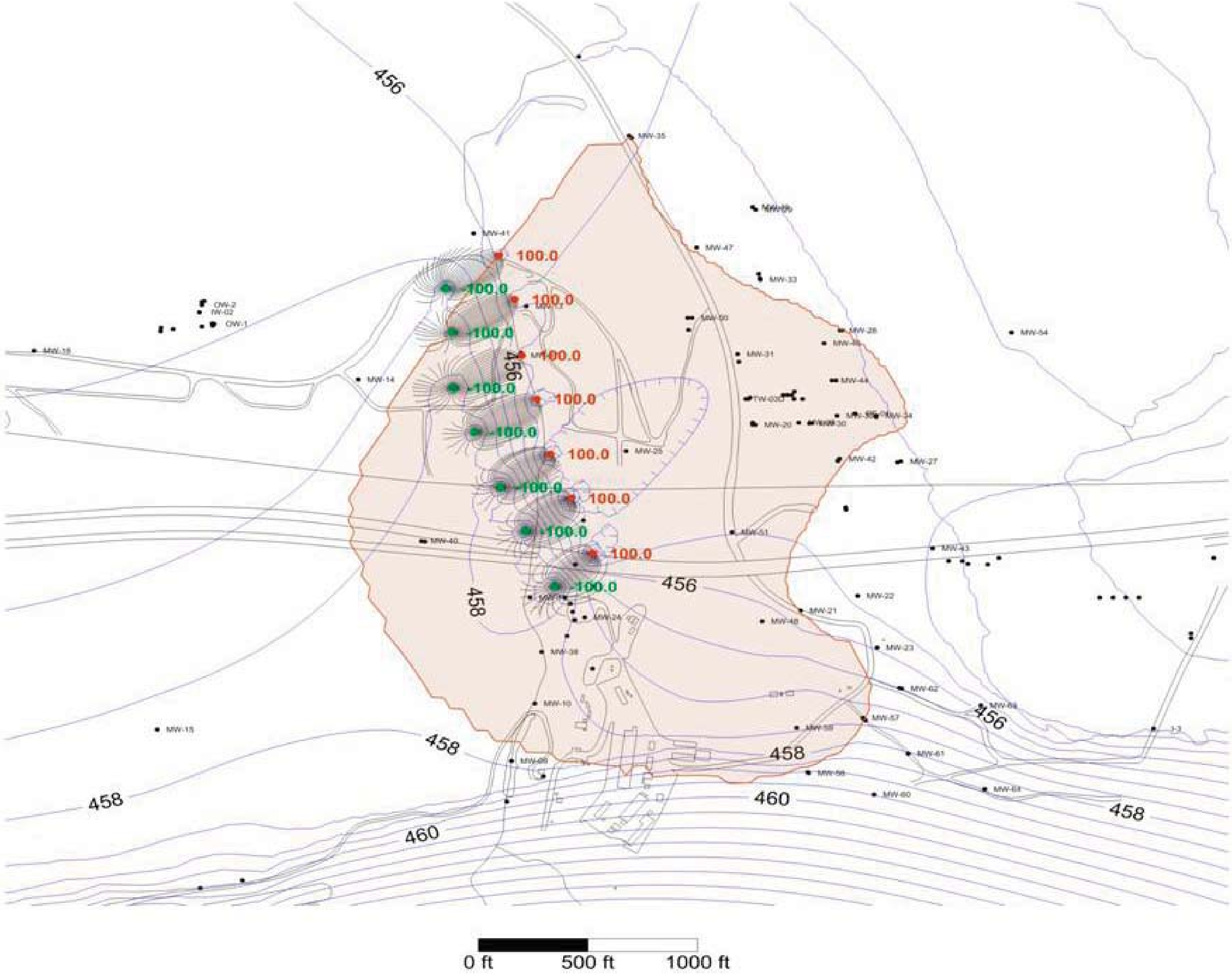
FINAL GROUNDWATER CORRECTIVE MEASURES STUDY/
FEASIBILITY STUDY REPORT FOR SWMU 1/AOC 1 and AOC 10
PG&E TOPOCK COMPRESSOR STATION
NEEDLES, CALIFORNIA

▨ = Plume capture target area for this model layer

Red = Extraction Well Rate (gpm)
Green = Injection Well Rate (gpm)
gpm = gallons per minute

N

CH2MHILL



▨ = Plume capture target area for this model layer

Red = Extraction Well Rate (gpm)

Green = Injection Well Rate (gpm)

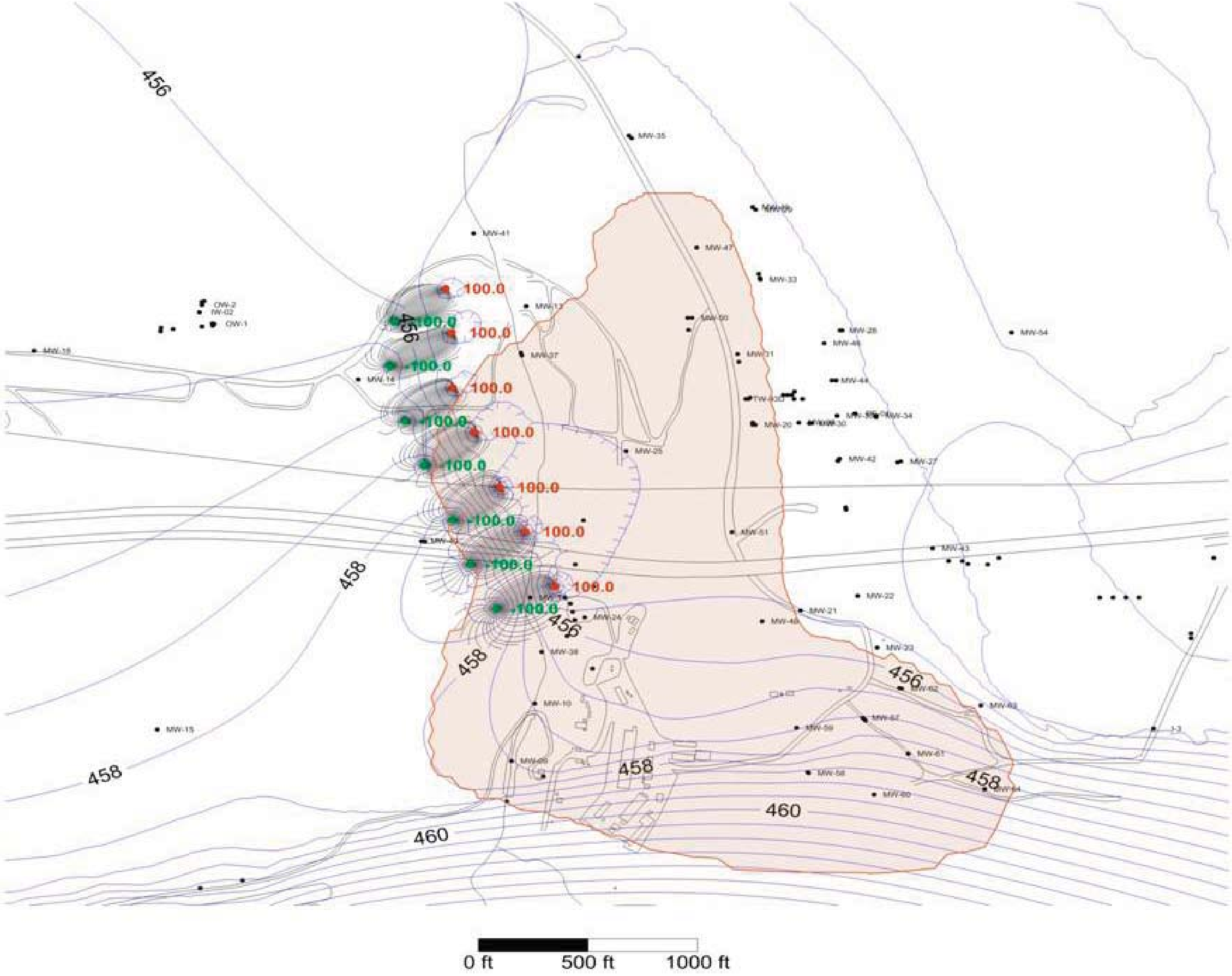
gpm = gallons per minute

FIGURE F3-20
ALTERNATIVE D PHASE 4: 190 DAY FLOWLINE STARTING IN MODEL LAYER 4

FINAL GROUNDWATER CORRECTIVE MEASURES STUDY/
FEASIBILITY STUDY REPORT FOR SWMU 1/AOC 1 and AOC 10
PG&E TOPOCK COMPRESSOR STATION
NEEDLES, CALIFORNIA

CH2MHILL

ES092008007BAO_FigF3_Alternatives_ModelLayers_v2.indd_121109_lho



▢ = Plume capture target area for this model layer

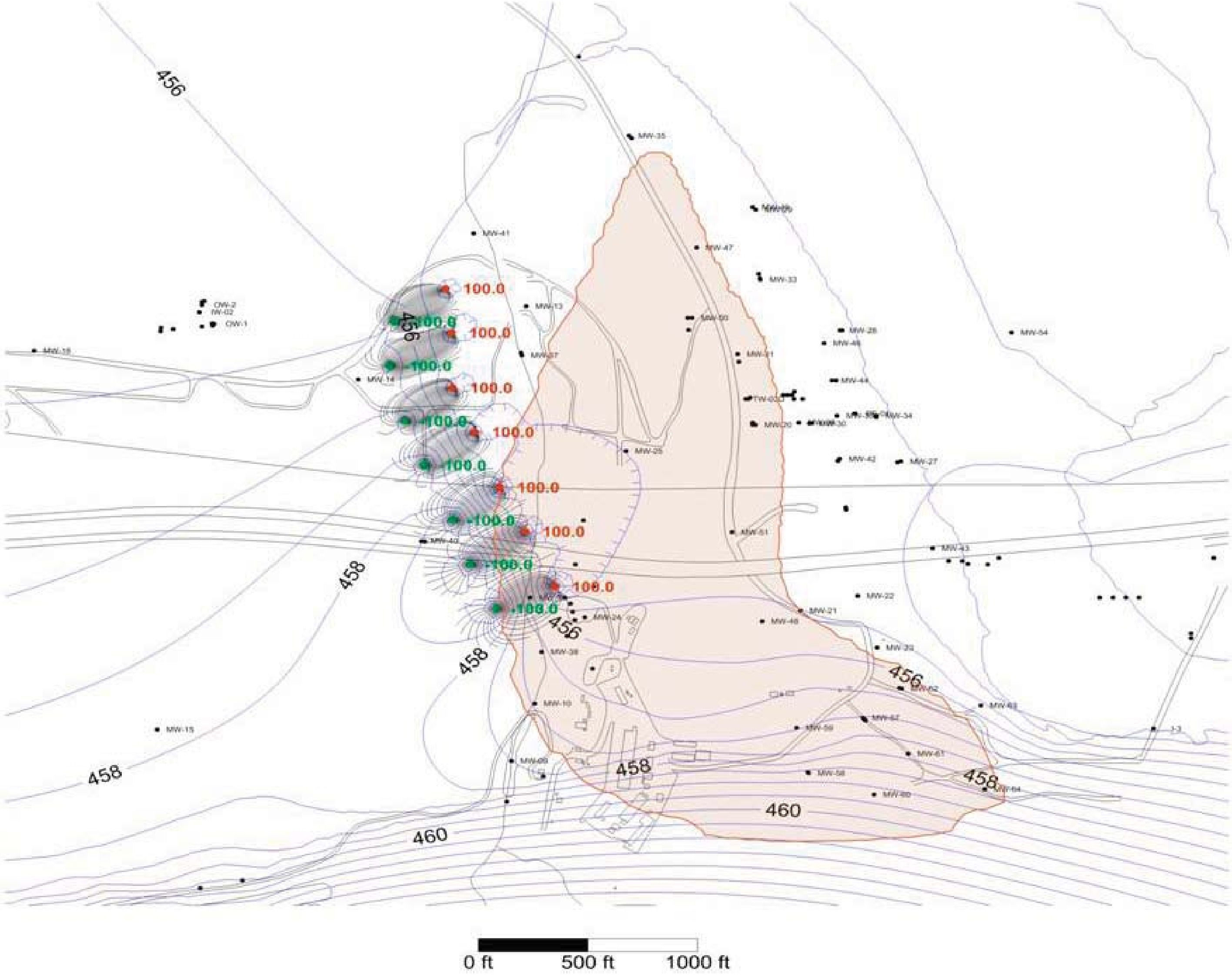
Red = Extraction Well Rate (gpm)

Green = Injection Well Rate (gpm)

gpm = gallons per minute

FIGURE F3-21
ALTERNATIVE D PHASE 5:
190 DAY FLOWLINE STARTING IN MODEL LAYER 1

FINAL GROUNDWATER CORRECTIVE MEASURES STUDY/
FEASIBILITY STUDY REPORT FOR SWMU 1/AOC 1 and AOC 10
PG&E TOPOCK COMPRESSOR STATION
NEEDLES, CALIFORNIA



▨ = Plume capture target area for this model layer

Red = Extraction Well Rate (gpm)

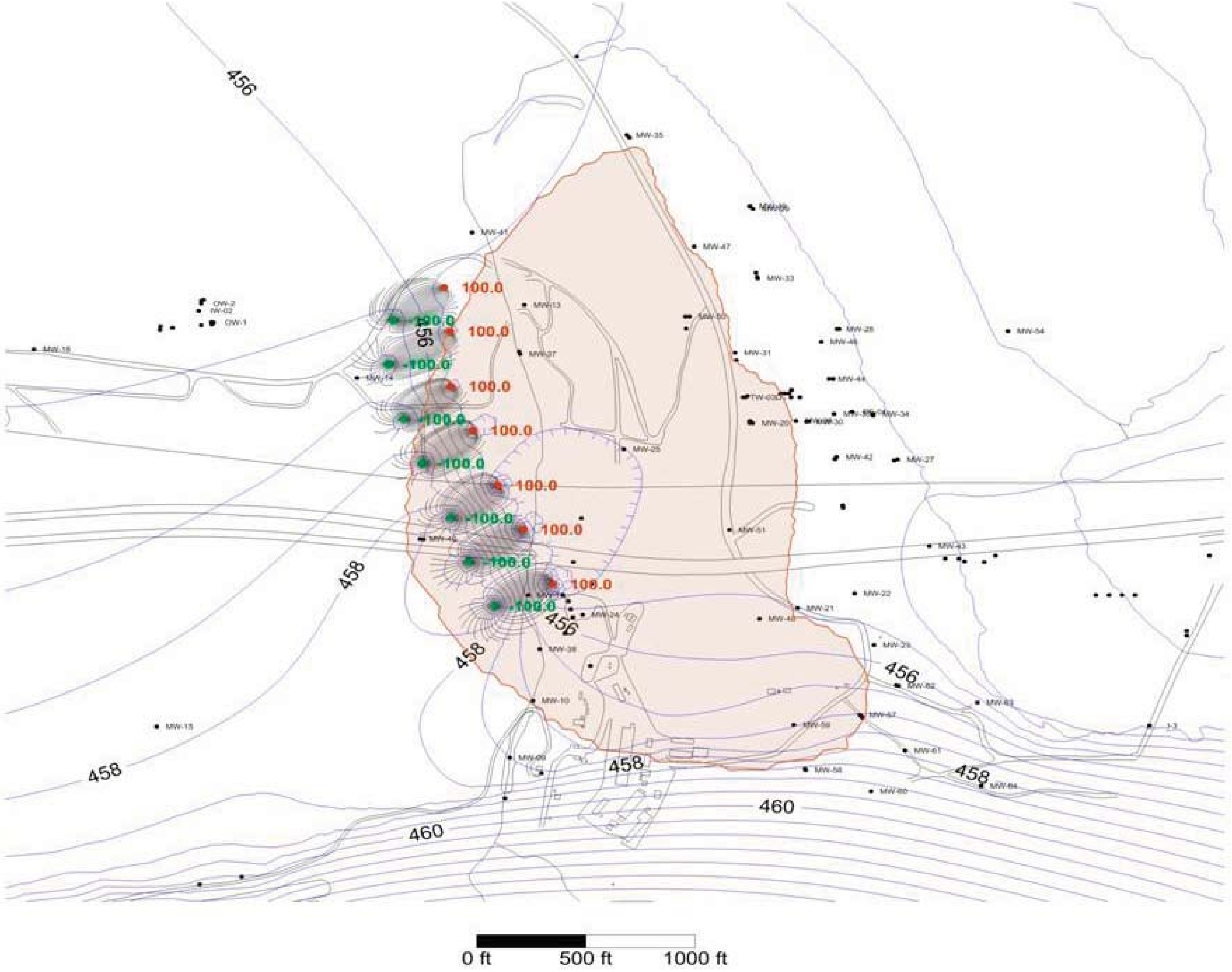
Green = Injection Well Rate (gpm)

gpm = gallons per minute

FIGURE F3-22
ALTERNATIVE D PHASE 5: 190 DAY FLOWLINE STARTING IN MODEL LAYER 2

FINAL GROUNDWATER CORRECTIVE MEASURES STUDY/
FEASIBILITY STUDY REPORT FOR SWMU 1/AOC 1 and AOC 10
PG&E TOPOCK COMPRESSOR STATION
NEEDLES, CALIFORNIA

CH2MHILL



▨ = Plume capture target area for this model layer

Red = Extraction Well Rate (gpm)

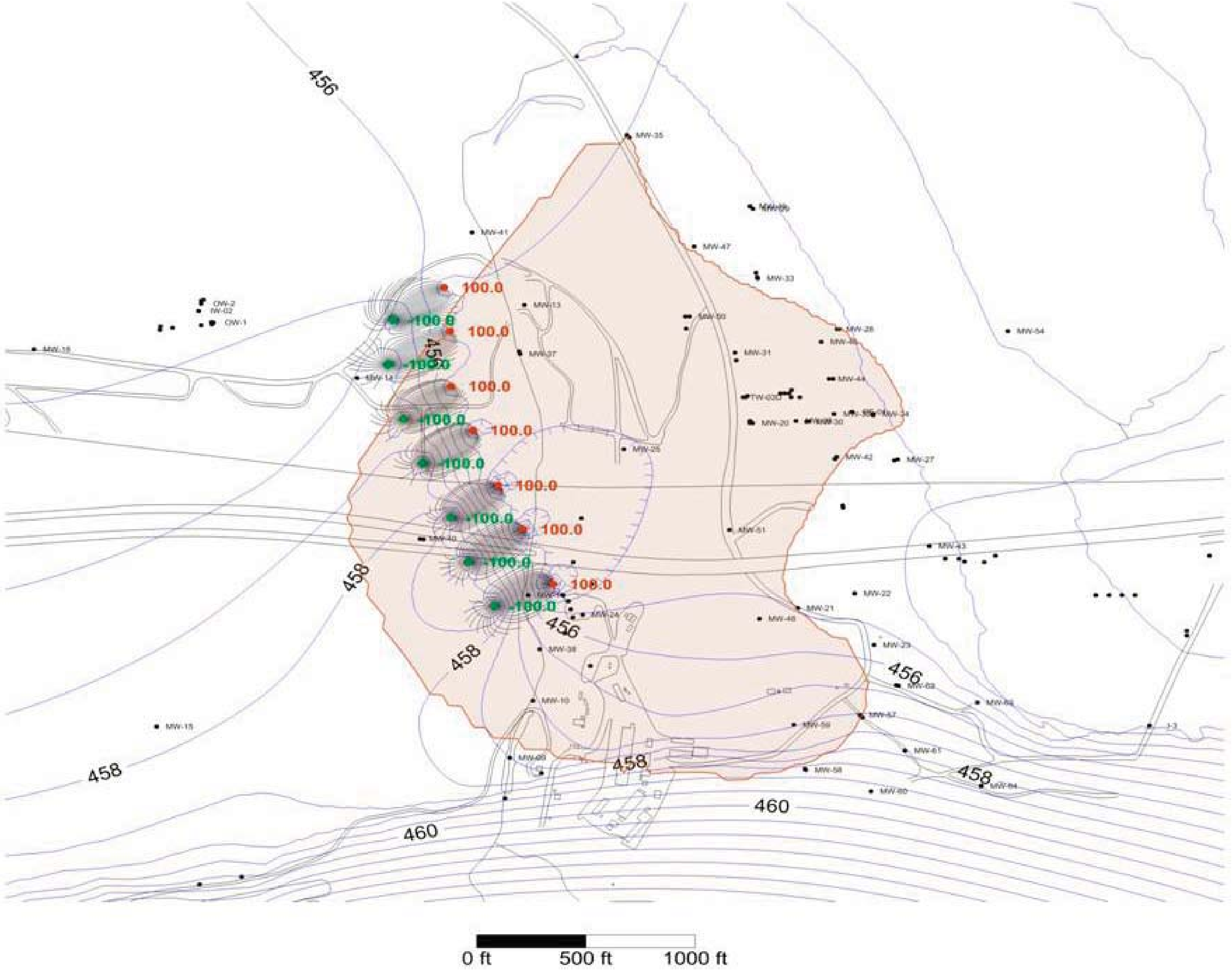
Green = Injection Well Rate (gpm)

gpm = gallons per minute

FIGURE F3-23
ALTERNATIVE D PHASE 5: 190 DAY FLOWLINE STARTING IN MODEL LAYER 3

FINAL GROUNDWATER CORRECTIVE MEASURES STUDY/
FEASIBILITY STUDY REPORT FOR SWMU 1/AOC 1 and AOC 10
PG&E TOPOCK COMPRESSOR STATION
NEEDLES, CALIFORNIA

CH2MHILL



▨ = Plume capture target area for
this model layer

Red = Extraction Well Rate (gpm)

Green = Injection Well Rate (gpm)

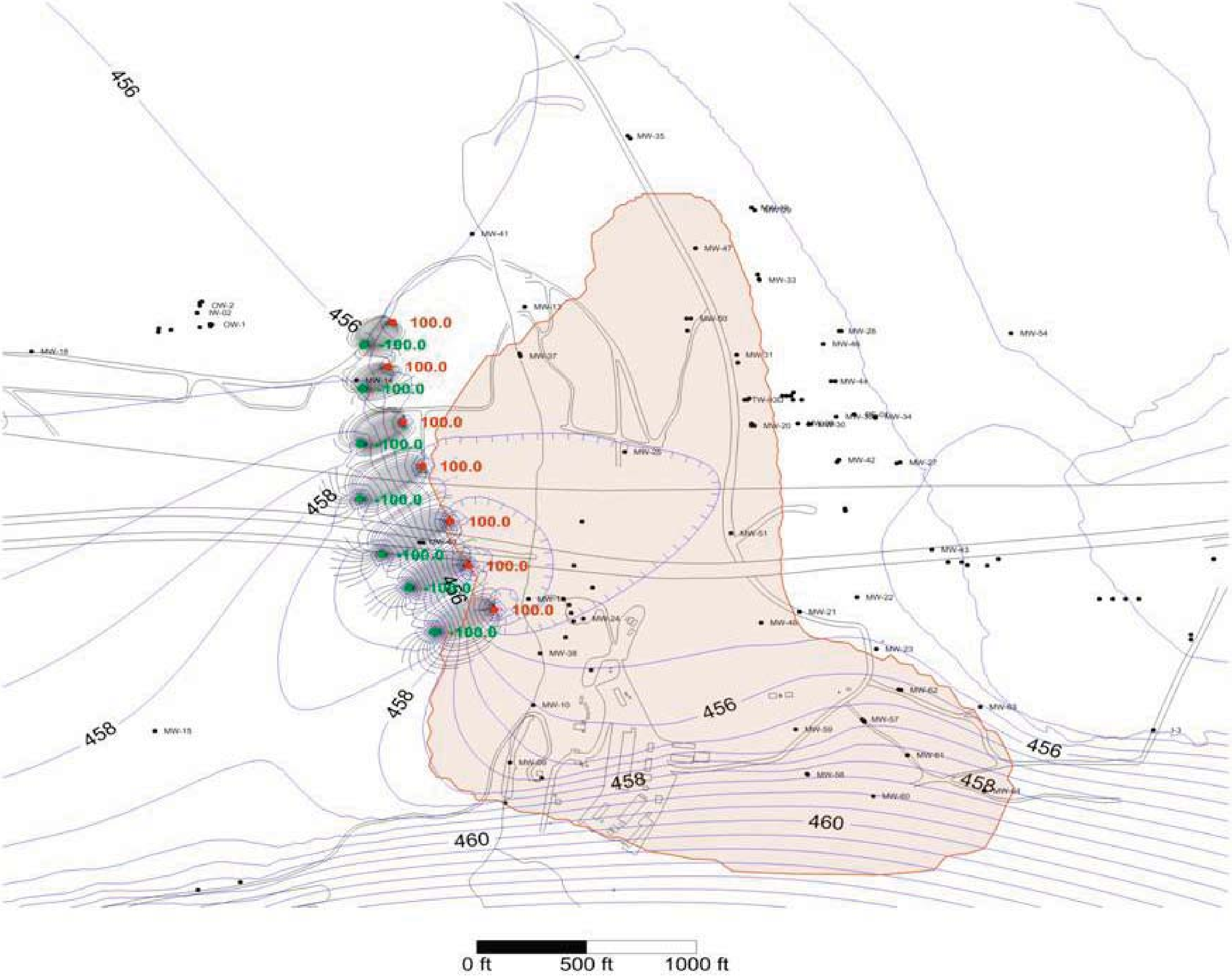
gpm = gallons per minute

N

FIGURE F3-24
ALTERNATIVE D PHASE 5: 190 DAY FLOWLINE STARTING IN MODEL LAYER 4

FINAL GROUNDWATER CORRECTIVE MEASURES STUDY/
FEASIBILITY STUDY REPORT FOR SWMU 1/AOC 1 and AOC 10
PG&E TOPOCK COMPRESSOR STATION
NEEDLES, CALIFORNIA

CH2MHILL



▨ = Plume capture target area for this model layer

Red = Extraction Well Rate (gpm)

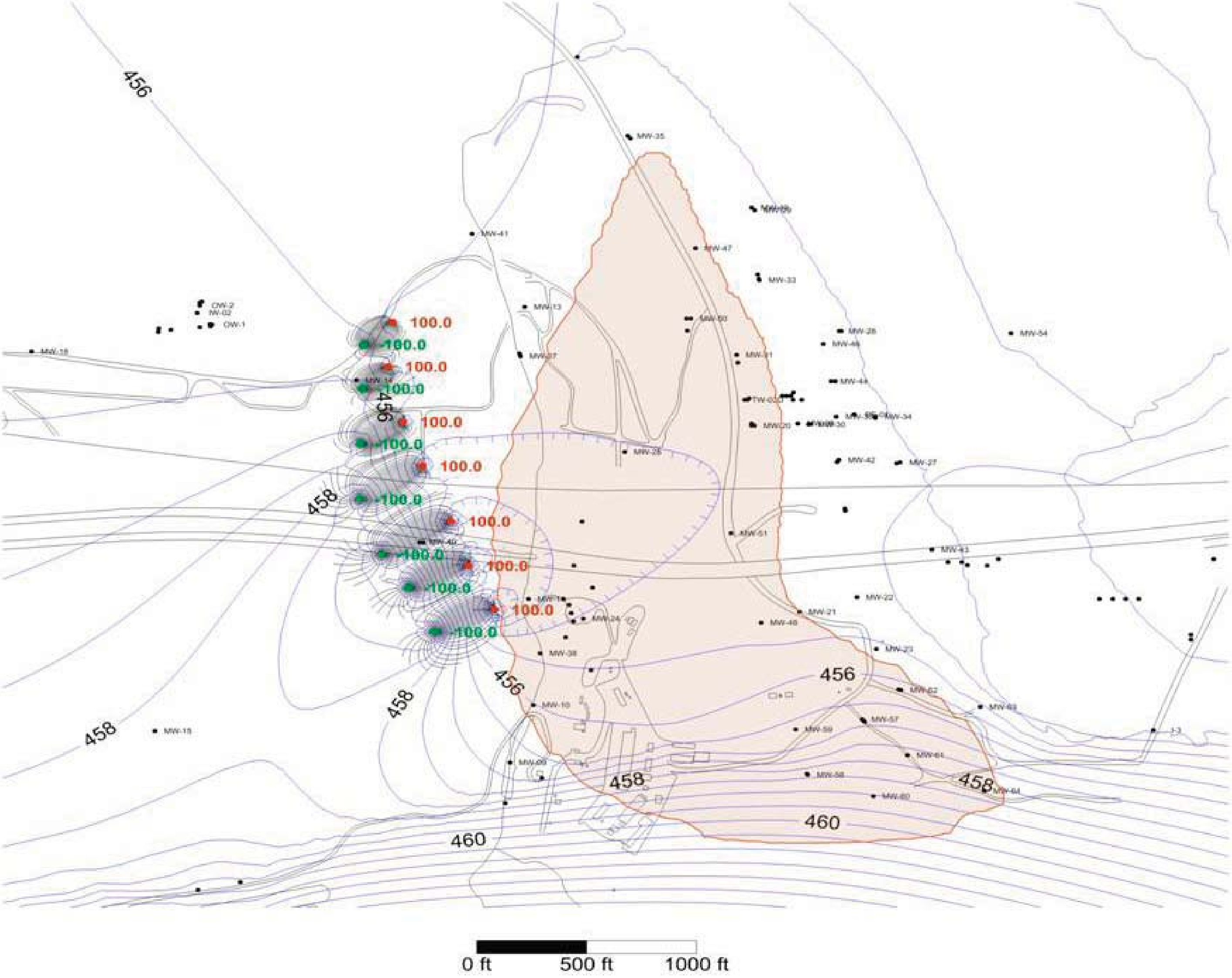
Green = Injection Well Rate (gpm)

gpm = gallons per minute

FIGURE F3-25
ALTERNATIVE D PHASE 6:
190 DAY FLOWLINE STARTING IN
MODEL LAYER 1

FINAL GROUNDWATER CORRECTIVE MEASURES STUDY/
FEASIBILITY STUDY REPORT FOR SWMU 1/AOC 1 and AOC 10
PG&E TOPOCK COMPRESSOR STATION
NEEDLES, CALIFORNIA

CH2MHILL



▨ = Plume capture target area for this model layer

Red = Extraction Well Rate (gpm)

Green = Injection Well Rate (gpm)

gpm = gallons per minute

N

FIGURE F3-26
ALTERNATIVE D PHASE 6: 190 DAY FLOWLINE STARTING IN MODEL LAYER 2

FINAL GROUNDWATER CORRECTIVE MEASURES STUDY/
FEASIBILITY STUDY REPORT FOR SWMU 1/AOC 1 and AOC 10
PG&E TOPOCK COMPRESSOR STATION
NEEDLES, CALIFORNIA

CH2MHILL

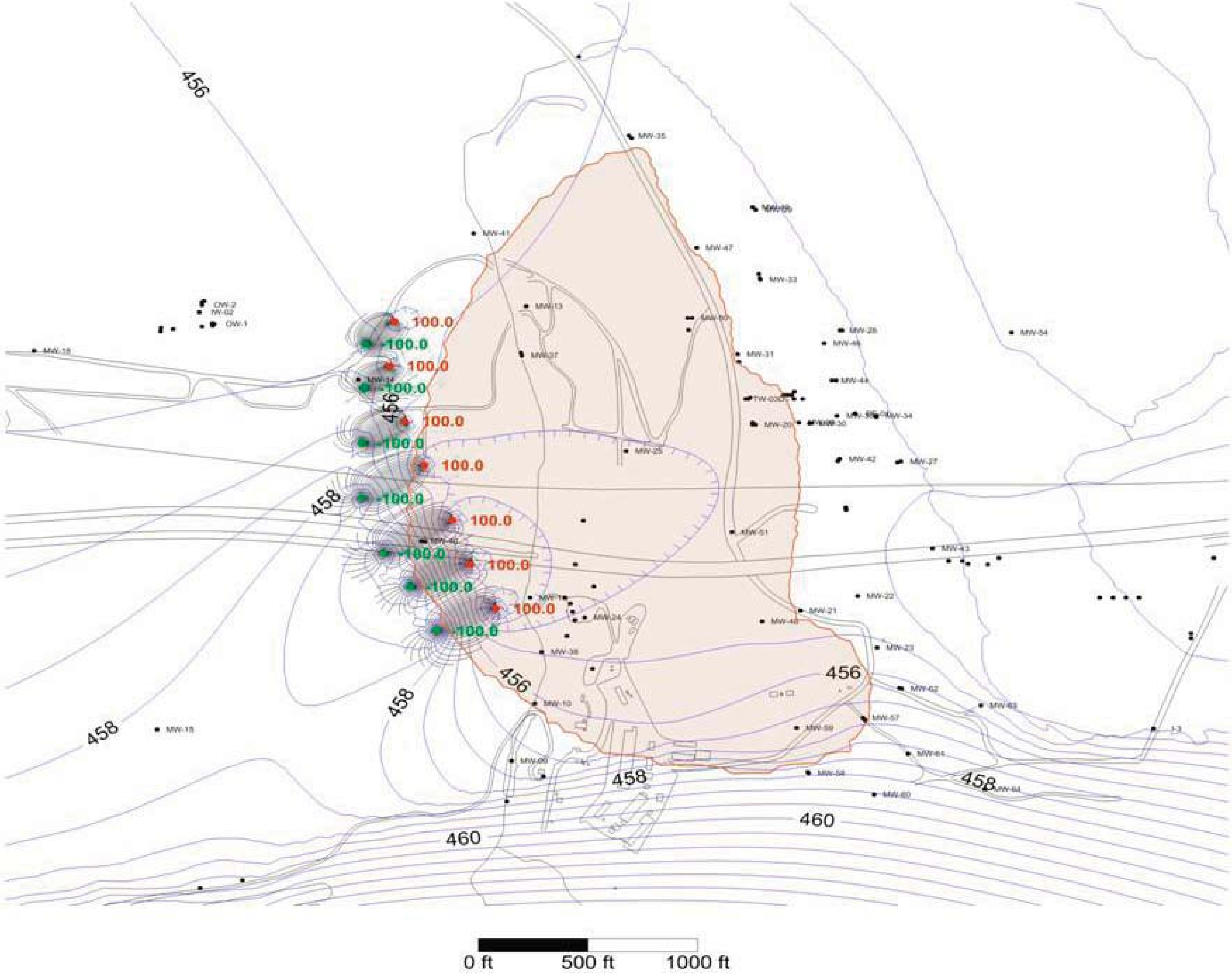


FIGURE F3-27
ALTERNATIVE D PHASE 6: 190 DAY FLOWLINE STARTING IN MODEL LAYER 3

FINAL GROUNDWATER CORRECTIVE MEASURES STUDY/
FEASIBILITY STUDY REPORT FOR SWMU 1/AOC 1 and AOC 10
PG&E TOPOCK COMPRESSOR STATION
NEEDLES, CALIFORNIA

▨ = Plume capture target area for this model layer

Red = Extraction Well Rate (gpm)

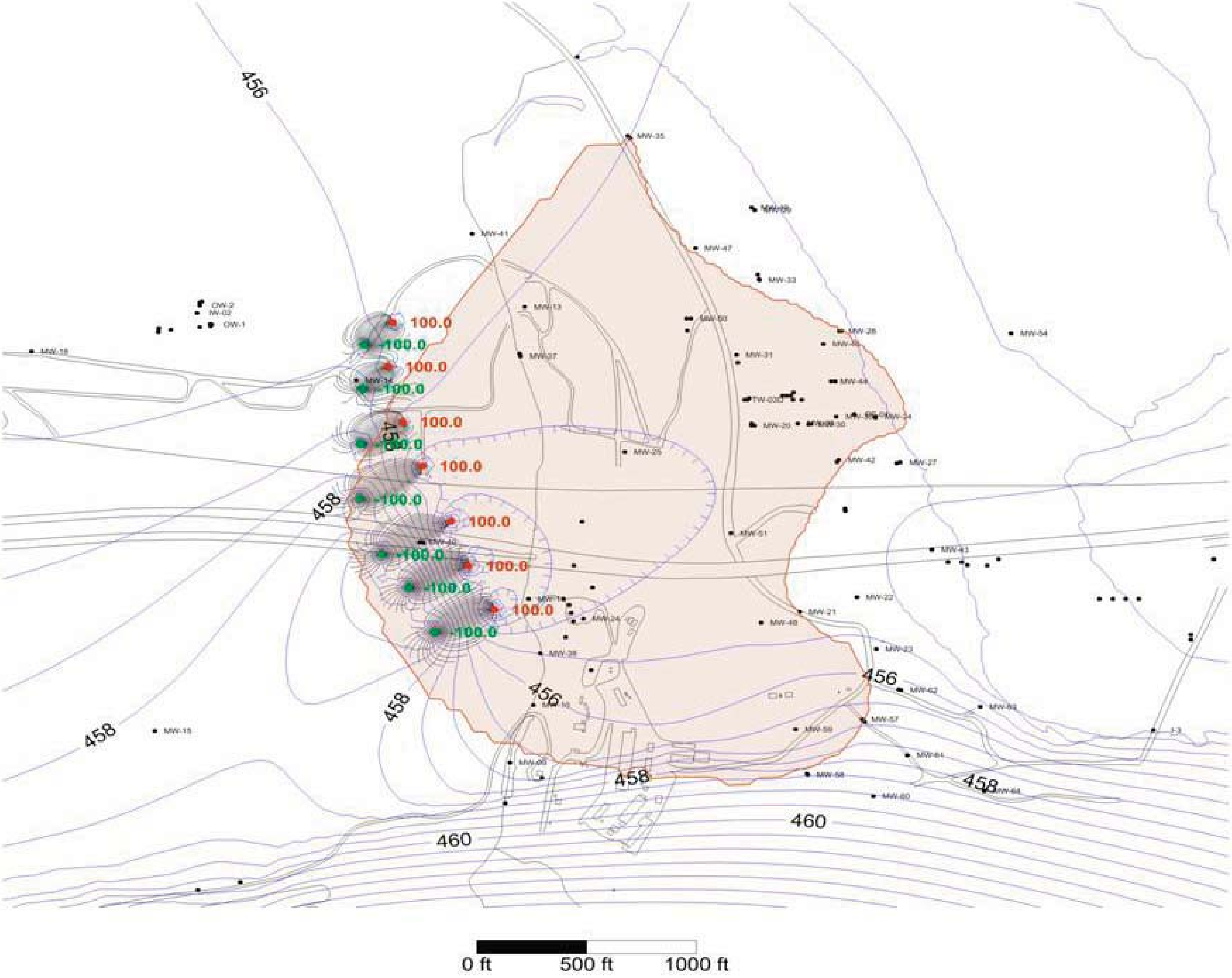
Green = Injection Well Rate (gpm)

gpm = gallons per minute

N

CH2MHILL

ES092008007BAO_FigF3_Alternatives_ModelLayers_v2.indd_121109_lho



▭ = Plume capture target area for this model layer

Red = Extraction Well Rate (gpm)

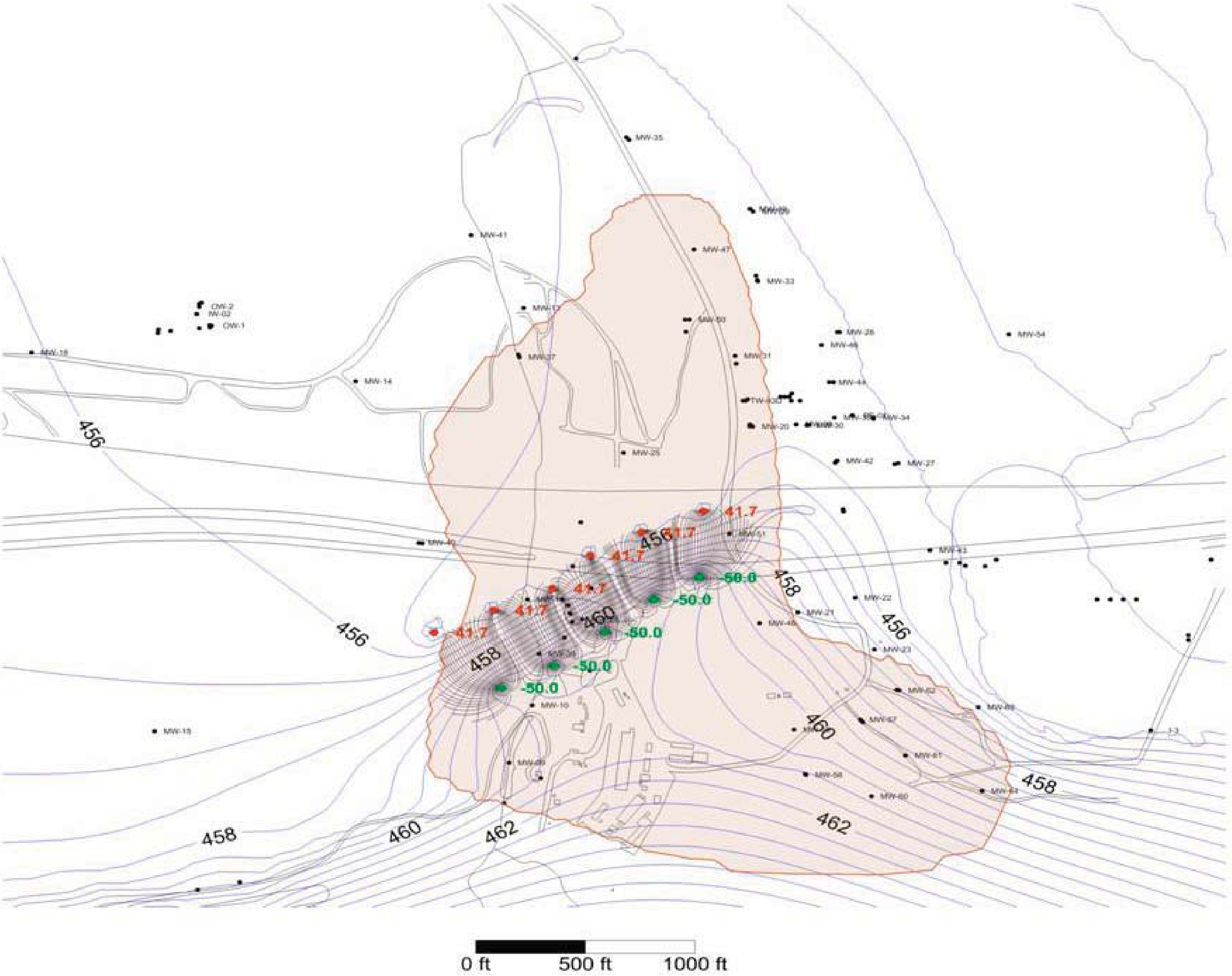
Green = Injection Well Rate (gpm)

gpm = gallons per minute

FIGURE F3-28
ALTERNATIVE D PHASE 6:
190 DAY FLOWLINE STARTING IN MODEL LAYER 4

FINAL GROUNDWATER CORRECTIVE MEASURES STUDY/
FEASIBILITY STUDY REPORT FOR SWMU 1/AOC 1 and AOC 10
PG&E TOPOCK COMPRESSOR STATION
NEEDLES, CALIFORNIA

CH2MHILL



▨ = Plume capture target area for this model layer

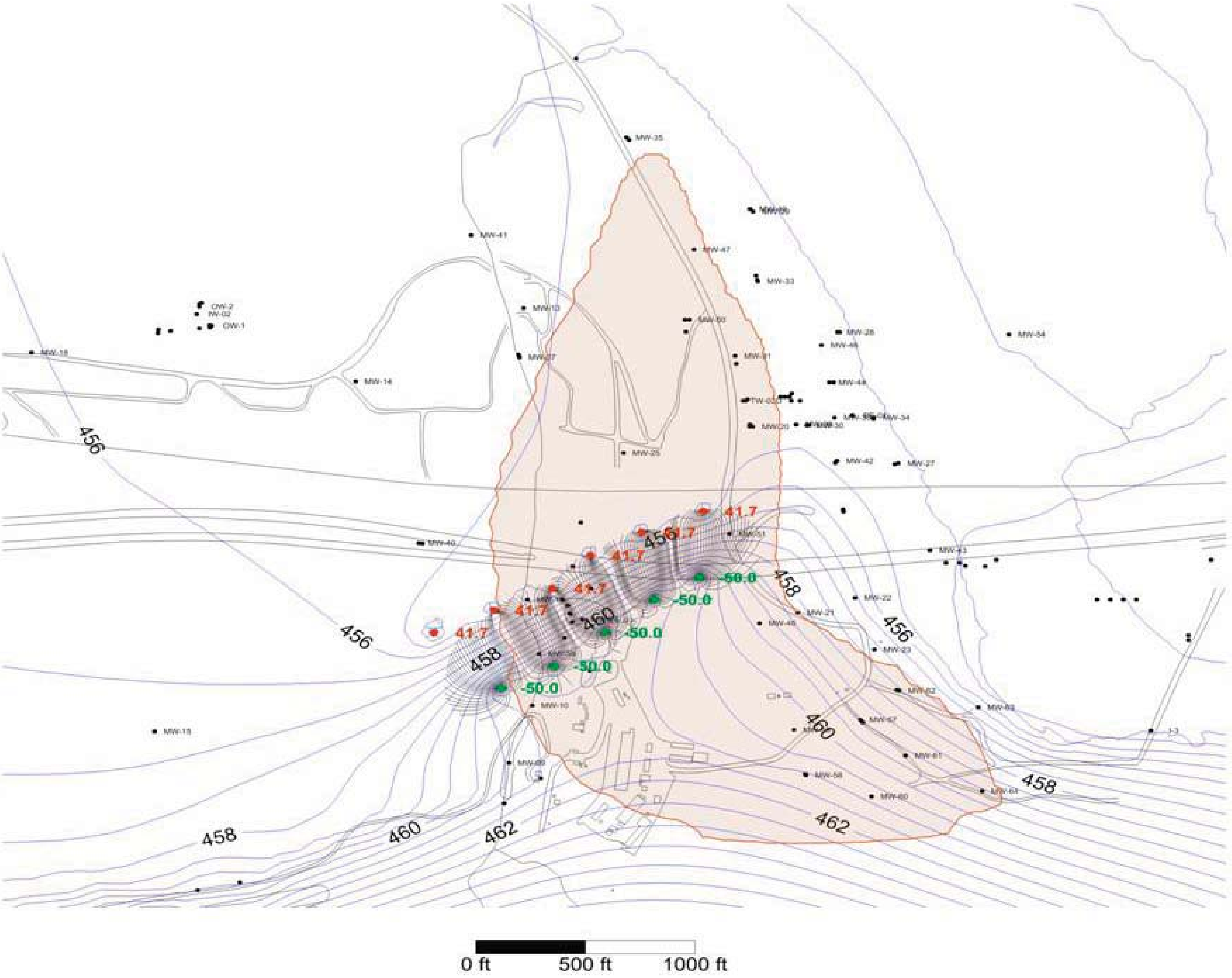
Red = Extraction Well Rate (gpm)

Green = Injection Well Rate (gpm)

gpm = gallons per minute

FIGURE F3-29
ALTERNATIVE D PHASE 7: 190 DAY FLOWLINE STARTING IN MODEL LAYER 1

FINAL GROUNDWATER CORRECTIVE MEASURES STUDY/
FEASIBILITY STUDY REPORT FOR SWMU 1/AOC 1 and AOC 10
PG&E TOPOCK COMPRESSOR STATION
NEEDLES, CALIFORNIA



▨ = Plume capture target area for this model layer

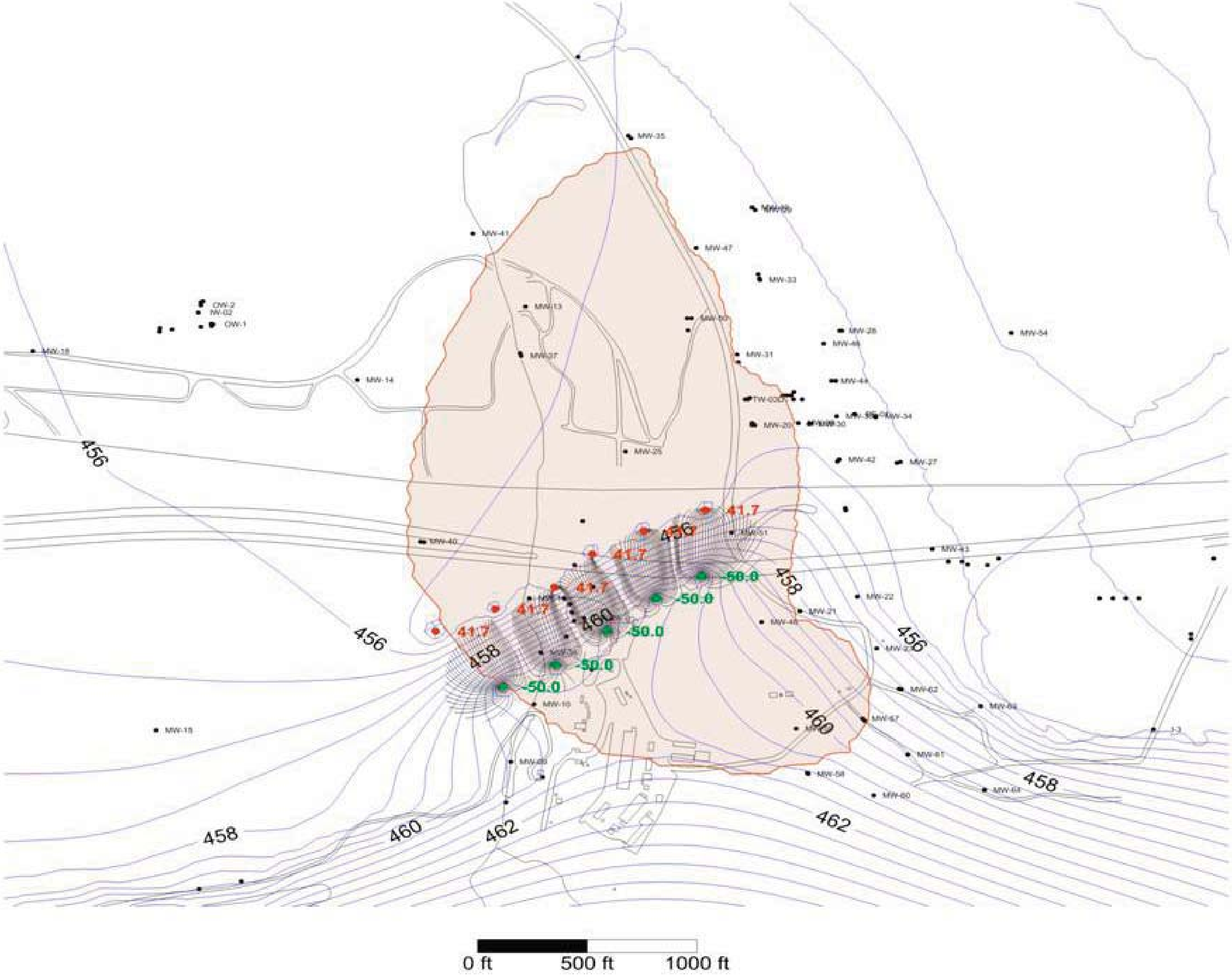
Red = Extraction Well Rate (gpm)

Green = Injection Well Rate (gpm)

gpm = gallons per minute

FIGURE F3-30
ALTERNATIVE D PHASE 7: 190 DAY FLOWLINE STARTING IN MODEL LAYER 2

FINAL GROUNDWATER CORRECTIVE MEASURES STUDY/
FEASIBILITY STUDY REPORT FOR SWMU 1/AOC 1 and AOC 10
PG&E TOPOCK COMPRESSOR STATION
NEEDLES, CALIFORNIA



▭ = Plume capture target area for this model layer

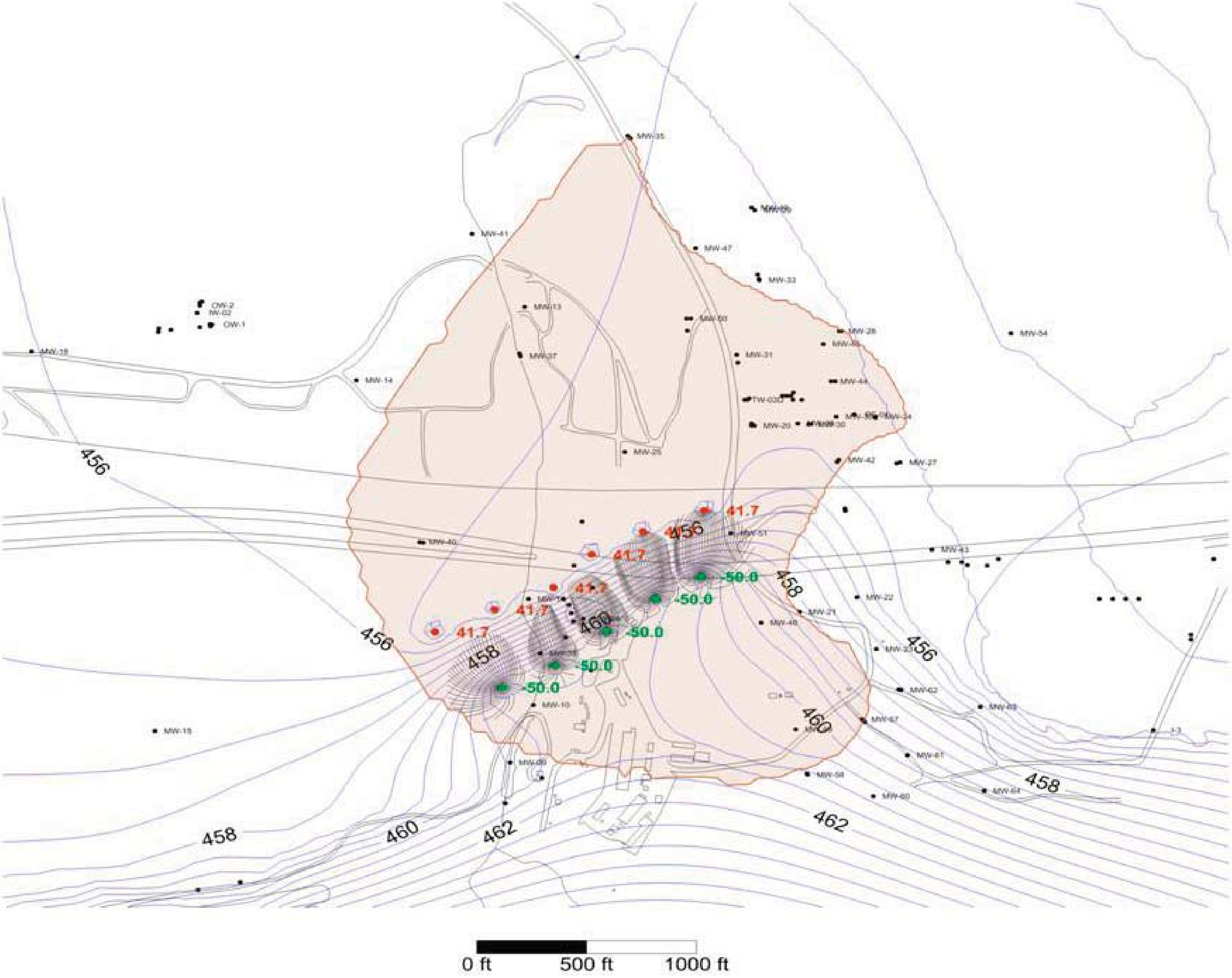
Red = Extraction Well Rate (gpm)

Green = Injection Well Rate (gpm)

gpm = gallons per minute

FIGURE F3-31
ALTERNATIVE D PHASE 7: 190 DAY FLOWLINE STARTING IN MODEL LAYER 3

FINAL GROUNDWATER CORRECTIVE MEASURES STUDY/
FEASIBILITY STUDY REPORT FOR SWMU 1/AOC 1 and AOC 10
PG&E TOPOCK COMPRESSOR STATION
NEEDLES, CALIFORNIA



▭ = Plume capture target area for this model layer

Red = Extraction Well Rate (gpm)

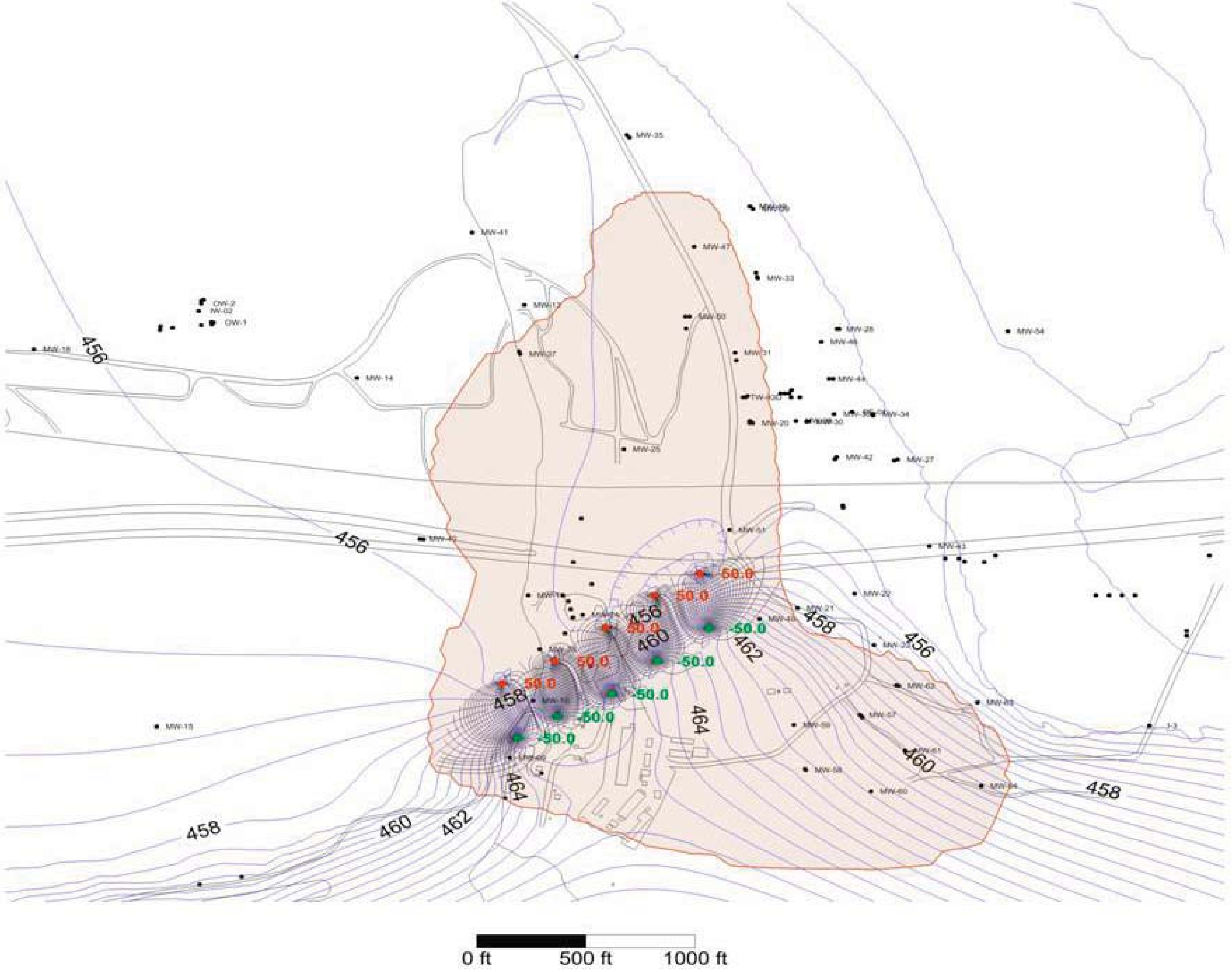
Green = Injection Well Rate (gpm)

gpm = gallons per minute

N

FIGURE F3-32
ALTERNATIVE D PHASE 7:
190 DAY FLOWLINE STARTING IN MODEL LAYER 4

FINAL GROUNDWATER CORRECTIVE MEASURES STUDY/
FEASIBILITY STUDY REPORT FOR SWMU 1/AOC 1 and AOC 10
PG&E TOPOCK COMPRESSOR STATION
NEEDLES, CALIFORNIA



▨ = Plume capture target area for this model layer

Red = Extraction Well Rate (gpm)

Green = Injection Well Rate (gpm)

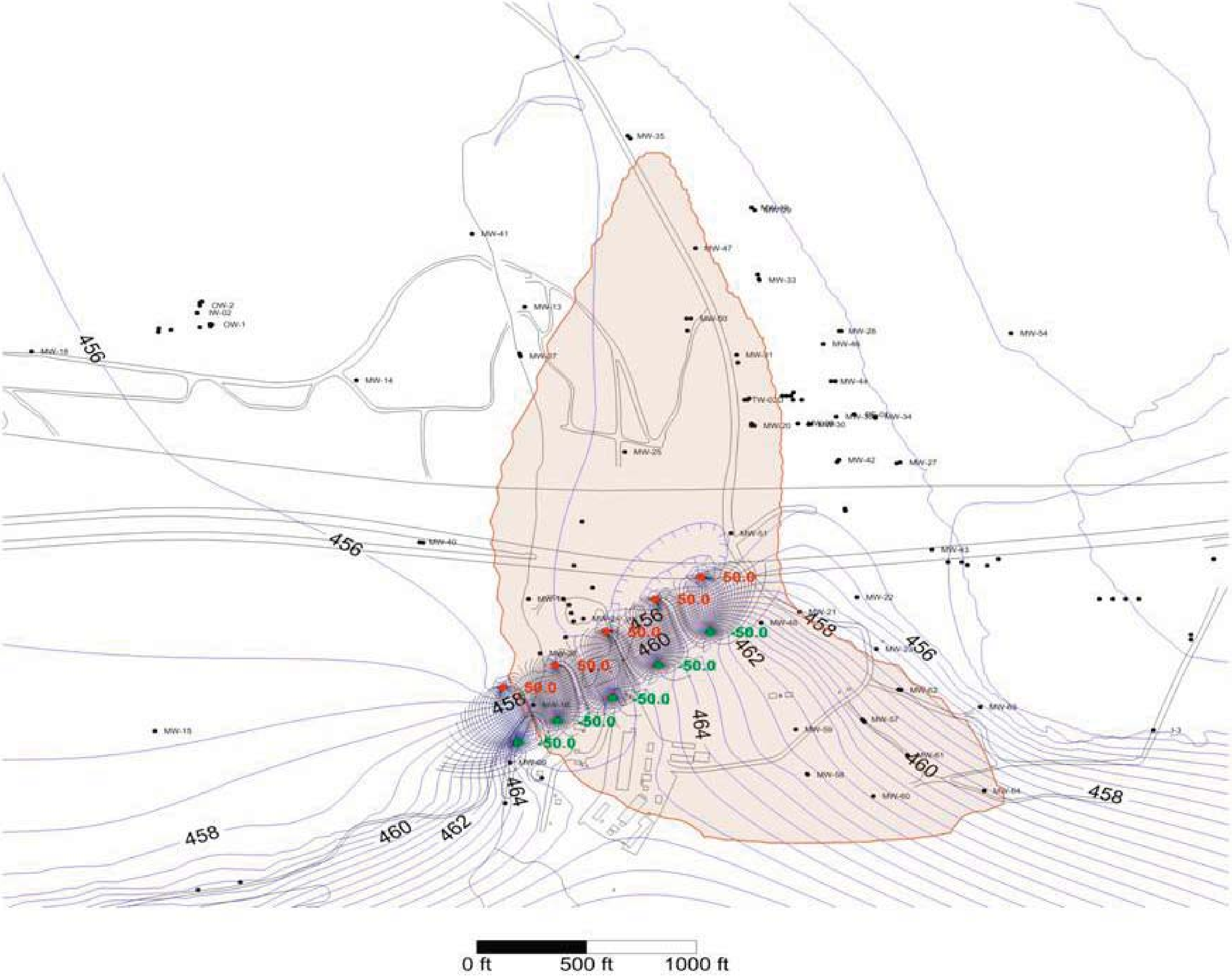
gpm = gallons per minute

N

FIGURE F3-33
ALTERNATIVE D PHASE 8: 190 DAY FLOWLINE STARTING IN MODEL LAYER 1

FINAL GROUNDWATER CORRECTIVE MEASURES STUDY/
FEASIBILITY STUDY REPORT FOR SWMU 1/AOC 1 and AOC 10
PG&E TOPOCK COMPRESSOR STATION
NEEDLES, CALIFORNIA

CH2MHILL



▭ = Plume capture target area for this model layer

Red = Extraction Well Rate (gpm)

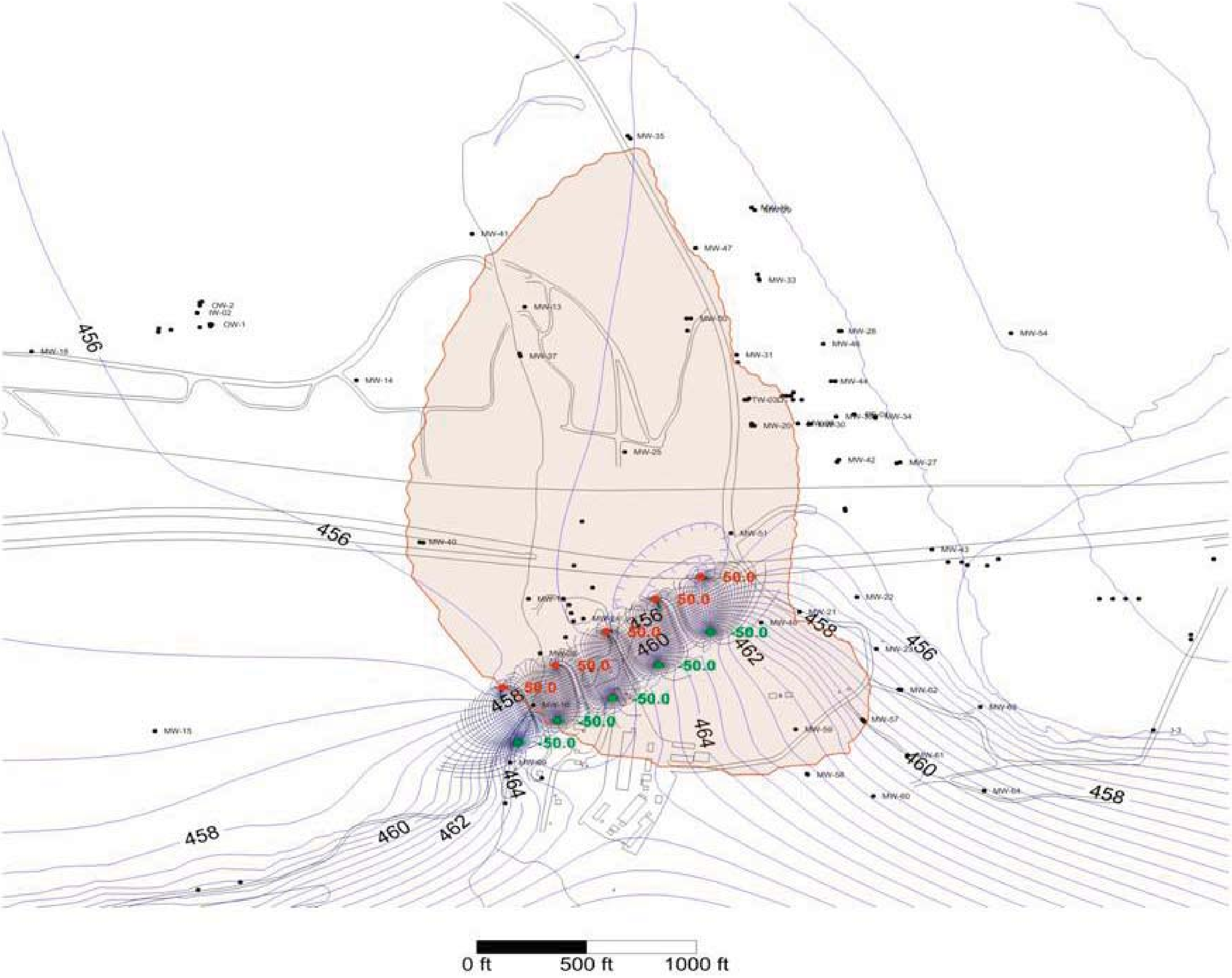
Green = Injection Well Rate (gpm)

gpm = gallons per minute

FIGURE F3-34
ALTERNATIVE D PHASE 8: 190 DAY FLOWLINE STARTING IN MODEL LAYER 2

FINAL GROUNDWATER CORRECTIVE MEASURES STUDY/
FEASIBILITY STUDY REPORT FOR SWMU 1/AOC 1 and AOC 10
PG&E TOPOCK COMPRESSOR STATION
NEEDLES, CALIFORNIA

CH2MHILL



▨ = Plume capture target area for this model layer

Red = Extraction Well Rate (gpm)

Green = Injection Well Rate (gpm)

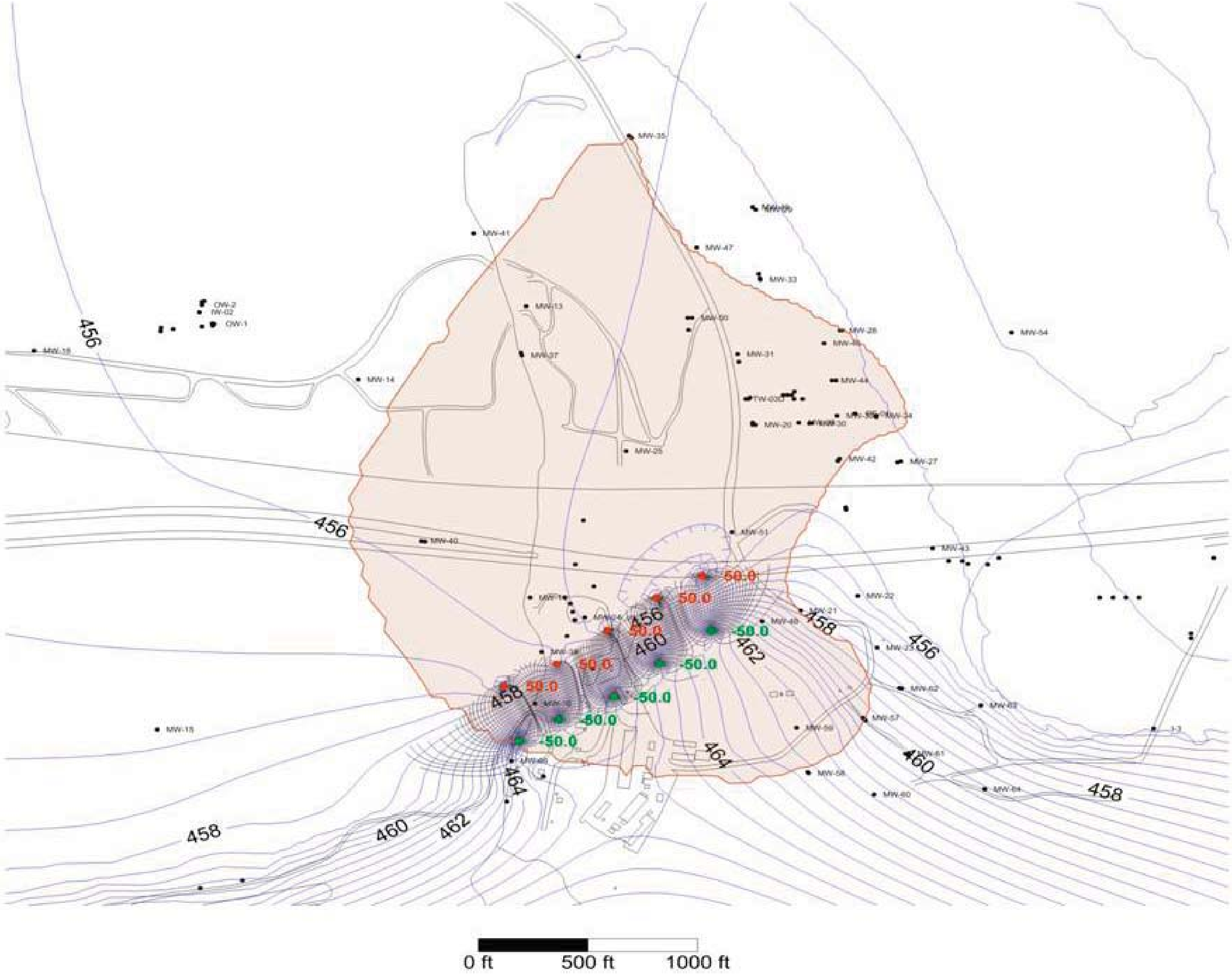
gpm = gallons per minute

N

FIGURE F3-35
ALTERNATIVE D PHASE 8: 190 DAY FLOWLINE STARTING IN MODEL LAYER 3

FINAL GROUNDWATER CORRECTIVE MEASURES STUDY/
FEASIBILITY STUDY REPORT FOR SWMU 1/AOC 1 and AOC 10
PG&E TOPOCK COMPRESSOR STATION
NEEDLES, CALIFORNIA

CH2MHILL



▨ = Plume capture target area for this model layer

Red = Extraction Well Rate (gpm)

Green = Injection Well Rate (gpm)

gpm = gallons per minute

FIGURE F3-36
ALTERNATIVE D PHASE 8: 190 DAY FLOWLINE STARTING IN MODEL LAYER 4

FINAL GROUNDWATER CORRECTIVE MEASURES STUDY/
FEASIBILITY STUDY REPORT FOR SWMU 1/AOC 1 and AOC 10
PG&E TOPOCK COMPRESSOR STATION
NEEDLES, CALIFORNIA

CH2MHILL

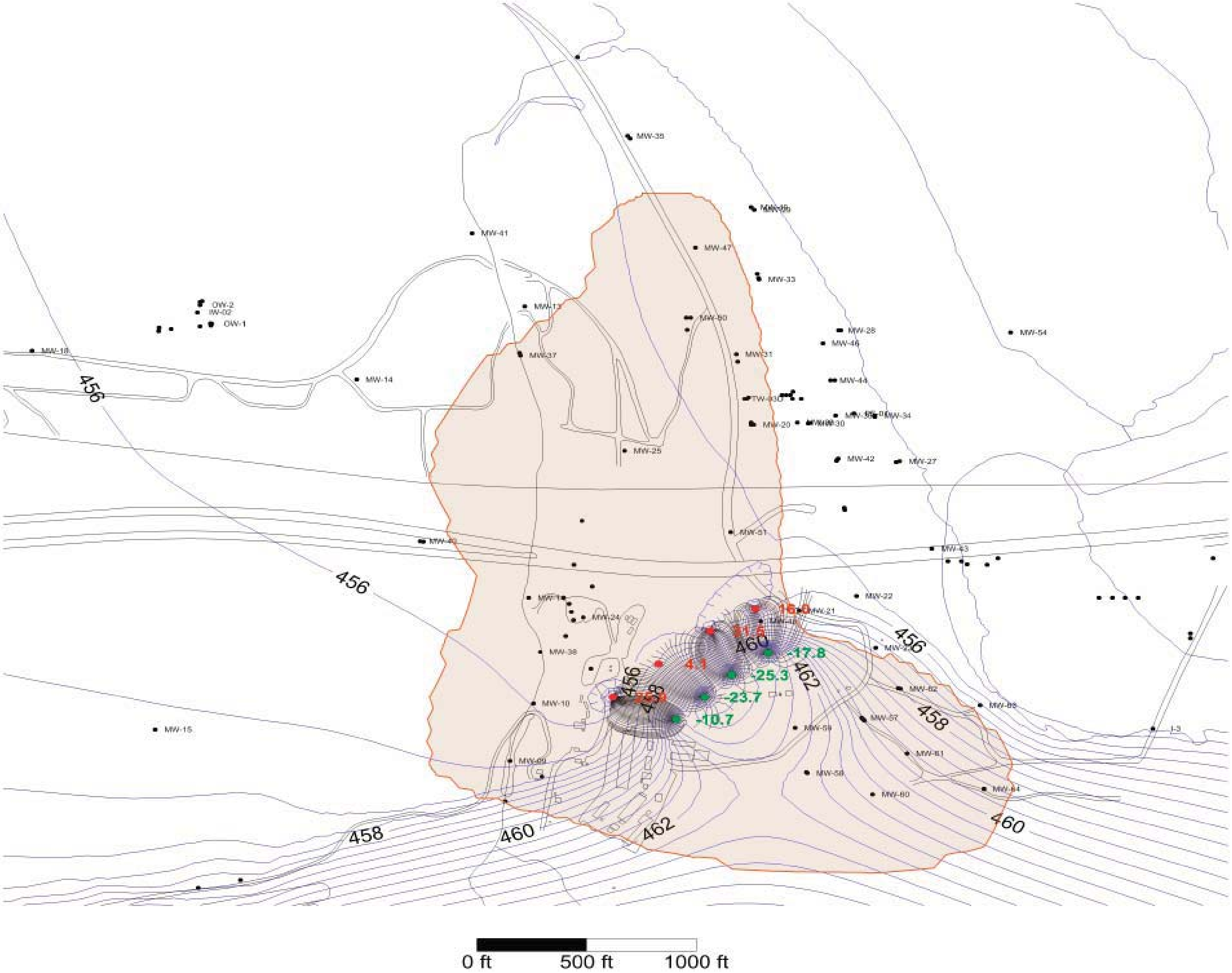


FIGURE F3-37
ALTERNATIVE D PHASE 9: 190 DAY FLOWLINE STARTING IN MODEL LAYER 1

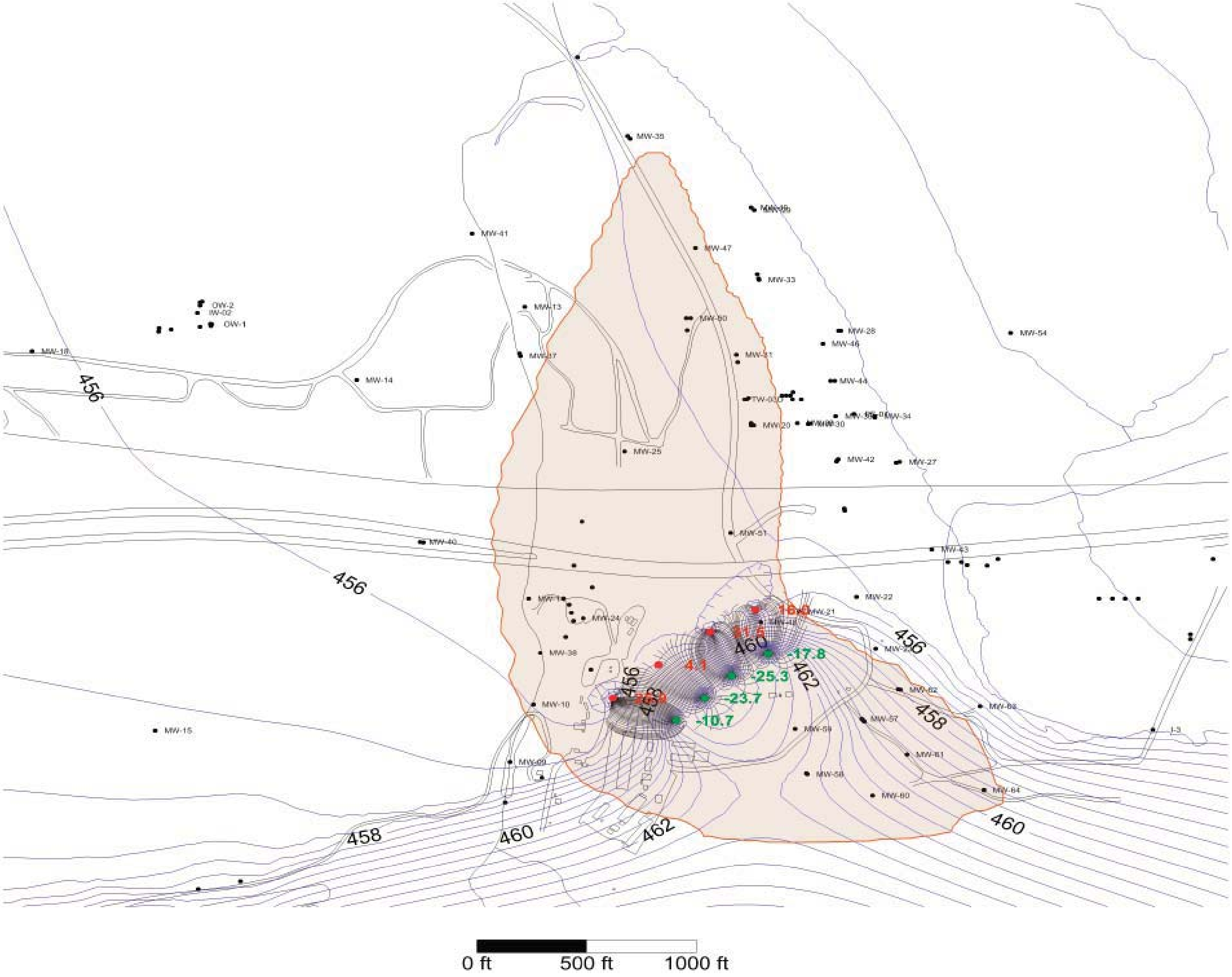
FINAL GROUNDWATER CORRECTIVE MEASURES STUDY/
FEASIBILITY STUDY REPORT FOR SWMU 1/AOC 1 and AOC 10
PG&E TOPOCK COMPRESSOR STATION
NEEDLES, CALIFORNIA

▨ = Plume capture target area for this model layer

Red = Extraction Well Rate (gpm)

Green = Injection Well Rate (gpm)

gpm = gallons per minute



▨ = Plume capture target area for
this model layer

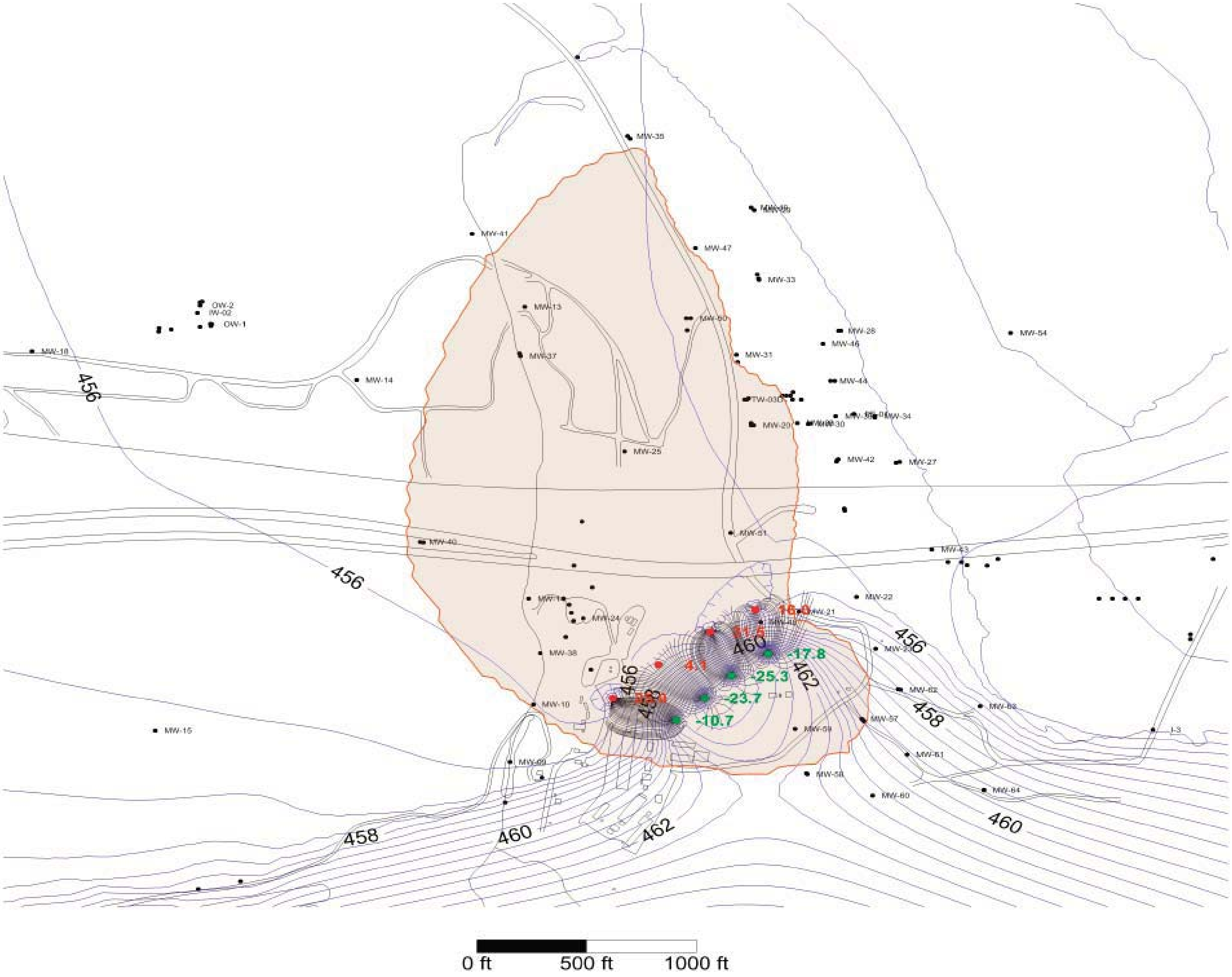
Red = Extraction Well Rate (gpm)

Green = Injection Well Rate (gpm)

gpm = gallons per minute

FIGURE F3-38
ALTERNATIVE D PHASE 9: 190 DAY FLOWLINE STARTING IN MODEL LAYER 2

FINAL GROUNDWATER CORRECTIVE MEASURES STUDY/
FEASIBILITY STUDY REPORT FOR SWMU 1/AOC 1 and AOC 10
PG&E TOPOCK COMPRESSOR STATION
NEEDLES, CALIFORNIA



▨ = Plume capture target area for this model layer

Red = Extraction Well Rate (gpm)

Green = Injection Well Rate (gpm)

gpm = gallons per minute

N

FIGURE F3-39
ALTERNATIVE D PHASE 9:
190 DAY FLOWLINE STARTING IN MODEL LAYER 3

FINAL GROUNDWATER CORRECTIVE MEASURES STUDY/
FEASIBILITY STUDY REPORT FOR SWMU 1/AOC 1 and AOC 10
PG&E TOPOCK COMPRESSOR STATION
NEEDLES, CALIFORNIA

CH2MHILL

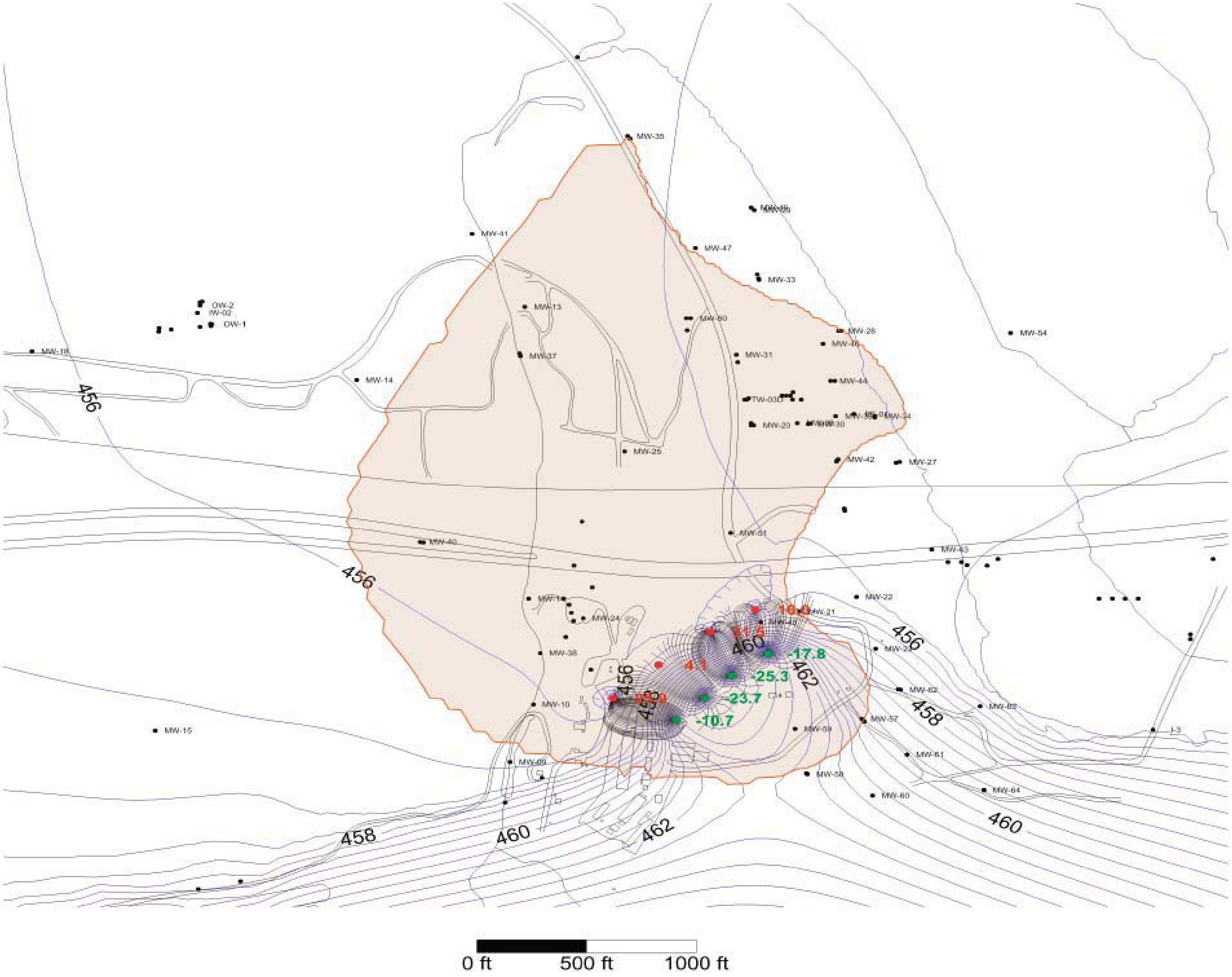


FIGURE F3-40
ALTERNATIVE D PHASE 9: 190 DAY FLOWLINE STARTING IN MODEL LAYER 4

FINAL GROUNDWATER CORRECTIVE MEASURES STUDY/
FEASIBILITY STUDY REPORT FOR SWMU 1/AOC 1 and AOC 10
PG&E TOPOCK COMPRESSOR STATION
NEEDLES, CALIFORNIA

▨ = Plume capture target area for this model layer

Red = Extraction Well Rate (gpm)

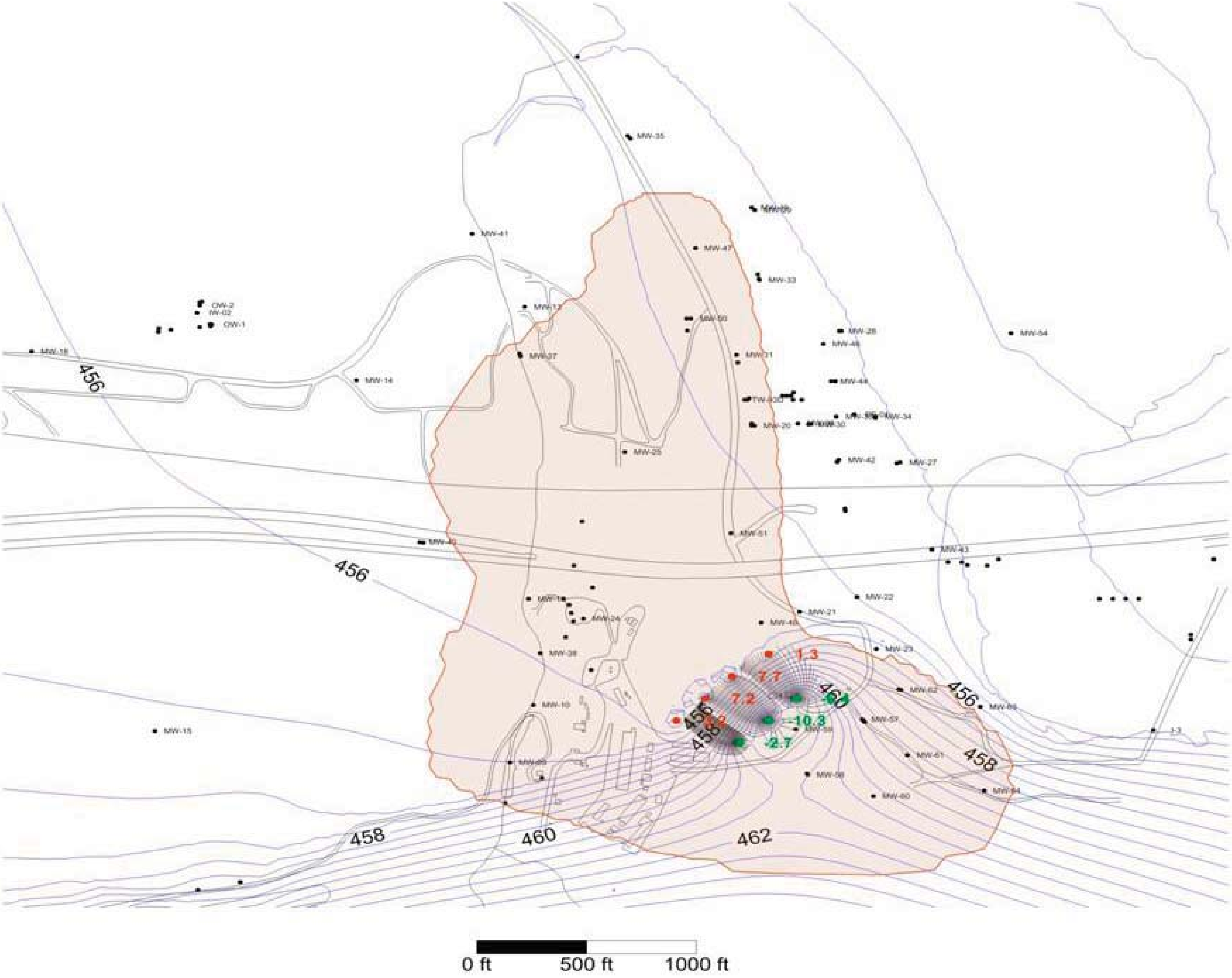
Green = Injection Well Rate (gpm)

gpm = gallons per minute

N

CH2MHILL

ES092008007BAO_FigF3_Alternatives_ModelLayers_v2.indd_121109_lho



▨ = Plume capture target area for this model layer

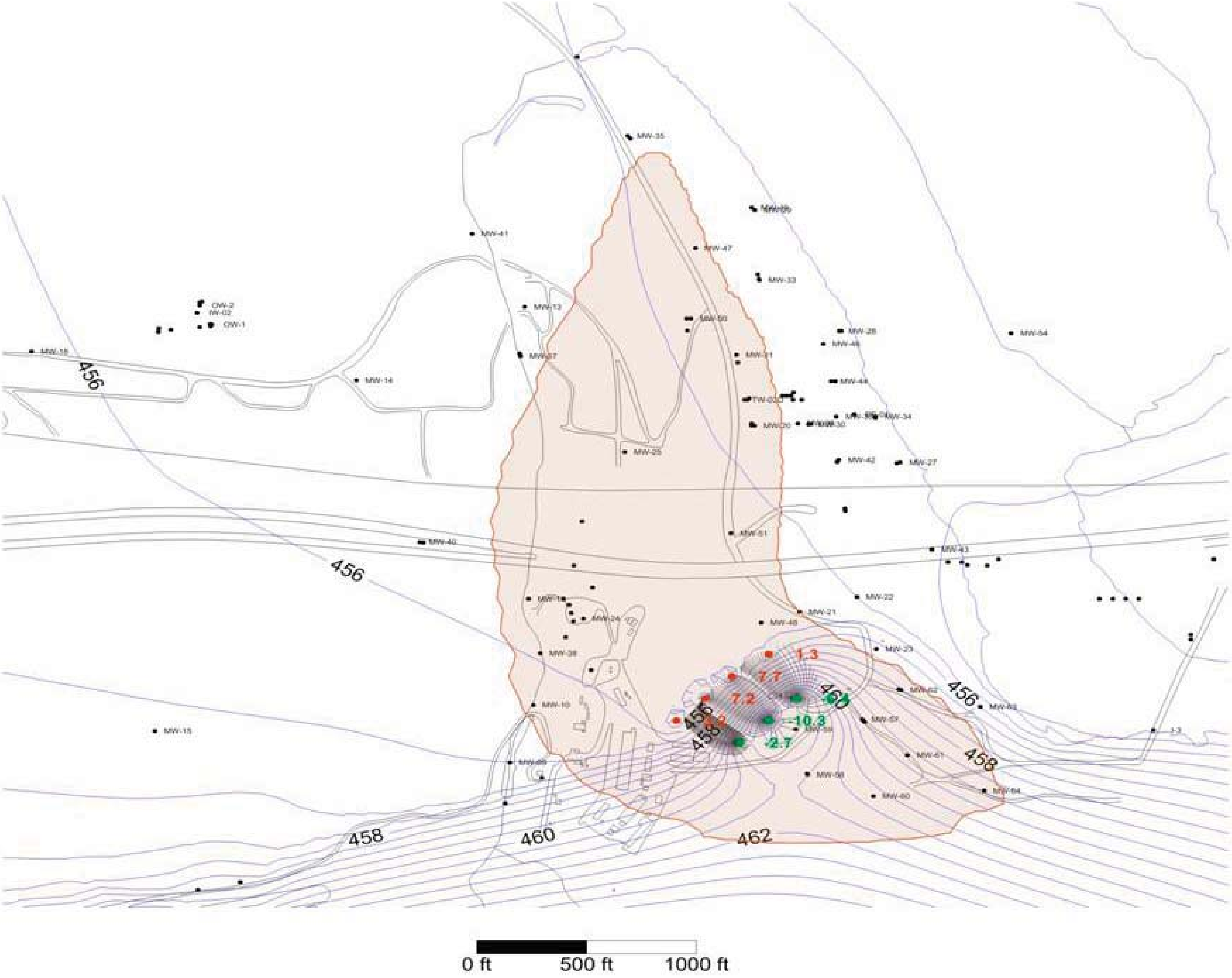
Red = Extraction Well Rate (gpm)

Green = Injection Well Rate (gpm)

gpm = gallons per minute

FIGURE F3-41
ALTERNATIVE D PHASE 10: 190 DAY FLOWLINE STARTING IN MODEL LAYER 1

FINAL GROUNDWATER CORRECTIVE MEASURES STUDY/
FEASIBILITY STUDY REPORT FOR SWMU 1/AOC 1 and AOC 10
PG&E TOPOCK COMPRESSOR STATION
NEEDLES, CALIFORNIA



▨ = Plume capture target area for this model layer

Red = Extraction Well Rate (gpm)

Green = Injection Well Rate (gpm)

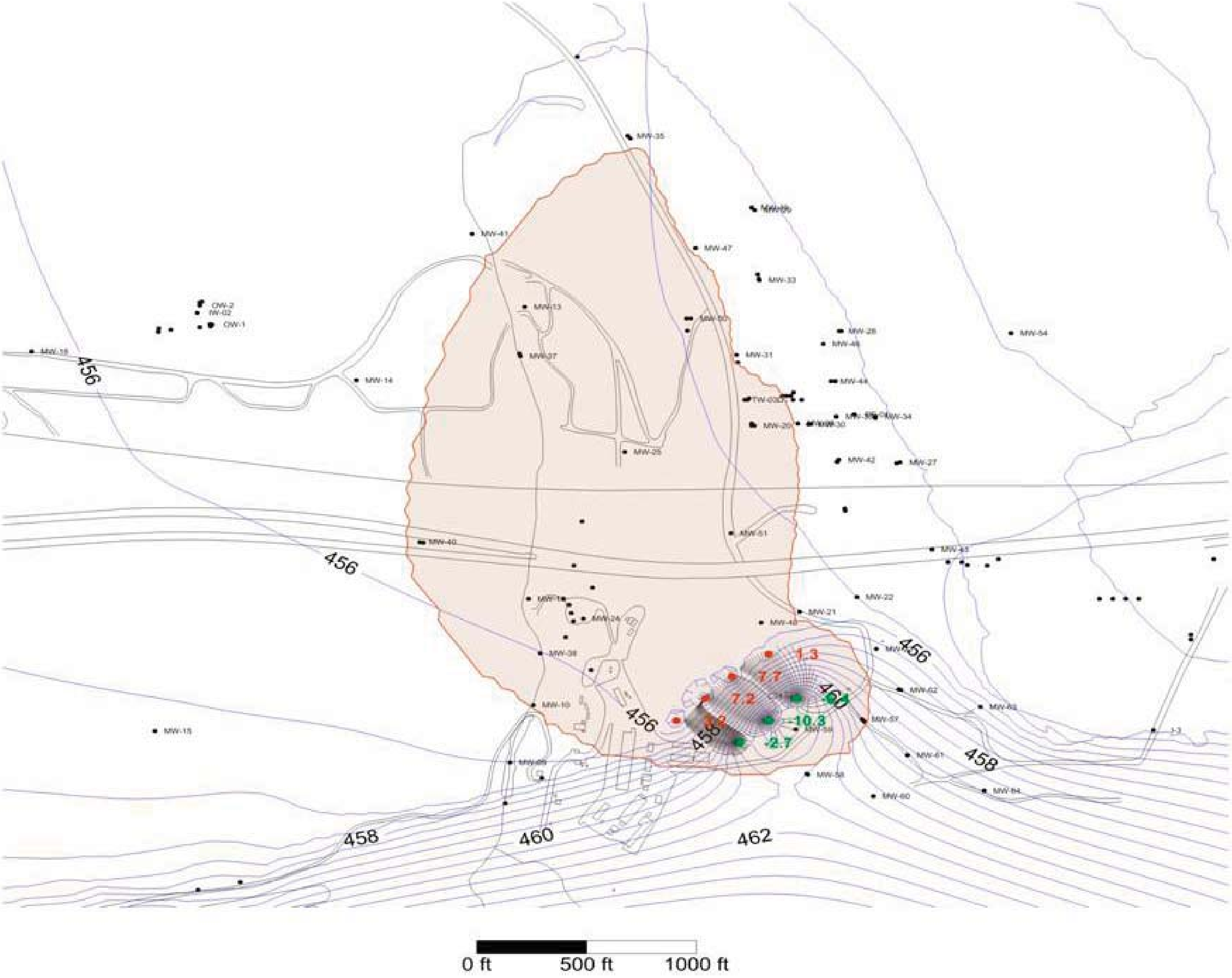
gpm = gallons per minute

N

FIGURE F3-42
ALTERNATIVE D PHASE 10: 190 DAY FLOWLINE STARTING IN MODEL LAYER 2

FINAL GROUNDWATER CORRECTIVE MEASURES STUDY/
FEASIBILITY STUDY REPORT FOR SWMU 1/AOC 1 and AOC 10
PG&E TOPOCK COMPRESSOR STATION
NEEDLES, CALIFORNIA

CH2MHILL



▨ = Plume capture target area for this model layer

Red = Extraction Well Rate (gpm)

Green = Injection Well Rate (gpm)

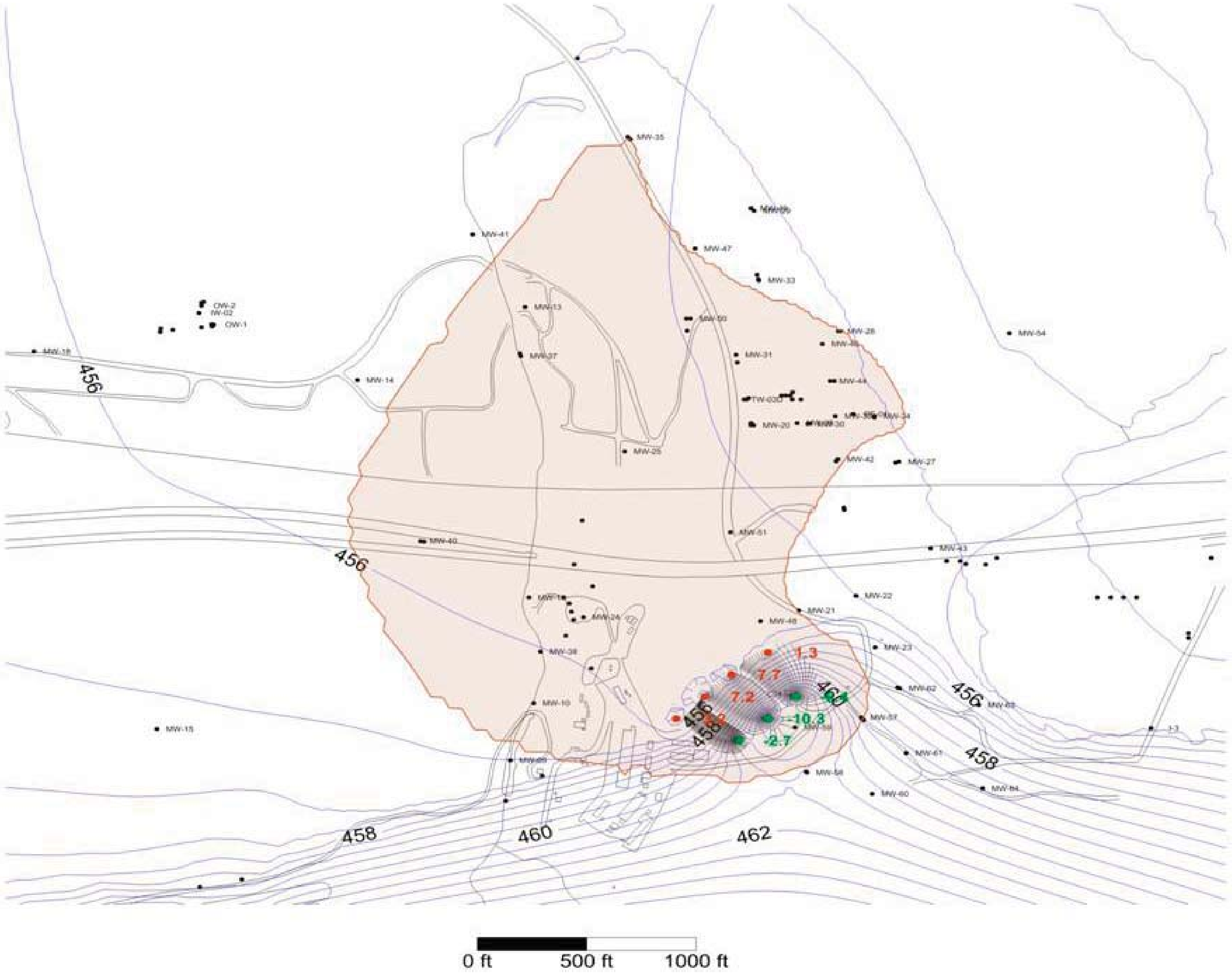
gpm = gallons per minute

N

FIGURE F3-43
ALTERNATIVE D PHASE 10: 190 DAY FLOWLINE STARTING IN MODEL LAYER 3

FINAL GROUNDWATER CORRECTIVE MEASURES STUDY/
FEASIBILITY STUDY REPORT FOR SWMU 1/AOC 1 and AOC 10
PG&E TOPOCK COMPRESSOR STATION
NEEDLES, CALIFORNIA

CH2MHILL



▨ = Plume capture target area for this model layer

Red = Extraction Well Rate (gpm)

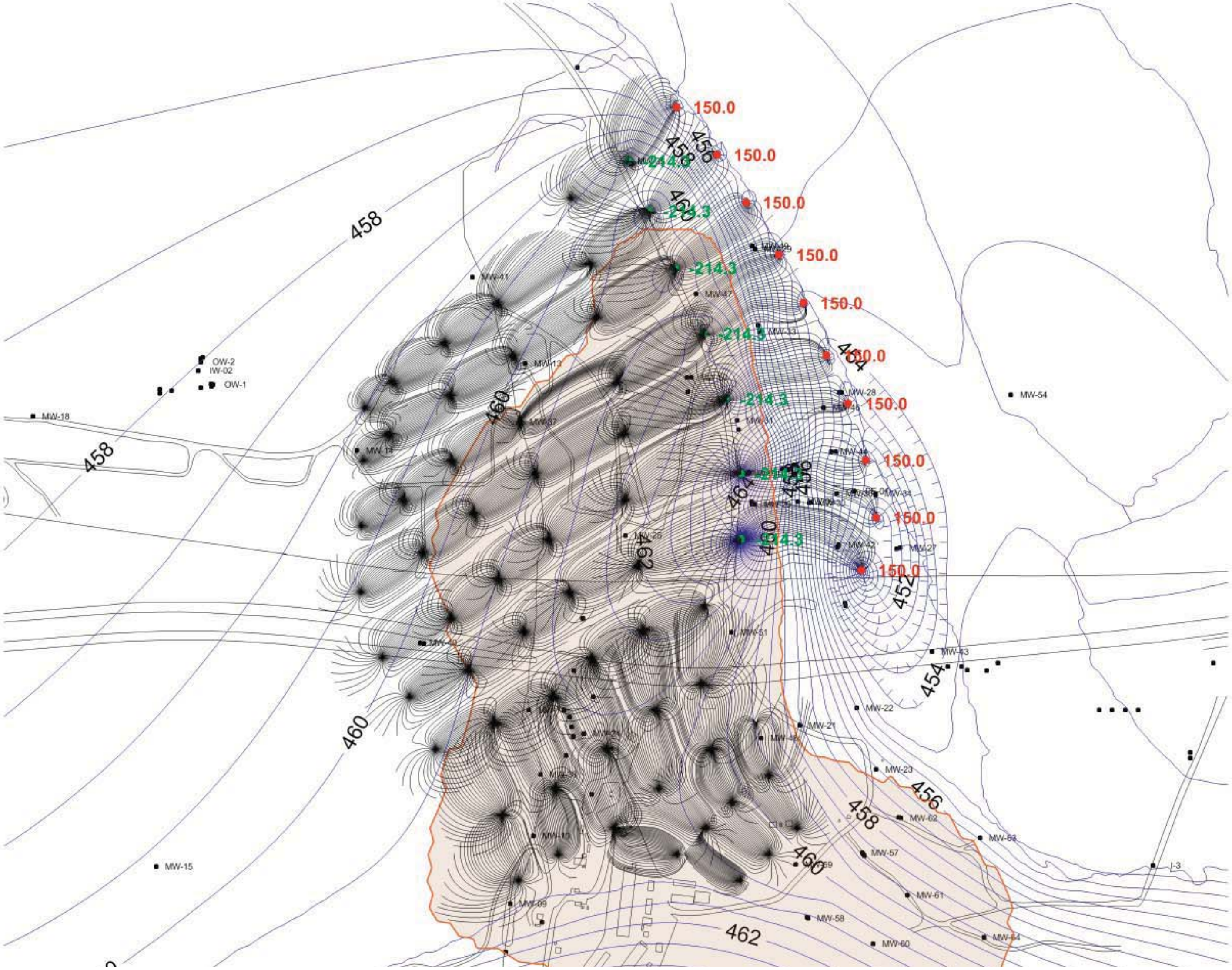
Green = Injection Well Rate (gpm)

gpm = gallons per minute

FIGURE F3-44
ALTERNATIVE D PHASE 10: 190 DAY FLOWLINE STARTING IN MODEL LAYER 4

FINAL GROUNDWATER CORRECTIVE MEASURES STUDY/
FEASIBILITY STUDY REPORT FOR SWMU 1/AOC 1 and AOC 10
PG&E TOPOCK COMPRESSOR STATION
NEEDLES, CALIFORNIA

CH2MHILL



▨ = Plume capture target area for this model layer

Red = Extraction Well Rate (gpm)

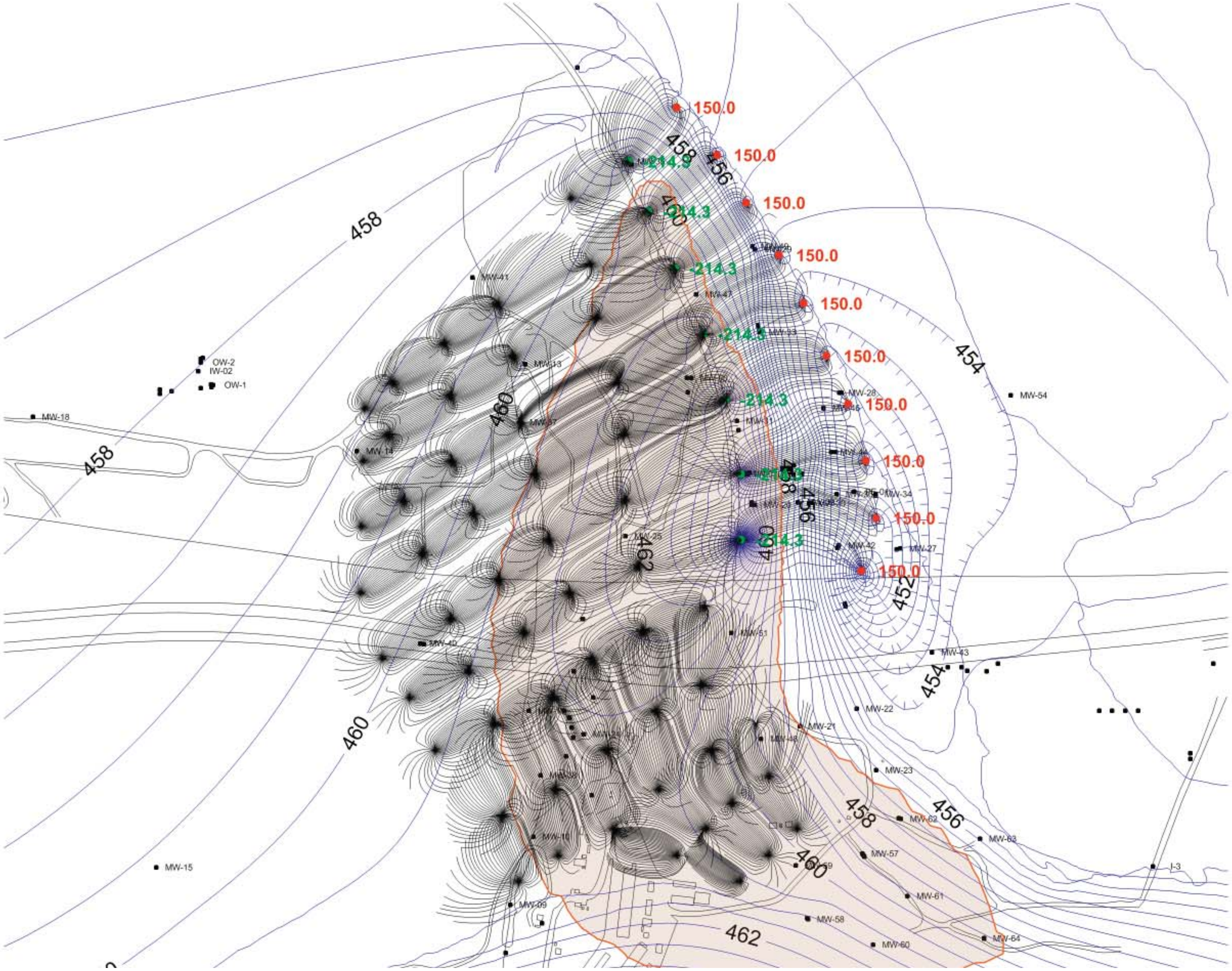
Green = Injection Well Rate (gpm)

gpm = gallons per minute

FIGURE F3-45
ALTERNATIVE D ALL PHASES: 190 DAY FLOWLINE STARTING IN MODEL LAYER 1

FINAL GROUNDWATER CORRECTIVE MEASURES STUDY/
FEASIBILITY STUDY REPORT FOR SWMU 1/AOC 1 and AOC 10
PG&E TOPOCK COMPRESSOR STATION
NEEDLES, CALIFORNIA

CH2MHILL



▨ = Plume capture target area for this model layer

Red = Extraction Well Rate (gpm)

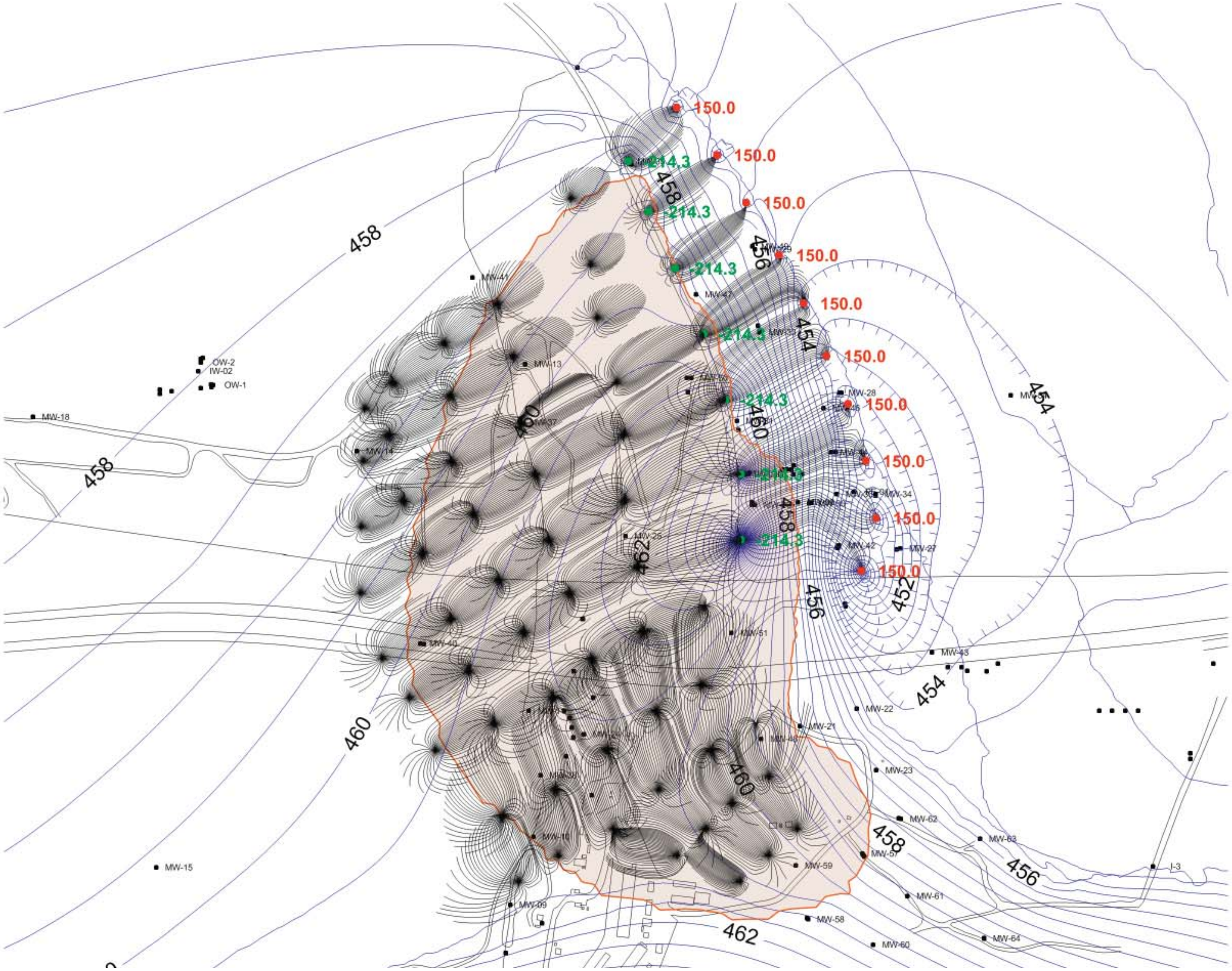
Green = Injection Well Rate (gpm)

gpm = gallons per minute

FIGURE F3-46
ALTERNATIVE D ALL PHASES: 190 DAY FLOWLINE STARTING IN MODEL LAYER 2

FINAL GROUNDWATER CORRECTIVE MEASURES STUDY/
FEASIBILITY STUDY REPORT FOR SWMU 1/AOC 1 and AOC 10
PG&E TOPOCK COMPRESSOR STATION
NEEDLES, CALIFORNIA

CH2MHILL



▨ = Plume capture target area for this model layer

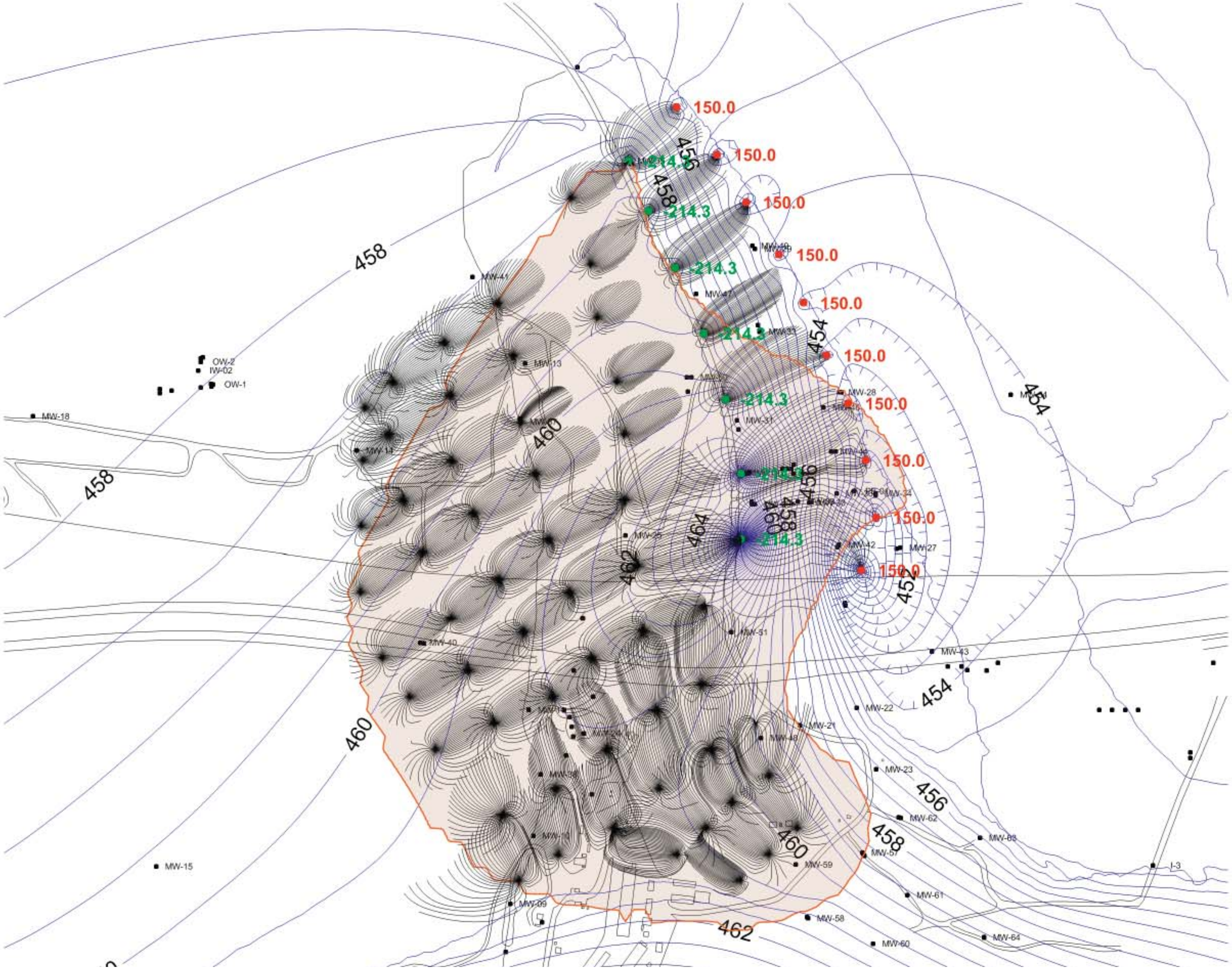
Red = Extraction Well Rate (gpm)

Green = Injection Well Rate (gpm)

gpm = gallons per minute

FIGURE F3-47
ALTERNATIVE D ALL PHASES: 190 DAY FLOWLINE STARTING IN MODEL LAYER 3

FINAL GROUNDWATER CORRECTIVE MEASURES STUDY/
FEASIBILITY STUDY REPORT FOR SWMU 1/AOC 1 and AOC 10
PG&E TOPOCK COMPRESSOR STATION
NEEDLES, CALIFORNIA



🟫 = Plume capture target area for this model layer

Red = Extraction Well Rate (gpm)

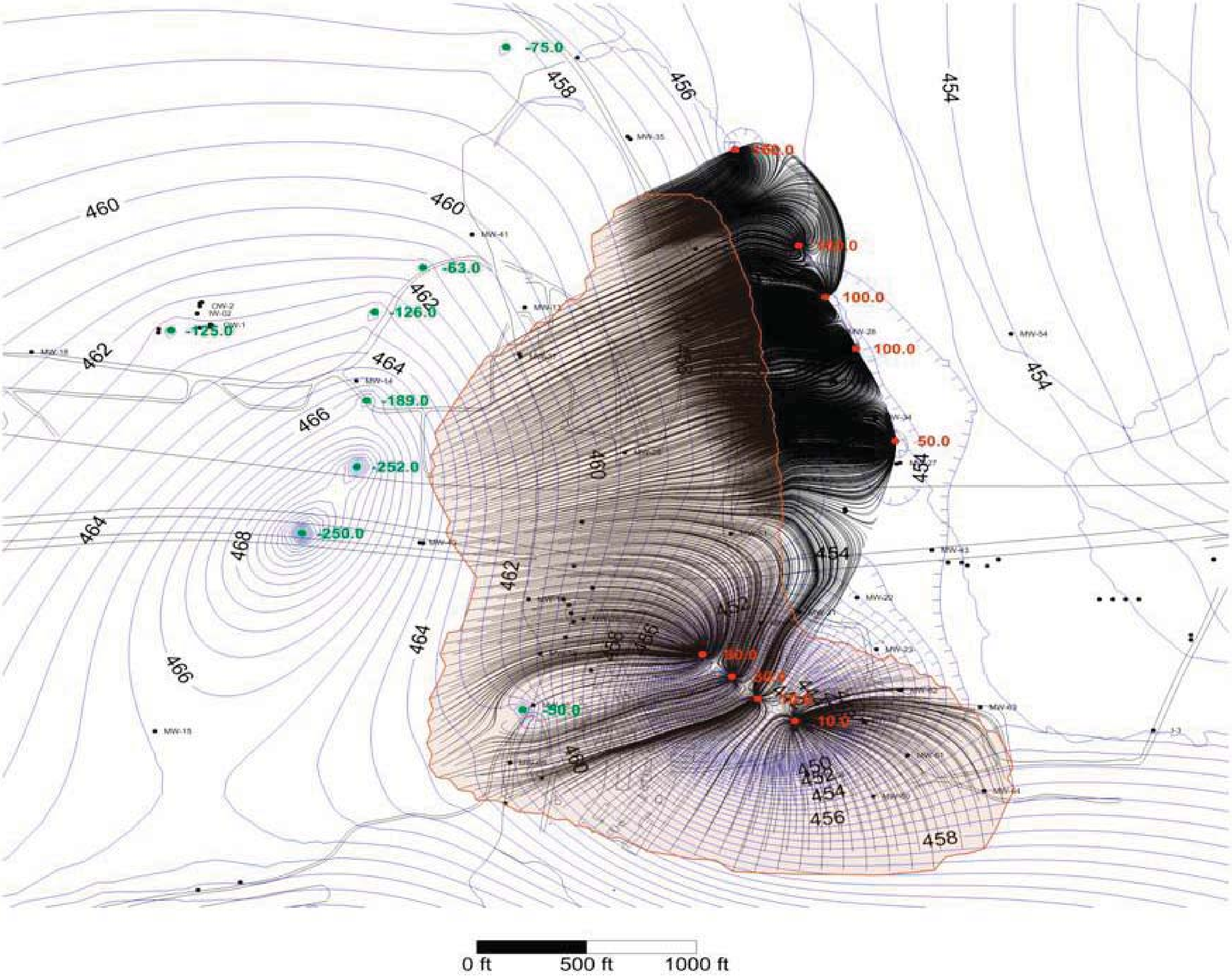
Green = Injection Well Rate (gpm)

gpm = gallons per minute

FIGURE F3-48
ALTERNATIVE D ALL PHASES: 190 DAY FLOWLINE STARTING IN MODEL LAYER 4

FINAL GROUNDWATER CORRECTIVE MEASURES STUDY/
FEASIBILITY STUDY REPORT FOR SWMU 1/AOC 1 and AOC 10
PG&E TOPOCK COMPRESSOR STATION
NEEDLES, CALIFORNIA

CH2MHILL



▨ = Plume capture target area for
this model layer

Red = Extraction Well Rate (gpm)

Green = Injection Well Rate (gpm)

gpm = gallons per minute

N

FIGURE F3-49
ALTERNATIVE E:
DOWNSTREAM FLOWLINES
STARTING IN MODEL LAYER 1

FINAL GROUNDWATER CORRECTIVE MEASURES STUDY/
FEASIBILITY STUDY REPORT FOR SWMU 1/AOC 1 and AOC 10
PG&E TOPOCK COMPRESSOR STATION
NEEDLES, CALIFORNIA

CH2MHILL

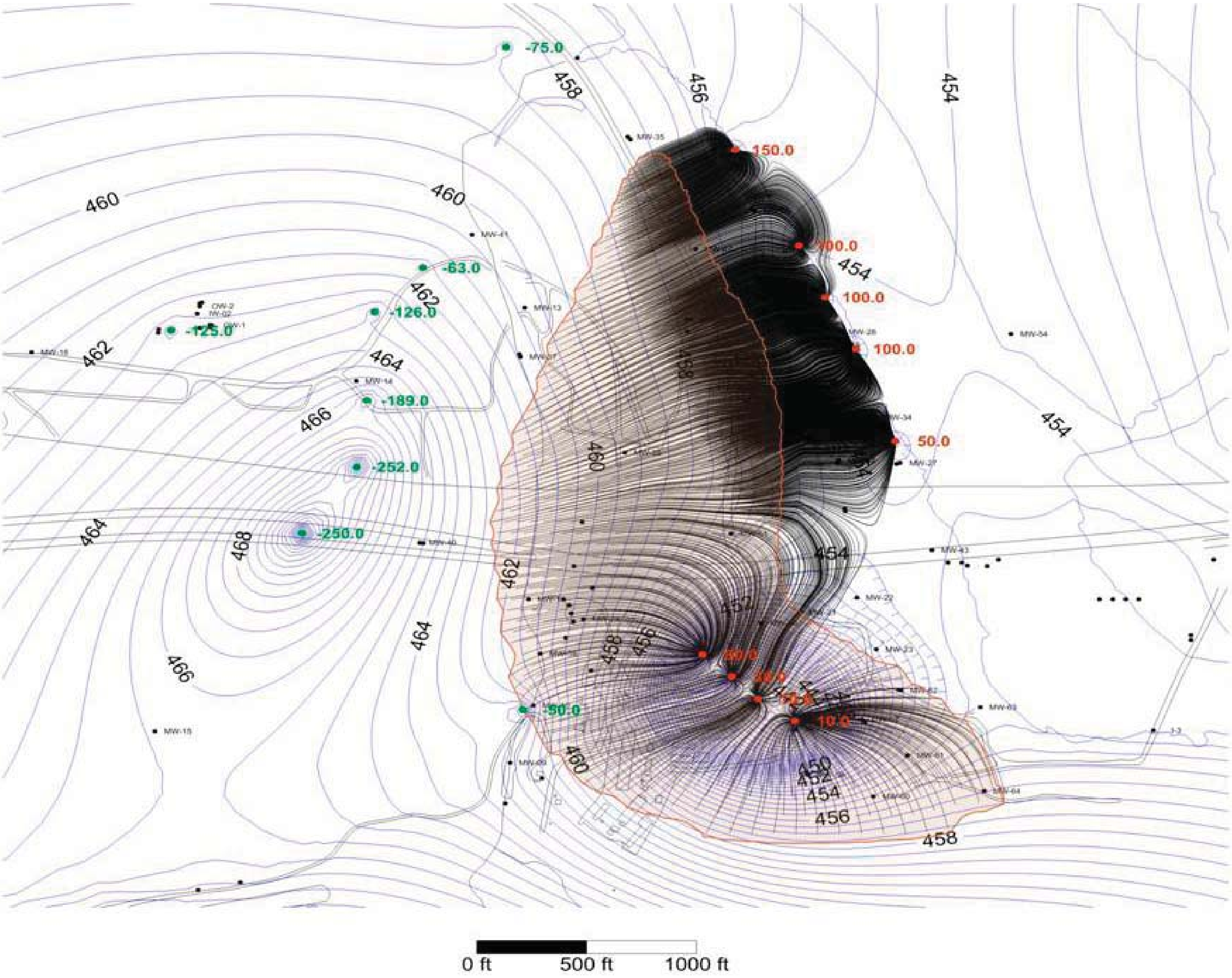


FIGURE F3-50
ALTERNATIVE E: DOWNSTREAM FLOWLINES STARTING IN MODEL LAYER 2

FINAL GROUNDWATER CORRECTIVE MEASURES STUDY/
FEASIBILITY STUDY REPORT FOR SWMU 1/AOC 1 and AOC 10
PG&E TOPOCK COMPRESSOR STATION
NEEDLES, CALIFORNIA

▨ = Plume capture target area for this model layer

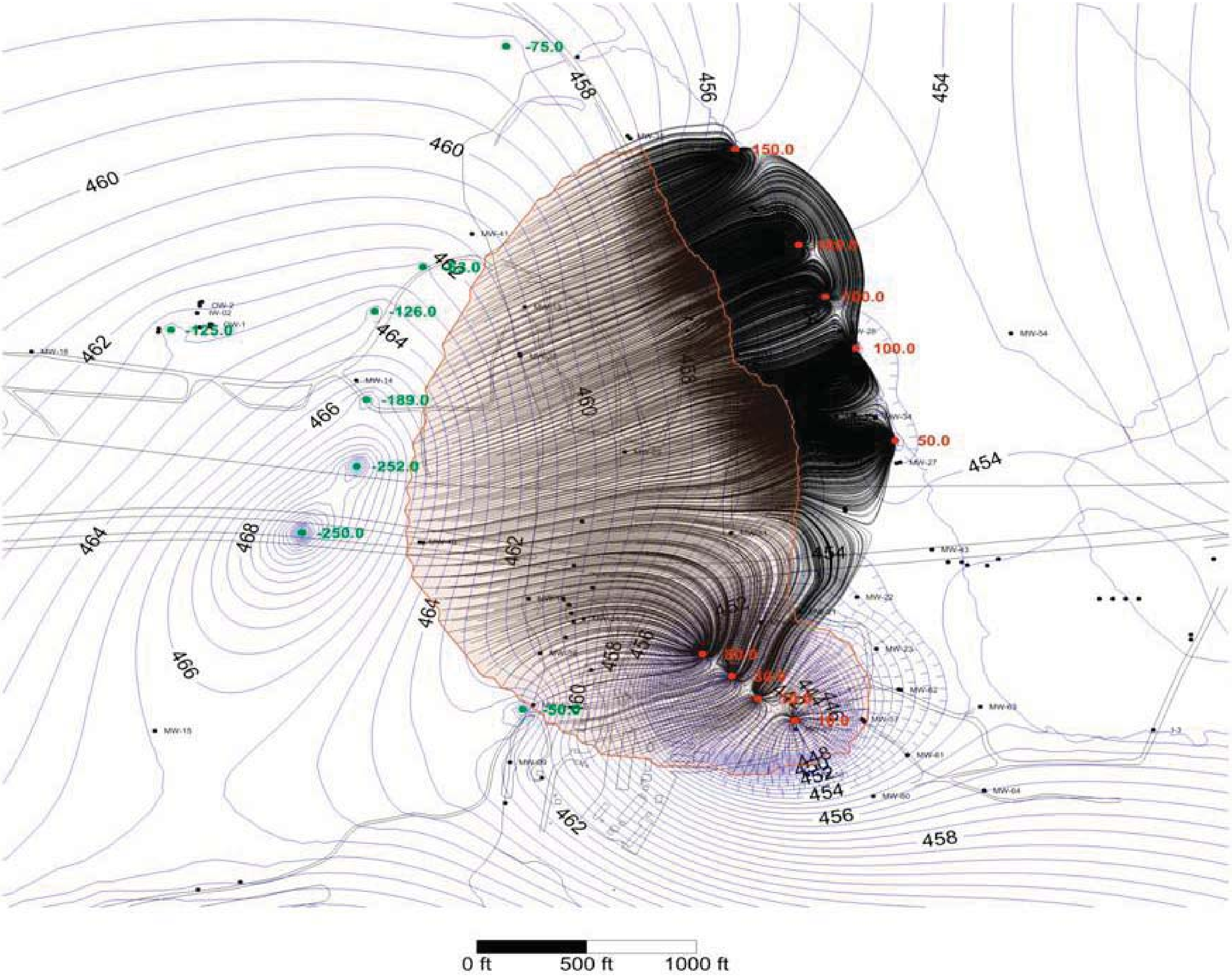
Red = Extraction Well Rate (gpm)

Green = Injection Well Rate (gpm)

gpm = gallons per minute

N

CH2MHILL



▨ = Plume capture target area for this model layer

Red = Extraction Well Rate (gpm)

Green = Injection Well Rate (gpm)

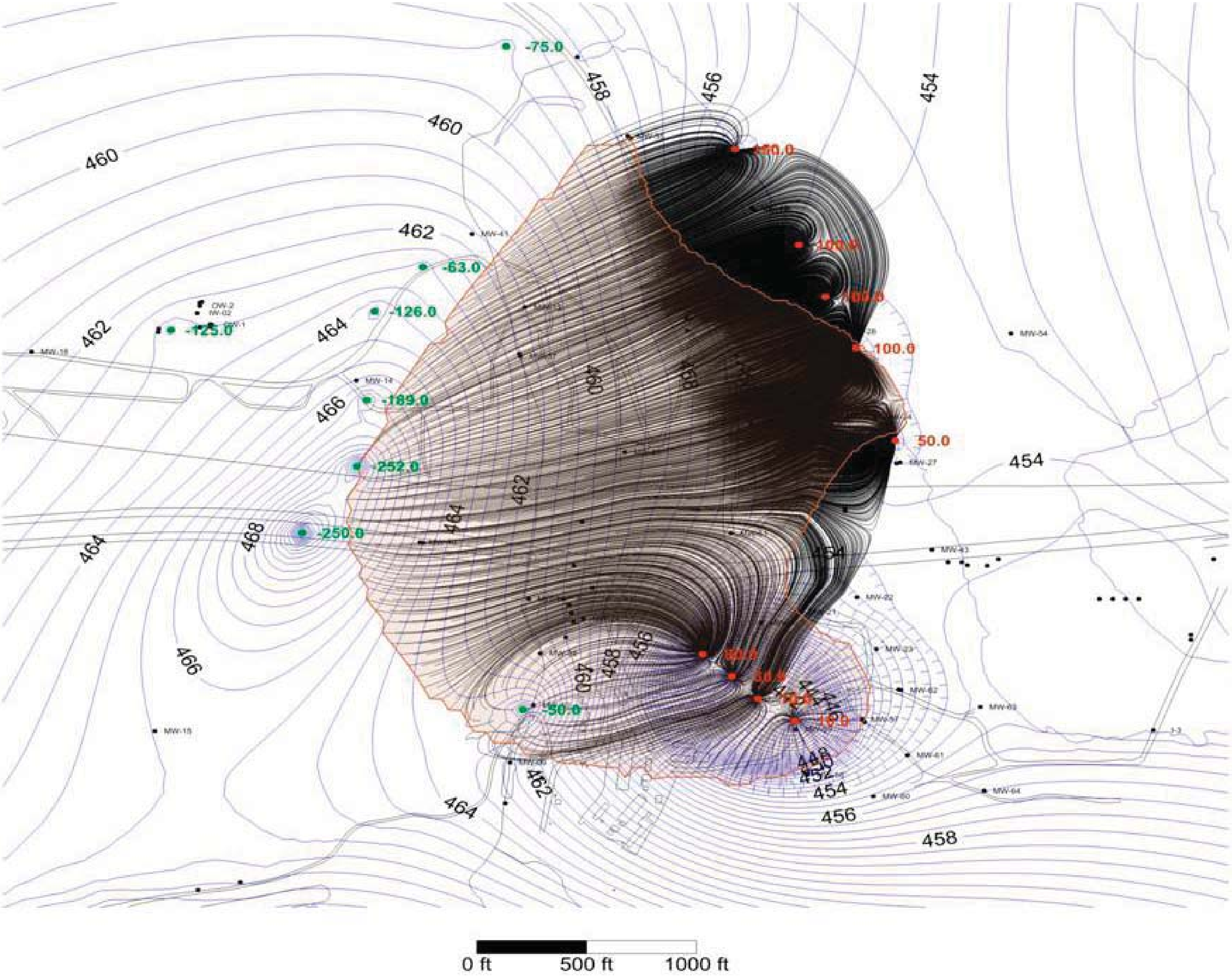
gpm = gallons per minute

N

FIGURE F3-51
ALTERNATIVE E: DOWNSTREAM FLOWLINES STARTING IN MODEL LAYER 3

FINAL GROUNDWATER CORRECTIVE MEASURES STUDY/
FEASIBILITY STUDY REPORT FOR SWMU 1/AOC 1 and AOC 10
PG&E TOPOCK COMPRESSOR STATION
NEEDLES, CALIFORNIA

CH2MHILL



▨ = Plume capture target area for this model layer

Red = Extraction Well Rate (gpm)

Green = Injection Well Rate (gpm)

gpm = gallons per minute

FIGURE F3-52
ALTERNATIVE E:
DOWNSTREAM FLOWLINES
STARTING IN MODEL LAYER 4

FINAL GROUNDWATER CORRECTIVE MEASURES STUDY/
FEASIBILITY STUDY REPORT FOR SWMU 1/AOC 1 and AOC 10
PG&E TOPOCK COMPRESSOR STATION
NEEDLES, CALIFORNIA

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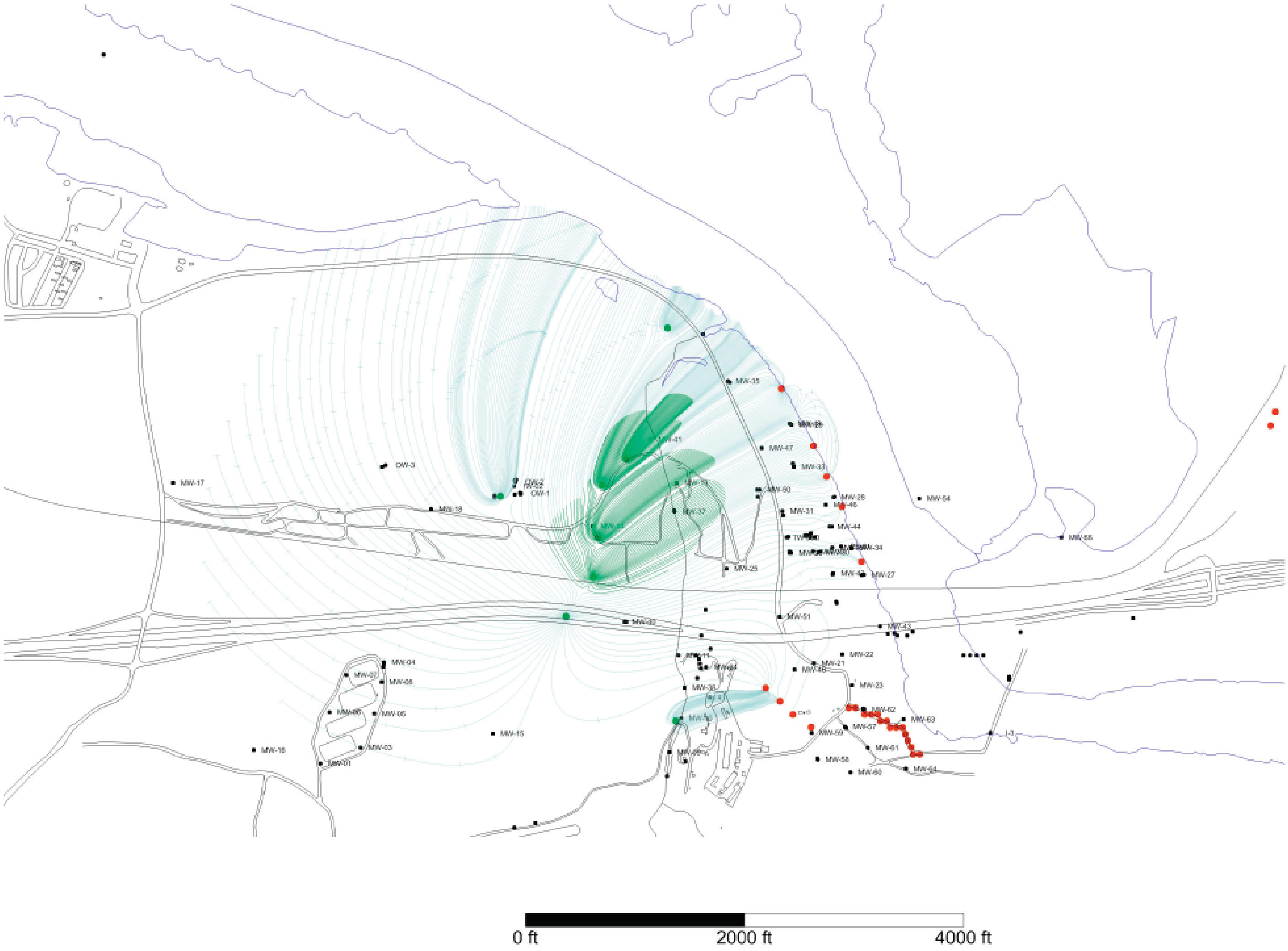
CH2MHILL



Green flow lines indicate 1-year travel time from amended water injection wells, the zone in which any in-situ byproducts are expected to attenuate.

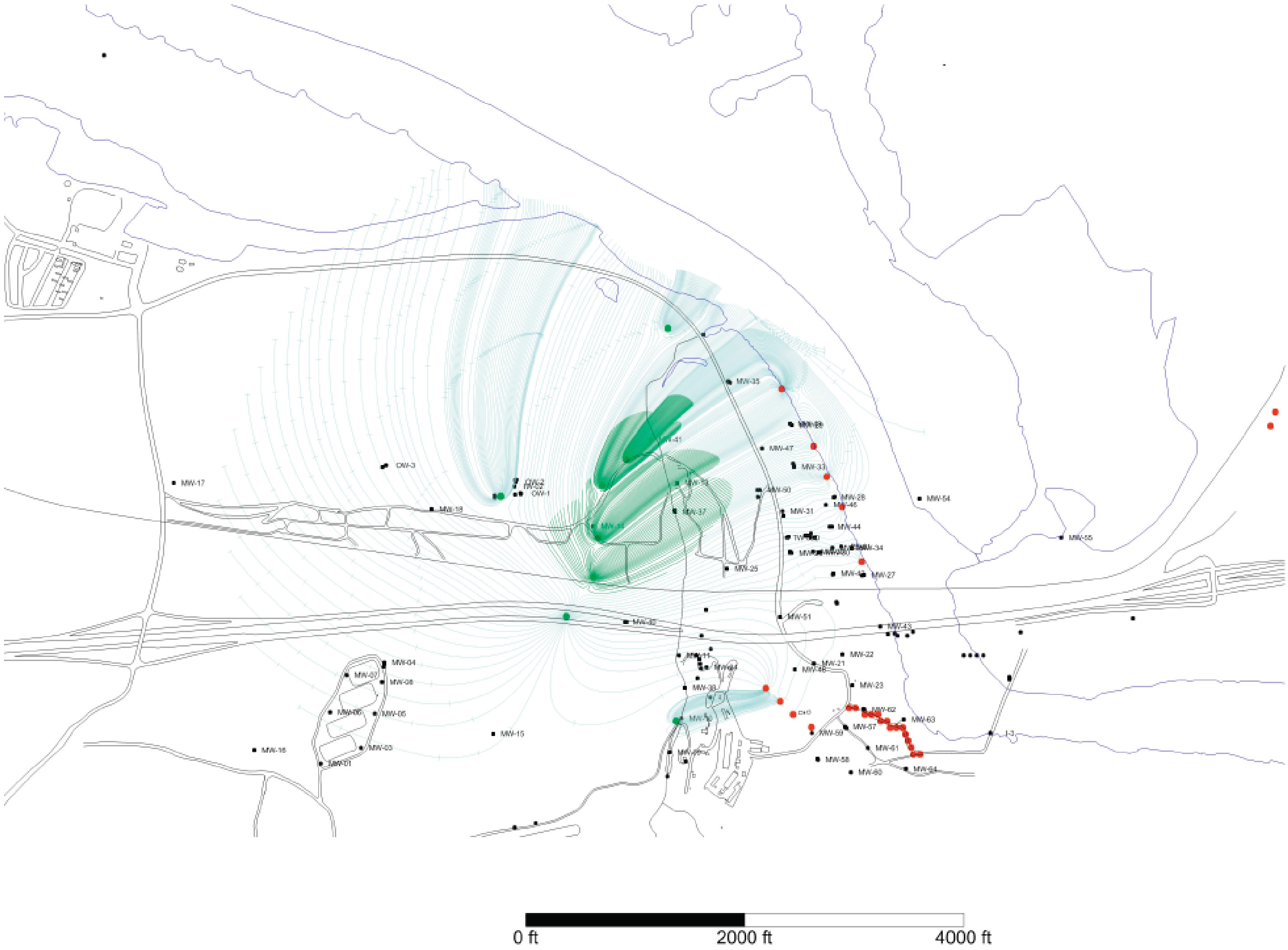
Travel time ticks at 5 year intervals

Red = Extraction Well Rate (gpm)
Green = Injection Well Rate (gpm)
gpm = gallons per minute

FIGURE F3-53
ALTERNATIVE E:
DOWSTREAM FLOWLINES FROM CARBON-AMENDED WATER INJECTION WELLS STARTING IN MODEL LAYER 1

FINAL GROUNDWATER CORRECTIVE MEASURES STUDY/
FEASIBILITY STUDY REPORT FOR SWMU 1/AOC 1 and AOC 10
PG&E TOPOCK COMPRESSOR STATION
NEEDLES, CALIFORNIA

CH2MHILL



Green flow lines indicate 1-year travel time from amended water injection wells, the zone in which any in-situ byproducts are expected to attenuate.

Travel time ticks at 5 year intervals

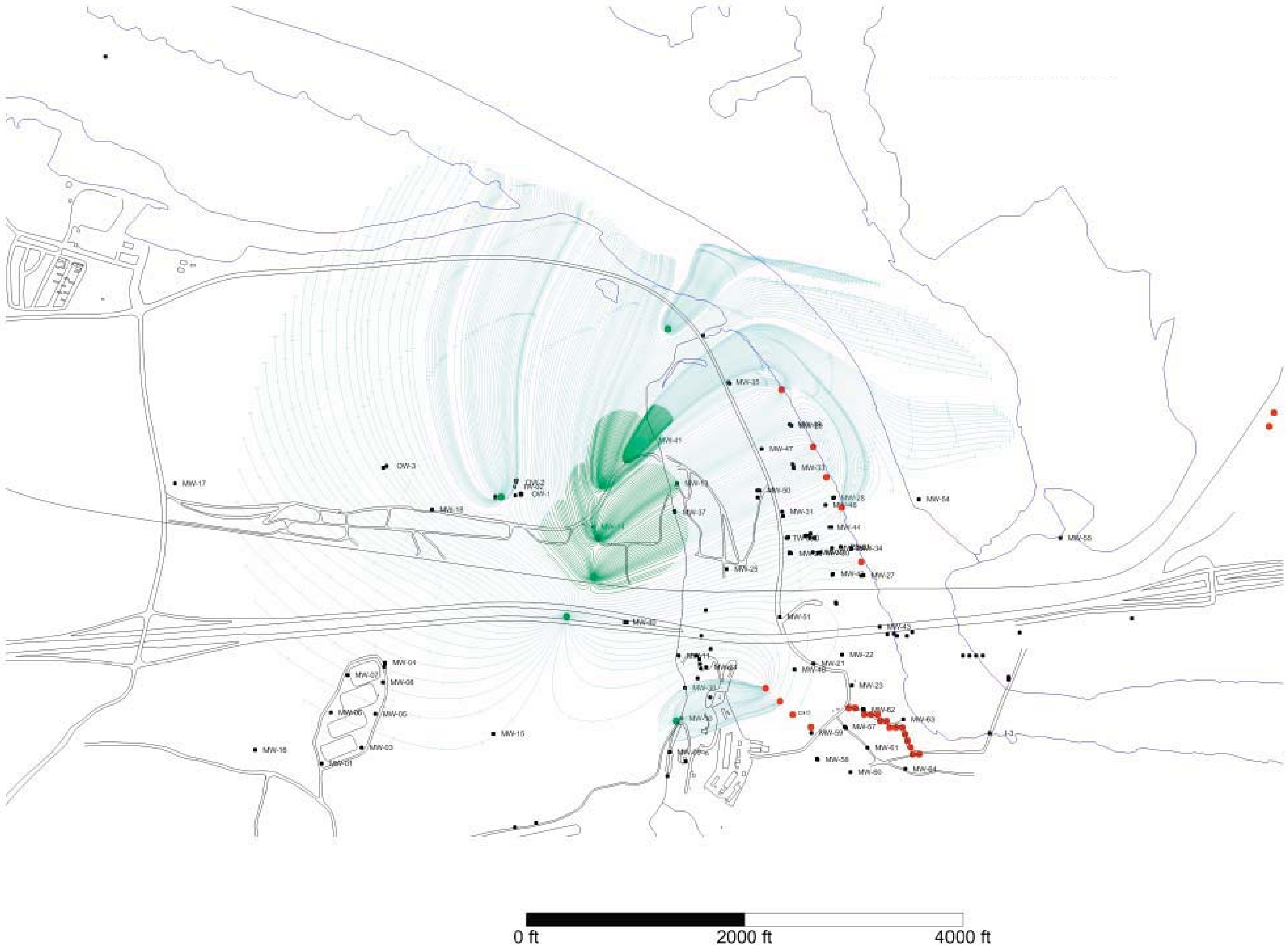
Red = Extraction Well Rate (gpm)
Green = Injection Well Rate (gpm)
gpm = gallons per minute

N

FIGURE F3-54
DOWSTREAM FLOWLINES FROM CARBON-AMENDED WATER INJECTION WELLS STARTING IN MODEL LAYER 2

FINAL GROUNDWATER CORRECTIVE MEASURES STUDY/
FEASIBILITY STUDY REPORT FOR SWMU 1/AOC 1 and AOC 10
PG&E TOPOCK COMPRESSOR STATION
NEEDLES, CALIFORNIA

CH2MHILL



Green flow lines indicate 1-year travel time from amended water injection wells, the zone in which any in-situ byproducts are expected to attenuate.

Travel time ticks at 5 year intervals

Red = Extraction Well Rate (gpm)

Green = Injection Well Rate (gpm)

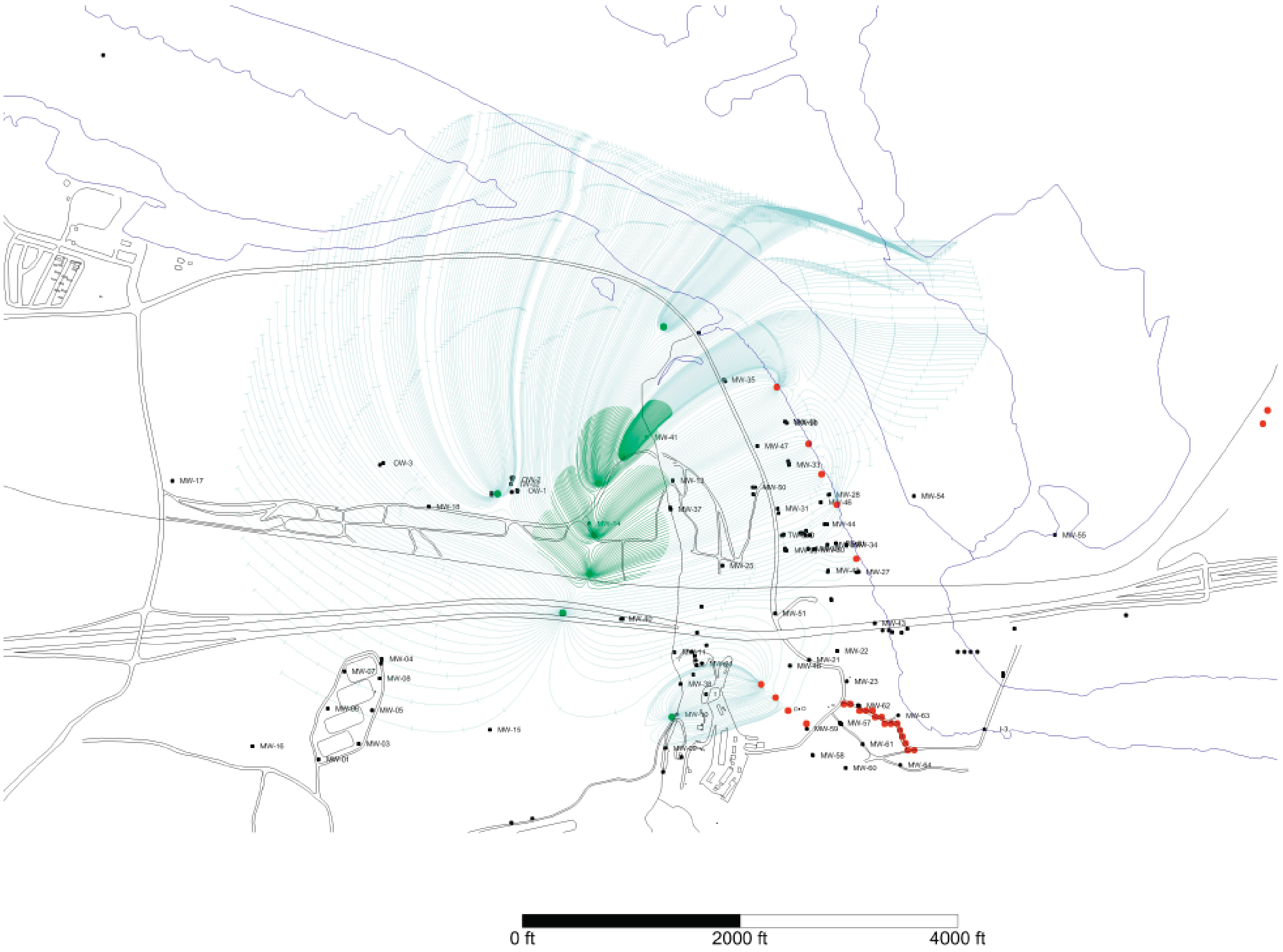
gpm = gallons per minute

N

FIGURE F3-55
DOWSTREAM FLOWLINES FROM CARBON-AMENDED WATER INJECTION WELLS STARTING IN MODEL LAYER 3

FINAL GROUNDWATER CORRECTIVE MEASURES STUDY/
FEASIBILITY STUDY REPORT FOR SWMU 1/AOC 1 and AOC 10
PG&E TOPOCK COMPRESSOR STATION
NEEDLES, CALIFORNIA

CH2MHILL



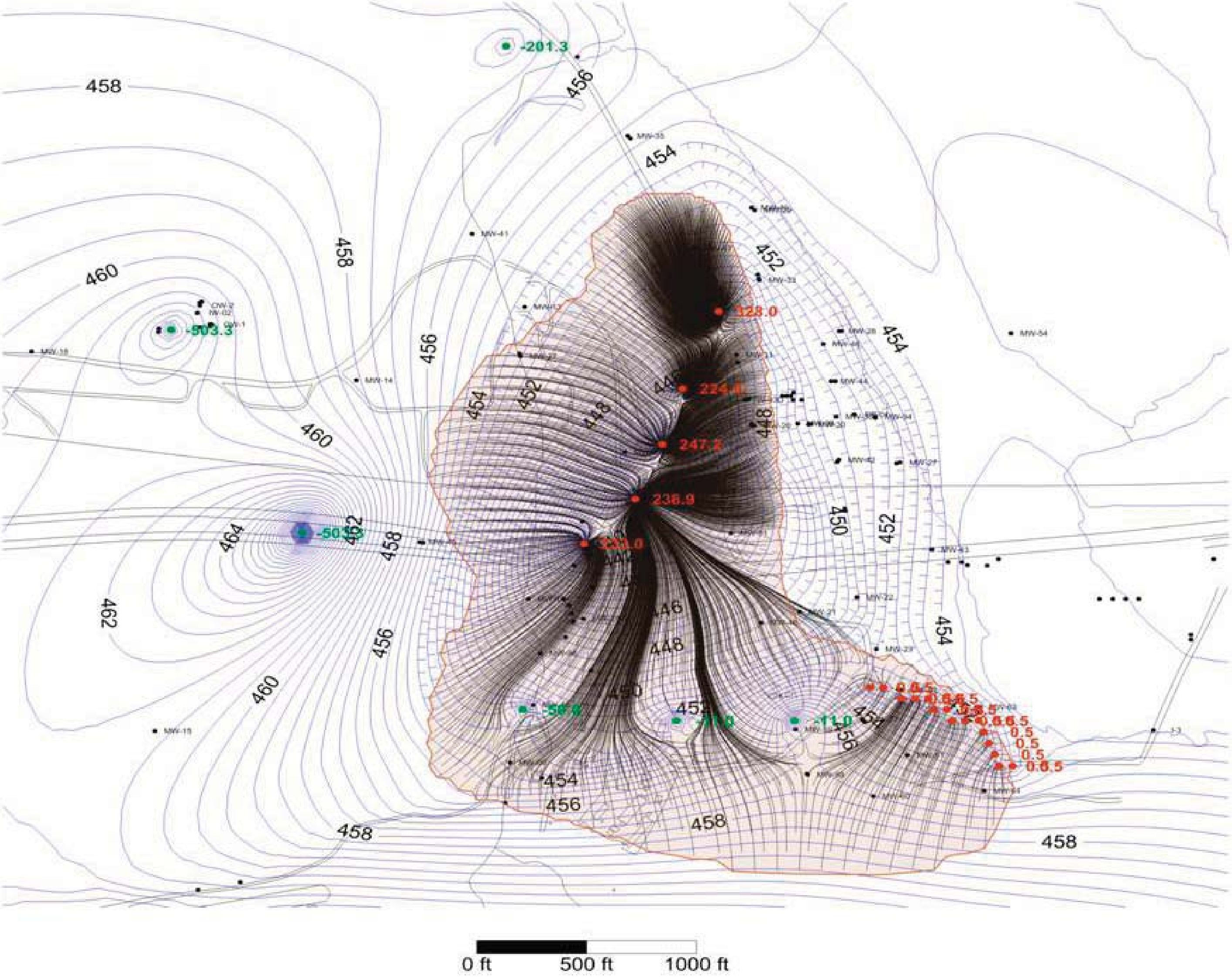
Green flow lines indicate 1-year travel time from amended water injection wells, the zone in which any in-situ byproducts are expected to attenuate.

Travel time ticks at 5 year intervals

Red = Extraction Well Rate (gpm)
Green = Injection Well Rate (gpm)
gpm = gallons per minute

FIGURE F3-56
DOWSTREAM FLOWLINES FROM CARBON-AMENDED WATER INJECTION WELLS STARTING IN MODEL LAYER 4

FINAL GROUNDWATER CORRECTIVE MEASURES STUDY/
FEASIBILITY STUDY REPORT FOR SWMU 1/AOC 1 and AOC 10
PG&E TOPOCK COMPRESSOR STATION
NEEDLES, CALIFORNIA



▭ = Plume capture target area for this model layer

Red = Extraction Well Rate (gpm)

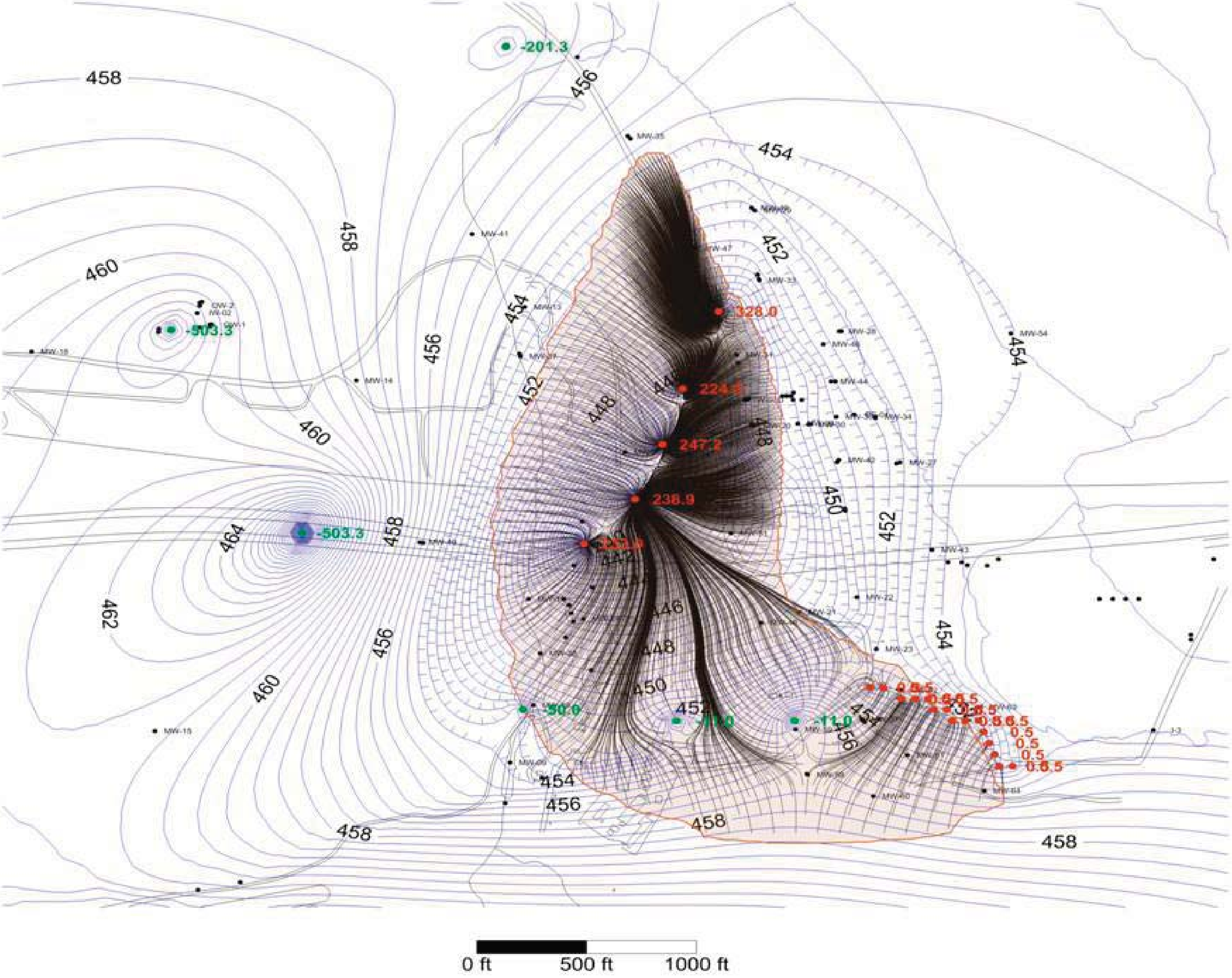
Green = Injection Well Rate (gpm)

gpm = gallons per minute

FIGURE F3-57
ALTERNATIVE F:
DOWNSTREAM FLOWLINES STARTING IN MODEL LAYER 1

FINAL GROUNDWATER CORRECTIVE MEASURES STUDY/
FEASIBILITY STUDY REPORT FOR SWMU 1/AOC 1 and AOC 10
PG&E TOPOCK COMPRESSOR STATION
NEEDLES, CALIFORNIA

CH2MHILL



▨ = Plume capture target area for this model layer

Red = Extraction Well Rate (gpm)

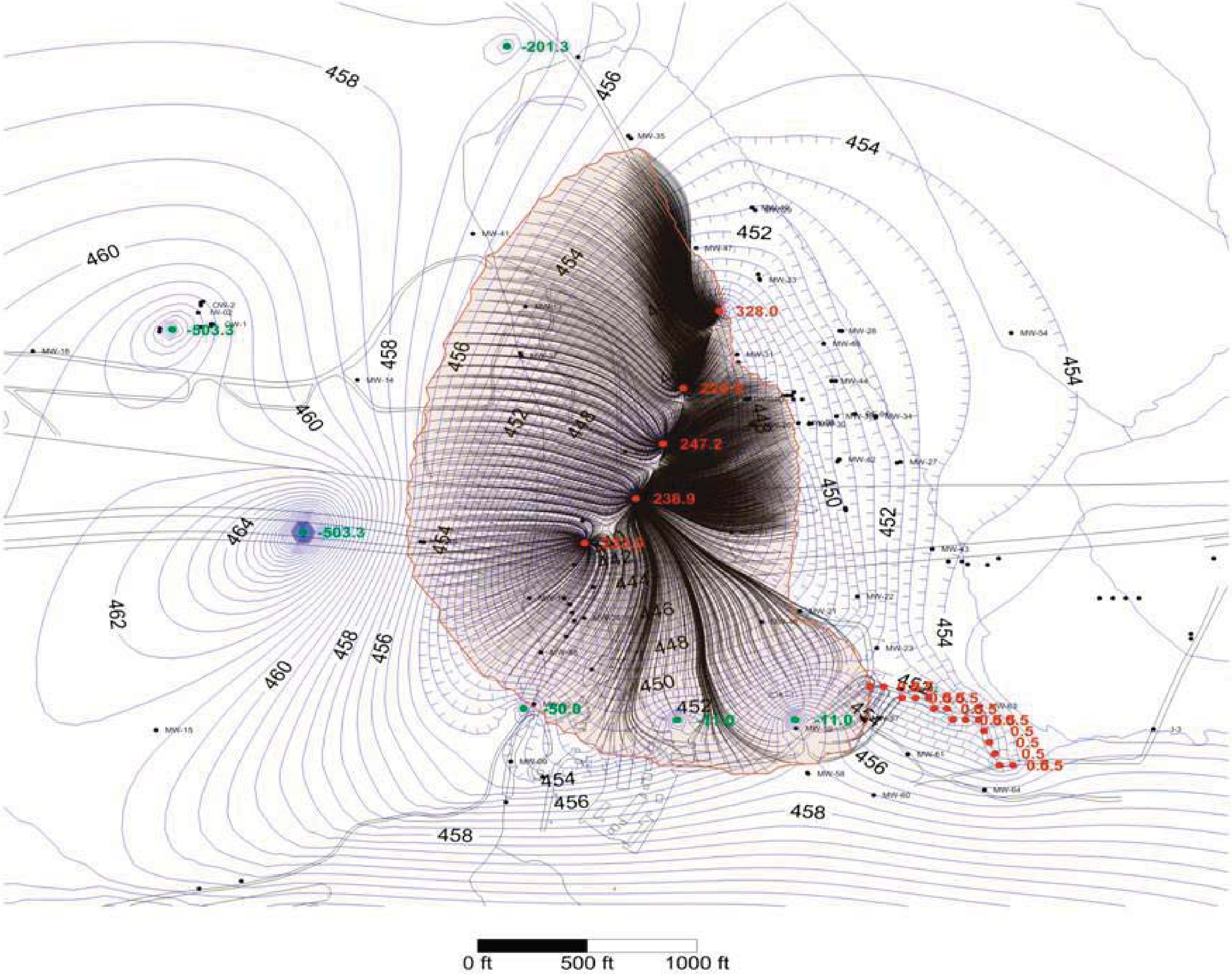
Green = Injection Well Rate (gpm)

gpm = gallons per minute

FIGURE F3-58
ALTERNATIVE F:
DOWNSTREAM FLOWLINES STARTING IN MODEL LAYER 2

FINAL GROUNDWATER CORRECTIVE MEASURES STUDY/
FEASIBILITY STUDY REPORT FOR SWMU 1/AOC 1 and AOC 10
PG&E TOPOCK COMPRESSOR STATION
NEEDLES, CALIFORNIA

CH2MHILL



▨ = Plume capture target area for
this model layer

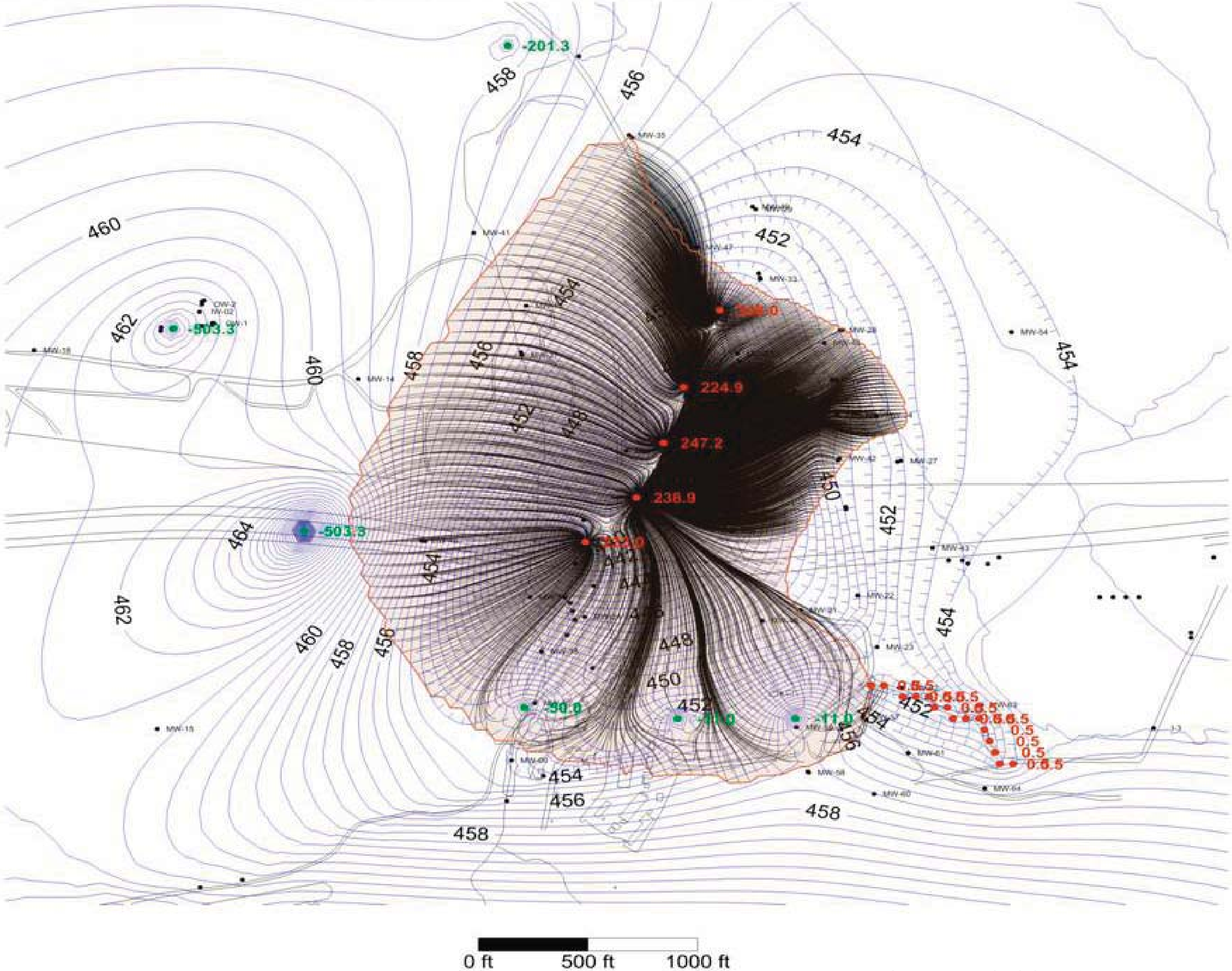
Red = Extraction Well Rate (gpm)

Green = Injection Well Rate (gpm)

gpm = gallons per minute

FIGURE F3-59
ALTERNATIVE F:
DOWNSTREAM FLOWLINES
STARTING IN MODEL LAYER 3

FINAL GROUNDWATER CORRECTIVE MEASURES STUDY/
FEASIBILITY STUDY REPORT FOR SWMU 1/AOC 1 and AOC 10
PG&E TOPOCK COMPRESSOR STATION
NEEDLES, CALIFORNIA



▨ = Plume capture target area for this model layer

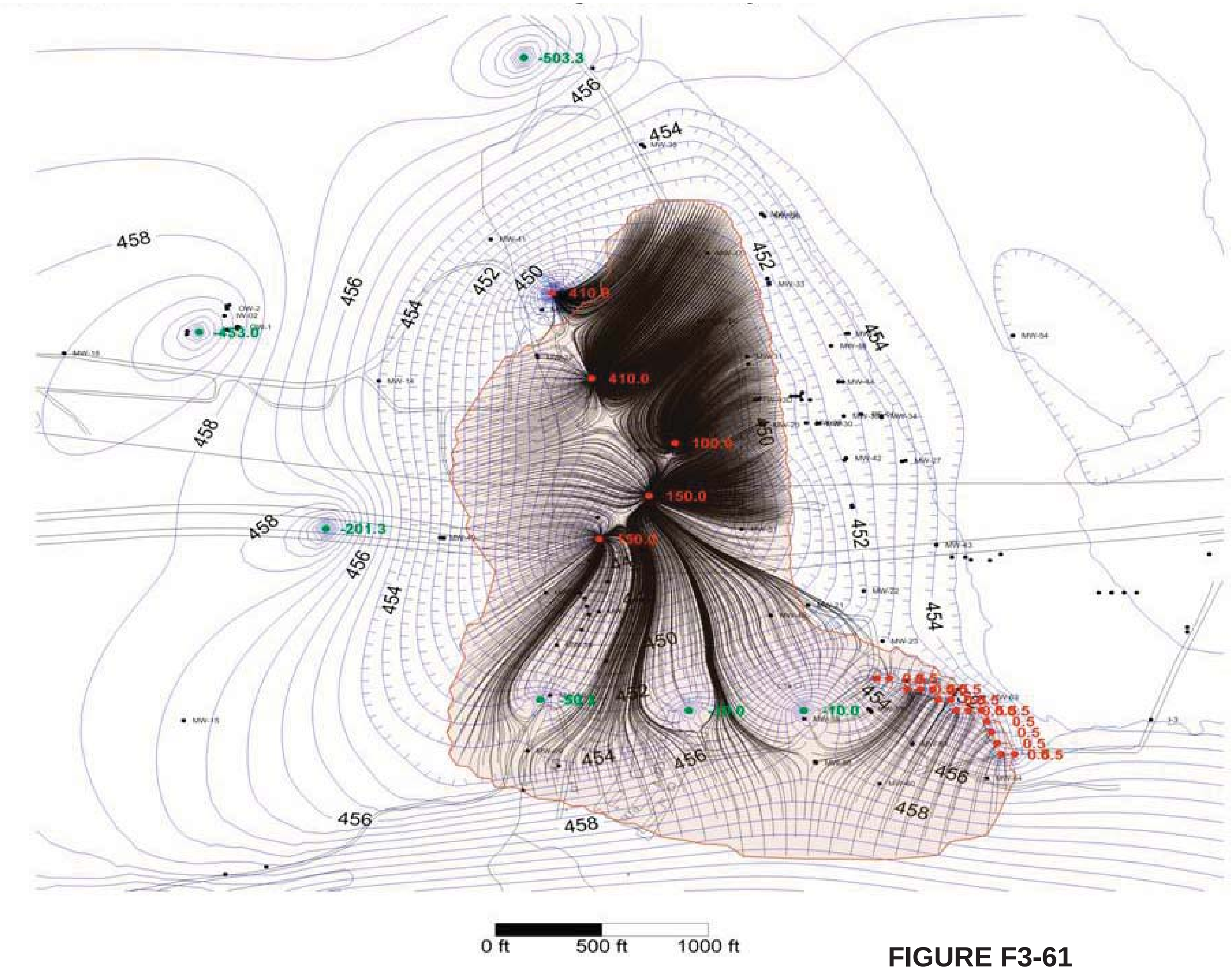
Red = Extraction Well Rate (gpm)

Green = Injection Well Rate (gpm)

gpm = gallons per minute

FIGURE F3-60
ALTERNATIVE F:
DOWNSTREAM FLOWLINES STARTING IN MODEL LAYER 4

FINAL GROUNDWATER CORRECTIVE MEASURES STUDY/
FEASIBILITY STUDY REPORT FOR SWMU 1/AOC 1 and AOC 10
PG&E TOPOCK COMPRESSOR STATION
NEEDLES, CALIFORNIA



▨ = Plume capture target area for this model layer

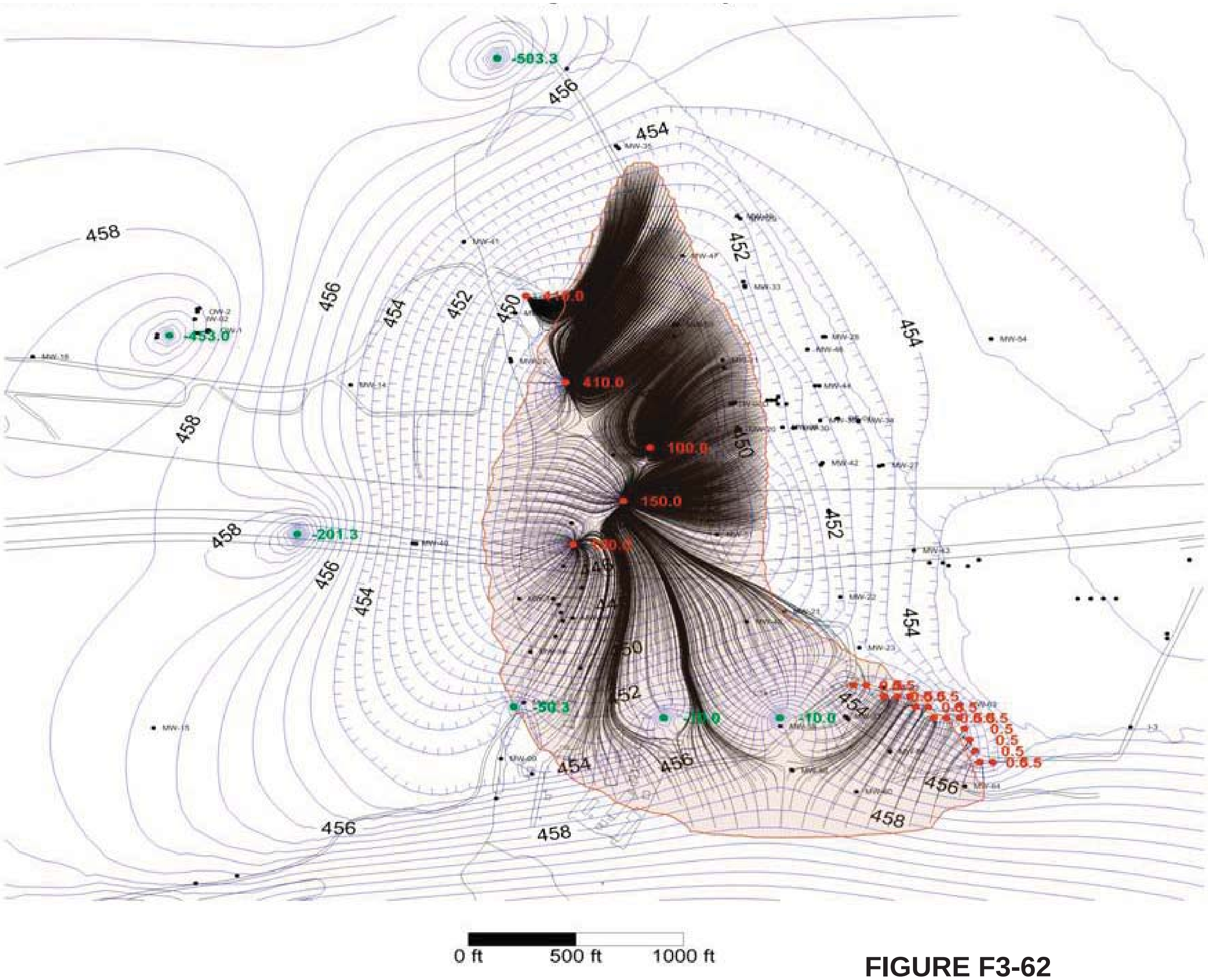
Red = Extraction Well Rate (gpm)

Green = Injection Well Rate (gpm)

gpm = gallons per minute

FIGURE F3-61
ALTERNATIVE G: DOWNSTREAM FLOWLINES STARTING IN MODEL LAYER 1

FINAL GROUNDWATER CORRECTIVE MEASURES STUDY/
FEASIBILITY STUDY REPORT FOR SWMU 1/AOC 1 and AOC 10
PG&E TOPOCK COMPRESSOR STATION
NEEDLES, CALIFORNIA



▨ = Plume capture target area for this model layer

Red = Extraction Well Rate (gpm)

Green = Injection Well Rate (gpm)

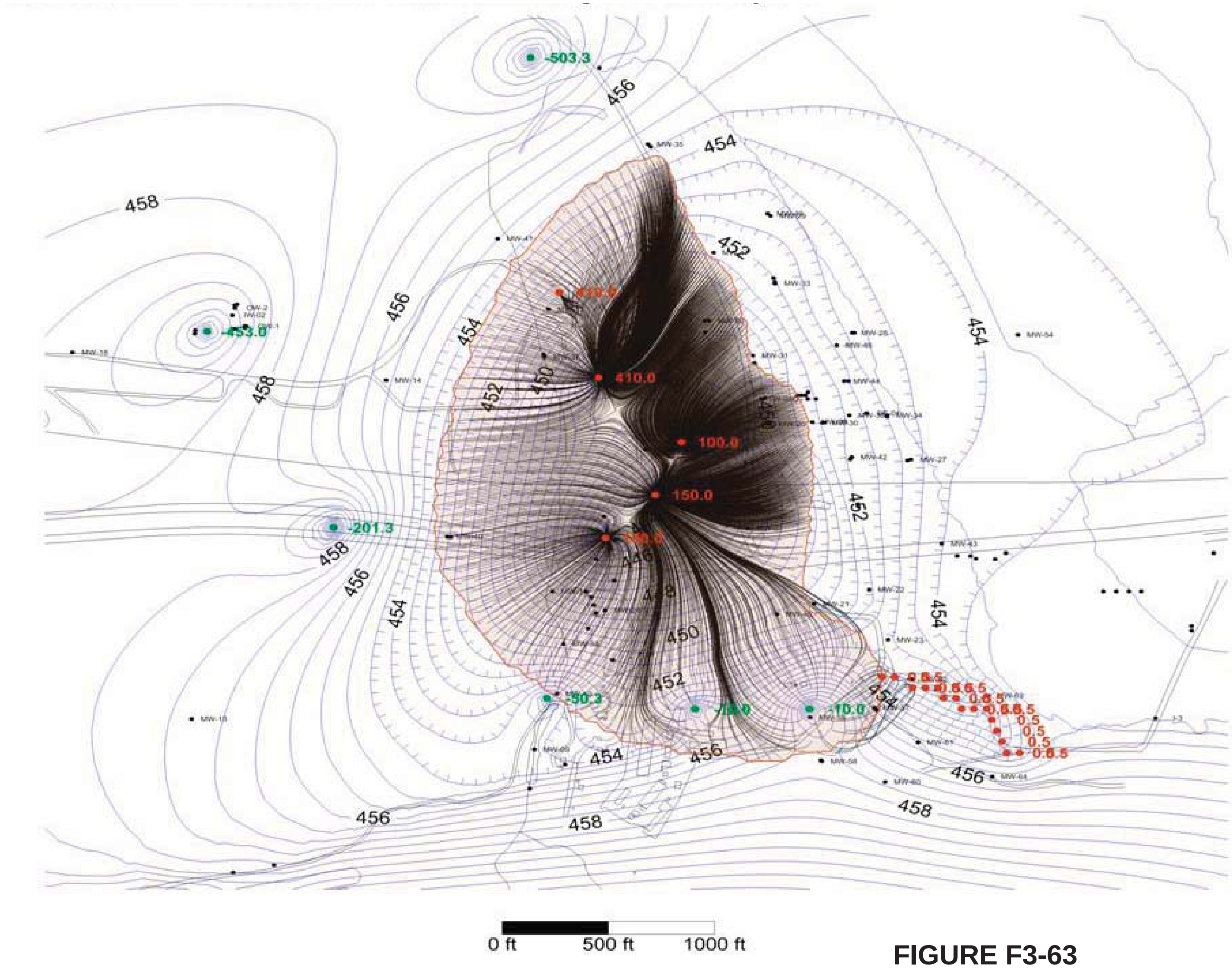
gpm = gallons per minute

N

FIGURE F3-62
ALTERNATIVE G:
DOWNSTREAM FLOWLINES STARTING IN MODEL LAYER 2

FINAL GROUNDWATER CORRECTIVE MEASURES STUDY/
FEASIBILITY STUDY REPORT FOR SWMU 1/AOC 1 and AOC 10
PG&E TOPOCK COMPRESSOR STATION
NEEDLES, CALIFORNIA

CH2MHILL



▨ = Plume capture target area for this model layer

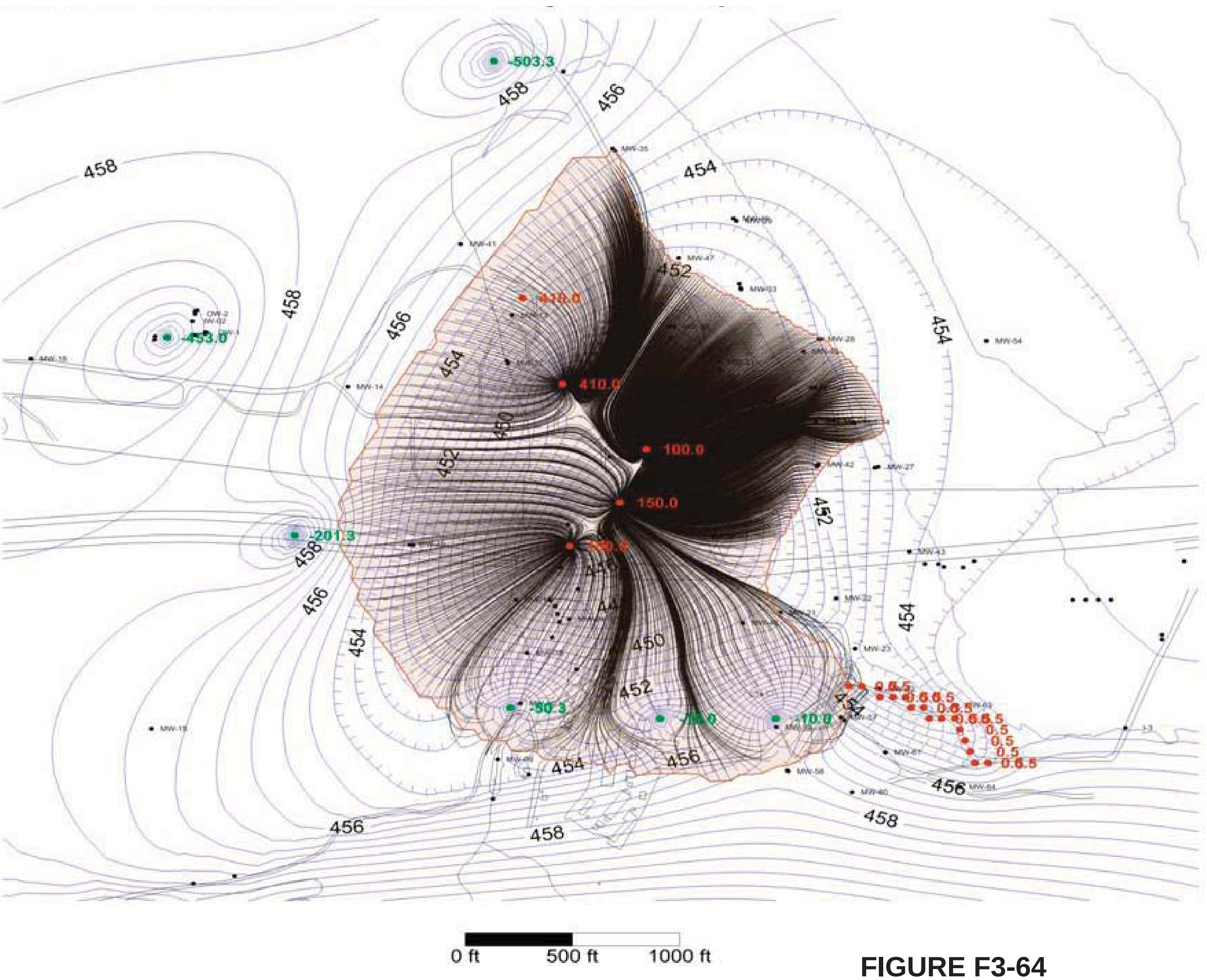
Red = Extraction Well Rate (gpm)

Green = Injection Well Rate (gpm)

gpm = gallons per minute

FIGURE F3-63
ALTERNATIVE G: DOWNSTREAM FLOWLINES STARTING IN MODEL LAYER 3

FINAL GROUNDWATER CORRECTIVE MEASURES STUDY/
FEASIBILITY STUDY REPORT FOR SWMU 1/AOC 1 and AOC 10
PG&E TOPOCK COMPRESSOR STATION
NEEDLES, CALIFORNIA



▨ = Plume capture target area for this model layer

Red = Extraction Well Rate (gpm)

Green = Injection Well Rate (gpm)

gpm = gallons per minute

N

FIGURE F3-64
ALTERNATIVE G: DOWNSTREAM FLOWLINES STARTING IN MODEL LAYER 4

FINAL GROUNDWATER CORRECTIVE MEASURES STUDY/
FEASIBILITY STUDY REPORT FOR SWMU 1/AOC 1 and AOC 10
PG&E TOPOCK COMPRESSOR STATION
NEEDLES, CALIFORNIA

CH2MHILL

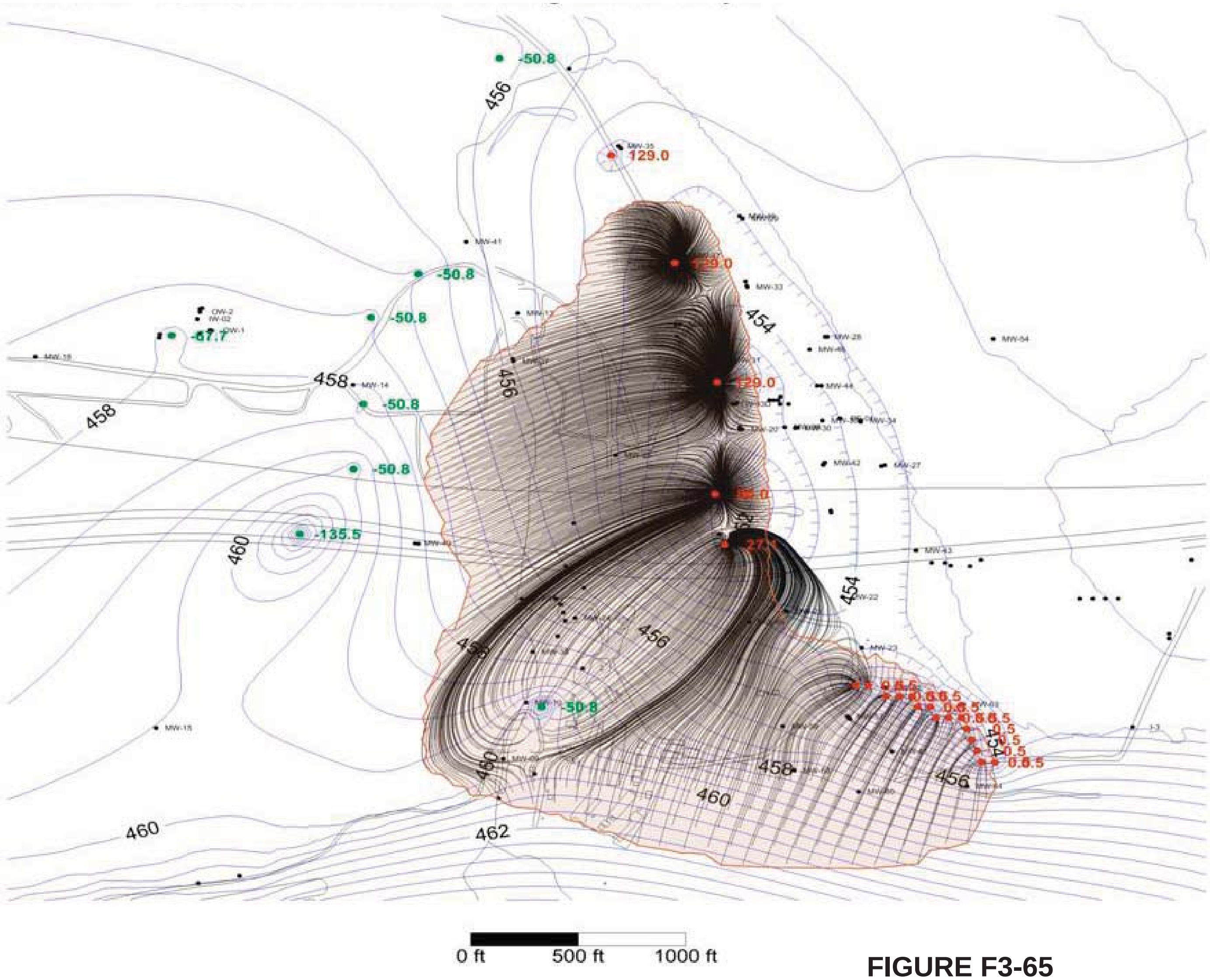
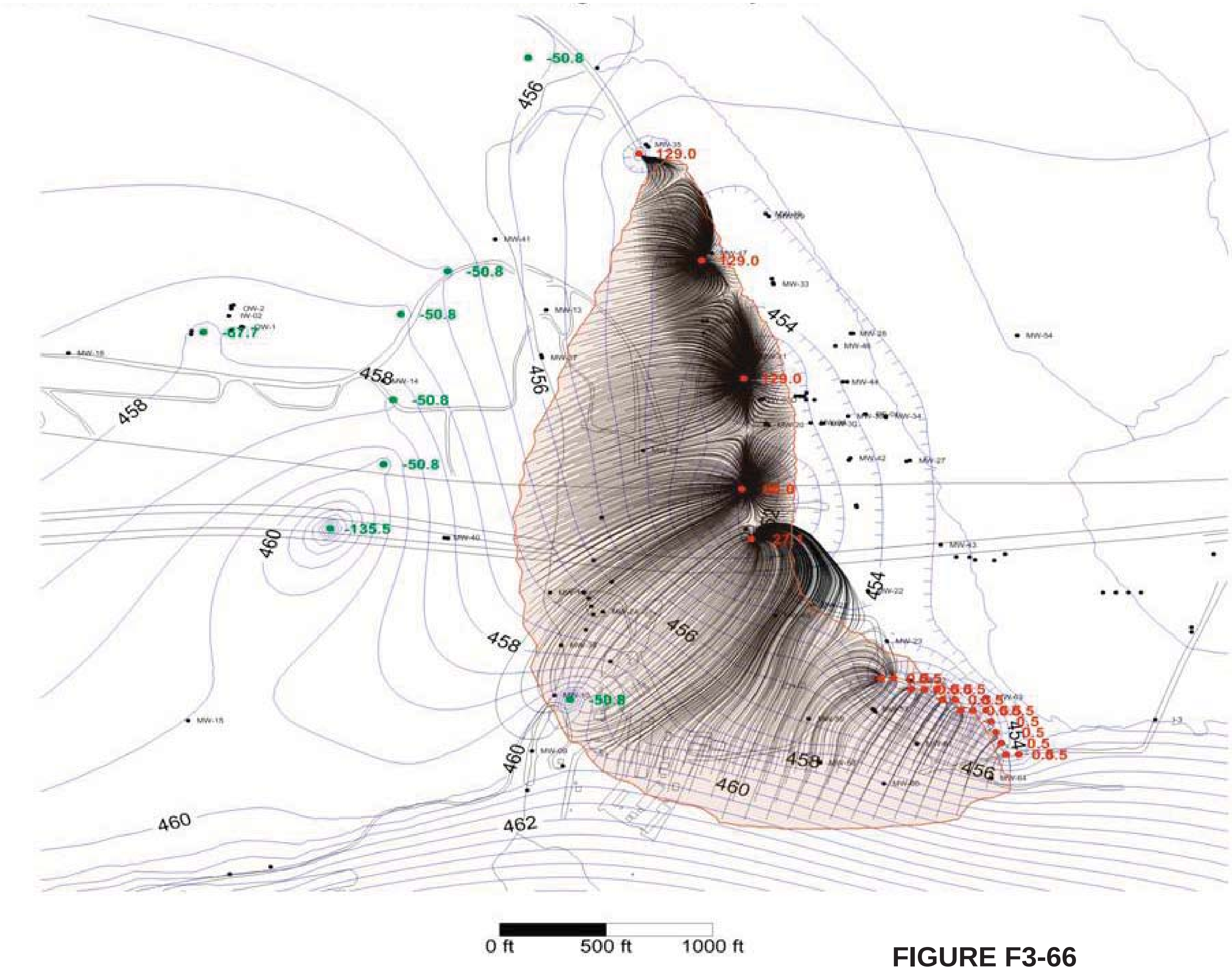


FIGURE F3-65
ALTERNATIVE H: DOWNSTREAM FLOWLINES STARTING IN MODEL LAYER 1

FINAL GROUNDWATER CORRECTIVE MEASURES STUDY/
FEASIBILITY STUDY REPORT FOR SWMU 1/AOC 1 and AOC 10
PG&E TOPOCK COMPRESSOR STATION
NEEDLES, CALIFORNIA

▭ = Plume capture target area for this model layer

Red = Extraction Well Rate (gpm)
Green = Injection Well Rate (gpm)
gpm = gallons per minute



▨ = Plume capture target area for this model layer

Red = Extraction Well Rate (gpm)

Green = Injection Well Rate (gpm)

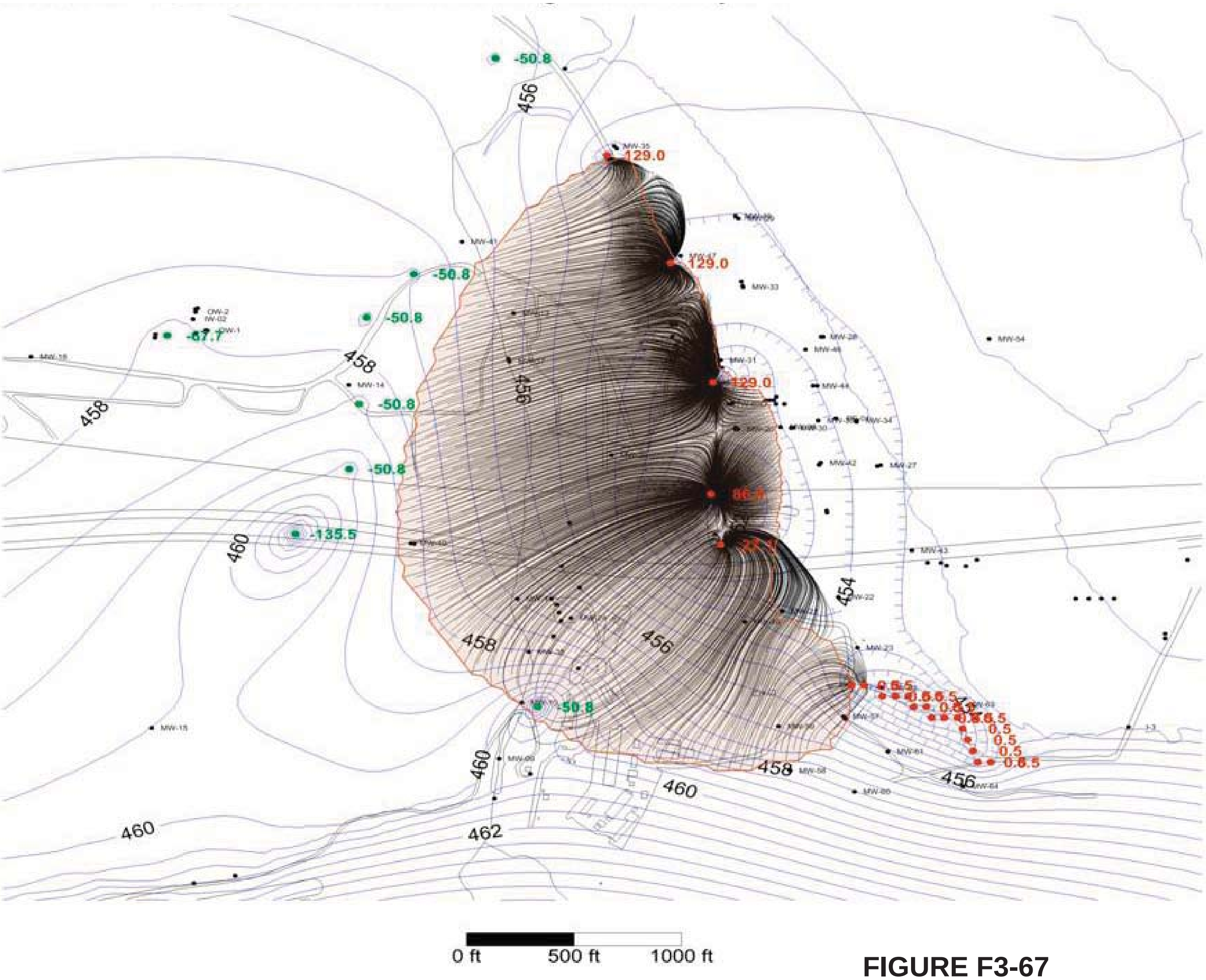
gpm = gallons per minute

N

FIGURE F3-66
ALTERNATIVE H:
DOWNSTREAM FLOWLINES STARTING IN MODEL LAYER 2

FINAL GROUNDWATER CORRECTIVE MEASURES STUDY/
FEASIBILITY STUDY REPORT FOR SWMU 1/AOC 1 and AOC 10
PG&E TOPOCK COMPRESSOR STATION
NEEDLES, CALIFORNIA

CH2MHILL



▨ = Plume capture target area for this model layer

Red = Extraction Well Rate (gpm)

Green = Injection Well Rate (gpm)

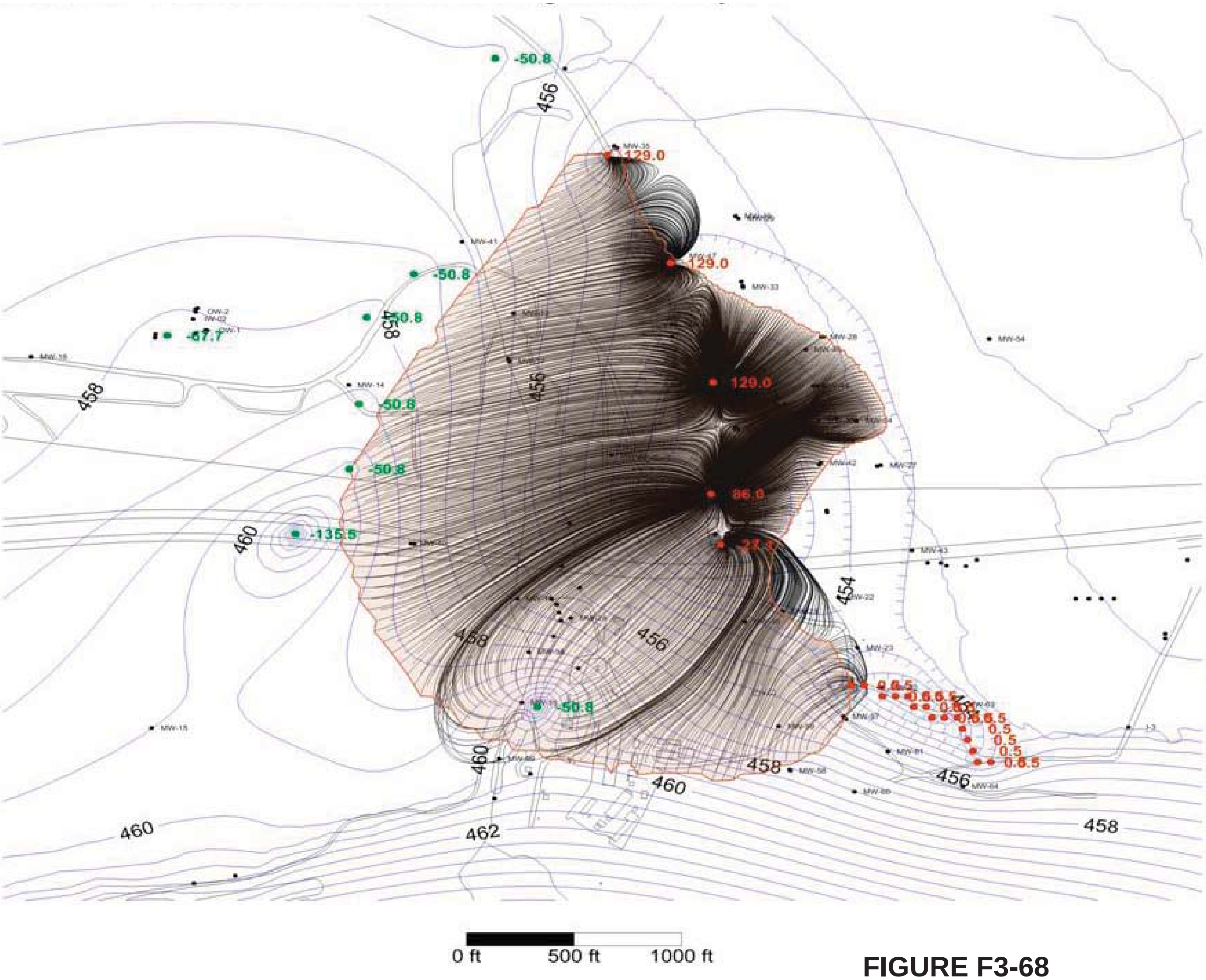
gpm = gallons per minute

N

FIGURE F3-67
ALTERNATIVE H: DOWNSTREAM FLOWLINES STARTING IN MODEL LAYER 3

FINAL GROUNDWATER CORRECTIVE MEASURES STUDY/
FEASIBILITY STUDY REPORT FOR SWMU 1/AOC 1 and AOC 10
PG&E TOPOCK COMPRESSOR STATION
NEEDLES, CALIFORNIA

CH2MHILL



▨ = Plume capture target area for
this model layer

Red = Extraction Well Rate (gpm)

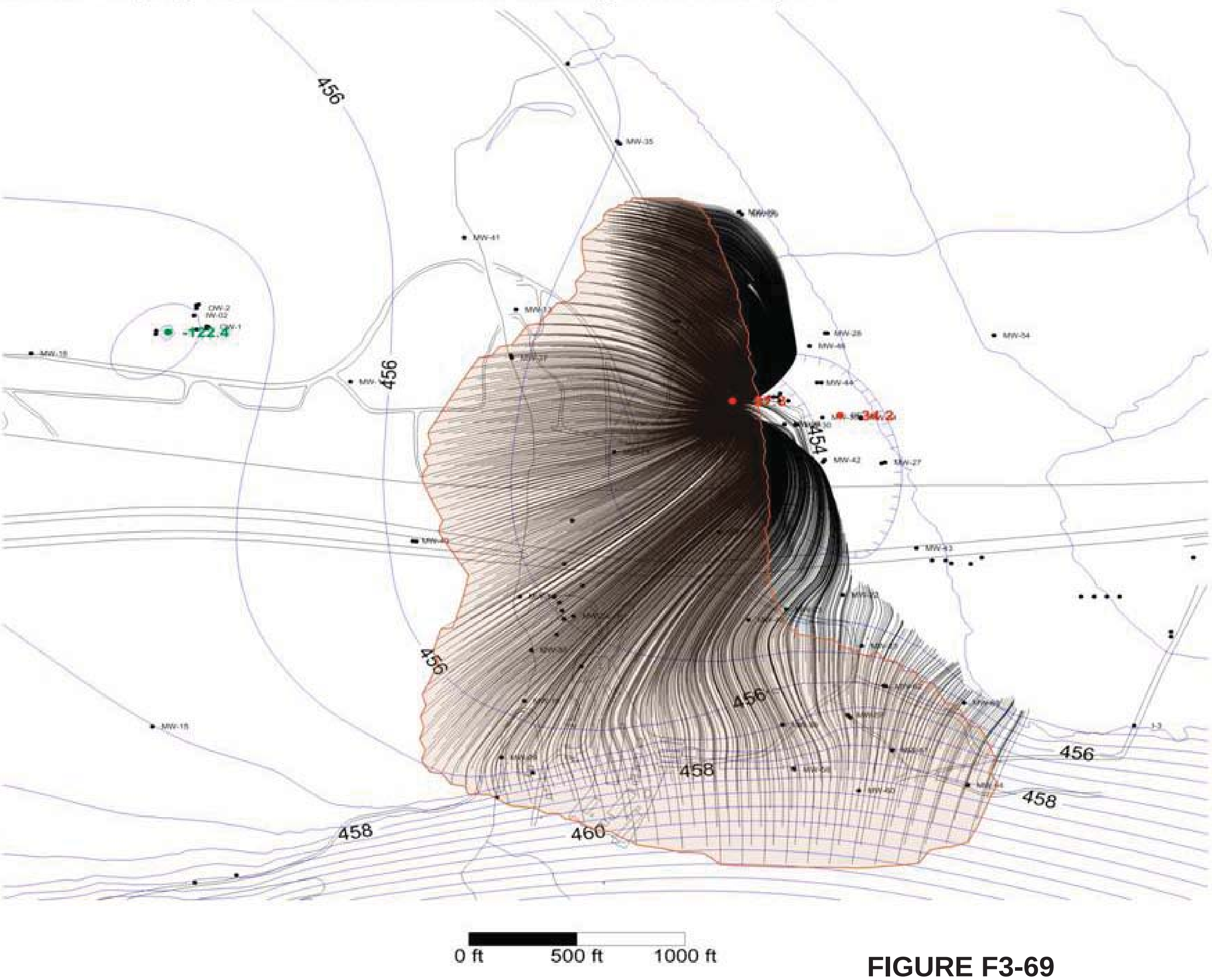
Green = Injection Well Rate (gpm)

gpm = gallons per minute

FIGURE F3-68
ALTERNATIVE H: DOWNSTREAM FLOWLINES STARTING IN MODEL LAYER 4

FINAL GROUNDWATER CORRECTIVE MEASURES STUDY/
FEASIBILITY STUDY REPORT FOR SWMU 1/AOC 1 and AOC 10
PG&E TOPOCK COMPRESSOR STATION
NEEDLES, CALIFORNIA

CH2MHILL



▨ = Plume capture target area for this model layer

Red = Extraction Well Rate (gpm)

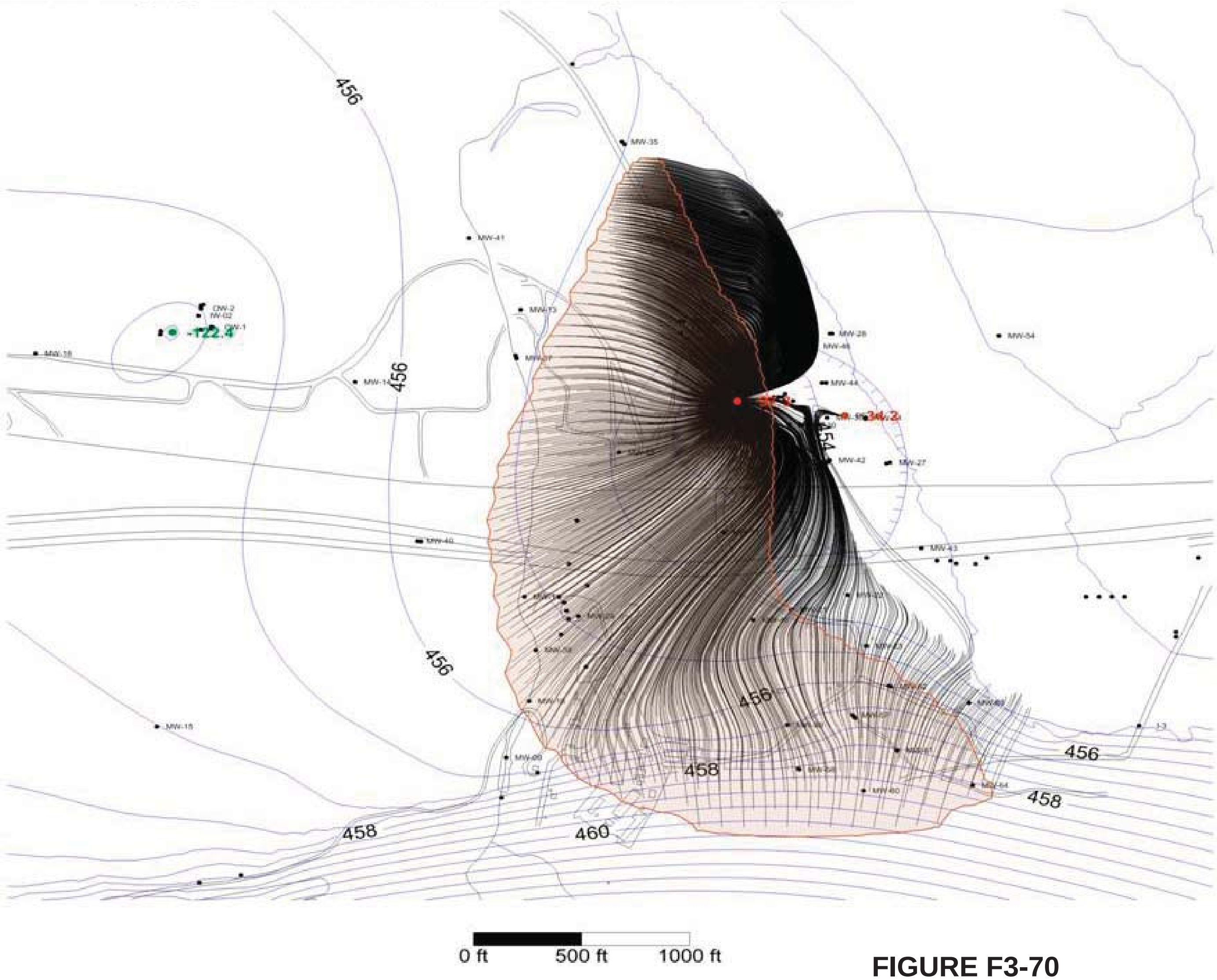
Green = Injection Well Rate (gpm)

gpm = gallons per minute

FIGURE F3-69
CURRENT PUMPING: DOWNSTREAM FLOWLINES STARTING IN MODEL LAYER 1

FINAL GROUNDWATER CORRECTIVE MEASURES STUDY/
FEASIBILITY STUDY REPORT FOR SWMU 1/AOC 1 and AOC 10
PG&E TOPOCK COMPRESSOR STATION
NEEDLES, CALIFORNIA

CH2MHILL



▨ = Plume capture target area for this model layer

Red = Extraction Well Rate (gpm)

Green = Injection Well Rate (gpm)

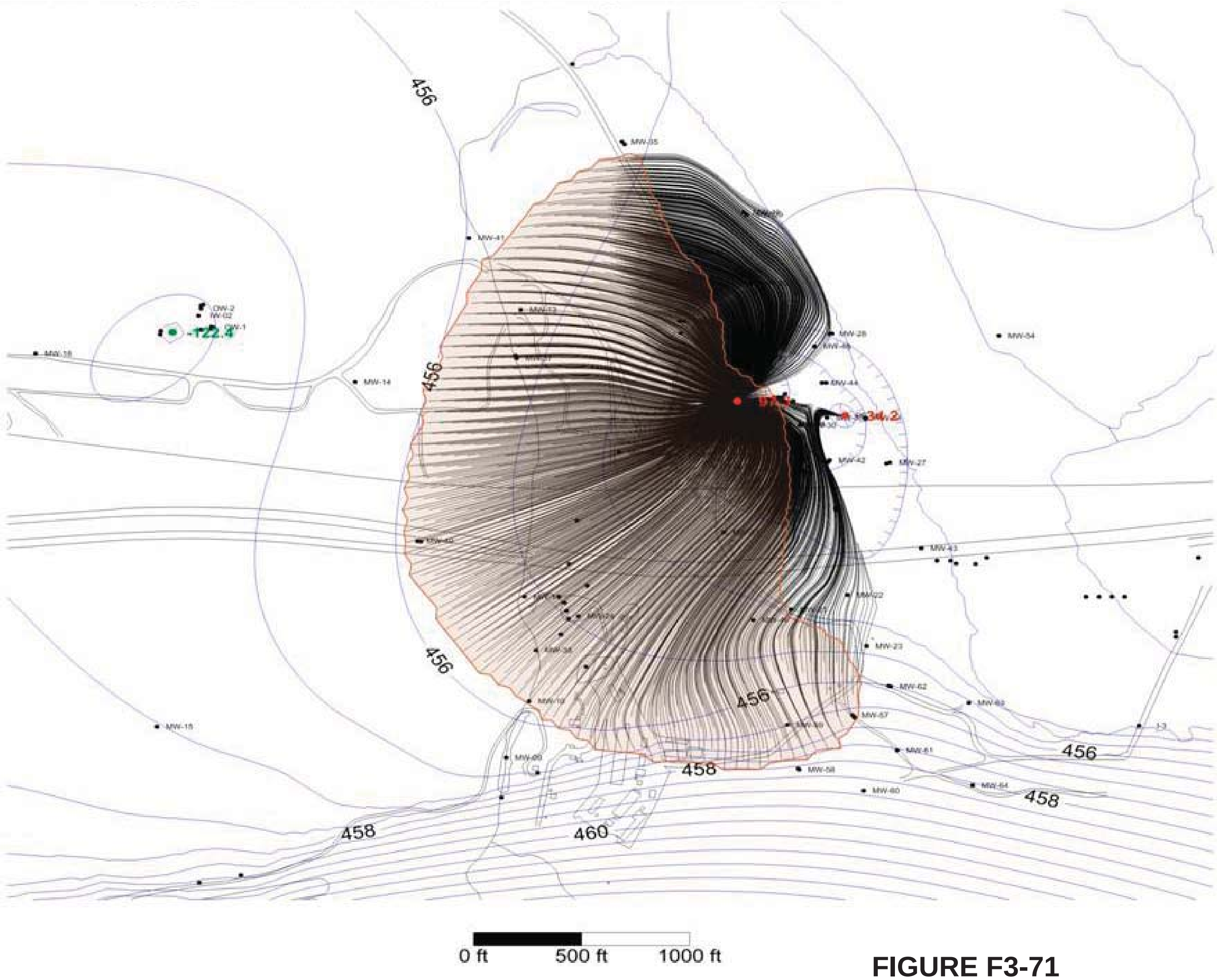
gpm = gallons per minute

N

FIGURE F3-70
CURRENT PUMPING: DOWNSTREAM FLOWLINES STARTING IN MODEL LAYER 2

FINAL GROUNDWATER CORRECTIVE MEASURES STUDY/
FEASIBILITY STUDY REPORT FOR SWMU 1/AOC 1 and AOC 10
PG&E TOPOCK COMPRESSOR STATION
NEEDLES, CALIFORNIA

CH2MHILL



▨ = Plume capture target area for
this model layer

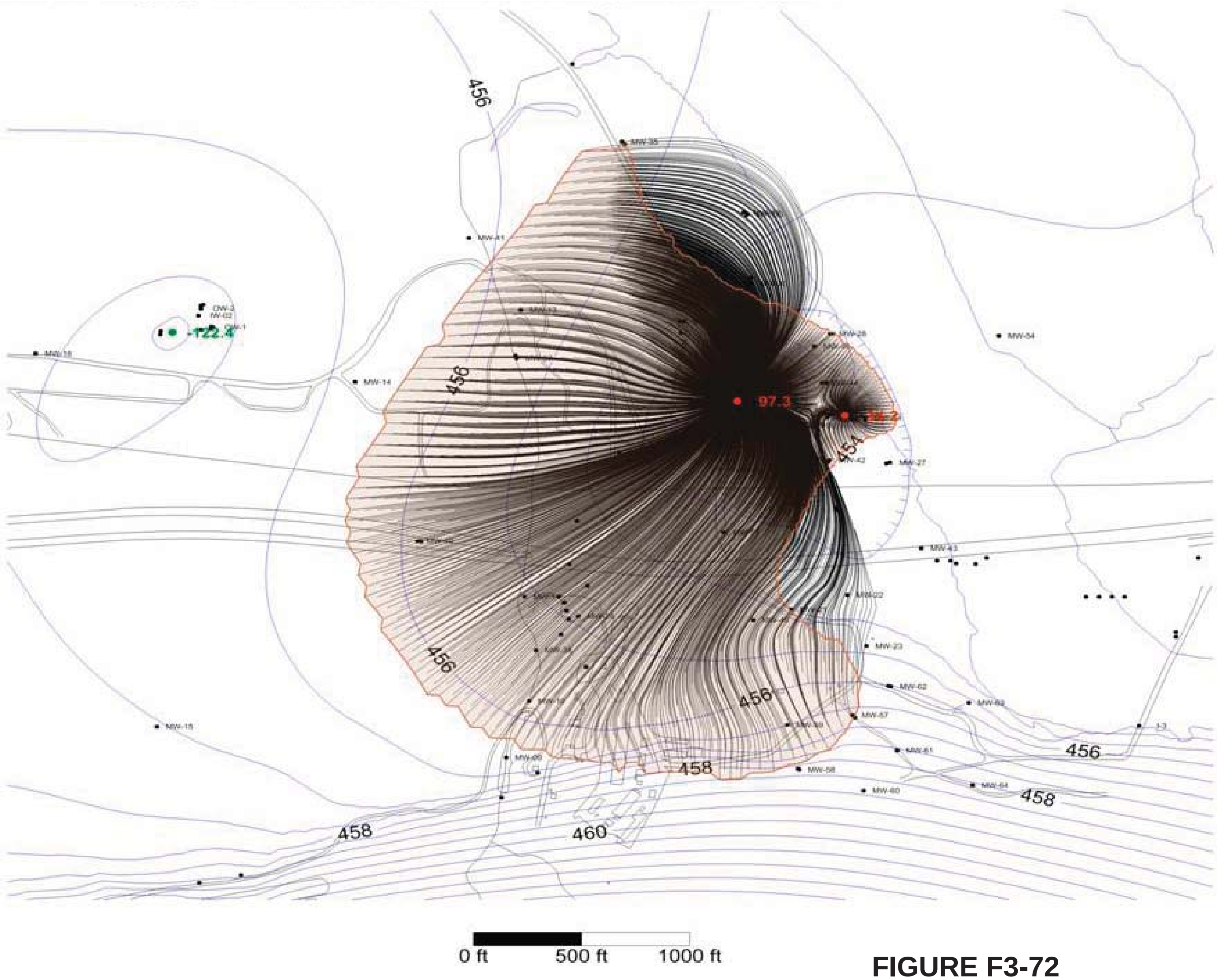
Red = Extraction Well Rate (gpm)

Green = Injection Well Rate (gpm)

gpm = gallons per minute

FIGURE F3-71
CURRENT PUMPING:
DOWNSTREAM FLOWLINES
STARTING IN MODEL LAYER 3

FINAL GROUNDWATER CORRECTIVE MEASURES STUDY/
FEASIBILITY STUDY REPORT FOR SWMU 1/AOC 1 and AOC 10
PG&E TOPOCK COMPRESSOR STATION
NEEDLES, CALIFORNIA



▨ = Plume capture target area for this model layer

Red = Extraction Well Rate (gpm)

Green = Injection Well Rate (gpm)

gpm = gallons per minute

FIGURE F3-72
CURRENT PUMPING: DOWNSTREAM FLOWLINES STARTING IN MODEL LAYER 4

FINAL GROUNDWATER CORRECTIVE MEASURES STUDY/
FEASIBILITY STUDY REPORT FOR SWMU 1/AOC 1 and AOC 10
PG&E TOPOCK COMPRESSOR STATION
NEEDLES, CALIFORNIA

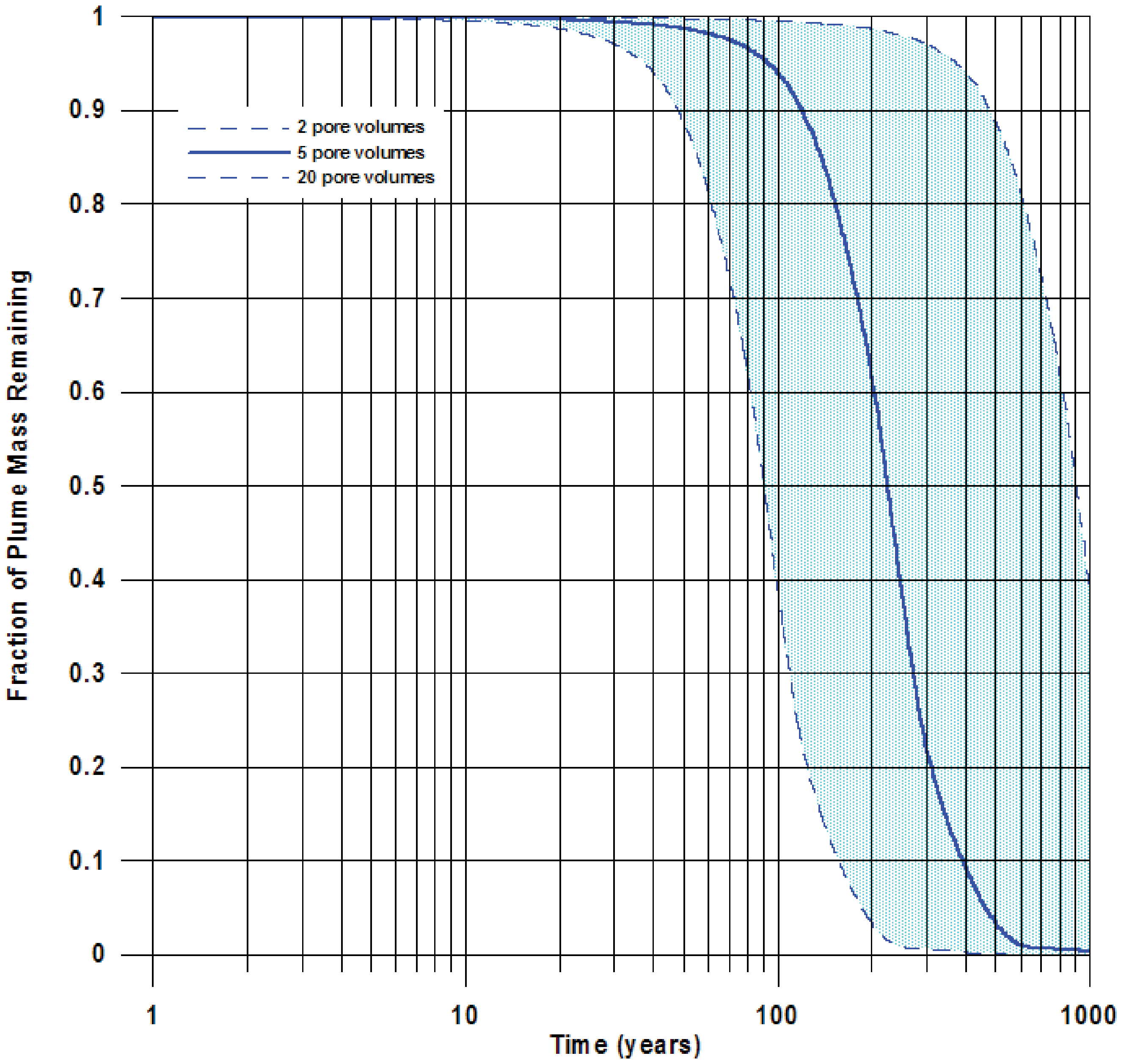


FIGURE F4-1
MOBILE PORE VOLUMES FLUSHED VS PLUME MASS
ALTERNATIVE A – NO REMEDIAL PUMPING
ALTERNATIVE B – NATURAL ATTENUATION

FINAL GROUNDWATER CORRECTIVE MEASURES STUDY/
FEASIBILITY STUDY REPORT FOR SWMU 1/AOC 1 and AOC 10
PG&E TOPOCK COMPRESSOR STATION
NEEDLES, CALIFORNIA

CH2MHILL

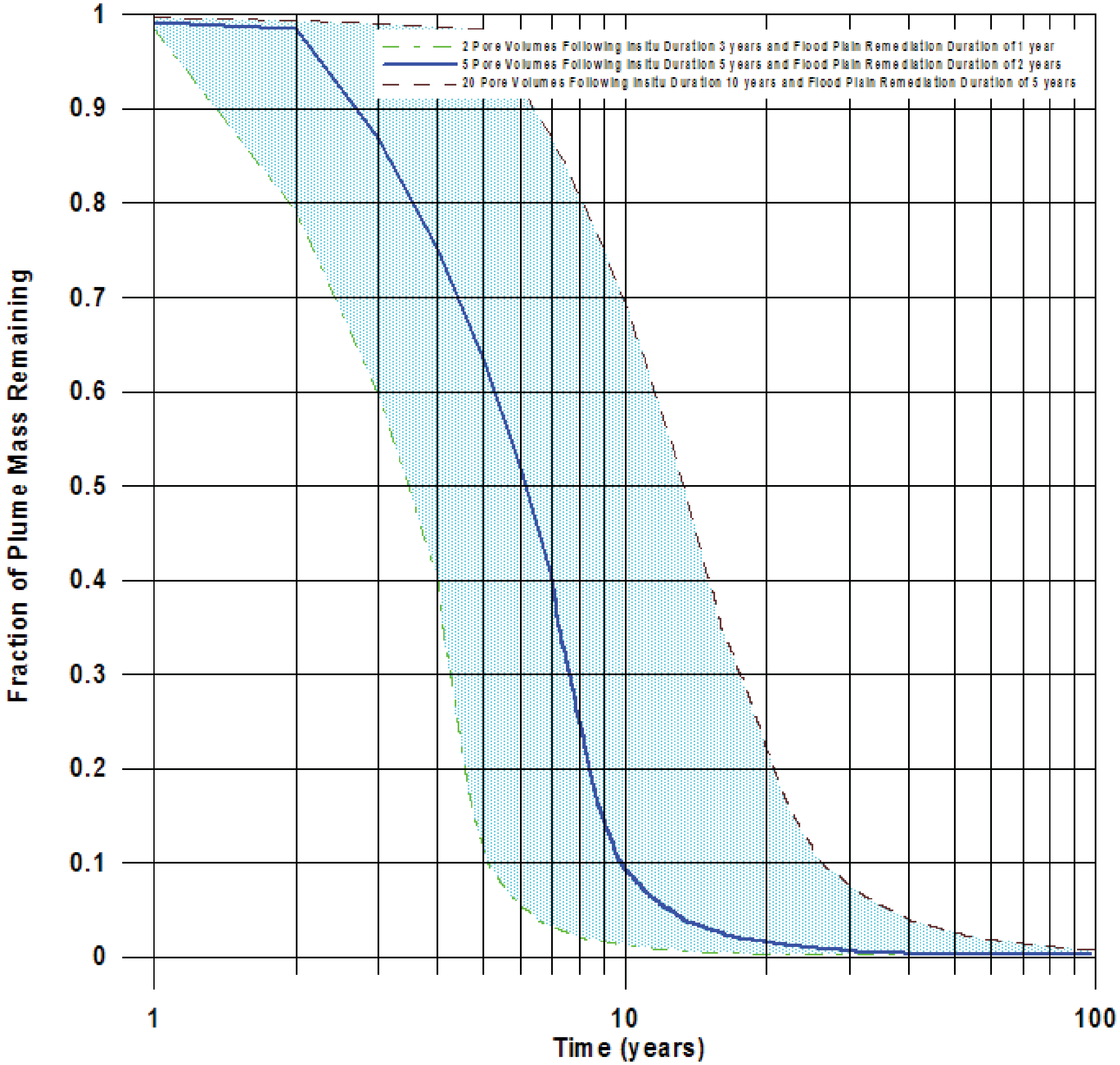


FIGURE F4-2
MOBILE PORE VOLUMES FLUSHED VS PLUME MASS ALTERNATIVE C – HIGH VOLUME IN-SITU TREATMENT

FINAL GROUNDWATER CORRECTIVE MEASURES STUDY/
FEASIBILITY STUDY REPORT FOR SWMU 1/AOC 1 and AOC 10
PG&E TOPOCK COMPRESSOR STATION
NEEDLES, CALIFORNIA

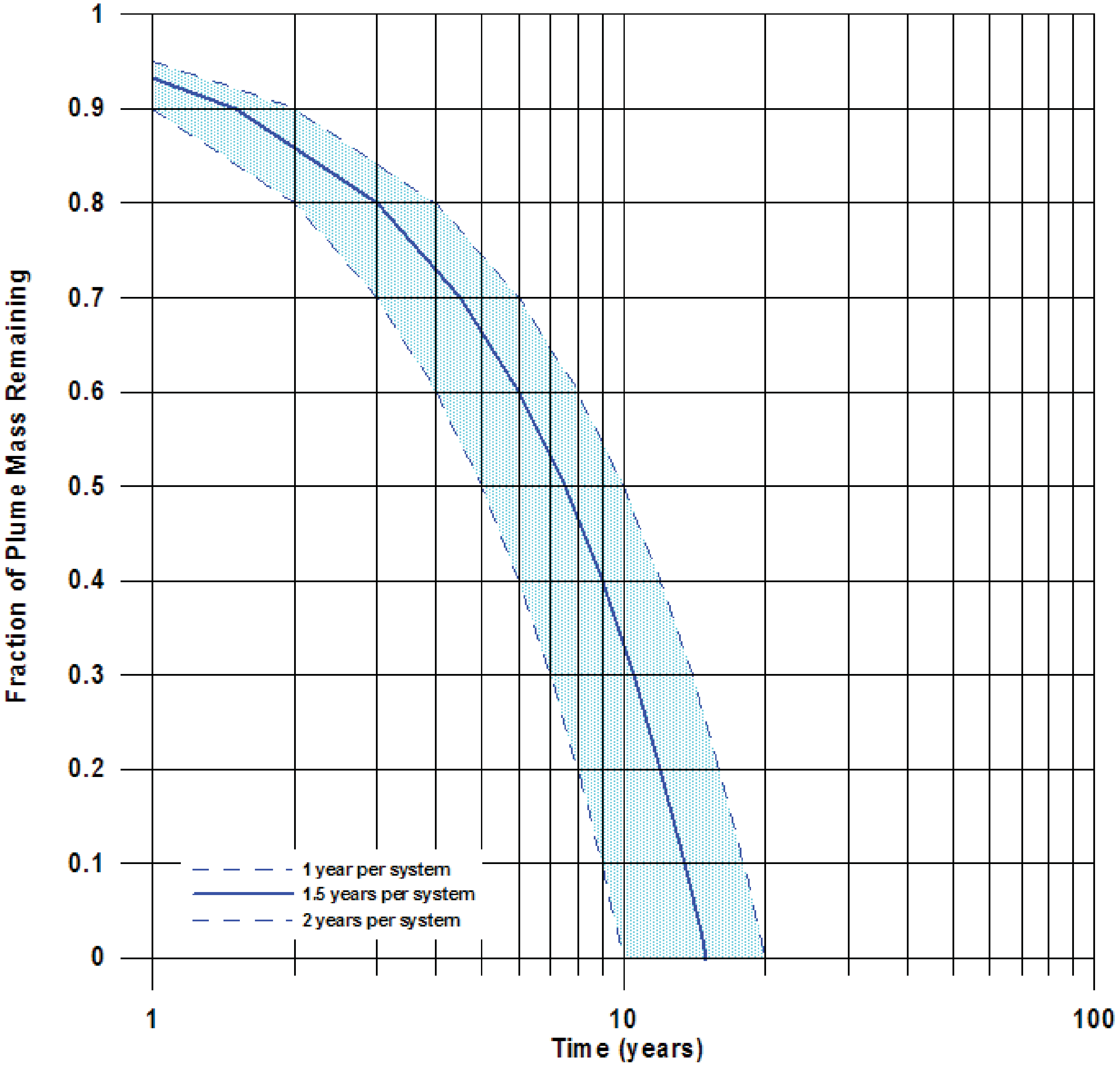


FIGURE F4-3
MOBILE PORE VOLUMES FLUSHED VS PLUME MASS ALTERNATIVE D – SEQUENTIAL IN SITU TREATMENT

FINAL GROUNDWATER CORRECTIVE MEASURES STUDY/
FEASIBILITY STUDY REPORT FOR SWMU 1/AOC 1 and AOC 10
PG&E TOPOCK COMPRESSOR STATION
NEEDLES, CALIFORNIA

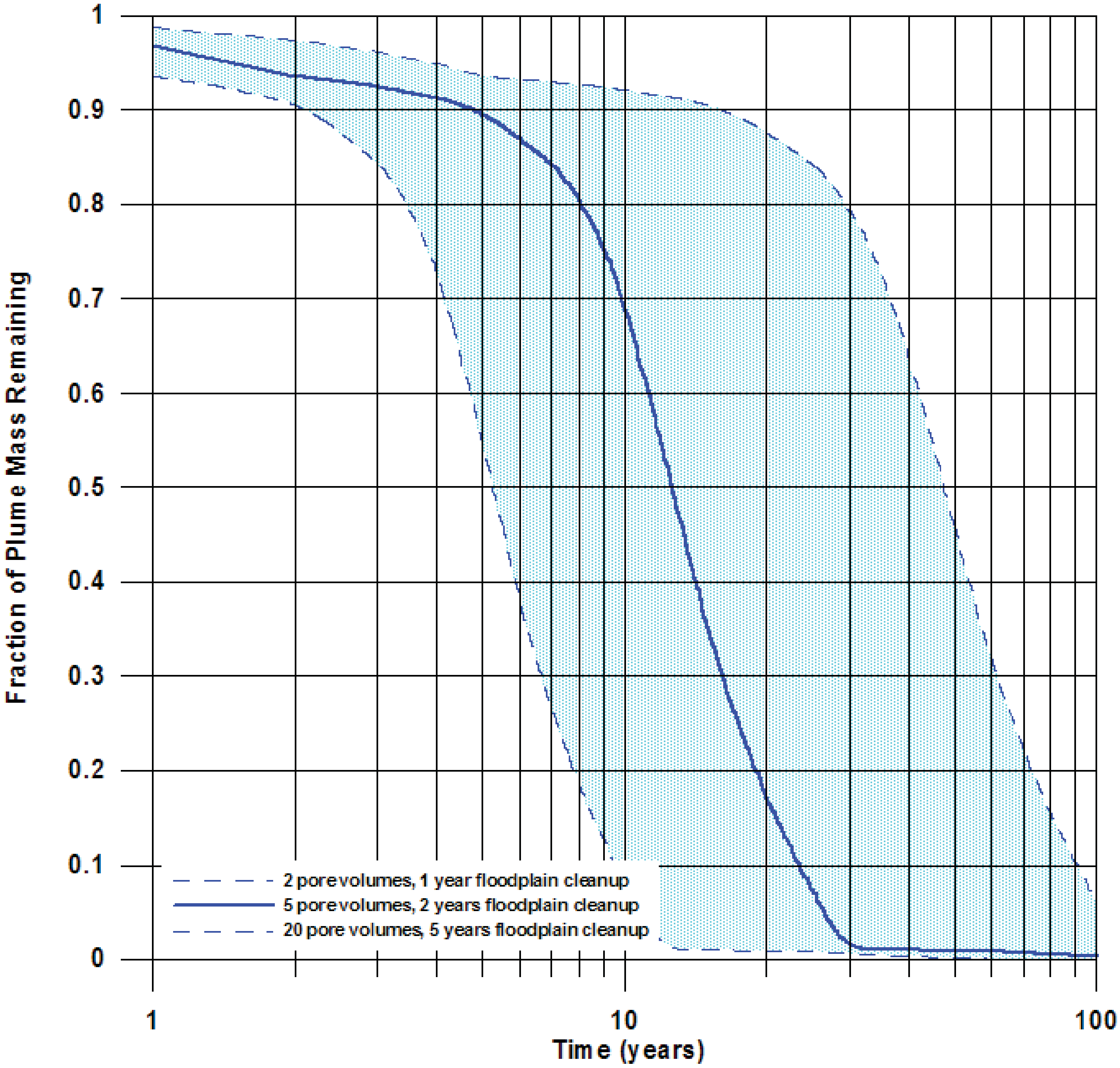


FIGURE F4-4
MOBILE PORE VOLUMES FLUSHED VS PLUME MASS
ALTERNATIVE E – IN SITU TREATMENT WITH FRESHWATER FLUSHING AND RECIRCULATION

FINAL GROUNDWATER CORRECTIVE MEASURES STUDY/
FEASIBILITY STUDY REPORT FOR SWMU 1/AOC 1 and AOC 10
PG&E TOPOCK COMPRESSOR STATION
NEEDLES, CALIFORNIA

CH2MHILL

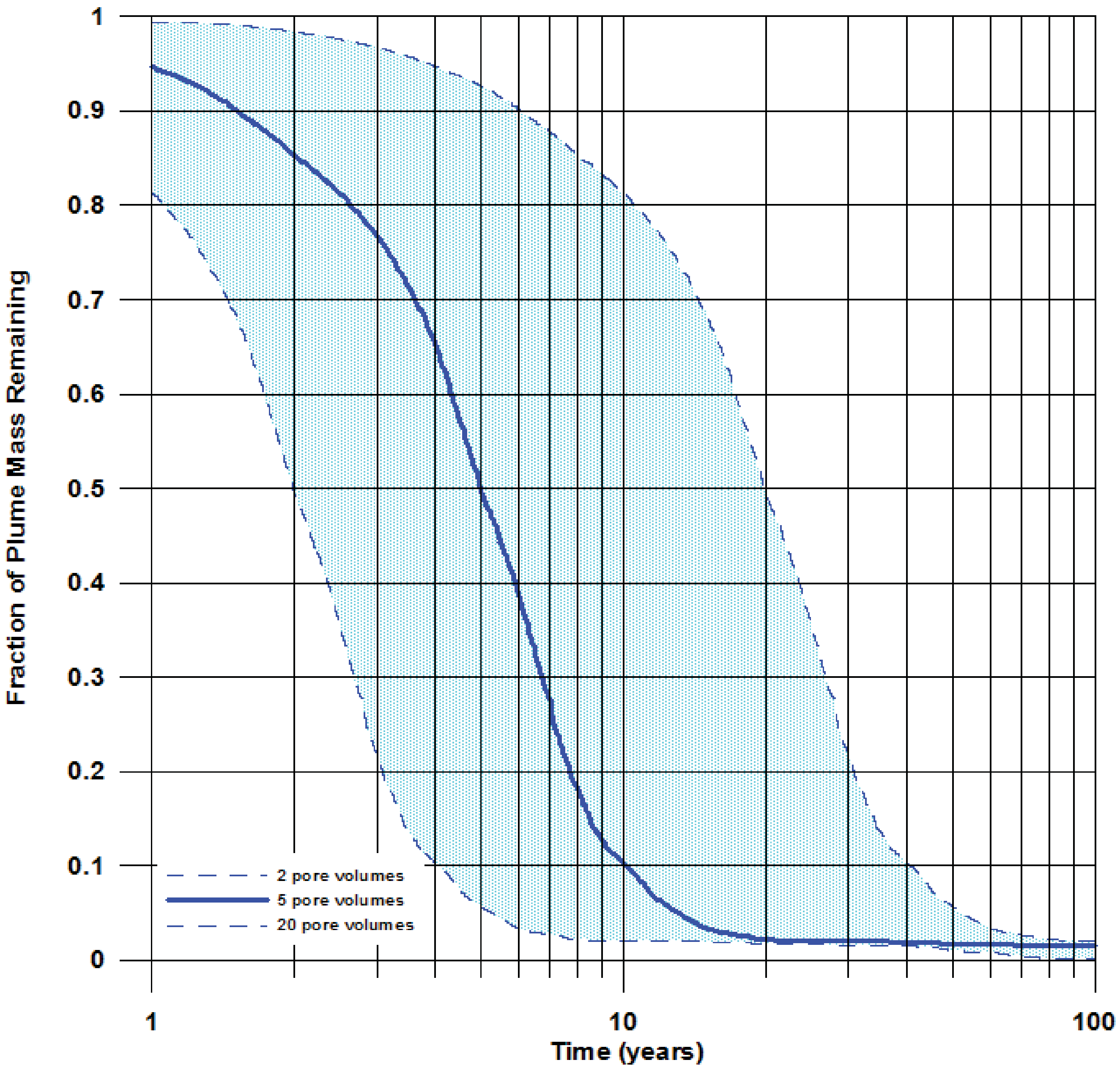


FIGURE F4-5
MOBILE PORE VOLUMES FLUSHED VS PLUME MASS
ALTERNATIVE F – PUMP AND TREAT

FINAL GROUNDWATER CORRECTIVE MEASURES STUDY/
FEASIBILITY STUDY REPORT FOR SWMU 1/AOC 1 and AOC 10
PG&E TOPOCK COMPRESSOR STATION
NEEDLES, CALIFORNIA

CH2MHILL

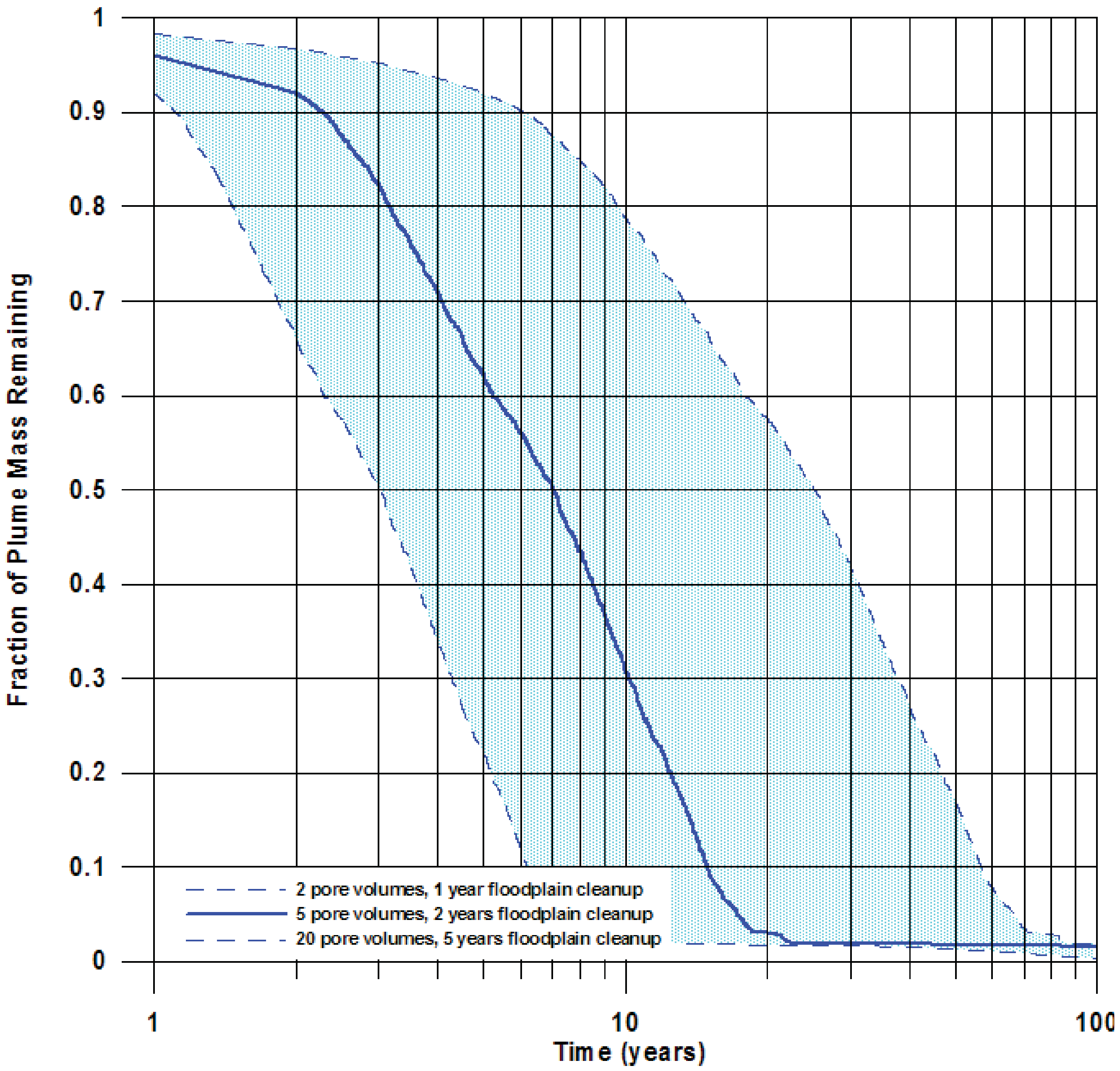


FIGURE F4-6
MOBILE PORE VOLUMES FLUSHED VS PLUME MASS
ALTERNATIVE G – COMBINED FLOODPLAIN IN SITU/PUMP AND TREAT

FINAL GROUNDWATER CORRECTIVE MEASURES STUDY/
FEASIBILITY STUDY REPORT FOR SWMU 1/AOC 1 and AOC 10
PG&E TOPOCK COMPRESSOR STATION
NEEDLES, CALIFORNIA

CH2MHILL

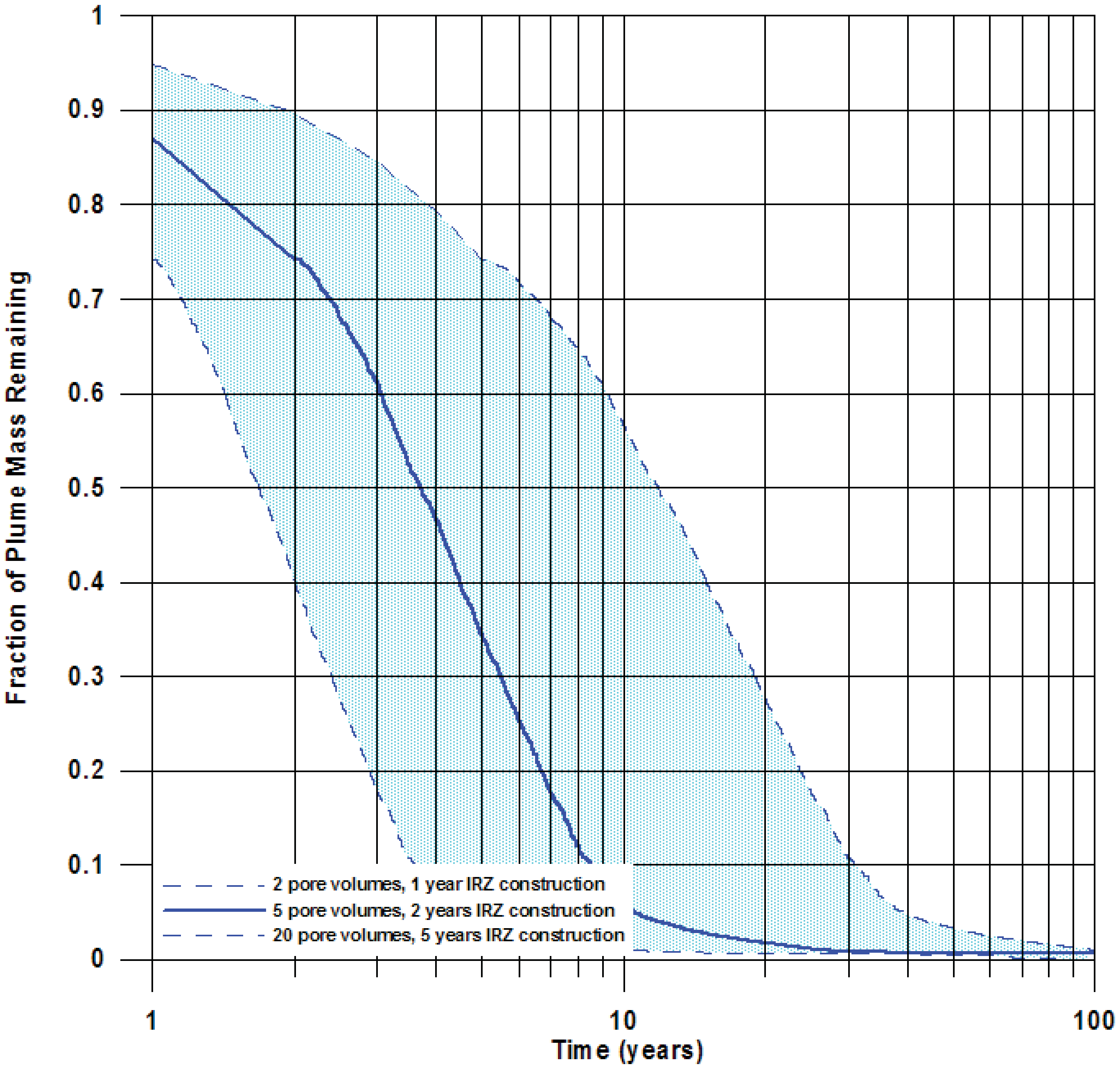


FIGURE F4-7
MOBILE PORE VOLUMES FLUSHED VS PLUME MASS
ALTERNATIVE H – COMBINED UPLAND IN SITU/PUMP AND TREAT

FINAL GROUNDWATER CORRECTIVE MEASURES STUDY/
FEASIBILITY STUDY REPORT FOR SWMU 1/AOC 1 and AOC 10
PG&E TOPOCK COMPRESSOR STATION
NEEDLES, CALIFORNIA

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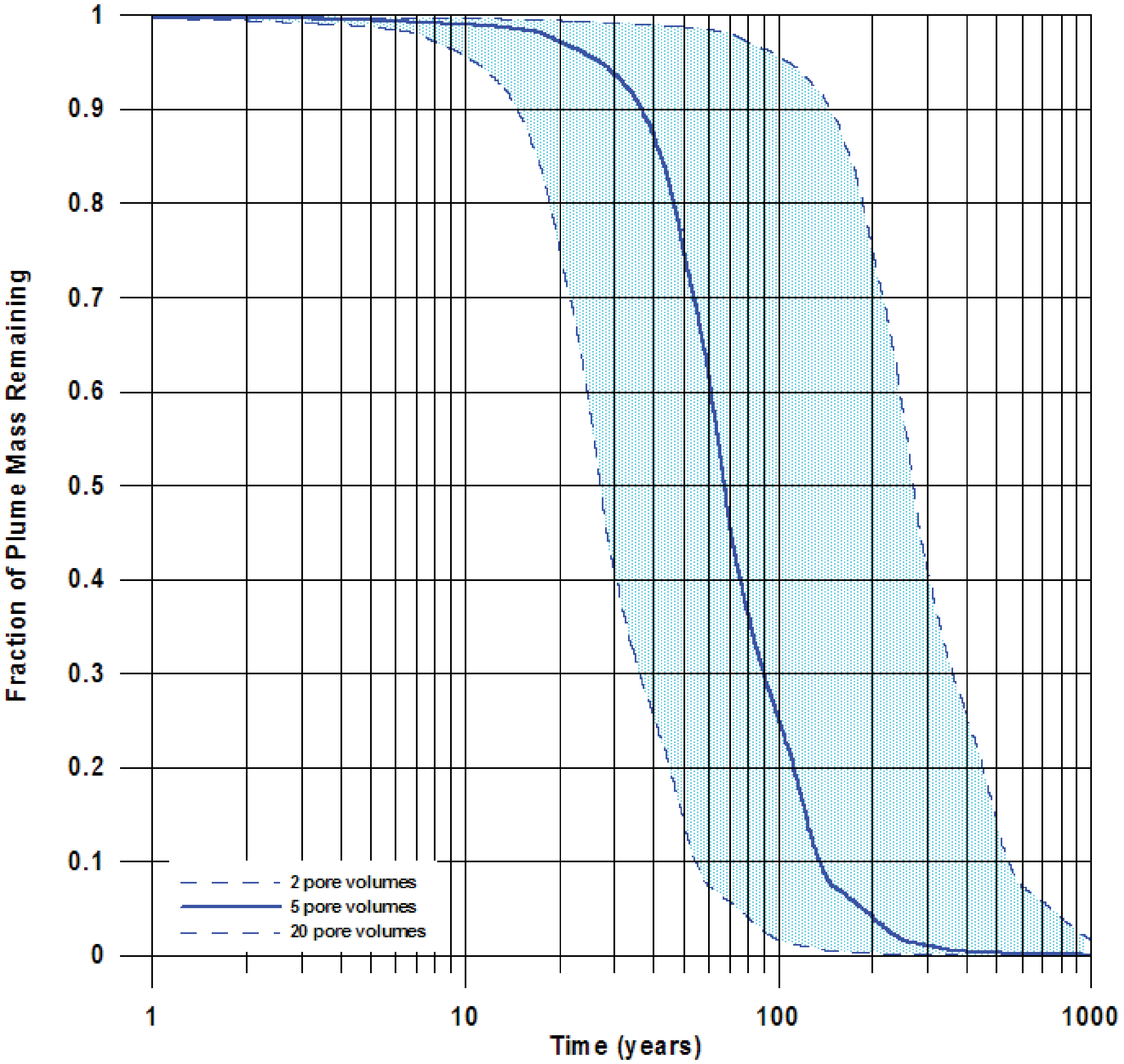

FIGURE F4-8
MOBILE PORE VOLUMES FLUSHED VS PLUME MASS
ALTERNATIVE I – CURRENT PUMPING

FINAL GROUNDWATER CORRECTIVE MEASURES STUDY/
FEASIBILITY STUDY REPORT FOR SWMU 1/AOC 1 and AOC 10
PG&E TOPOCK COMPRESSOR STATION
NEEDLES, CALIFORNIA

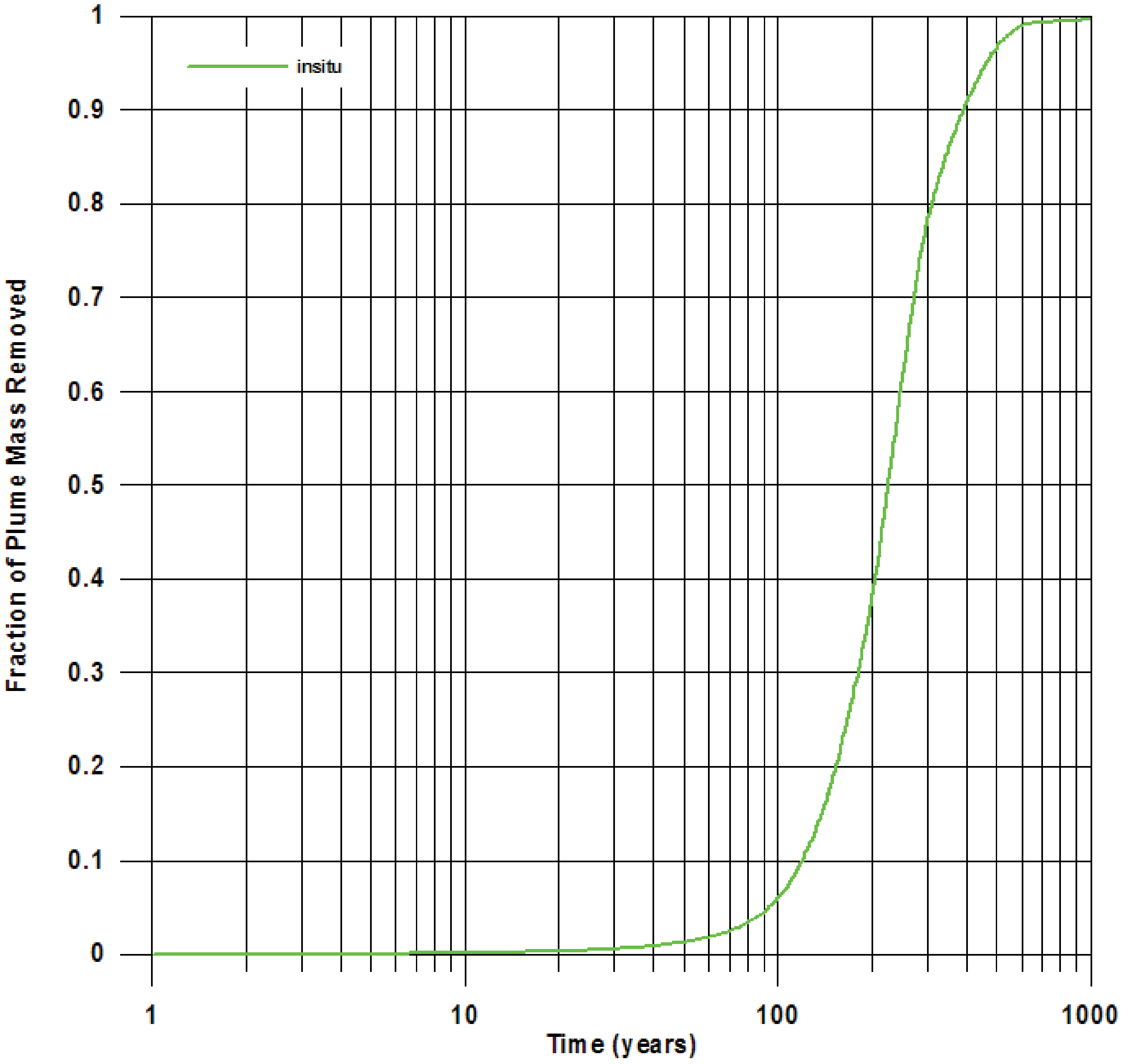

FIGURE F4-9
ESTIMATED RATE OF MASS REMOVAL OVER TIME ALTERNATIVE A (NO ACTION) ALTERNATIVE B (MONITORED NATURAL ATTENUATION)

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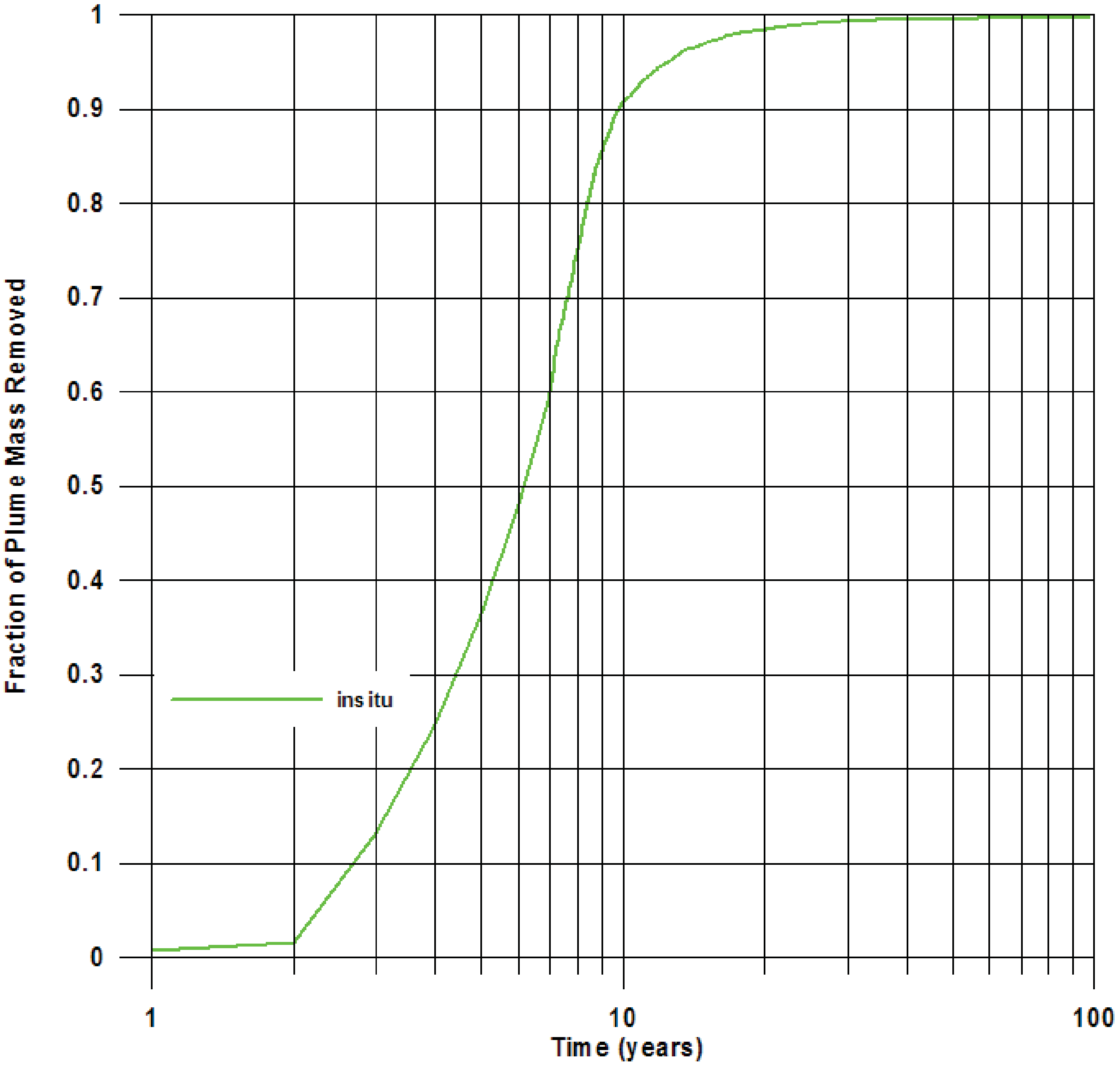

FIGURE F4-10
ESTIMATED RATE OF MASS REMOVAL OVER TIME ALTERNATIVE C (HIGH VOLUME IN-SITU TREATMENT)

FINAL GROUNDWATER CORRECTIVE MEASURES STUDY/
FEASIBILITY STUDY REPORT FOR SWMU 1/AOC 1 and AOC 10
PG&E TOPOCK COMPRESSOR STATION
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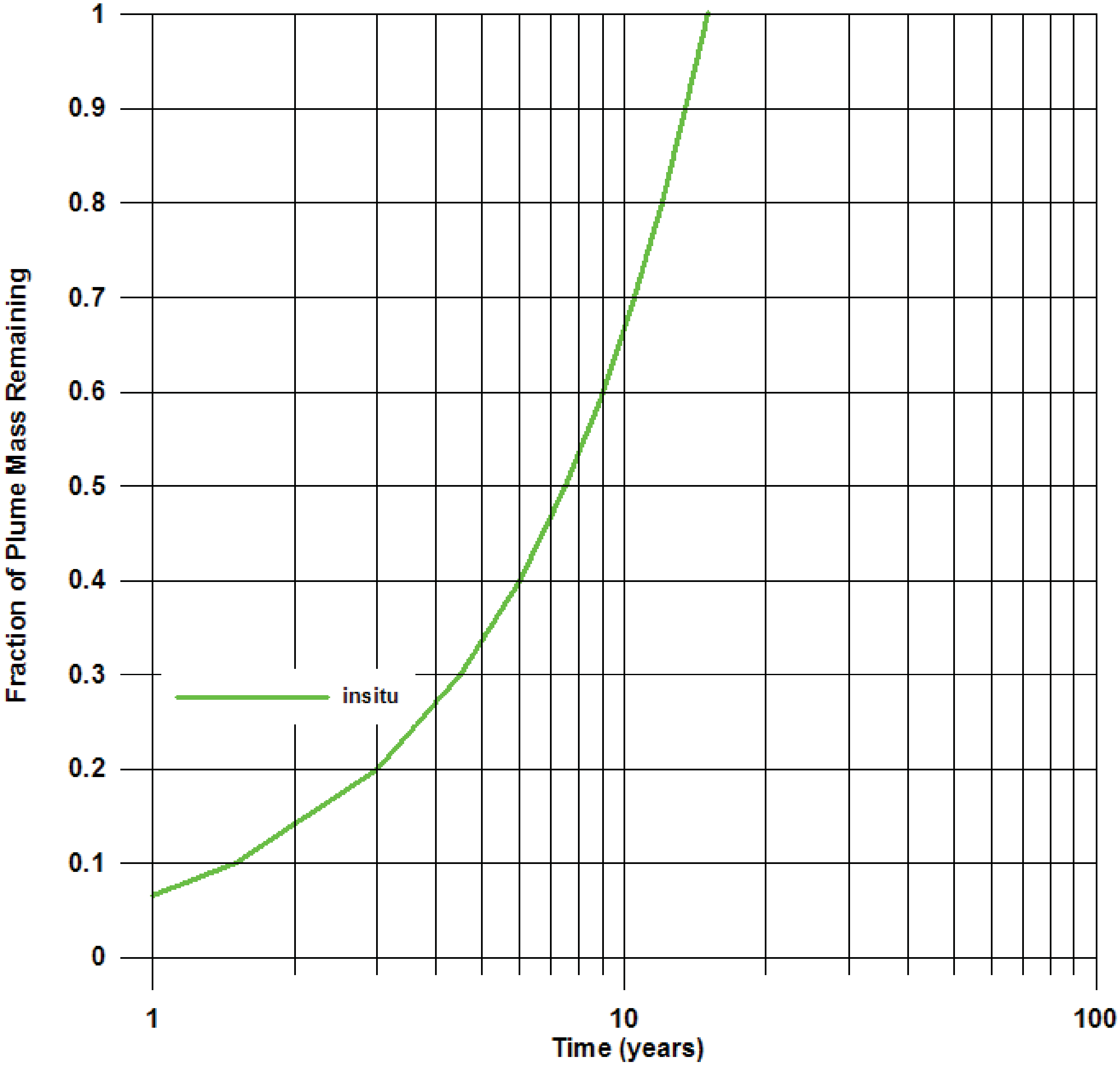

FIGURE F4-11
ESTIMATED RATE OF MASS REMOVAL OVER TIME ALTERNATIVE D (SEQUENTIAL IN-SITU TREATMENT)

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FEASIBILITY STUDY REPORT FOR SWMU 1/AOC 1 and AOC 10
PG&E TOPOCK COMPRESSOR STATION
NEEDLES, CALIFORNIA

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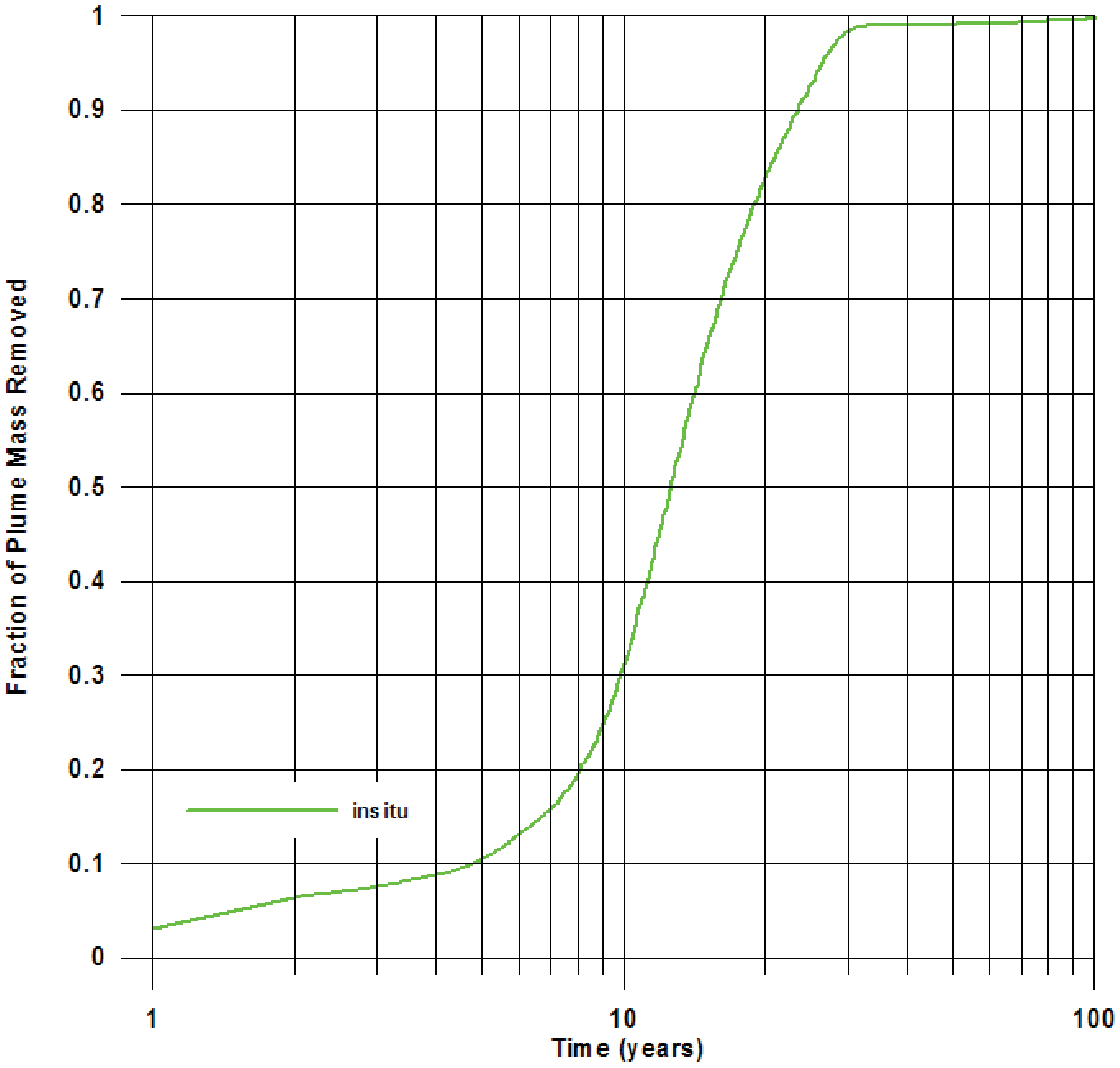

FIGURE F4-12
ESTIMATED RATE OF MASS REMOVAL OVER TIME ALTERNATIVE E (IN-SITU TREATMENT WITH FRESHWATER FLUSHING)

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FEASIBILITY STUDY REPORT FOR SWMU 1/AOC 1 and AOC 10
PG&E TOPOCK COMPRESSOR STATION
NEEDLES, CALIFORNIA

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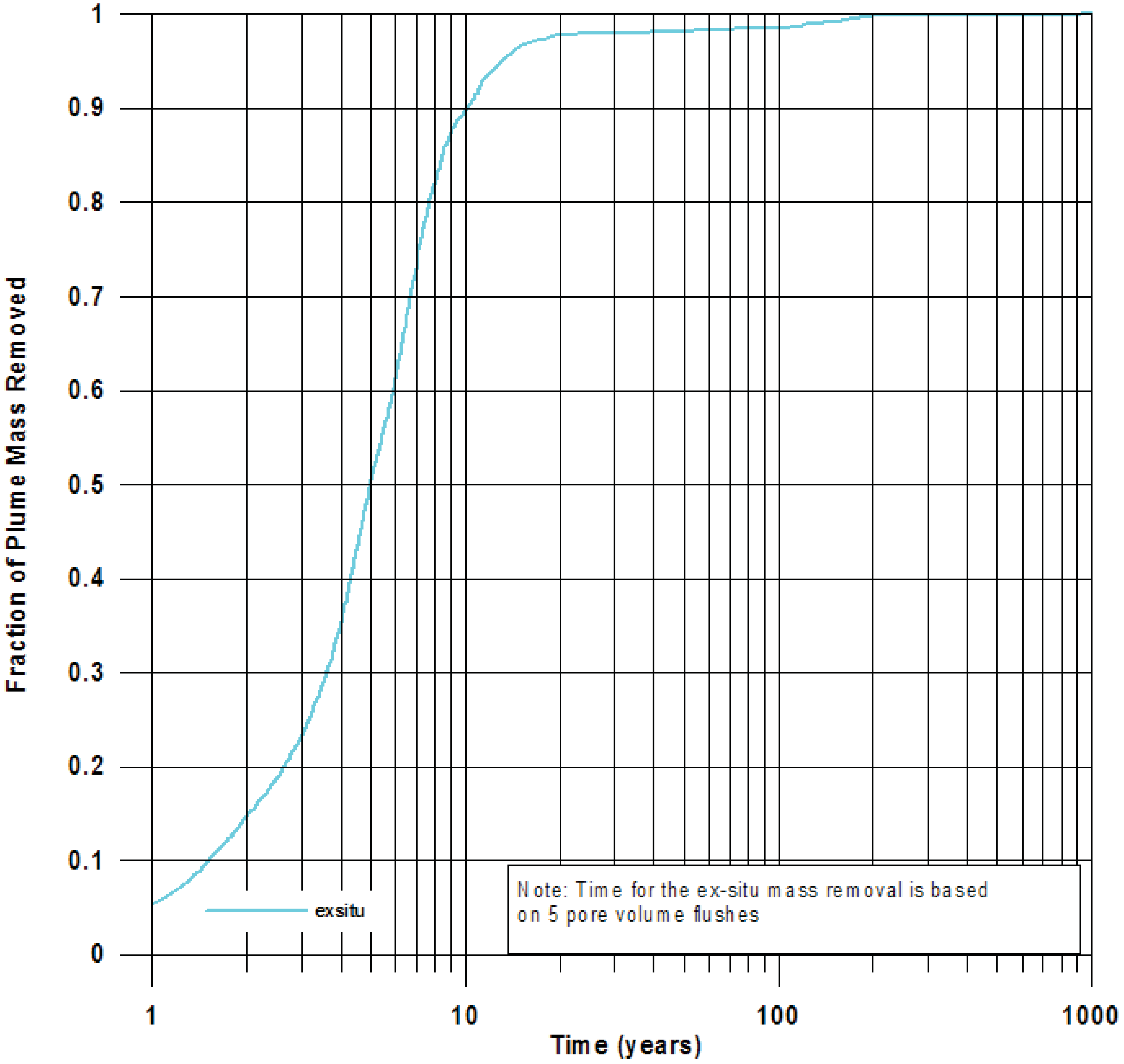

FIGURE F4-13
ESTIMATED RATE OF MASS REMOVAL OVER TIME ALTERNATIVE F (PUMP AND TREAT)

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FEASIBILITY STUDY REPORT FOR SWMU 1/AOC 1 and AOC 10
PG&E TOPOCK COMPRESSOR STATION
NEEDLES, CALIFORNIA

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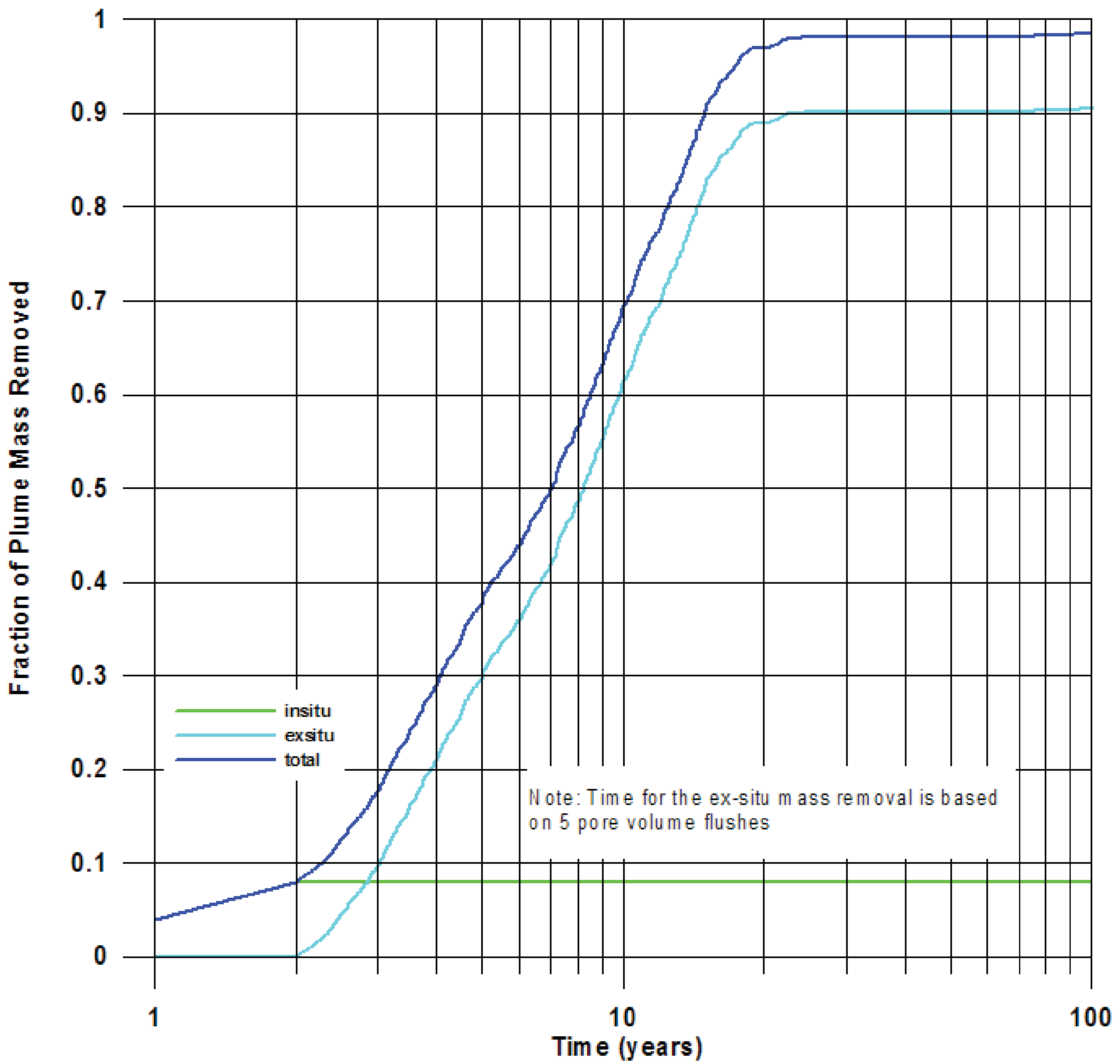

FIGURE F4-14
ESTIMATED RATE OF MASS REMOVAL OVER TIME ALTERNATIVE G (COMBINED FLOODPLAIN IN SITU/PUMP AND TREAT)

FINAL GROUNDWATER CORRECTIVE MEASURES STUDY/
FEASIBILITY STUDY REPORT FOR SWMU 1/AOC 1 and AOC 10
PG&E TOPOCK COMPRESSOR STATION
NEEDLES, CALIFORNIA

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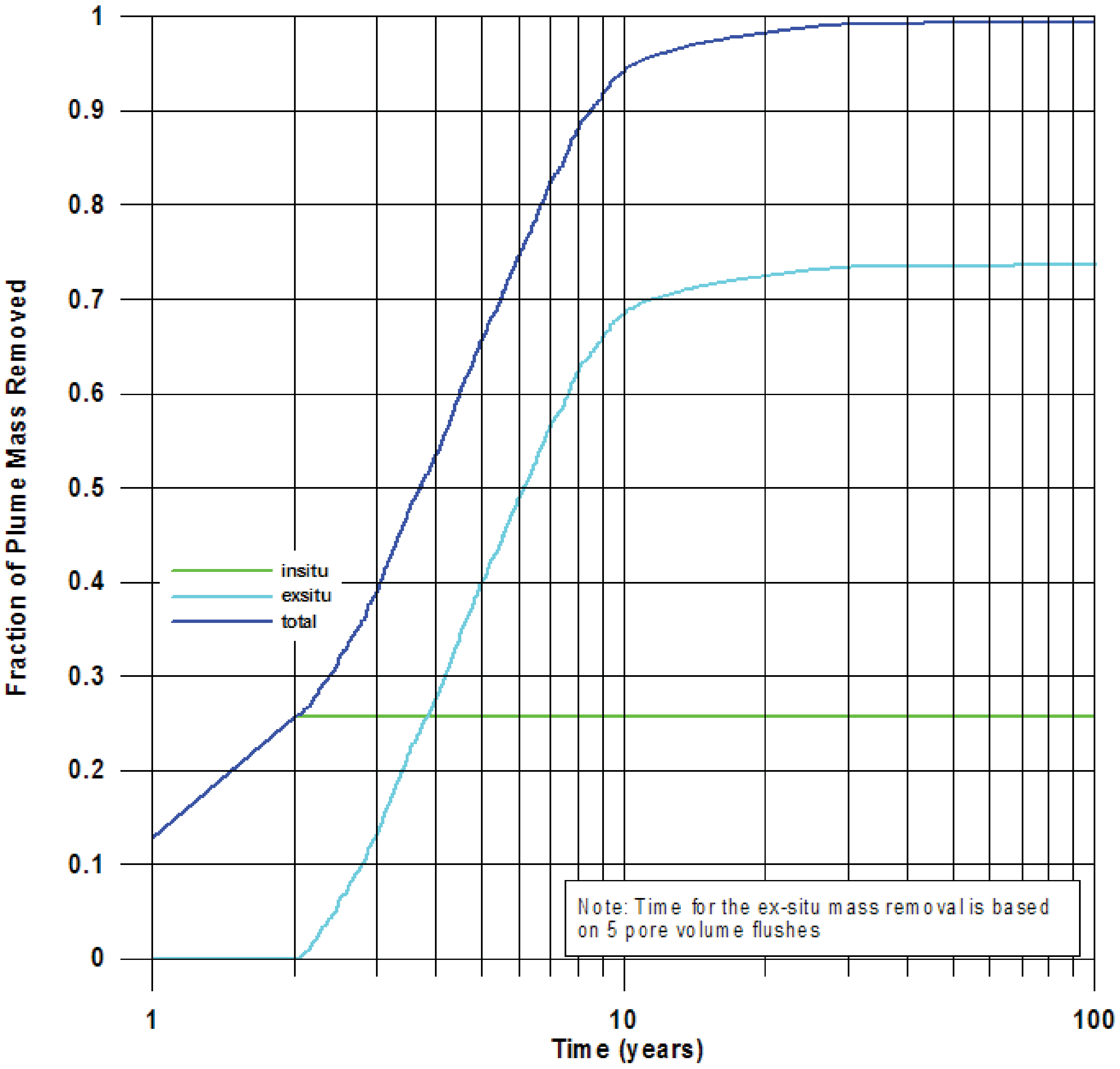

FIGURE F4-15
ESTIMATED RATE OF MASS REMOVAL OVER TIME ALTERNATIVE H (COMBINED UPLAND IN SITU/PUMP AND TREAT)

FINAL GROUNDWATER CORRECTIVE MEASURES STUDY/
FEASIBILITY STUDY REPORT FOR SWMU 1/AOC 1 and AOC 10
PG&E TOPOCK COMPRESSOR STATION
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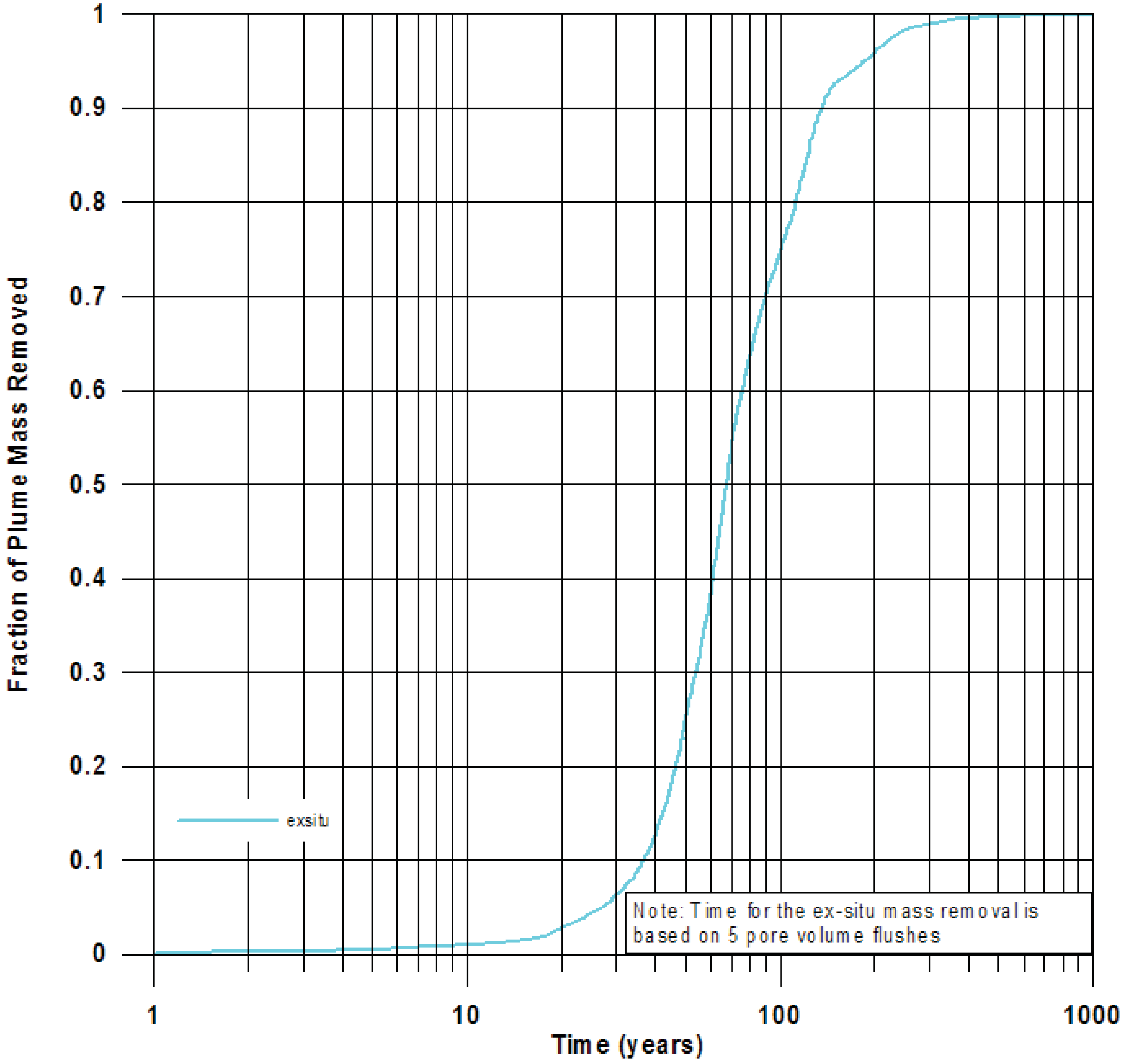

FIGURE F4-16
ESTIMATED RATE OF MASS REMOVAL OVER TIME ALTERNATIVE I (CONTINUED OPERATION OF INTERIM MEASURE)

FINAL GROUNDWATER CORRECTIVE MEASURES STUDY/
FEASIBILITY STUDY REPORT FOR SWMU 1/AOC 1 and AOC 10
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NEEDLES, CALIFORNIA

Appendix G

Supporting Information for *In-situ* Treatment Design Elements

ARCADIS
Infrastructure, environment, buildings

Imagine the result

PG&E Topock Compressor Station
Needles, California

In-Situ Reactive Zone Treatment Design Elements

Corrective Measures/Feasibility Study Report for
Chromium in Groundwater

Final

ARCADIS

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In-Situ Reactive Zone Treatment Design Elements

Corrective Measures/Feasibility Study Report for Chromium in Groundwater

Final

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Our Ref.:
RC000689.0001.00003

Date:
11 December 2009

ARCADIS

In-Situ Reactive Zone Treatment Design Elements

Corrective Measures/Feasibility Study Report for Chromium in Groundwater

Final

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Figures

1. Introduction

In support of the Corrective Measures/Feasibility Study Report for the Pacific Gas and Electric (PG&E) Topock Compressor Station (Topock), this appendix provides a summary of the *In-Situ* Reactive Zone (IRZ) technology being considered as part of several remedial alternatives. Following this brief introduction, relevant background is presented on the technology and specific process being considered for application at Topock, followed by brief discussions regarding field testing results, critical design elements, operation and monitoring of the technology, and the overall effectiveness and permanence of treatment.

2. Process Background

The term *In-Situ* Reactive Zone (IRZ) applies to a class of technologies through which the subsurface environment is manipulated to destroy or sequester contaminants. IRZs are created through the injection of reagents and can be biological in nature, chemical, or in some cases a combination of both. They can be configured as a barrier to contaminant migration, or for mass-reduction throughout a plume. Such technologies have often provided more effective options for restoring groundwater quality, by allowing lower endpoints to be achieved and by overcoming the physical, chemical, and kinetic limitations of conventional (physical) treatment. On the other hand, the complexity of treatment can be greater because it takes place in the porous media where the groundwater resides.

At the Topock Compressor Station, IRZ technology is being considered for the biologically-mediated treatment of hexavalent chromium (Cr[VI]). This involves the stimulation of native microorganisms through the delivery of a degradable source of organic carbon. The goal of this process is to overcome the aquifer's supply of aerobic electron acceptors (primarily oxygen and nitrate), to reach iron and sulfate reducing conditions. In this environment, microorganisms can support the reduction of Cr(VI) by a variety of mechanisms. While this includes enzymatic extracellular reduction and intracellular reduction (Zhu et al, 2008), the primary mechanism may be through the reduction of naturally-occurring iron and sulfate (by microbial respiration) to create ferrous iron (Fe[II]) and sulfides (H2S, HS-) that can react abiotically with Cr(VI), reducing it to trivalent chromium (Cr[III]) and forming Cr(III)-hydroxide solids via the following reactions (reflective of circumneutral pH):

$$(1) 2CrO_4^{2-} + 3HS^- + 7H^+ \rightarrow 2Cr(OH)_{3(s)} + 3S^0_{(s)} + 2H_2O$$

$$(2) CrO_4^- + 3Fe^{2+} + 8H_2O \rightarrow Cr(OH)_{3(s)} + 3Fe(OH)_{3(s)} + 4H^+$$

It has also been found that in most groundwater systems, Cr(VI) can react with ferrous iron to form a mixed iron-chromium hydroxide that is considerably less soluble and more stable than pure chromium hydroxide (Sass and Rai 1987; Eary and Rai 1988), as follows:

$$(3) CrO_4^{2-} + 3Fe^{2+} + 8H_2O \rightarrow 4Fe_{0.75}Cr_{0.25}(OH)_{3(s)} + 4H^+$$

This process is designed to reductively precipitate and permanently fix/immobilize the chromium in the aquifer, thereby removing chromium from the groundwater.

In addition, anaerobic IRZs developed to treat Cr(VI) may also be beneficial for other metals that are found in groundwater at the site. For instance, under proper conditions, selenium can be reduced to form elemental selenium (a form of selenium with low solubility; or possibly iron selenide in the presence of sufficient ferrous iron), and molybdenum can be precipitated as a sulfide mineral (its most common natural form). Selenium, molybdenum, and nitrate will all be treated by a reductive *in-situ* approach, along with chromium, as follows:

- Nitrate is removed by denitrification forming nitrogen gas.
- Molybdenum exists as highly soluble molybdate in groundwater and it is transformed to very low solubility forms of molybdenum (sulfide) during *in-situ* treatment. The process is similar to chromate, where hexavalent Cr (Cr[VI]) is transformed to trivalent Cr (Cr[III]) which is much less soluble. Molybdenum is reduced from Mo(VI) to Mo(IV) and reacts with sulfide formed within the IRZ and precipitates as molybdenum sulfide.
- Selenium exists as highly soluble selenate in groundwater and it too is transformed to less soluble forms during *in-situ* treatment. Selenate (Se[VI]) is reduced to selenite (Se[IV]) and then to Se(0) and even Se(-II). Selenite can sorb to aquifer soil, Se(0) has very low solubility, and Se(-II) combines with iron to form iron selenide that also has very low solubility.

The reductive *in-situ* treatment will therefore create very low solubility forms of chromium, selenium and molybdenum. Along with chromium, the molybdenum and selenium are therefore effectively “locked up” in the aquifer solid phase after treatment.

When applying anaerobic IRZ technology, interactions with the solid aquifer matrix are unavoidable. This interaction can affect the stability of native minerals incorporated in the aquifer solids, and can temporarily mobilize certain naturally-occurring metals within the treatment zone (primarily iron, manganese, and arsenic). Such secondary effects are important to acknowledge, and can be successfully managed during system operation. In fact, some of these secondary effects are essential to the process, as in the case of iron dissolution. As previously mentioned, some fraction of the ferric iron in the aquifer minerals will be reductively dissolved. This iron is then available not only for immediate reaction with Cr(VI), but also to form reduced iron minerals that will remain reactive with Cr(VI). This includes ferrous iron sorbed to the surfaces of other iron minerals, mixed valance iron oxides and hydroxides such as magnetite and green rust, as well as iron sulfides and iron carbonates. All of these reduced iron minerals are effective for reaction with Cr(VI), and will continue to reduce Cr(VI) to Cr(III) and immobilize it following active carbon substrate injection. As will be discussed later, this presents the opportunity in certain scenarios to limit operational cycling of an IRZ system, where a short period of active operation could be followed by a much longer period of passive treatment with the injection system shut down/on standby.

3. Proof of Concept: Field Applications

Field-scale applications of the anaerobic IRZ approach have been implemented at both the PG&E Topock site and the PG&E Hinkley Compressor Station in Hinkley, California. To date, two field-scale pilot tests have been conducted at Topock, along with four field-scale efforts at Hinkley. These have clearly demonstrated that the IRZ process effectively removes Cr(VI) from groundwater and converts it to very low solubility Cr(III). Additional details are summarized in the following subsections.

3.1 Topock Floodplain (ARCADIS, 2008a)

This pilot test involved the periodic/batch injection of sodium lactate (degradable organic carbon substrate) into a single well cluster in order to develop the IRZ. Results indicated that Cr(VI) concentrations dropped from a maximum of 4,350 micrograms per liter (µg/L) to less than 0.2 µg/L, with the subsequent precipitation of Cr(III) sufficient to reduce total dissolved chromium concentrations to less than 1 µg/L. Following a period of 6 injections over 18 months, the reactive zone has continued to treat Cr(VI) to non-detect levels for at least 25 months following the final injection event.

While the IRZ operations were not focused on treatment of compounds other than Cr(VI), nitrate concentrations in well PT-1D decreased from pre-test concentrations of approximately 2.27 mg/L to below the 0.5 mg/L limit of detection.

3.2 Topock Uplands (ARCADIS, 2008b; ARCADIS, 2008c)

This pilot test involved the injection of ethanol (degradable organic carbon substrate) through a pair of continuously operated dual-screened circulation wells spaced 150-feet apart, a design that facilitates substrate distribution both laterally and vertically throughout the treatment area. This setup effectively delivered ethanol between the wells. Results indicated that within 5-months, Cr(VI) concentrations dropped from a maximum of 8,010 µg/L to less than 0.2 µg/L, with the subsequent precipitation of Cr(III) sufficient to reduce total dissolved chromium concentrations to less than 1 µg/L.

Again, while the IRZ operations were not focused on treatment of compounds other than Cr(VI), nitrate concentrations decreased from a maximum pre- test concentration of 30.4 mg N/L at PT-7M to not detected (0.5 mg/L N) at pilot test wells PT-7M, PT-7D, PT-8S, and MW-24A. In addition, molybdenum concentrations decreased from a maximum pre-treatment concentration of 203 µg/L in PT-7D to below the 5 µg/L limit of detection in PT-7M, PT-7D and MW-24A. Selenium concentrations decreased from a maximum pre-treatment concentration of 101 µg/L in PT-7M to below the 5 µg/L limits of detection in PT-7M, PT-7D and MW-24A.

3.3 Hinkley Cell 1 and Cell 2 (CH2MHill, 2005b; ARCADIS, 2008f)

The first field applications at Hinkley involved two small-scale pilot studies. The “Cell 1” pilot involved the use of sodium lactate as a degradable organic carbon substrate, and “Cell 2” made use of emulsified vegetable oil. Both studies were conducted from December 2004 through May of 2005 and the results demonstrated complete reduction of Cr(VI) within the pilot study area. Cr(VI) concentrations have remained below the limits of detection (0.2 µg/L) in both of these areas, approximately 4 years after the end of the injection activities, demonstrating the longevity of the reductive zones generated in these pilot studies.

3.4 Hinkley Central Area (ARCADIS, 2008d)

This involved construction of a 1,800-foot wide IRZ transect spanning the Central Area of the Hinkley Cr(VI) plume (see **Figure G1** for photos of typical system components). The objective of the system was to create an *in-situ* treatment barrier to prevent further downgradient migration of Cr(VI). Operation of the system has been ongoing since November of 2007, distributing an organic carbon substrate; initially lactate, and now ethanol (selected because it was a more cost-effective source of carbon for the Central Area system) through the operation of paired injection and extraction wells spaced 150 feet apart, perpendicular to the direction of groundwater flow. Within the first 4-months, Cr(VI) concentrations dropped to less than 1 µg/L across 80 percent of the barrier, with the subsequent precipitation of Cr(III) sufficient to reduce total dissolved chromium concentrations. Within 2 years, declining Cr(VI) concentrations were observed 900-1,100 feet downgradient of the IRZ barrier, as the treated water flowing out of the barrier began to reduce residual concentrations downgradient of the IRZ barrier.

3.5 Hinkley Source Area (ARCADIS, 2008e)

Following construction of the Hinkley Central Area system, a second recirculation-based system was constructed to target selected portions of the former Source Area. In this system, groundwater is recovered from a downgradient line of extraction wells, amended with lactate or ethanol, and delivered to two sets of upgradient injection wells: one located approximately 400 feet upgradient and the other located approximately 1,100 feet upgradient of the extraction wells. Operation of the system has been ongoing since May 2008. Within the first 2-months, Cr(VI) concentrations dropped from a maximum of 1,180 µg/L to less than 0.2 µg/L throughout an area approximately 250 by 400 feet, with the subsequent precipitation of Cr(III) sufficient to reduce total dissolved chromium concentrations to approximately 1 µg/L. The maximum Cr(VI) concentrations within the capture zone of the extraction wells was approximately 7,000 µg/L.

Other data collected during these field activities include substrate utilization rates (bulk attenuation half-lives), aquifer hydraulic characteristics controlling the accommodation of injected fluid, and direct observation of groundwater flow rates and flow direction. These data are used to support the design of full-scale technology applications. Secondary byproducts generated within the IRZ were also monitored, but were observed to attenuate within a minimal distance downgradient of the IRZ.

4. IRZ Strategies & System Design

There are two different IRZ application strategies that are being considered for use at Topock. The first involves treatment throughout the plume through a large network of IRZ circulation wells and/or alternating lines of groundwater extraction wells and IRZ injection wells. The second involves an IRZ barrier across the plume in the floodplain with a smaller network of IRZ wells as a component of alternatives that rely on pumping or flushing with clean water to remove chromium from the main body of the plume.

These types of applications offer several key advantages over more conventional remediation techniques (e.g., pump and treat): they promote the overall reduction of dissolved contaminant mass through direct treatment, and do so by making use of naturally-occurring microbes to enhance natural processes, they eliminate the generation of treatment wastes and can be designed to have a low profile and minimal impact on the landscape, and they can potentially be used in conjunction with other technologies to decrease overall remedial timeframes.

In-situ technology has not often been applied to treat an entire plume of this size and depth. There is some uncertainty regarding the ability to obtain complete distribution of substrates across this large an area, but this uncertainty can be reduced by taking advantage of the use of system hydraulics to enhance distribution. Concentrations of byproducts such as Mn and As are expected to temporarily increase within portions of the treatment zone and will require monitoring to ensure they are properly managed.

Regardless of which of the two strategies is considered, the following are critical factors that must be addressed in the design in order to successfully implement anaerobic IRZ technology to treat the Cr(VI) plume at Topock.

4.1 Carbon Substrate Delivery and Distribution

Because degradable organic carbon is the driver for the entire treatment process, the single most critical factor in the successful application of anaerobic IRZ technology is adequate delivery and distribution of degradable organic carbon in the subsurface to achieve contact with the impacted groundwater targeted for treatment. This requires an adequate understanding of the hydrogeologic environment, plume configuration, and the specific responses to fluid injection as a function of the geology.

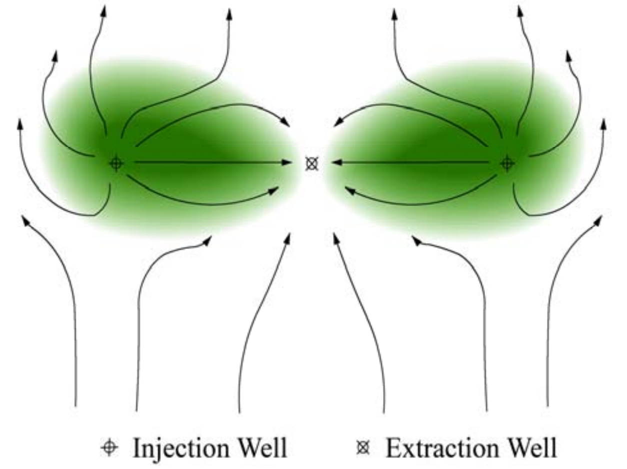
There are a number of different types of injection strategies that can be applied, ranging from batch injection through individual vertical wells using an available water source, to various scenarios involving the recovery of groundwater, amendment, and re-injection (typically referred to as re-circulation systems). Batch-type injection is an adequate delivery method for treatment zones that are relatively limited in lateral and vertical extent. In situations where the portion of the aquifer requiring treatment is very large, aquifer heterogeneities can prevent batch-type systems from being effective by exacerbating the scale of unpredictable distribution which in turn results in non-uniform treatment. By comparison, re-circulation systems provide a measure of hydraulic control that can overwhelm aquifer heterogeneities, reducing the uncertainties in substrate distribution, and reducing the number of wells required for coverage. Re-circulation systems are typically designed to accommodate variable flow rates and are typically operated in a balanced manner so that extraction rates equal injection rates. At Topock, two different types of re-circulation systems are being considered, as follows:

Dipoles. Dipoles are configured in two different arrangements:

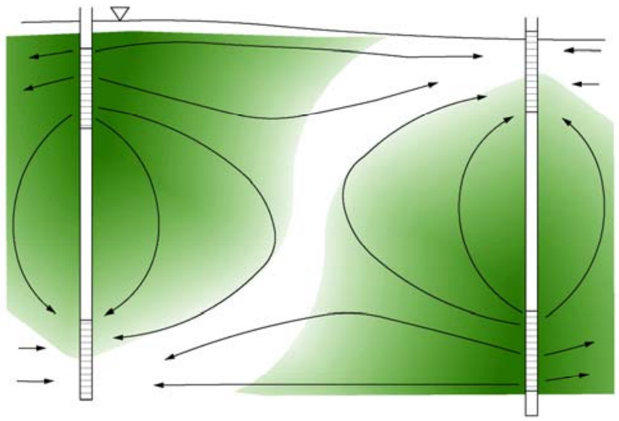
Transverse dipole: As depicted below on inset (a), this configuration consists of a set of wells each with a single screened interval positioned across from each other on a line perpendicular to groundwater flow. One well operates for extraction, with the extracted water being amended with carbon, and then conveyed to one or two adjacent wells for re-injection. This sets up a strong groundwater gradient toward the extraction well that helps distribute the injection fluid laterally between the wells (cross-gradient to ambient groundwater flow).

Transverse dipoles with multiple screen zones: As depicted below on inset (b), this configuration consists of a pair of wells with two (or more) discrete screened intervals positioned across from each other on a line perpendicular to groundwater flow. In each well, one screened interval is used for extraction and the other for injection, with the functions of the screened intervals in adjacent wells opposite from each other. This setup results in both lateral and vertical gradients that can greatly enhance substrate distribution over a simple transverse dipole.

Line-to-line re-circulation. This configuration involves transects of extraction wells oriented across the plume and designed to provide hydraulic capture, subsequently conveying groundwater for amendment and re-injection in other transects strategically positioned either in between the extraction transects or upgradient of them. This encourages flushing as well as development of large-scale IRZ coverage of the plume.



(a) Plan View



(b) Cross-Section View

Well-to-well injection configurations are suitable for creating IRZ barriers along the direction of groundwater flow. Line-to-line configurations are more suitable for plume-wide treatment. However, in either case, proper design of the well network requires pre-design testing to understand the site-specific aquifer response to the injection. This typically involves the use of one or more conservative tracers in the injection water (innocuous and non-reactive compounds also used in water supply systems) coupled with monitoring at strategic positions surrounding and downgradient of the injection points. Tracer studies are specifically designed to provide insight on the following:

- Injectability factors: Direct observation of sustainable rates of injection up to maximum flow rates supported by the well design, and the corresponding pressures up to maximum pressures protective of the formation (to avoid fracturing).
- Injection volume-delivery radius relationships: Real-time tracer monitoring during the injection to determine the injection volume relationship to reagent delivery (distance and geometry of distribution). This allows direct determination of the porosity fraction that participates in accommodation of the injection solution (the mobile porosity).
- Groundwater flow rate & direction: Post-injection monitoring of tracer breakthrough to observe the effects of preferential flow paths on groundwater flow direction, as well as the maximum and average flow rates.
- Reagent concentration profiles: Post-injection evaluation of tracer dilution to provide insight on diffusional mass transfer.

As previously mentioned, the field applications that have been conducted to date at Topock have been designed to provide insight on the issues listed here.

4.2 Injection Well Design

A critical component of delivery system performance is tied to the integrity and performance of the injection wells. The wells must have a good hydraulic connection with the aquifer, and must be durable enough to resist corrosion and endure aggressive well development/redevelopment activities including jetting, brushing, swabbing, and chemical treatments. Further, selection and installation of the well screen and filter pack need to be based on the physical properties of the aquifer to allow for optimal injection performance. Additional observations specific to Topock are presented in the following subsections.

4.2.1 Well screen construction

The screen is the component of a well that is direct hydraulic communication with the aquifer. Optimal well-screen designs maximize this communication in the target interval by balancing screen diameter and slot-size to minimize conveyance of fines while maximizing open area per linear foot of screen. Stainless-steel wire-wrapped screens or PVC screens will likely be the material of choice for the remediation wells at Topock, likely at a minimum of six inches in diameter.

4.2.2 Filter pack & annular seal

Engineered filter packs are required in formations that contain fine-grained materials, because the required screen slot-size needed to retain these materials would be too small to maintain hydraulic efficiency. The grain size of the filter pack used on remediation wells at Topock will be matched to the formation to attempt to keep out fine particles, as well as to prevent the intrusion of material from the annular seal into the screened interval. The purpose of the annular seal is to provide a high-integrity, low-permeability seal between the well casing and formation. For injection or extraction wells, the strength of the annular seal is important to avoid failure and short circuiting. While high-quality bentonite pellets might be suitable for monitoring wells, injection and extraction wells may benefit from the use of neat cement to maintain the structural integrity and will likely be used in the designs for Topock.

4.2.3 Development

Proper well development is critical to the function of all well types. The use of modest surging techniques and limited pumping can result in wells that never run clear or have poor communication with the aquifer. Aggressive surging should not be used in fine-grained systems, because it results in formation damage and blockage of the filter pack. Rather, a combination of jetting and pumping should be used to clear the screen and the filter pack prior to putting the well into operation, a system that will likely be used in development of the remediation wells at Topock.

4.3 Substrate Selection, Loading, and Persistence

There is a wide spectrum of organic carbon substrates available for anaerobic IRZ applications, including fermentable soluble substrates such as molasses, lactate, and whey; alcohols such as ethanol and methanol; semi-soluble substrates such as emulsified vegetable oil; and solids such as chitin and bark mulch. The selection of the appropriate substrate for a site depends on the balance between the mode of delivery and the substrate properties, and the rate of carbon utilization and the ability to overcome the ambient electron acceptor recharge (to establish a sufficiently reducing environment). More details on the various donor types as they relate to IRZ activities at Topock are discussed below.

4.3.1 Fermentable soluble substrates

These are typically carbohydrate or fatty-acid based substrates such as molasses, lactate, and whey. The more complex the organic substrate, the more slowly it tends to be metabolized (whey>molasses>lactate).

- **Lactate** was used in the floodplain pilot test at Topock, and was rapidly degraded (half-life as fast as 5 days).
- **Whey** is a complex substrate that is being considered as an alternative for use at Topock as a means of extending substrate longevity (estimated at up to 25 days for the Topock site), while still being sufficiently degradable to create the anaerobic conditions needed for Cr(VI) reduction. Up to 85% (by weight) of whey is comprised of soluble milk proteins (casein, lysine) and the milk sugar, lactose (a disaccharide). Neither of these poses a challenge from an injection or distribution perspective, and they can diffuse into fine grained materials the same way that other soluble carbon substrates can. The proteins and lactose are slightly less easily metabolized by microbes than alcohols or simple sugars (monosaccharide) found in other substrates, which helps the organic carbon from whey last longer.
- **Molasses** is an example of a readily degradable sugar consisting of predominantly glucose, as well as sucrose and fructose.

4.3.2 Alcohols

This includes ethanol and methanol, both of which are easily/rapidly degradable (much faster than most fermentable substrates). During its metabolism, alcohol yields more reducing equivalents (electrons) per carbon than fermentable substrates. They also have the advantage of acting as a biocide at high enough concentrations, which can help minimize the potential for well fouling. This concept is discussed further under system operation. The use of ethanol has been very successful in the Topock Uplands pilot test, and it will likely continue to be part of any full-scale IRZ program implemented at the site.

4.3.3 Insoluble liquid substrates

The main insoluble liquid substrates that are employed for remediation purposes are vegetable oils (typically soybean oil). These rely on triglyceride hydrolysis to slowly release dissolved organic carbon. Liquid oil injection is impractical and causes a loss in aquifer permeability; however, emulsified vegetable oil (EVO) products are made into a microemulsion with food-grade surfactants and water and can migrate through aquifer pore spaces, gradually coating the soil with a thin layer of oil. These thin oil coatings slowly release degradable organic carbon, and can last for several years. Experience from pilot tests at the Hinkley site show more than 3 years of continued Cr(VI) reduction from one injection. There are a number of trade-offs, however, including 1) the substrate is not substantially mobile in groundwater, which limits the effective distance to which it can be delivered and thereby requiring significantly more infrastructure (especially injection wells) than other substrates; 2) delivery is further hampered by the effects of viscosity and aquifer heterogeneity; and 3) the hydrolysis-dependent dissolved organic carbon yield from the oil is a rate-limiting factor and must be balanced against the influx of electron acceptors.

4.3.4 Solid substrates

Plant mulch, compost, and other solid-phase sources of organic carbon can be used in permeable biological remediation barriers that can intercept and treat certain contaminants. These barriers were conceived primarily for chlorinated solvents and perchlorate, but may have applicability to Cr(VI). It may be possible to incorporate solid biostimulants into a means for treating extracted groundwater in a "bioreactor" configuration where treated water is re-infiltrated.

4.3.5 Persistence and Half-life Estimates Used for Soluble Substrates in Model

The modeling analyses of the alternatives defines the limit of degradable carbon substrate distribution above a minimum concentration (~3 milligrams per liter [mg/L]) equivalent to the IRZ footprint, or zone of active Cr(VI) treatment. The travel (or residence) time of a degradable solute is calculated using the following equation:

$$t = \frac{\ln(C / C_0)}{-k} \qquad (1)$$

where t is the solute residence time, C is the minimum total organic carbon (TOC) concentration (3 mg/L) for sustaining an IRZ, C_0 is the injected TOC concentration, and k is the substrate bulk decay rate. The corresponding half-life (t1/2) is related to the decay rate by:

$$t_{1/2} = \frac{\ln(0.5)}{-k} \qquad (2)$$

Therefore, the key parameter in determining the travel time for a given degradable solute and the predicted extent of the IRZ is the half-life of the substrate. The anticipated half-life of a long-lived substrate (such as a whey-based substrate) for the site is anticipated to be approximately 25 days based upon a data set for powdered and liquid whey at a site in Colorado, along with data for a conservative tracer injected at the same time. The half-life of the whey was determined by comparison of the change in concentration of the whey to the change in concentration of the tracer. Specific conductivity was used as a conservative tracer to characterize advective/diffusive control on concentration decline. Overall decay rate (including biological degradation and dilution related to advection and dispersion) was determined from change in concentration of TOC in the system. Removing the component attributed to dilution processes represented by the conservative tracer would provide the decay rate occurring due to biological processes.

Half-life was calculated using first order degradation rate equation: $t_{1/2} = \ln(2)/\lambda$, where λ stands for the degradation rate determined from change in concentration over time for liquid and powdered whey. Half-life for powdered whey was calculated to be 65 days and for liquid whey it was 61 days at the Colorado site. The half-life determined at this site was then corrected for the site-specific groundwater temperature at Topock. Generally, an increase in temperature of 10 degrees C results in a doubling of microbiological activity. Because the temperature at Topock site is roughly 15 degrees C higher than that in Colorado, the anticipated whey half-life at Topock site would be approximately 25 days.

Assuming an applied TOC concentration (C0) of approximately 1,000 mg/L, carbon substrate is anticipated to persist in the above the minimum threshold concentration for approximately 8 to 9 half-lives, equating to 8.5 x 25 days = 212 days. ARCADIS has consistently observed TOC to travel at transport rates indistinguishable from conservative tracers (this behavior was also observed at the two pilot tests conducted at the Topock site). Therefore, sorption of TOC to aquifer materials is known to be very low. However, to account for some possible minor sorption, an effective retardation coefficient of 1.1 was assumed. This potential retardation was accounted for in the modeling analyses by defining the limit of IRZ footprint by the calculated travel time of

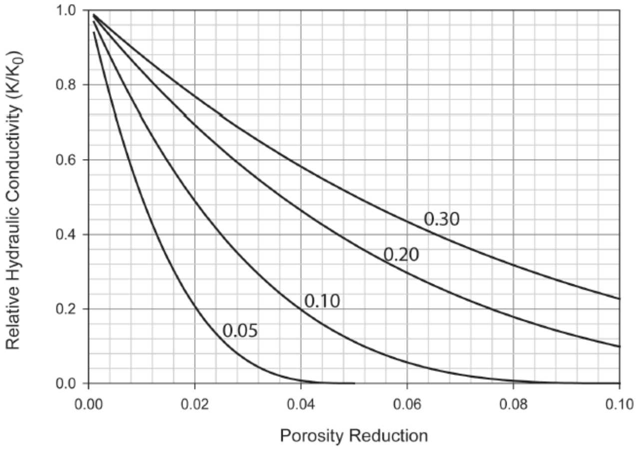
190 days, which was calculated by dividing the time of carbon persistence (~210 days) by the assumed retardation factor of 1.1.

In implementation, applied substrate concentrations and half-lives may differ from the assumptions in this estimate. For instance, if applied TOC concentrations increase, the travel time would increase, and vice versa. For instance, if the applied TOC concentration is doubled to 2,000 mg/L, the estimated travel time increases from 190 to 213 days. If TOC concentration is cut in half to 500 mg/L, the estimated travel time decreases from 190 to 168 days. The half-life may also vary in implementation for different substrates and over time as the microbial populations are established. The 25 day half-life used for this estimate is at the upper end of the anticipated range. If the half-life were less by a factor of 2 (12.5 days), the estimated travel time would decrease from 190 days to 95 days. These calculations provide a preliminary estimate of what is expected to be observed; the injection program (dose, duration, etc.) will be actively adapted based on what is observed in the field.

4.4 Long Term Effect on Aquifer Permeability

Remedial technologies that promote mineral precipitation in natural aquifers can have an effect on permeability through reductions in porosity, if the mass of precipitates being formed is significant. This relationship is depicted below in a chart excerpted and adapted from Payne et al, 2008 (see below).

At Topock, the mean background concentration of total Cr in soil is 22.3 ± 8.8 mg/kg. The amount of additional total Cr that will be added by the *in-situ* treatment is very small compared to the naturally-occurring concentration of total Cr in the soil, and will be at or much below the standard deviation of the background data set. The resulting Cr precipitates will predominately take the form of hydroxides, with amorphous $Cr(OH)_3$ the least dense/occupying the most volume relative to the spectrum of Cr oxy-hydroxide minerals (published density of 2.4 g/cm^3, (Bell and Matijević, 1974). Thus, 9 mg/kg of Cr would result in a porosity reduction of 1.3E-5 (absolute), a level that will have a negligible effect on aquifer permeability for any of the mobile porosities noted in the figure below.



Reduction in hydraulic conductivity/permeability that results from a reduction of porosity due to mineral precipitation. Calculations shown for initial mobile porosities ranging from 5% to 30%. The calculations are based on the Kozeny-Carmen equation and conservatively assume that the mobile porosity is the dominant contributor to observed hydraulic conductivity. Porosity reductions are in absolute units, so a 10% total reduction represents a 100% reduction for the 10% initial mobile porosity case.

One final consideration is that changes in permeability will be a net effect. In addition to the creation of Cr precipitate mass that was not there initially, other precipitates may also be created such as carbonates of calcium, iron, and manganese, and iron sulfides. However, this will be balanced against the reductive dissolution of natural iron and manganese (and other) minerals. Based on field experience, the overall net effect of simply maintaining an anaerobic environment is neutral, even after years of operation.

4.5 Adaptability

There are a number of system elements outside the well networks that are critical to successful system operation. These include the pumps involved in capturing and moving groundwater, the piping within which the extracted groundwater is conveyed, the carbon substrate storage equipment, the groundwater/substrate blending and distribution equipment, and the process control and electrical systems. By incorporating flexibility into this supporting infrastructure, the system operation can be adapted if necessary to support the use of different substrates or different configurations of groundwater extraction and injection. In addition to flexibility in the system, redundancy will be used wherever appropriate (i.e. critical or long lead items such as pumps) to ensure that the system will operate as continuously as possible, and can be adjusted to meet changing site conditions. This redundancy includes cross connections within the mechanical piping to allow for recirculation of groundwater or injection of the carbon in multiple configurations.

4.6 Site factors

Factors related to the setting and logistical limitations of a specific site must always be considered in the design. There are a few challenges presented at the Topock that will need to be considered in the engineering- level design of the IRZ systems, as follows:

- Temperature. Consideration of the extreme temperatures at the site (which regularly exceed 100°F) will be an important aspect of the design. Heat resistance, photodegradability, and heat expansion of materials will be taken in to consideration during the design process.
- Topography. The significant topographic relief at the site will require consideration in the positioning and design of key system components including buildings, wells, and piping.
- Seismic activity. Because the site is in a seismically active zone, structures erected at the site will be designed per the State of California requirements (Zone 3 seismic zone).

5. IRZ System Operation

Operation of IRZ systems is guided in real time by the monitoring data collected in the field. This can result in adjustments to operating flow rates and configurations (extraction/injection) of the existing system wells, along with adjustments to the injection solution concentrations within a pre-designed range. In extreme cases, the installation of additional wells can be warranted. This adaptive management of the system based on process feedback is critical to its success.

As mentioned earlier in the background discussion, during operation of the system, a significant portion of the reducing equivalents delivered to the subsurface by the organic carbon will end up stored as either biomass or reduced mineral phases. This includes reactive forms of ferrous iron (surface-sorbed & ferrous iron minerals). This storage of reducing equivalents can allow an IRZ to remain sufficiently active to effectively reduce Cr(VI) to Cr(III) and immobilize Cr(III) precipitates for a significant period of time even after active carbon substrate injections have stopped. This presents the opportunity to cycle the operation of an IRZ system, where a short period of active operation could be followed by a much longer period of passive treatment with the injection system shut down/on standby. Evidence of this has been observed in the floodplain pilot area, where following a period of 6 injections over 18 months, the reactive zone has continued to treat Cr(VI) for at least 2 years following the final injection event.

In addition to the above, system operation will include activities designed to minimize and manage the potential for well fouling. The delivery/circulation of reagents creates nutrient-rich conditions within and just beyond the injection wells that favor rapid microbial growth and biofilm formation. If this occurs, it will cause losses in well efficiency, and ultimately limit the proper function of the well. Well management and rehabilitation will include both mechanical methods and chemical methods.

Mechanical well maintenance physically removes deposits from the inside of the casing and screen and can partially impact the filter pack and formation by pushing fluid through the screen. Methods of mechanical treatment include brushing, surging, swabbing, and jetting. While mechanical treatments can remove significant amounts of material from within the well, their effectiveness is greatly enhanced when used in conjunction with chemicals that are selected based on the types of fouling, groundwater chemistry and site constraints.

There are a variety of chemical agents that can be applied in conjunction with mechanical methods to more aggressively rehabilitate a fouled well, each of which is commonly applied for supply well maintenance. These include acids to dissolve mineral deposits as well as shock and break up biofilm accumulations typically adapted to neutral pH (muriatic acid, phosphoric acid, glycolic acid, etc., some with appropriate stabilizers commonly accepted in water supply well maintenance); oxidizing agents to disinfect and degrade microbial biofilm (hydrogen peroxide, chlorine); biocides to inhibit microbial growth (tolcide, ethanol); and chelating agents to aid acid and disinfectant penetration, remove mineral deposits, and break down and disperse biofilm (citric acid).

To date, no significant fouling has been observed in any of the pilot IRZ system injection wells at Topock. This may be related to the batch injection configuration used in the Floodplain pilot (limited flow of nutrients through the screen), and the high-concentration ethanol solution used in the Uplands pilot (doubles as a biocide inside the well and related piping). It is also likely that the limited duration of the pilot studies may not have allowed adequate time for fouling to occur to a degree that it impacted operations. A longer duration full-scale system will likely have to deal with well fouling. Therefore, these options will need to remain part of the operations and maintenance program.

6. IRZ Monitoring

The monitoring well network ultimately developed for a full-scale IRZ application is typically configured to maximize use of existing monitoring wells, and minimize the need for new monitoring wells. In any case, it is the positioning of the wells that is critical. For barrier systems, monitoring locations are usually placed in three key positions:

Within the anticipated radius of substrate delivery. These are referred to as “dose response” wells and serve to verify adequate distribution of the injection solution. These wells will also be located within the resulting IRZ and so can track process performance.

At the anticipated downgradient edge of the IRZ to monitor its extent, as well as to monitor the overall quality of the groundwater exiting the IRZ.

Beyond the downgradient edge of the IRZ, in the zone where the groundwater exiting the IRZ begins to rebound toward the ambient redox condition (referred to as the “redox recovery zone”). Wells in this location can demonstrate decreases in target contaminant concentrations as a result of the upgradient treatment, in this case Cr(VI). They can also track the migration and attenuation of any secondary byproducts of the remediation.

For plume-wide treatment systems, the above still apply, but positions (2) and (3) may be downgradient of the overall system and potentially outside of the plume. Accurate positioning will be based on an understanding of the hydraulic performance of the system, the longevity of the substrate, and advective groundwater travel times; all information that can be extracted from the tracer and pilot studies.

Once the monitoring network is established, an initial round of groundwater elevation measurements and groundwater quality samples is collected to establish baseline conditions (i.e., groundwater conditions prior to the start of injections). Groundwater samples collected as part of the baseline event typically involve a comprehensive suite of biogeochemical parameters, to provide a benchmark for comparative analysis in future troubleshooting, as warranted. Following completion of the baseline sampling event and initiation of injection activities, ongoing monitoring typically involves a critical subset of the initial baseline to evaluate the extent of the IRZ and the effectiveness of the treatment process. This is broken into two types of monitoring, process monitoring and operational monitoring.

Process monitoring will focus on parameters that support evaluation of the treatment process. This would include chromium speciation, along with other parameters that serve as indicators of the targeted biogeochemical environment. In addition, monitoring would include secondary byproducts, e.g. manganese and arsenic, to ensure that they are being properly managed through controlled substrate injections. This monitoring is typically completed on a quarterly frequency, or less.

Operational monitoring is typically completed at a much higher frequency than the process monitoring (monthly) until proper operation of the system has been verified. The focus is on the collection of down-hole pH measurements and grab samples for TOC analysis, to demonstrate that the pH is within a range compatible to the treatment process, and that organic carbon is being sufficiently distributed throughout the targeted treatment zone. This data will allow real-time evaluation of the injection program performance and provide the basis for timely adjustments.

Modifications to the monitoring program are often made as warranted based on the data collected. This includes sampling frequency, the number of wells included, and the inclusion of additional parameters for comparison against the baseline data set (or standalone evaluation) to troubleshoot if performance is lagging despite adequate distribution of organic carbon.

7. Effectiveness and Permanence of Treatment

When attempting *in-situ* remediation for any groundwater contaminant, it is important to understand the limits of what is achievable compared to the remedial objectives, both in the short term (during treatment) and the long term (after treatment). This section provides a discussion of the effectiveness and permanence, of *in-situ* treatment, broken into the following topics:

1. Dissolved concentration of Cr(VI) achievable through treatment, and resulting forms of Cr(III).

2. Natural mechanisms that can re-oxidize the treated Cr(III), and consideration of natural background.
3. Physical and chemical controls on the mechanisms in 1 and 2 that can support permanence of treatment over the long-term.

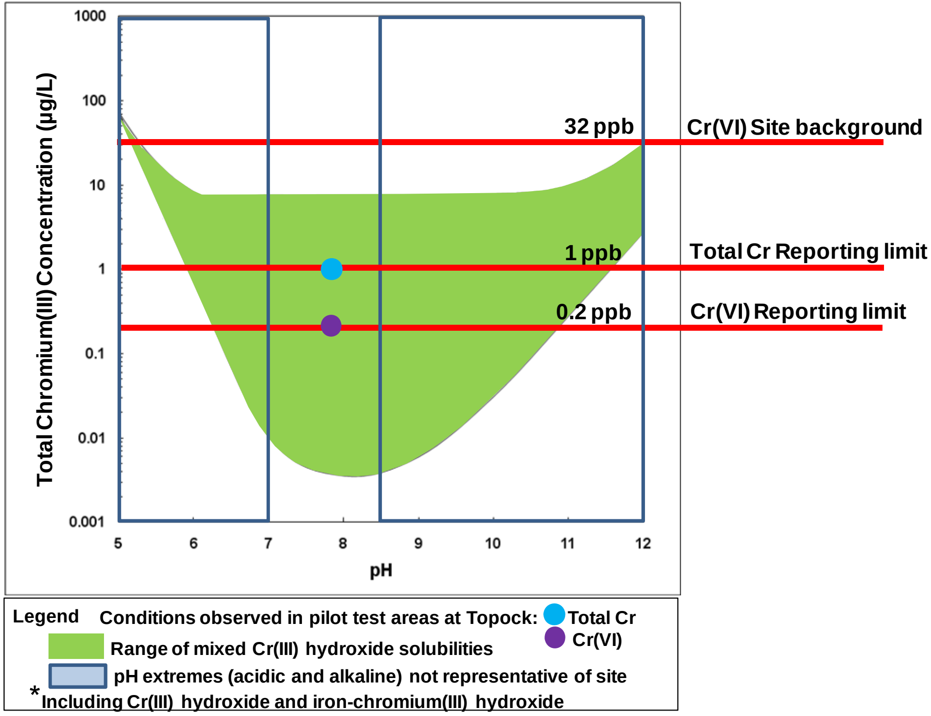
Chromium is naturally occurring in soil at the Topock site; the mean background concentration of total Cr in soil at Topock is 22.3 ± 8.8 mg/kg (range from 4.2 to 53) (CH2M Hill, 2009). In addition, Cr(VI) is naturally occurring in groundwater at the Topock site, in background areas outside of the Cr(VI) plume (the Upper Tolerance Limit [UTL] background concentration of Cr(VI) in groundwater is 32 µg/L)(CH2M Hill, 2008b). The chemical form of chromium created through the *in-situ* treatment strategy will likely be more stable than that which currently exists in the aquifer. While it cannot be said that the Cr(VI) reduction reaction is completely irreversible; the evidence presented here indicates that over the long term re-oxidation of Cr(III) to Cr(VI) is expected to be minimal and not lead to concentrations that exceed background.

7.1 Level of Treatment Achievable through *In-situ* Treatment.

As previously discussed, *in-situ* chromium remediation relies on the precipitation of low solubility Cr(III) hydroxide minerals, which can include both pure Cr(III) hydroxides and mixed iron-Cr(III) hydroxides. The anaerobic bioprecipitation of Cr(VI) relies in large part on the reductive dissolution of naturally-occurring iron which subsequently reacts with the Cr(VI). Consequently, it is likely that mixed Fe/Cr-hydroxides are the dominant precipitated phase. In either case, the aqueous solubility of Cr(III) hydroxides are highly pH-dependent.

The figure below depicts theoretical solubility curves for both pure Cr(III) hydroxide and mixed iron/Cr(III) hydroxide minerals, relative to the 32 µg/L cleanup goal for Cr(VI) being applied to the Topock site. Note that these solubility curves are for Cr(III), but the standard is for Cr(VI). Chromium(VI) will not persist in iron reducing environments, so this comparison is intended to show how the low solubility of Cr(III) will limit the availability of Cr(III) to participate in re-oxidation reactions. This figure was prepared based on published solubility constants for pure Cr(III) hydroxide (both the amorphous form (Rai et al., 2004) and the more crystalline form [from the MINEQL thermodynamic database]). The solubility curves generated for the mixed Cr(III) hydroxides show that these minerals are at least one order of magnitude less soluble than pure Cr(III) hydroxides in the pH range of 2 to 6 (Sass and Rai, 1987). This demonstrates that it is possible to achieve chromium concentrations at/below the cleanup goal for the site via anaerobic bioprecipitation and corroborates the performance monitoring data being collected at the site. For reference, the pH of Topock waters is in the range of 7 to 8.

Range of Cr solubilities for mixed Cr(III) hydroxides*



7.2 Mechanisms of Cr(III) Re-oxidation and Natural Background Cr(VI)

Beyond the ability to achieve the prescribed endpoints, the long-term success of any *in-situ* remediation approach is dependent on the permanence of treatment. This is particularly true for metals, which unlike organics cannot be destroyed but can only be converted from one form to another. This makes the potential for re-oxidation of Cr(III) to Cr(VI) something to be considered carefully to guard against the potential for post-treatment rebound. This discussion can focus on natural oxidants that could conceptually be a factor for the Topock site.

While the kinetics of Cr(VI) reduction are rapid in typical groundwater environments, the same is not true of Cr(III) oxidation. There are only a few oxidants present in natural systems that are known to be capable of oxidizing Cr(III) to Cr(VI). These include:

- Oxygen. Dissolved oxygen can oxidize Cr(III) to Cr(VI), but the kinetics are very slow at the neutral to slightly acidic groundwater pH typical of most sites. As a result, dissolved oxygen is more likely to react with other materials in the subsurface before reacting with aqueous Cr(III). This is particularly true in a former anaerobic reactive zone, where reduced minerals (such as iron sulfides) are formed/stored in the aquifer during the treatment cycle. In addition, Cr(III) will have sufficient time to be sequestered through precipitation and sorption reactions before oxygen can react with it. As a result, the available literature concludes that the oxidation of Cr(III) by dissolved oxygen is not a meaningful pathway in typical groundwater systems (Schroeder & Lee, 1975; Eary & Rai, 1987; Rai et al, 1989; Hwang et al, 2002; Guertin et al, 2005).
- Manganese oxides. These minerals are more effective at the oxidation of Cr(III) than dissolved oxygen and occur in the subsurface primarily as coatings on soil grains. The rate at which they react with available (dissolved) Cr(III) is affected by both the reactive surface area of the manganese oxides and the dissolved concentrations of Cr(III). For the oxidation reactions to proceed, Cr(III) must sorb directly to the surface of the manganese oxide mineral (Schroeder & Lee, 1975; Rai et al, 1986; Eary & Rai, 1987; Richard & Bourg, 1991; Hwang et al, 2002; Guertin et al, 2005). Because aqueous Cr(III) concentrations will be effectively controlled by low solubility Cr(III) hydroxides and mixed iron-Cr(III) hydroxides, the amount of aqueous Cr(III) available for adsorption onto manganese oxide surfaces and subsequent oxidation will be limited.

The mechanisms discussed above that act to re-oxidize Cr(III) are responsible for the natural background concentration of Cr(VI) in groundwater. These processes have acted upon natural Cr(III) in the soil, and have occurred both in the unsaturated and saturated zone.

Work by USGS geologist Frederick Robertson (Robertson, 1991) provided a comprehensive survey of naturally occurring Cr(VI) and other compounds in groundwater across the desert Southwest. Robertson’s work concluded that naturally elevated concentrations of Cr(VI) in groundwater was principally due to source rock type in aquifers with naturally high Cr and Mn, and that “the basins that contain the largest concentrations are those that receive the least recharge, resulting in groundwater having long residence time”. Recent work by Morrison discusses a similar comprehensive study in northern CA, including the Sierra Nevada Mountains, the Sacramento Valley, and the northern Coast Range (Morrison et al., 2009). This work correlates elevated natural concentrations of Cr(VI) in groundwater to extremely high concentration of natural Cr and Mn in soils.

Several other locations in California have been studied in order to understand the natural processes that result in Cr(VI) in groundwater (Izbicki et al., 2008; Izbicki, 2008). In particular, work performed by USGS focused on a portion of the western Mojave desert (the Sheep Creek Fan) with elevated Cr(III) in soil (150 – 300 mg/kg) as well as manganese (800-16,000 mg/kg). The soil mineralogy in this location is naturally enriched in chromite and manganese minerals from the geologic deposition of eroded mafics, which is different from Topock where the background study did not show elevated chromium in soils. The findings of this work concluded that background concentrations of Cr(VI) in groundwater were due to Cr(III) oxidation processes that occur in the vadose-zone, with the specific mineralogy at this location playing a significant role in the creation of elevated concentrations of natural Cr(VI). The very long residence time of porewater in the vadose zone (retained as the non-drainable fraction that represents the natural soil moisture), available oxygen and manganese in the vadose zone, coupled with strongly alkaline pH have allowed chromium concentrations to build up in the porewater that eventually drains to the saturated zone. Some of these processes also occur in the saturated zone.

Cr(VI) can therefore occur naturally in groundwater/porewater when the following conditions exist:

- Abundant available Cr(III) exists in presence of abundant Mn. This creates opportunity for the reaction. The abundance of Cr(III) in the presence of abundant Mn is characteristic of certain sediments weathered from specific rock types and is enhanced in fine grained sediments (due to high specific surface area).
- Environment is alkaline and highly aerobic. This suppresses the solubility of Cr(III), but enhances reaction rates & stability of oxidized forms.
- Residence times are long. This provides the opportunity for accumulation and counteracts solubility limitations.

In contrast to the Sheep Creek Fan site, the average naturally occurring concentration of chromium in soil at Topock is much lower, 22.3 ± 8.8 mg/kg (range from 4.2 to 53) (CH2M Hill, 2009), as is the naturally occurring concentration of manganese, (average 314 ± 112 mg/kg; ranging from 150-550 mg/kg (ARCADIS, 2009). The natural balance of processes that act upon the lower Cr(III) content in soil at Topock has resulted in a

Cr(VI) UTL background concentration of 32 µg/L in groundwater, much lower than observed at the Sheep Creek Fan site. **Figure G2** depicts the conditions in the soil at the Sheep Creek Fan as compared to the Topock site.

7.3 Physical and Chemical Controls on Cr(III) Re-oxidation After *In-situ* Treatment

The post-remedial setting at Topock is very different from the Sheep Creek Fan, and from the current conditions in the aquifer. Considering the data on natural background conditions and the effects of the *in-situ* treatment, there are a number of mechanisms that will work together to minimize re-oxidation of the treated Cr. These include the following:

- **Formation of low solubility Cr(III) precipitates**. The Cr(III) minerals formed in the IRZ will include pure chromium hydroxides but are expected to predominately take the form of a mixed iron-chromium hydroxide. Both mineral forms are least soluble at neutral to slightly alkaline pH, controlling Cr(III) solubility to < 0.01 µg/L.
- **Limited availability of reactive MnO_2 surfaces**. The reaction between Cr(III) and MnO_2 occurs at the surface of the MnO_2. Within an IRZ treatment zone, there are a number of things that will limit the availability of reactive MnO_2 surfaces to support re-oxidation of Cr(III). First, a portion of the Mn liberated in the IRZ will precipitate as a carbonate mineral. Second, both during and after treatment, there will be a number of minerals that form along with manganese precipitates (e.g., calcite, ferrous and ferric iron minerals). This bulk precipitation will cover up (occlude) the surfaces of any MnO_2 that might form, reducing the opportunity for reaction with dissolved Cr(III). This is depicted in **Figure G3**. In fact, chromium hydroxide precipitates themselves have been shown to passivate the reactive surfaces of MnO_2 through the same mechanisms (Fendorf et al., 1992; Fendorf, 1995). In addition, reaction of manganese with Cr(III) will be inhibited by reduced iron minerals such as iron sulfide/FeS (Deng and Wu, 2006), a mineral that will be formed within IRZs in the same area where chromium is precipitated. Iron sulfide essentially inactivates manganese oxides and precludes them from reacting with Cr(III).
- **Reduction in availability of easily exchangeable Cr(III).)**. Weakly sorbed Cr(III) will be more reactive than Cr(III) incorporated into stable mineral phases because it is more easily displaced into the dissolved phase. Under the pH conditions at Topock, most of this fraction is likely to be a weathering product of natural Cr(III) minerals. In an anaerobic IRZ, this fraction can be displaced and converted into the stable mineral forms discussed above, along with the dissolved Cr(VI) that is the

primary target. This is substantiated by baseline and post-treatment soil data collected in the area of the upland pilot at Topock, which as depicted on **Figure G4** demonstrate a significant decrease in the easily exchangeable Cr(III) after treatment. This figure shows that prior to the upland pilot IRZ, a greater portion of chromium in soil could be extracted by dilute acid (0.5 molar hydrochloric acid) labeled "H-H" on the x-axis of **Figure G4** or chemical reagents that dissolve the labile mineral phases (amorphous iron is dissolved by hydroxylamine hydrochloride "H-H Hydroxy") and crystalline iron minerals are dissolved by citrate-bicarbonate-dithionite ("CBD"). After treatment there was a significantly lower concentration of chromium that could be extracted by these reagents – and there was not a significant difference in the total chromium concentration in the soil. This indicates that after IRZ treatment, the Cr(III) was redistributed into a more stable mineral phase in the soil (ARCADIS, 2009). In addition, the average concentration of Cr(VI) in the pre-treatment soil was 0.794 mg/kg; post-treatment the Cr(VI) was non-detect (<0.1 mg/kg) in soil indicating treatment of sorbed Cr(VI) after operation of the upland pilot (ARCADIS, 2009).

- **No meaningful change in total Cr in soil**. Background Cr concentrations measured in the Topock soil range from 4.2 to 53 mg/kg, with an average of 22.3 ± 8.8 mg/kg (CH2M Hill, 2008b). *In-situ* treatment of the dissolved Cr(VI) plume might result in the accumulation of an additional 1 to 2 mg/kg of total Cr. This is well below the standard deviation associated with the natural soil and as such would not be meaningful or distinguishable. As an example of this, the average baseline Cr measured in aquifer soil at the depths of the upland pilot was 25.8 ± 7.9 mg/kg (20 soil samples with a maximum of 42 mg/kg). After operation of the upland pilot IRZ for 9 months, additional samples were collected yielding an average Cr of 24.0 ± 7.3 mg/kg (12 soil samples with a maximum of 39.8 mg/kg)(ARCADIS, 2009).

In summary, two key factors are expected to limit the re-conversion of Cr(III) to Cr(VI) after *in-situ* reduction: the limited solubility of Cr(III) and the lack of reactivity of an adequate oxidizer (MnO_2). Together these factors are expected to limit any reoxidized Cr(VI) concentrations to levels similar to ambient background. The reduction of Cr(VI) to Cr(III) results in the formation of Cr(III) oxides that have a very low solubility under the neutral and alkaline pH encountered in site groundwater. The following section presents the case that *in-situ* treatment of the aquifer will create reducing conditions where MnO_2 is not stable and Mn^{2+} will be present along with reduced levels of MnO_2. Section 7.3 (above) presents data demonstrating the formation of more stable Cr(III) precipitates as a result of the IRZ and discusses the occlusion and passivation of MnO_2 surfaces as a result of the precipitation of a variety of non-reactive minerals formed in the IRZ. Thus, it is possible that MnO_2 capable of re-oxidizing Cr(III) could still be present in the same area of the aquifer where Cr(VI) has been reductively precipitated. Therefore, while over the long term it cannot be said that the Cr(VI) reduction reaction is completely irreversible, the evidence presented here (Sections 7.1-7.3) indicates that re-oxidation of Cr(III) to Cr(VI) is expected to be minimal and not lead to concentrations that exceed background.

Similarly, reduced selenium and molybdenum that may end up sequestered within the IRZ are more susceptible to re-oxidation to soluble forms under aerobic conditions, but there are a number of factors that will limit their rebound. Some portion of the reduced selenium and molybdenum minerals will likely be incorporated within and occluded by other reduced mineral precipitates, such as iron sulfides. During the restoration of aerobic conditions, the surfaces of these minerals can develop a protective coating that would passivate the rest of the underlying mineral mass, offering long-term protection of incorporated selenium and molybdenum, preventing it from reacting completely (Todd et al., 2003). Further, freshly formed iron oxyhydroxide minerals formed during this process will have some capacity to sequester (through sorption) re-mobilized selenium and molybdenum and suppress the formation of dissolved metals at concentrations requiring additional remediation.

8. Secondary Water Quality

When anaerobic conditions exist, or are engineered within aquifers, chemical reduction of both dissolved and solid mineral phases in the aquifer is part of the reduction process. Dissolved phases that are reduced include dissolved oxygen, nitrate, Cr(VI), and sulfate. The solid phases that are reduced include iron oxides, manganese oxides, and some trace elements associated with these phases. Naturally occurring anaerobic environments, such as the fluvial zone immediately adjacent to the Colorado River and the engineered anaerobic IRZs created in the alluvial aquifer, typically have dissolved iron, manganese, and sometimes arsenic in groundwater. This section discusses the fate and transport of these constituents, both in the natural fluvial zone around the Colorado River and in the temporary reducing zones proposed to be created with the implementation of IRZs as a component of several of the remedial alternatives (C, D, E, G, and H) being considered for the site. The overall aesthetic quality of the Topock groundwater will not be negatively impacted by operation of IRZs in the short and long term.

The available information on both the natural fluvial zone around the Colorado River and the temporary reducing zones created in the Floodplain IRZ pilot test leads to the conclusion that implementation of anaerobic IRZs as part of the site restoration will not increase the flux of iron, manganese, arsenic or overall TDS to the Colorado River. The main concepts comprising the model are as follows:

1. Conditions in the shallow floodplain are naturally reducing, with some variability (there is a range in redox conditions and resulting water quality). In addition, the zone where groundwater and surface water interface beneath the river (hyporheic zone) is an important natural control mechanism. These conditions in the floodplain will persist over geologic timeframes, well beyond the endpoint of any site restoration program.
2. Engineered IRZs will liberate naturally occurring metals, which based on the field testing data will be within the range of concentrations currently observed in the floodplain. In our experience, the extent of metals liberation correlates with the strength of the reducing environment as driven by available organic carbon. The range of TOC loading for the IRZ remedies falls within the range tested in the field, providing a level of certainty as to the secondary effects; and the range of iron, manganese, and arsenic expected in the proposed IRZ remedies is also in the range observed in the floodplain pilot test.
3. Metals liberated by the IRZs will be acted on by a variety of physical and geochemical processes that together with the anticipated operational cycling will limit flux out of the treatment zone and attenuate concentrations as groundwater flows toward the river.
4. When the remedial actions are complete, biogeochemical conditions in the treatment zones will return to baseline over time. There are a number of processes that will enable this. If it is desired to shorten the duration of this restoration process, the process can be accelerated by engineered measures that can also be strategically applied as part of the remedy.

Each of these four concepts is discussed in more detail below.

8.1 Overview of Natural Site Conditions

Figure G5 depicts the range of natural biogeochemical conditions present in the aquifer underlying the Topock site. As shown, conditions in the alluvial deposits upgradient and beneath the shallow Colorado River floodplain are generally aerobic, with low concentrations of iron, manganese and arsenic, but elevated concentrations of hexavalent chromium (relative to the 32 µg/L cleanup goal).

As groundwater moves into the floodplain, the environment in the shallow fluvial sediments shifts to incorporate a range of redox conditions including areas that are anaerobic/reducing. This is fueled by natural organic material (plant matter) that has been incorporated into the fluvial sediments over the geologic history of the Colorado River, something that has been directly observed during well drilling activities in the form of wood bits found in the soil cuttings. This solid organic material provides a long-term source of dissolved organic carbon (ranging up to 76 mg/L) which stimulates microbial activity in various portions of the floodplain. As a result, there are areas in the floodplain where hexavalent chromium is absent (reductively precipitated) and iron, manganese, and arsenic are naturally elevated in concentration (reductively dissolved) relative to the upgradient aquifer, something that is commonly observed in fluvial sediments (Welch et al., 2000). **Figures G6(a)-(d)** depict the range of naturally occurring arsenic and manganese concentrations observed in the floodplain adjacent to the compressor station, as well as regional floodplain and alluvial locations. Arsenic ranges from 2.6 to 49.4 µg/L and manganese ranges from <1 to 9,260 µg/L. The concentration of iron ranges from <20 to 30,000 µg/L (data not shown). The regional background UTL for arsenic in groundwater is reported to be 24.3 µg/L (CH2M Hill, 2008b).

Figures G6(a)-(d) depict the range of naturally occurring arsenic and manganese in the fluvial and alluvial groundwater including waters adjacent to the river. Thus PT-6S is in the same interval as the river, while PT-6M and PT-6D are relatively deeper, and groundwater at PT-6M and PT-6D may or may not pass through a zone similar to PT-6S before reaching the hyporheic zone. In light of this, the shallow fluvial groundwater is the most relevant to understand geochemical conditions of the groundwater entering the hyporheic zone.

The data depicted on these figures show that there are elevated naturally occurring concentrations of arsenic and manganese in fluvial well samples. The maximum arsenic concentration measured in samples collected from PT-6S was 49.4 µg/L. The arsenic data from the shallow fluvial wells (including PT-6S) were subjected to a statistical analysis, including an outlier test. **Figure G6(e)** shows a box-and-whisker plot of the arsenic data from all of the shallow fluvial wells, as compared to a plot of the arsenic data for well PT-6S. The line through the middle of the boxes is the median of the data set, with 25% of the data above the line and 25% of the data below the line. The “whiskers” extending from the top and bottom of the box capture the upper 90% and lower 10% of the data. The dots are values that lie outside of this range. The plots show that there is variability in the data due to the range of natural conditions in the floodplain; an outlier analysis was performed at the 95% significance level and none of the data points were considered outliers. The purpose of inclusion of well PT-6S is to establish a range of natural fluvial groundwater conditions close to the river that is unaffected by an IRZ operation. Well PT-6S has an extensive data set (approximately 20 samples over 2+ years) with clear trends reflecting high concentrations of total organic carbon (range 13-76 mg/L) dissolved iron (range 1,180 to 30,000 µg/L), dissolved manganese (range 1,050 to 9,260 µg/L) as well as dissolved arsenic (range 12.6 to 49.4 µg/L) (Tables 9 and 10, *Floodplain Reductive Zone In-Situ Pilot Test Final Completion Report*). Examination of the data for this well shows clear sustained trends of elevated concentrations of metals associated with reducing conditions, with 17 of the19 analyses in this well containing arsenic >25 µg/L. It is noted that this well, along with some additional wells sampled in September 2009 (MW-32-20 [65 µg/L] and MW-32-35 [53 µg/L]) show elevated arsenic concentrations within the fluvial system wells. These wells in combination exhibit an average value of 14.3 µg/L (Figure G5, G6e). Additional arsenic data is being collected to better evaluate arsenic distribution in the floodplain.

Some fluvial wells in the aquifer have lower arsenic concentrations. PT-6S was installed as a pilot test well that would be upgradient and outside the radius of influence of the pilot test injection well PTI-1S in order to gather information about groundwater flowing into the pilot test area. The analytical data from the pilot test verify that this well was likely not influenced by the pilot test injections. In May through June 2006 following the only injection into PTI-1S, tracer did not arrive at detectable levels and manganese concentrations did not increase at PT-6S (similar to downgradient well PT-1S), however, arsenic and iron did increase over baseline concentrations (similar to PT-1S). In contrast at PT-3S, tracer did arrive with increasing TOC concentrations in May and June 2006, indicating that this location was within the radius of influence of PTI-1S.

If groundwater continues to move toward the river, it eventually encounters the zone beneath and adjacent to the river where groundwater and surface water begin to mix, referred to as the hyporheic zone. Moving through the hyporheic zone, there is a gradual shift in geochemical conditions as a result of the influx of oxygen from the surface water. This supports the oxidative precipitation of dissolved iron and manganese, leading to lower porewater concentrations relative to concentrations observed in the reducing fluvial sediments (**Figure G7). **This is typical of these hyporheic transition zones (Winter et al., 1998) with the river providing a constant supply of dissolved oxygen to sustain the processes. The hyporheic zone is discussed in further detail in the following subsection.

8.1.1 Details of the Hyporheic Zone.

In the hyporheic zone, ground water mixes with river water in variable proportions through the process of hyporheic exchange; this creates fluctuations in the redox conditions within the zone. Hyporheic exchange may be driven by tidal cycles caused by diurnal fluctuations of hydroelectric dams. **Figure G8** depicts a conceptual cross-section of the hyporheic zone underneath the Colorado River. A temperature profile of the water below the river bottom was performed during the pore water study conducted for the RFI Volume 2; RFI Volume 2 Figure 8-1 demonstrates that the river tide influences the temperature in the pore water to a depth of 3 feet below the river bottom. At 6 feet below the river bottom the temperature was constant and was not influenced by the river tide; at this depth the pore water is dominated by groundwater. The extent of the hyporheic zone is therefore defined from the river sediment surface to 6 feet below the river bottom. Within this zone oxygenated river water infiltrates into the sediment, and anoxic fluvial aquifer groundwater discharges; a biogeochemical gradient is therefore established. This gradient is common in hyporheic zones and is well characterized (Winter et al., 1998).

As depicted in **Figure G8**, at the sediment surface there is abundant dissolved oxygen; at depth in the sediment the dissolved oxygen concentration decreases due to aerobic microbial activity as well as the influence of the anoxic groundwater. Microbial activity in the sediments is supported by abundant organic carbon introduced from the river water column and into the river sediments. Anaerobic microbial activity is prevalent at depth, with reducing conditions resulting in elevated concentrations of ferrous iron, and depletion of nitrate. Within the porewater at depth below the hyporheic zone this anaerobic microbial activity and/or the ferrous iron present in the pore water or sediment solid phases will transform Cr(VI) to Cr(III); as discussed in the pore water study Cr(VI) was not detected in the reducing sediments.

Above these reducing sediments, as groundwater moves upward into the hyporheic zone, hyporheic exchange within the sediments establishes a redox transition zone that will create iron biominerals through iron cycling between ferrous and ferric iron phases. These iron biominerals, such as carbonate green rust ($Fe^{II}_4Fe^{III}_2[OH]_{12}CO_3$) and magnetite ($Fe_3O_4$), have very strong affinity for dissolved arsenic in both the pentavalent (As[V]) and trivalent (As[III]) oxidation states (Ona-Nguema et al., 2009). Above this transition zone, in the predominantly oxic water below the river bottom, freshly precipitated ferric (hydr)oxides form such as ferrihydrite. This iron mineral has a high capacity for sorption of both arsenic and manganese (Smedley and Kinniburgh, 2002). However, manganese will also precipitate simply due to reoxidation; discharge of manganese-bearing groundwater from the naturally reduced fluvial aquifer at the oxic interface results in the development of extensive Mn oxide precipitates in the hyporheic zone. This has been studied extensively at Pinal Creek, in Arizona, and has been shown to be sustained by the neutral pH, oxic water that infiltrates into the zone combined with aerobic microbial activity (Hem and Lind, 1994; Harvey and Fuller, 1998; Bargar et al., 2009). Manganese oxide precipitation is self-supported through enhanced precipitation on freshly formed Mn(IV) oxides; precipitation is more rapid in the presence of manganese oxidizing bacteria (Tebo et al., 2004).

The hyporheic zone is therefore the interface between the oxic river water and the anoxic fluvial groundwater that occurs below the bottom of the river. In the upper portion of the hyporheic zone, the pore water is oxygenated and ferric iron, arsenic, and manganese are precipitated. In the lower portion of the hyporheic zone, the environment transitions into the naturally reducing conditions that prevail within the fluvial aquifer sediments, and Cr(VI) is removed through precipitation as Cr(III) minerals with very low solubility. The redox transitions that occur within the hyporheic zone are well characterized and the mechanisms of iron, arsenic, and manganese removal are effective at preventing discharge of these elements to the river.

In summary, the seepage rate of groundwater through this zone (and along it, given that groundwater flow will shift to partially follow the River) is slow compared to the rates of iron and manganese oxidation, providing sufficient residence time for these reactions to go to completion. Iron and manganese oxides previously formed act as a catalyst for the continued oxidation and precipitation of new dissolved iron and manganese. As iron and manganese are oxidized, arsenic will also be removed through sorption to and co-precipitation with the newly formed iron and manganese minerals. Both iron oxyhydroxides and manganese oxides are particularly effective in the co-precipitation of arsenic (Dixit and Hering, 2003; Stollenwerk, 2002). This is further supported by the high iron to arsenic ratio observed in the fluvial aquifer; more than 800 to 1 on a molar basis while typical water treatment employs much lower ratios on the order of approximately 10 to 1 (Mercer and Tobiason, 2008). Where present, pockets of more aerobic conditions within the fluvial aquifer will support additional iron and manganese attenuation through sorption and precipitation reactions (with formation of iron and manganese hydroxides and oxides).

8.2 Metals Dissolution within the Anaerobic IRZs

The same geochemical processes that naturally dissolve iron, manganese, and arsenic within the fluvial deposits will occur upon the establishment of anaerobic/reducing conditions within the engineered IRZs. **Figure G9** shows trends in dissolved manganese and arsenic concentrations that were observed during the Floodplain pilot test. This test was completed in the deeper fluvial and alluvial sediments underlying the shallow fluvial sediments. These deeper fluvial and alluvial sediments are relatively oxidizing compared to the shallow fluvial sediments where naturally reducing conditions are already prevalent.The zone of alluvial sediments is relatively aerobic compared to the fluvial sediments where naturally reducing conditions are already prevalent. During the test, although iron, manganese and arsenic concentrations increased, the concentrations observed were within the range of the natural concentrations observed in the shallow fluvial sediments across the Colorado River floodplain. Iron is not shown on **Figure G9**; the concentration of iron increased in the IRZ to within the range of iron concentrations observed in the floodplain.

In the Floodplain pilot test (**Figure G9**) the rate of attenuation varied depending upon the carbon loading, with PT-3D returning to baseline arsenic concentrations about two years after organic carbon injections ceased. PT-1D, where more carbon was delivered at the very end of the operation of the IRZ was slower to show attenuation. Arsenic has returned to pretest concentrations at both PT-1D and PT-3D locations, whereas manganese attenuation within the reducing zone has in general been slower (possibly due to a difference in the primary mechanisms of attenuation between arsenic and manganese [arsenic association with various reduced iron minerals that form in the IRZ]) but attenuation has been more rapid where carbon loading was lower (PT-3D).

In the Upland pilot test (**Figure G10** carbon was distributed and a reactive zone was created along the flow path in the shallow zone from PTR-2 through MW-24A and PT-8S. Within this reactive zone, manganese concentrations up to 17,200 μg/L and arsenic concentrations up to 82.8 μg/L were generated. By the time treated water reached PT-7S located less than 100 feet outside of the reactive zone, as evidence by decreased hexavalent chromium and nitrate concentrations and the presence of groundwater tracers fluorescein and eosine, manganese concentrations decreased by 87% to 2,300 μg/L and arsenic concentrations decreased by 85% to 12.1 μg/L. It is expected that concentrations would have decreased further, if given more distance.

At another California site located in the Mojave Desert (**Figure G11**) a full-scale IRZ in a barrier configuration similar to what might be installed at National Trails Highway has been in operation for 18 months, and treated groundwater arrival has been observed up to approximately 1,100 feet downgradient. Within the reactive zone, dissolved manganese concentrations ranging between 1,950 and 4,670 µg/L were generated within the IRZ. As treated groundwater migrated downgradient of the IRZ into the redox recovery zone, dissolved manganese attenuated. Within approximately 500 feet downgradient of the injection locations, dissolved manganese concentrations decreased and ranged from less than 10 µg/L to 1,360 µg/L. Within approximately 1,000 feet of the injection locations, manganese attenuated completely and concentrations ranged from less than 10 µg/L to 21.8 µg/L. Decreasing dissolved manganese concentrations with distance along the flowpath is shown for various locations across the IRZ in **Figure G11**. Arsenic generation was not observed.

The degree to which naturally occurring metals are mobilized is tied to the strength of the reducing environment created within the IRZ, which in turn is driven by the availability of degradable organic carbon. Empirical data demonstrates this as shown in **Figures G12**, **G13**, and **G14** which depict relative trends of iron, manganese, and arsenic versus total organic carbon (TOC) observed at several sites where large-scale, long-term IRZ remedies are currently being applied. The variability in the data is related to variability in 1) the consistency and length of time over which the organic carbon was present at the monitoring location, 2) mineral content, 3) aquifer structure to support mixing/flushing, and 4) anaerobic sequestration mechanisms that can work to dampen the dissolution response (discussed further in the next section). Overall, the data show a higher concentration of dissolved iron, manganese, and arsenic where a higher concentration of organic carbon is delivered.

In keeping with this concept, the basis for the IRZ-based alternatives included in this CMS assumes a level of organic carbon dosing that is consistent with the range of dosing used in the floodplain pilot demonstration. This provides a measure of certainty relative to the range in resulting concentrations of naturally occurring iron, manganese, and arsenic reductively dissolved within the treatment zones. As a point of comparison, the pump and treat alternatives can have similar effects on the aquifer geochemistry if dissolved organic carbon in the fluvial zone is pulled into the alluvial materials deeper in the Floodplain, allowing the establishment of reducing conditions and resulting in the dissolution of iron, manganese, and arsenic in the newly reduced sediments. In floodplain pilot test data from wells PT-5S and PT-6S, which are upgradient and outside the influence of the pilot test, organic carbon concentrations increased from March 06 to Dec 06, potentially indicating that more naturally reduced water was being pulled to those locations. During that time and into 2007, dissolved iron and dissolved arsenic increased at PT-5S (Fe 971 to 4,090 µg/L, As 8.86 to 18.8 µg/L). Dissolved manganese was relatively stable at PT-5S, but the elevated baseline concentrations are indicative of naturally occurring reducing conditions). At PT-6S, the TOC concentration increased similarly along with dissolved iron (3,530 to 24,900 µg/L) and arsenic (12.6 to 49.4 µg/L).

8.2.1 Expected Range of Byproducts Anticipated from the Proposed Remedies

The expected range of Fe, Mn and As anticipated from the proposed remedies will be within the range observed in natural reducing zones at the site, or approximately 0 to 30,000 µg/L Fe, 0 to 10,000 µg/L Mn, and 0 to 50 µg/L As. This range is consistent with the range observed in the floodplain IRZ pilot test. Higher concentrations were temporarily observed in a few upland pilot test monitoring wells (**Figure G10**), but this test had far higher carbon loading concentrations than would be utilized in IRZs at the Topock site as proposed in these alternatives. Close to injection wells where organic carbon is being injected the high range will likely be observed, and a short time after cessation of injection, these concentrations will drop off. With further distance from the injection wells, substantially attenuated concentrations of these constituents will be observed, which in time will return to baseline conditions associated with the natural aquifer conditions (fluvial materials typically reducing, and alluvial materials typically oxidizing).

As demonstrated in **Figures G12** through **G14** controlling the carbon dose will limit the generation of metals. The specific concentrations observed will be unique to each site, but the process has been observed at many IRZ sites.

In a full-scale IRZ remedy, TOC would likely be added at a concentration not greater than 1,000 mg/L, this was the concentration used in the floodplain pilot test. **Figure G9** presents the range of concentrations of Mn and As generated by 1,000 mg/L TOC.

8.3 Fate of Metals Liberated within the Anaerobic IRZs: During Remedy Operation

The geochemical processes responsible for attenuation of inorganics include sorption to soil minerals (and organic matter) under both anaerobic and aerobic conditions, diffusion processes (with movement from areas of high concentration to areas of low concentration) related to groundwater flow patterns, and precipitation or co-precipitation. The movement of inorganics such as arsenic involves the continual back-and-forth interplay of these processes, which restricts flux out of a zone of reductive dissolution, something that is supported by studies of areas with regionally elevated arsenic in groundwater. Further, these studies do not exhibit evidence of accumulation along flow paths, but rather exhibit the greater significance of mineral characteristics, aquifer structure, and redox poise on the distribution of arsenic (Kinniburgh et al., 2002).

As a result of these processes, geologic timeframes would typically be required to flush out the mass of naturally occurring metals liberated by reductive dissolution (Kinniburgh et al, 2002). Given the relatively short timeframes associated with the remedial alternatives incorporated in this CMS, it is reasonable to expect that the bulk of the liberated mass of metals won’t mobilize beyond the edge of the treatment zone, leaving them to re-stabilize after treatment is complete (discussed in the next section). For the fraction that does mobilize beyond the treatment zone, the variety of processes previously mentioned will work to limit transport as follows:

- In areas that are naturally reducing, there is still significant attenuation potential in the form of reactive minerals. For example, arsenic has been shown to sorb to iron sulfide minerals that form in anaerobic environments (Bostick and Fendorf, 2003; Wolthers et al., 2005). Other minerals that can form in natural anaerobic settings that have capacity for arsenic uptake include mixed ferric/ferrous iron oxides (Pedersen et al., 2006), ferrous iron hydroxides (Lin and Puls, 2001), and ferrous iron carbonates (Nath et al., 2009). Given the natural iron and manganese content of the site soils, there is potential for all of these minerals to be present. The footprints over which each specific mineral might be present will be dependent on a variety of factors, but they would all ultimately be expected to overlap.
- In areas that are naturally aerobic, there are a host of minerals that have sorptive capacity for arsenic (Smedley and Kinniburgh, 2002; Stollenwerk, 2002). This includes ferric iron minerals, manganese minerals, aluminosilicates (clays), and even quartz.

The effects of the above processes are more pronounced at the relatively low concentrations anticipated in the IRZs. For example, under these conditions the aquifer soil has an excess of available sorption capacity relative to the concentration of arsenic that is released (Kersten and Vlasova, 2009; Smedley and Kinniburgh, 2002). While it is true that given sufficient time, the continual influx of metals from an engineered IRZ will consume the effective sequestration capacity of the natural formation, the short timeframes, low groundwater flow rates, and low dissolved concentrations that will be released should have limited impact on this natural capacity.

As an example, **Figure G15** depicts relative trends of iron, manganese, and arsenic through the centerline of an IRZ at a site where the technology has been in place for over 5 years, just upgradient of a river floodplain. The data are from different wells along a flowpath. The x-axis represents how many days it takes groundwater to travel from the injection wells to each monitoring well along the flowpath. This site is being operated at much higher organic carbon dosing than is planned for Topock, and has liberated much higher concentrations of metals than has been observed at Topock. As depicted, the metals liberated in the IRZ have not mobilized beyond the downgradient edge even after 5 years of flushing. At this site, the anaerobic zone created extended 250 feet downgradient of the injection locations and beyond that the redox conditions recovered to the baseline oxic conditions. The limit on the length of the anaerobic zone, however, was intentional and did not limit the extent of *in-situ* treatment. Treated groundwater continued to migrate downgradient of the reactive zone, and treated groundwater arrived at locations in the redox recovery zone. As presented in several of the *in-situ* treatment alternatives, the chromium present downgradient of the reactive zone of one IRZ would be treated in the subsequent IRZ as treated groundwater arrives in the area, flushing the chromium originally present into the downgradient IRZ.

Increased metals concentrations in a well hundreds of feet or more from the river does not equate to increased flux into the river. Transport of iron, manganese, or arsenic from the reducing zone is not conservative with groundwater flow, because these constituents attenuate with distance, in both reducing zones and in oxidizing zones. Mechanisms of attenuation will occur both during remedy operation and after cessation of injection. Attenuation processes in reducing zones such as the floodplain natural reducing zone or the reducing zone associated with an IRZ include attenuation through precipitation, sorption, diffusion and co-precipitation. Arsenic and Mn do not need to be transported to an oxidized zone to precipitate as a carbonate (for Mn) or sulfide (for As), both of which happen in reducing zones of an IRZ. Adsorption of these elements also occurs in the reducing zone to minerals that are stable in the reducing zone, including iron sulfides, mixed valence iron oxides such as magnetite or green rust, and some aluminum hydroxides and silicates. Thus transport of these elements from the reducing zone to an oxidizing zone is not required for them to return to low solubility forms. If transported into the oxidized zone, As and Mn will also be attenuated by sorption and co-precipitation to metal oxides, and by the oxidation of manganese to form an oxide precipitate. Any Mn and As that is transported out of the reducing zone will eventually be immobilized as they enter the more oxidizing environment.

The most significant residual byproducts will be manganese (Mn) and arsenic (As), natural constituents of the aquifer matrix released into solution by reduction reactions. Once released, the reduced forms of Mn and As will be attenuated through sorption, diffusion, precipitation and co-precipitation, processes that occur in both the reduced zone in the IRZ, and the oxidized zones adjacent to the IRZ or after the IRZ injections are completed and the natural ambient oxidizing conditions are re-established. Residual byproducts will be managed through system monitoring and operations. Several examples of byproduct attenuation with time and distance were presented in Section 8.2; the following sections present a description of the mechanisms responsible for byproduct attenuation both during and after IRZ remedy operation.

8.4 Fate of Metals Liberated within the Anaerobic IRZs: After Remedy Completion

The dissolution of iron, manganese and arsenic in IRZs is temporary. When the organic carbon injected to form the IRZ is consumed, the concentrations of iron, manganese, and arsenic begin to return toward baseline concentrations. The amount of time it takes for iron, manganese, and arsenic dissolution to cease depends on how much residual organic carbon is present. In the Floodplain pilot test, it took longer for manganese dissolution to decline after injections in locations that received a high dose of organic carbon (PT-1D) than locations which received less (PT-3D) (**Figure G5**). After the organic carbon is exhausted and microbial dissolution is halted following injections, other mechanisms will begin to help attenuate the residual concentrations. These include dilution, sorption of dissolved manganese to the aquifer soil (even under reducing conditions manganese can sorb to aquifer minerals (Jun et al., 2005), co-precipitation with iron oxyhydroxides, and precipitation as carbonate minerals (such as manganese carbonate). As discussed above, under reducing conditions arsenic can sorb to various reduced iron minerals, including hydroxides, oxides, carbonates, and sulfides.

The restoration of aerobic conditions in the treatment area will achieve further reductions as the controlling mineral phases for iron and manganese transition to oxide minerals and the formation of fresh iron oxides also enhances arsenic removal (Dixit and Hering, 2003). Because of the slow rate of natural groundwater transport, this has the potential to take a period of time. Natural oxygen recharge must overcome the fraction of the reducing equivalents delivered during treatment that ended up stored in reactive forms in the aquifer.

Another factor that will further limit the overall flux of reductively dissolved metals is the conceptual operational configuration of the IRZ systems being contemplated. In each case, the IRZs will be cycled in the sense that organic carbon injection will not be continuous. This allows the system to begin cycling back to more aerobic conditions between injection cycles, in turn dropping concentrations of the metals back toward baseline. If monitoring indicates that by-products remain temporarily elevated above baseline and background for an extended period of time, appropriate actions will be taken.

8.5 Implications for Total Dissolved Solids

Geochemical processes that will alter the concentrations of constituents that contribute to TDS include mineral precipitation and microbially mediated redox reactions. **Figure G16** shows the changes in concentrations of TDS and constituents which contribute to TDS during and following the Floodplain *in-situ* pilot test at a representative monitoring well, PT-1D. In general, TDS concentrations decreased during injections, and returned to baseline concentrations following injections.

Several parameters which contribute to TDS will decrease within the IRZ. Calcium and magnesium concentrations will decrease due to carbonate mineral precipitation. Increasing alkalinity and carbonate concentrations that result from microbial oxidation of organic carbon will exceed the solubility of the calcium and magnesium carbonate minerals, causing their precipitation. In the Floodplain pilot test, calcium concentrations decreased by 200 to 250 mg/L, while magnesium decreased by 10-15 mg/L (data not shown). Nitrate and sulfate are also removed under the reducing conditions within an IRZ. Denitrifying bacteria convert nitrate to nitrogen gas. Sulfate reduction results in the conversion of sulfate to sulfide which is removed from solution through the precipitation of (iron) sulfide minerals. Sulfate is a significant component of TDS, and sulfate reduction in the Floodplain pilot test resulted in 600 to 800 mg/L decrease in sulfate concentrations.

Other parameters which contribute to TDS will increase as a result of the establishment of reducing conditions within an IRZ. As discussed above in Section 8.1, dissolved metals (iron, manganese, arsenic) concentrations increase. However, the concentration changes are on the order of tens of mg/L, which are insignificant in comparison with baseline TDS concentrations in the range of several grams per liter (g/L). Bicarbonate concentrations also increase due to oxidation of organic carbon (i.e., lactate in the Floodplain pilot test). In the Floodplain pilot test, bicarbonate alkalinity increased by several hundred mg/L.

Various substrates could be used to create reducing conditions within an IRZ suitable for hexavalent chromium reduction (Section 4.3). The TDS content varies with substrate. Food grade substrates, such as whey, molasses, and corn syrup, may contain small amounts of various cations, anions, or metals. Anionic substrates, such as lactate, may contain a counter ion, such as sodium, which would contribute to TDS. Alcohols, such as ethanol and methanol, are relatively pure and do not contain significant amounts of constituents that contribute to TDS. Regardless of the substrate used, the impact of the substrate itself is not expected to result in an increase in TDS concentrations. The total TDS concentrations at working strengths for each is lower than the baseline TDS at Topock. The ionic strength of the sodium lactate injection solutions used during the Floodplain pilot test averaged approximately 4,900 mg/L TDS. The TDS of undiluted sodium lactate is 786,000 mg/L. In addition, the majority of the TDS in each substrate is the carbon substrate. A fraction of the organic carbon substrate concentration, but not the entire concentration, will end up contributing to TDS in the form of bicarbonate. The remainder of the carbon substrate will end up in microbial biomass and off-gassed as carbon dioxide.

The net effect of an operating anaerobic IRZ at the Topock site will be TDS neutral or slightly reduce TDS concentrations as evidenced in **Figure G16**.

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FIGURES

Remediation system buildings and substrate tank matching desert landscape.

Recirculation well field – wells are below grade within vaults.

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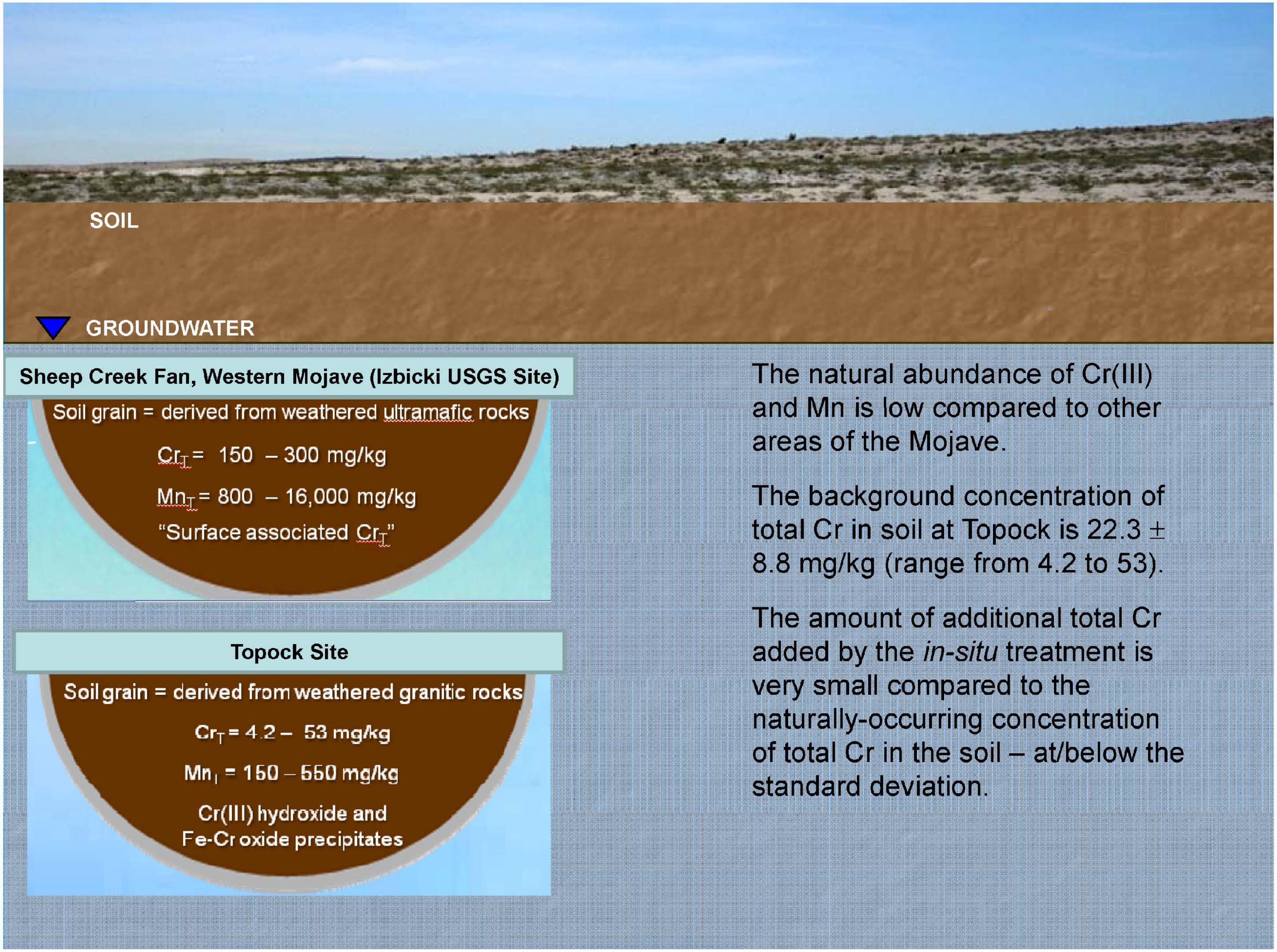
Hinkley Central Area In-situ Reactive Zone

Corrective Measures Study/Feasibility Study Report
for Chromium in Groundwater
Appendix G: *In-situ* Reactive Zone Treatment Design Elements

PGE Topock Facility
Needles, California

DATE: 11/06/2009

FIGURE
G1



Sheep Creek Fan, Western Mojave (Izbicki USGS Site)

Soil grain = derived from weathered ultramafic rocks

Cr_T = 150 – 300 mg/kg

Mn_T = 800 – 16,000 mg/kg

"Surface associated Cr_T"

Topock Site

Soil grain = derived from weathered granitic rocks

Cr_T = 4.2 – 53 mg/kg

Mn_T = 150 – 550 mg/kg

Cr(III) hydroxide and
Fe-Cr oxide precipitates

The natural abundance of Cr(III) and Mn is low compared to other areas of the Mojave.

The background concentration of total Cr in soil at Topock is 22.3 ± 8.8 mg/kg (range from 4.2 to 53).

The amount of additional total Cr added by the *in-situ* treatment is very small compared to the naturally-occurring concentration of total Cr in the soil – at/below the standard deviation.

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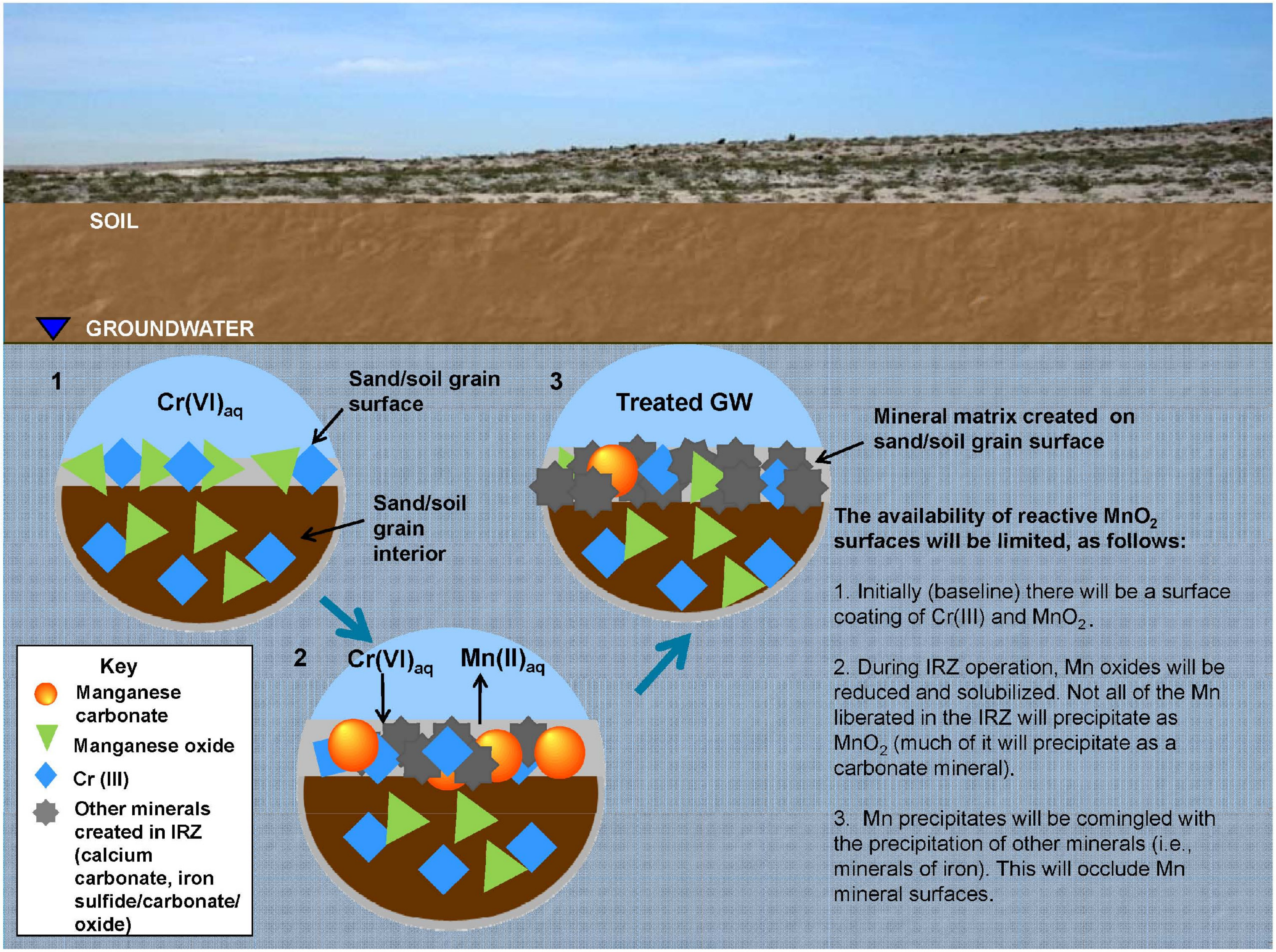
Permanence of Chromium Treatment: Limited total Cr and Mn in soils

Corrective Measures Study/Feasibility Study Report
for Chromium in Groundwater
Appendix G: *In-situ* Reactive Zone Treatment Design Elements

PGE Topock Facility
Needles, California

DATE: 11/06/2009

FIGURE
G2



The availability of reactive MnO_2 surfaces will be limited, as follows:

1. Initially (baseline) there will be a surface coating of Cr(III) and MnO_2.

2. During IRZ operation, Mn oxides will be reduced and solubilized. Not all of the Mn liberated in the IRZ will precipitate as MnO_2 (much of it will precipitate as a carbonate mineral).

3. Mn precipitates will be comingled with the precipitation of other minerals (i.e., minerals of iron). This will occlude Mn mineral surfaces.

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Permanence of Chromium Treatment: Limited availability of reactive Mn

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Appendix G: *In-situ* Reactive Zone Treatment Design Elements

PGE Topock Facility
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DATE: 11/06/2009

FIGURE
G3

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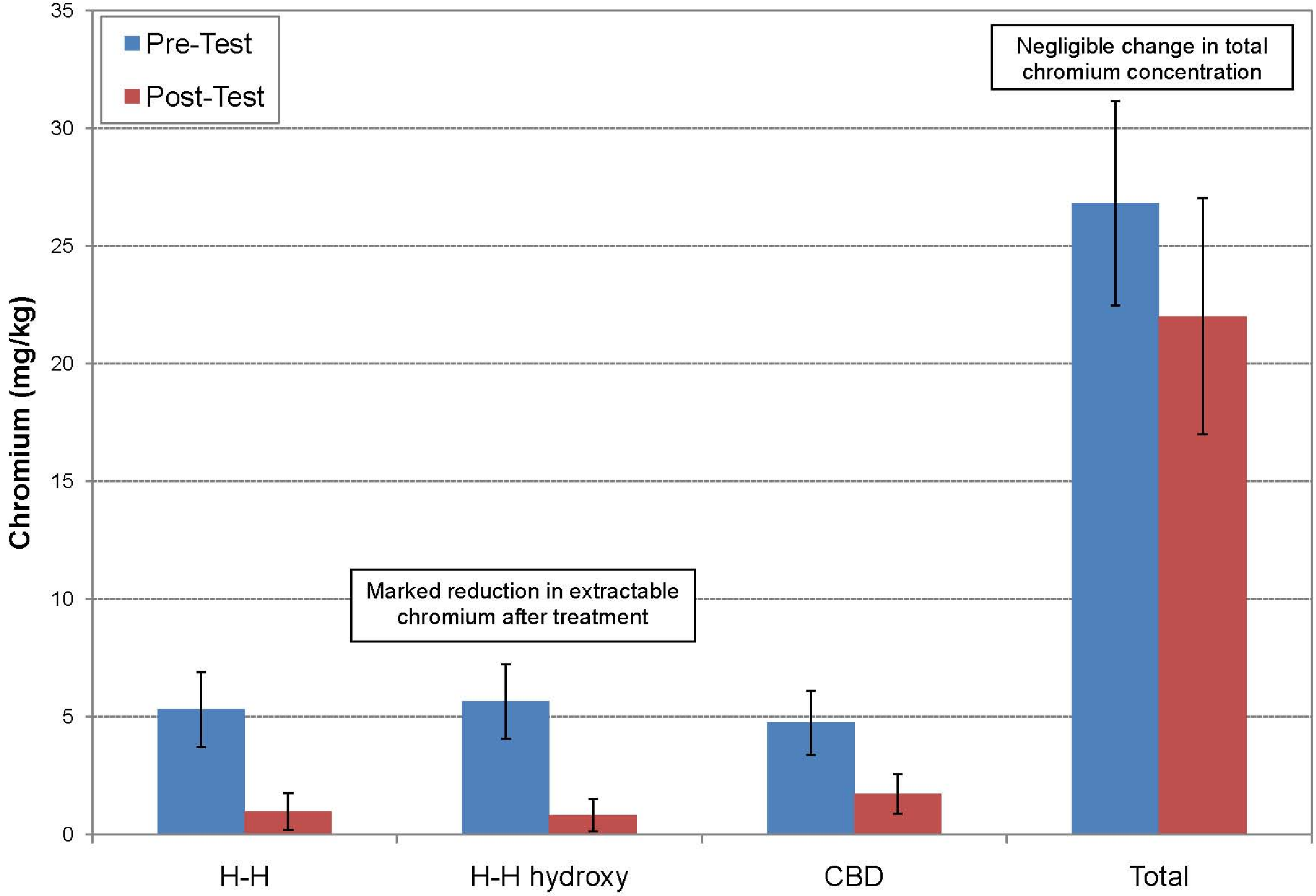

Negligible change in total chromium concentration

Marked reduction in extractable chromium after treatment

H-H: dilute hydrocholic acid extraction
H-H hydroxy: hydroxylamine hydrochloric extraction
CBD: citrate bicarbonate dithionite extraction

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Characterization of the total chromium in Topock Upland soil before and after IRZ treatment

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for Chromium in Groundwater
Appendix G: *In-situ* Reactive Zone Treatment Design Elements

PGE Topock Facility
Needles, California

DATE: 11/06/2009

FIGURE
G4

LEGEND

- ▨ Fluvial Deposits of Colorado River } Alluvial Aquifer
- 🟨 Older Alluvial Fan Deposits } Alluvial Aquifer
- ▩ Natural reducing zone in fluvial deposits (estimated beneath river and marsh)
- 🟧 Bedrock (Conglomerate and Igneous/Metamorphic Rocks)
- 🟥 Hyporheic Zone
- ⬛ Upland
- ▼ Water Table
- → Groundwater Flow Direction
- ❶ Observation Point

Fluvial deposits that reduce chromium are high in TOC, Mn, and As

❶

Alluvial Aquifer		
Groundwater	**Average Conc* (µg/L)**	**Conc Range (µg/L)**
Cr(VI)	1,401	100 ~ 16,000
Mn	129	<1 ~ 2,400
Fe	<500	below detection
As	3.6	<1 ~ 33.6
TOC	2,000	300 ~ 21,800
ORP (mV)	56	-419 ~ 520

Total Samples: 254

❷

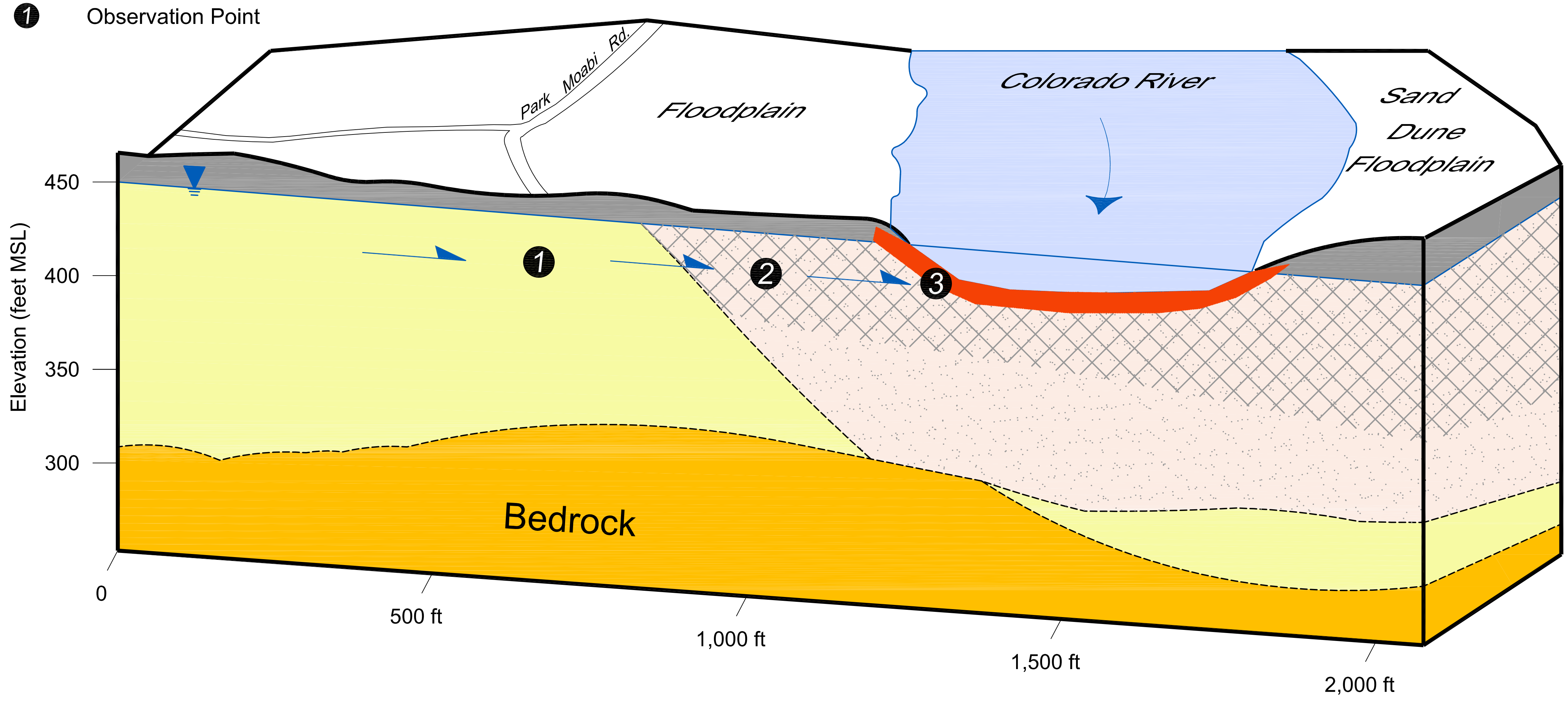
Fluvial Aquifer		
Groundwater	**Average Conc* (µg/L)**	**Conc Range (µg/L)**
Cr(VI)	<0.2	<0.2
Mn	999	<5 ~ 9,260
Fe	2,297	20 - 30,000
As	14.3	<5 ~ 65.0
TOC	4,730	300 ~ 76,000
ORP (mV)	-106	-344 ~ 516

Total Samples: 287

❸

Hyporheic Zone**		
Groundwater	**Average Conc* (µg/L)**	**Conc Range (µg/L)**
Cr(VI)	<0.2	<0.2
Mn	983	500 ~ 2,400
Fe	3,613	549 ~ 16,800
As	not analyzed	not analyzed
TOC	4,330	2,290 ~ 5,880
ORP (mV)	-162	-231 ~ -46

Total Samples: 10



NOTES:

* Average Conc = Arithmetic Average of Concentration.

** Data collected from sediments at a depth of six feet below the bottom of river.

< Less than reporting limit.

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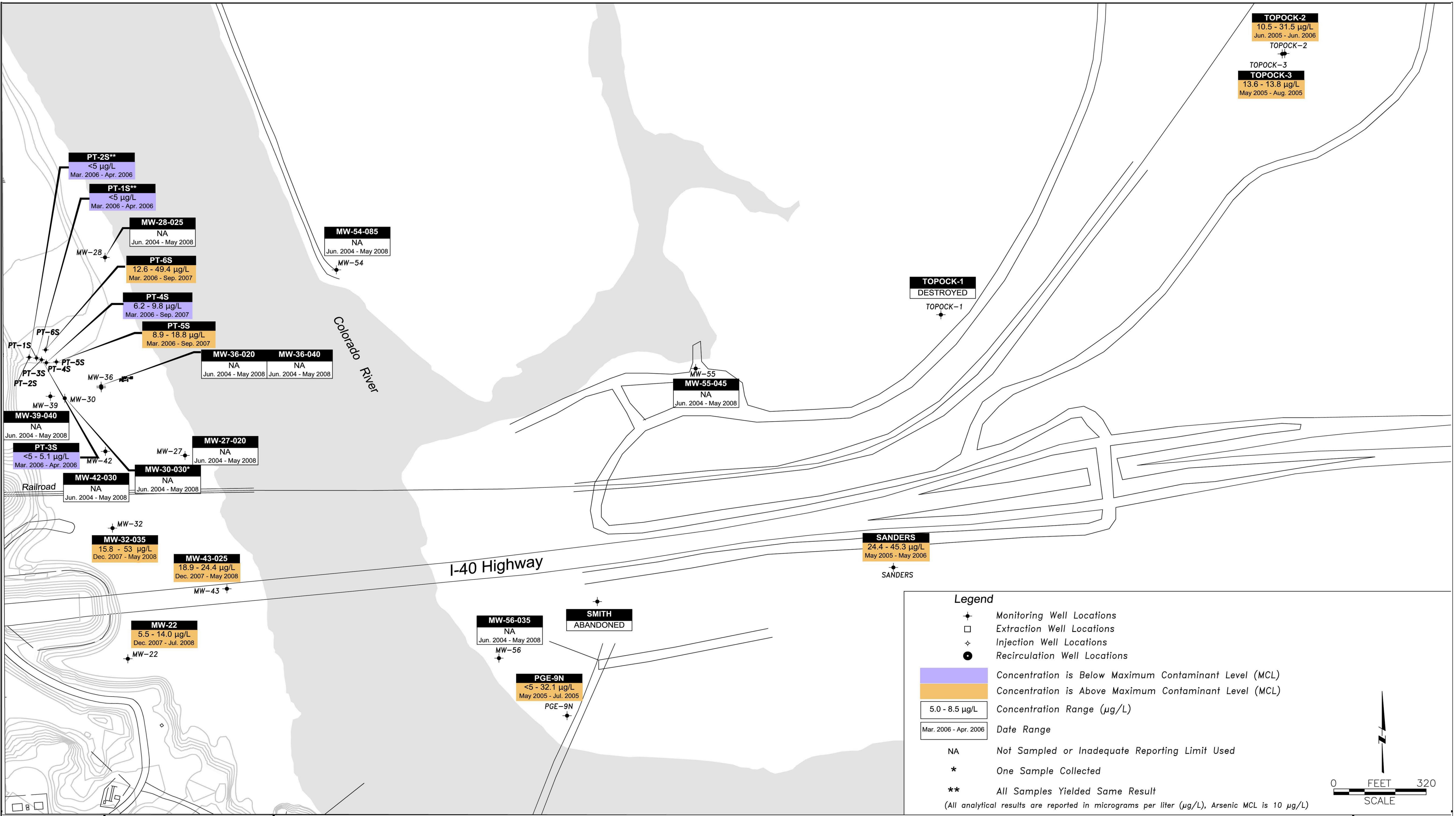
Floodplain and Upland Natural Geochemical Conditions

Corrective Measures Study/Feasibility Study Report
for Chromium in Groundwater
Appendix G: *In-situ* Reactive Zone Treatment Design Elements

PGE Topock Facility
Needles, California

DATE: 12/10/09

FIGURE
G5



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Near-Site Arsenic Data for Shallow Fluvial Aquifer

Corrective Measures Study/Feasibility Study Report
for Chromium in Groundwater
Appendix G: *In-situ* Reactive Zone Treatment Design Elements

PGE Topock Facility
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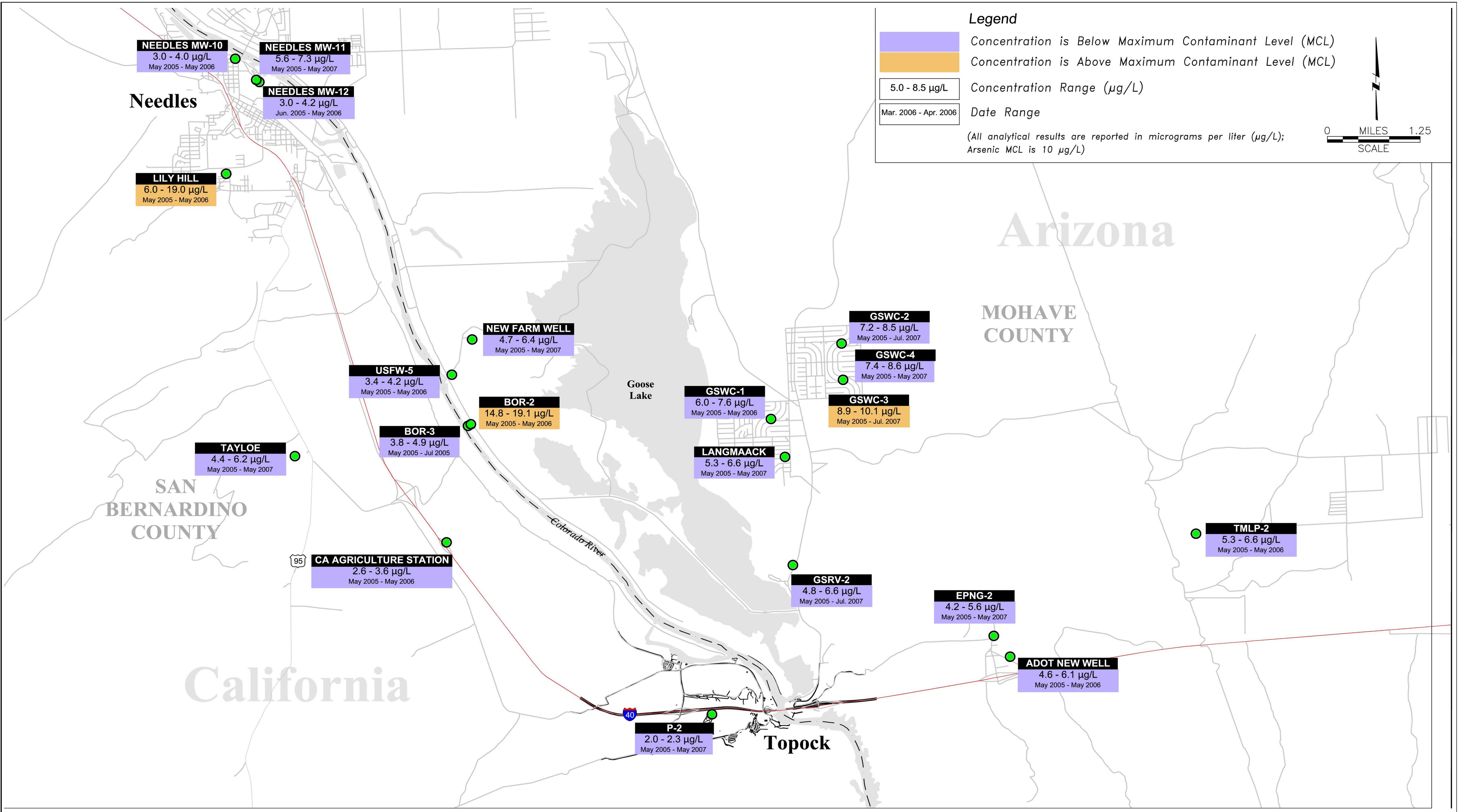
DATE: 11/06/2009

FIGURE
G6a



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Area-Wide Arsenic Data

Corrective Measures Study/Feasibility Study Report
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Appendix G: *In-situ* Reactive Zone Treatment Design Elements

PGE Topock Facility
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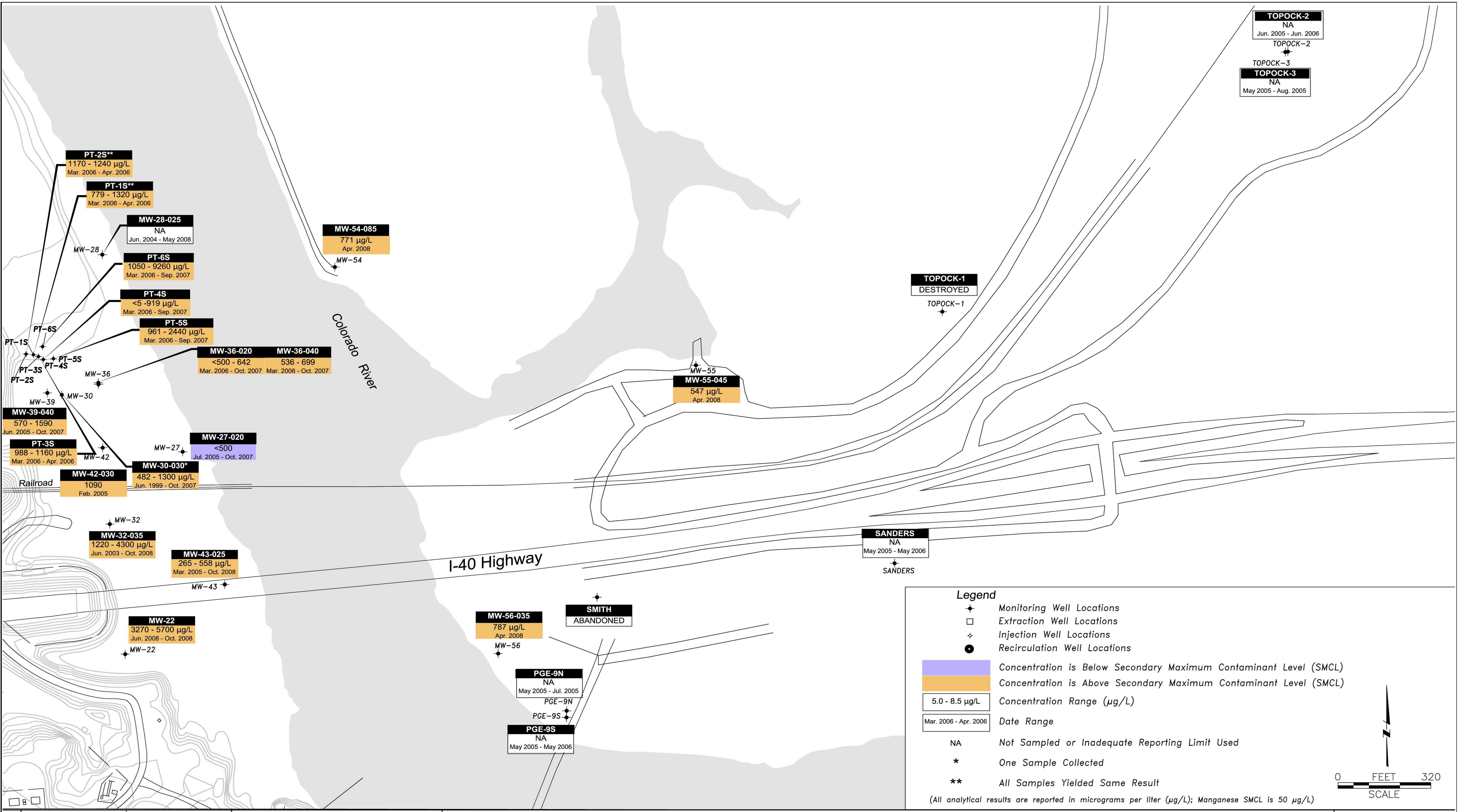
DATE: 11/06/2009

FIGURE
G6b



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Near-Site Manganese Data for Shallow Fluvial Aquifer

Corrective Measures Study/Feasibility Study Report
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Appendix G: *In-situ* Reactive Zone Treatment Design Elements

PGE Topock Facility
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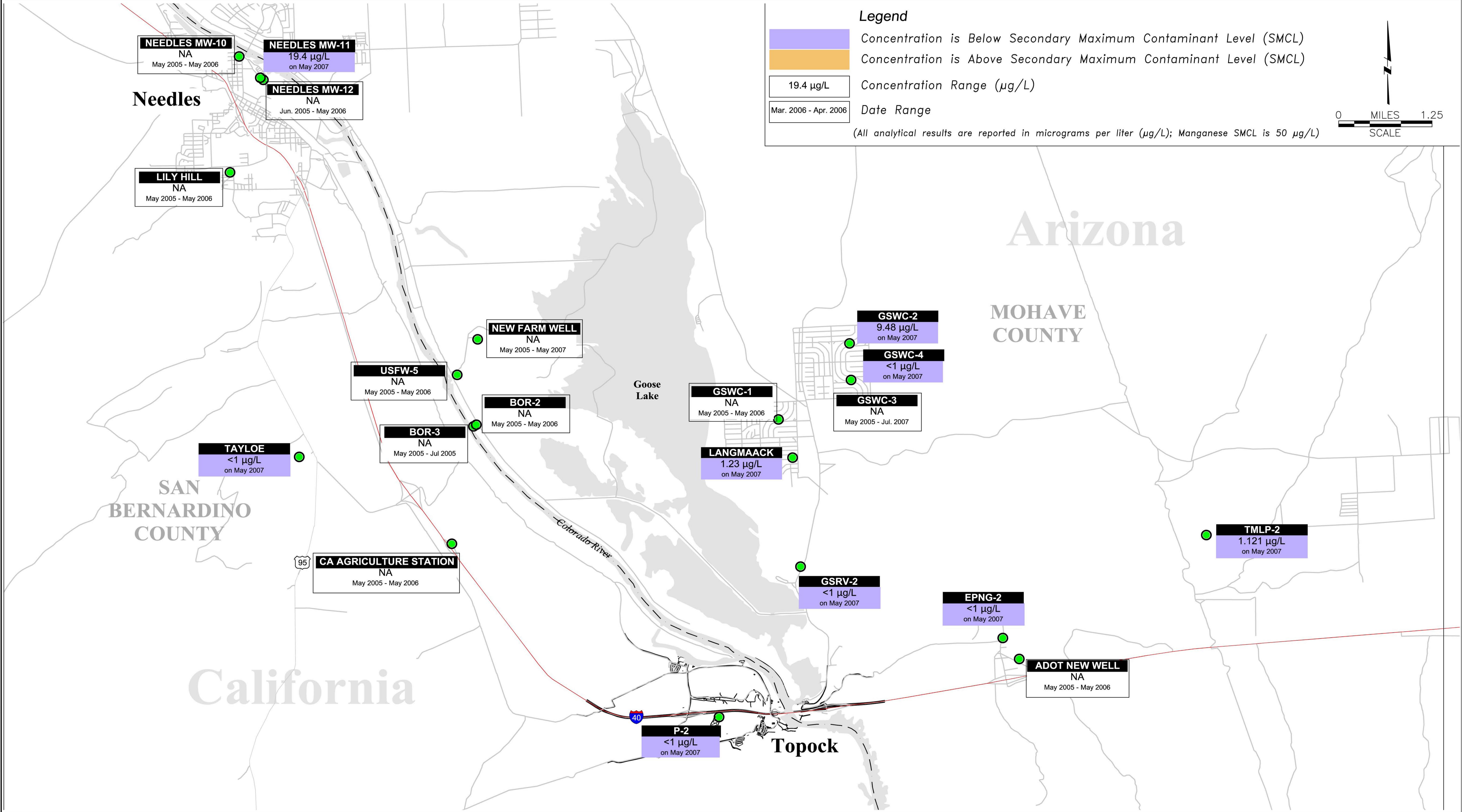
DATE: 11/06/2009

FIGURE
G6c



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Area-Wide Manganese Data

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Appendix G: *In-situ* Reactive Zone Treatment Design Elements

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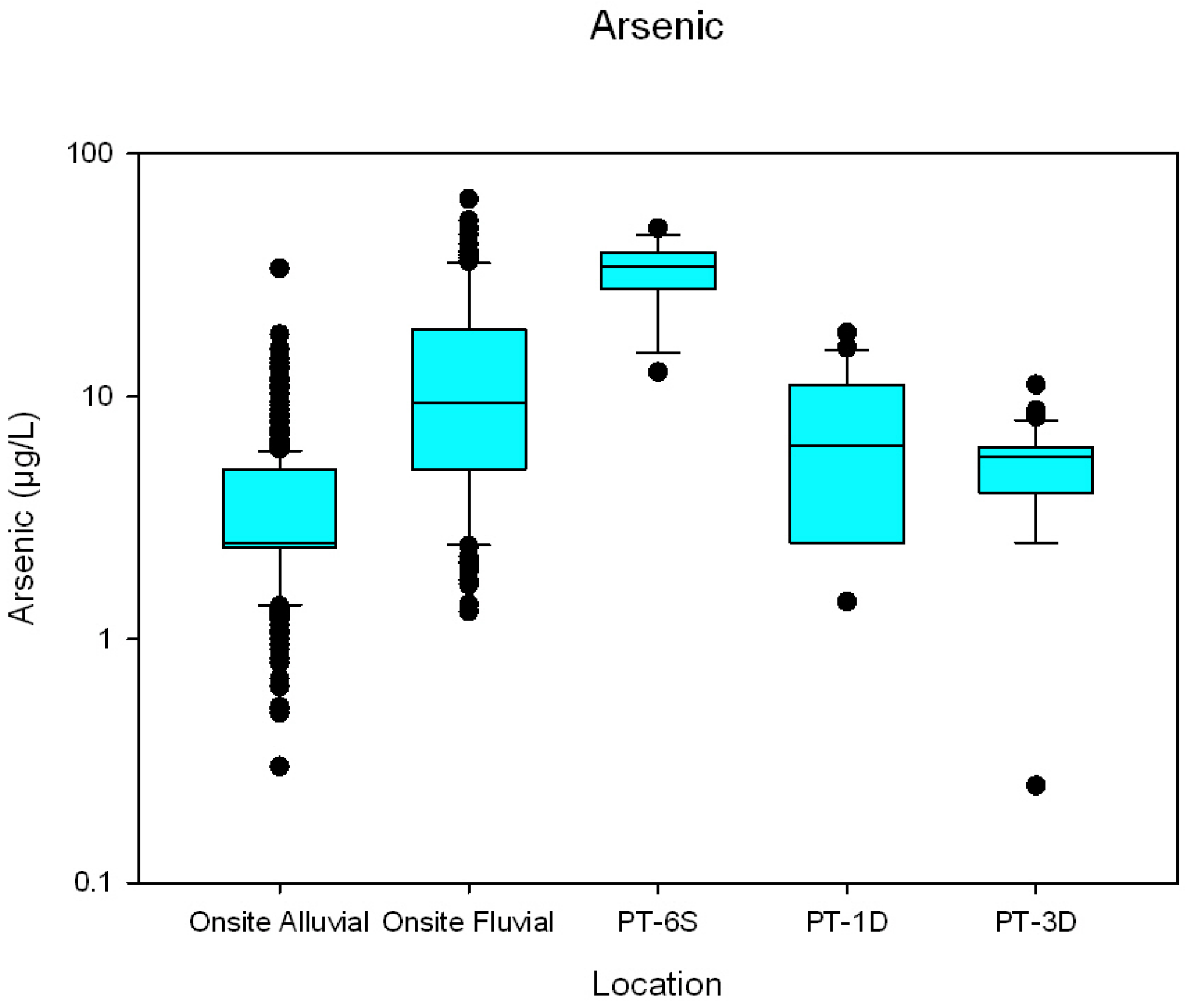
DATE: 11/06/2009

FIGURE
G6d



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Arsenic Concentrations

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Appendix G: *In-situ* Reactive Zone Treatment Design Elements

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DATE: 11/06/2009

FIGURE
G6e

Natural oxidation process decreases Mn, Fe, and As in porewater

LEGEND

▨ Fluvial Deposits of Colorado River } Alluvial Aquifer
🟨 Older Alluvial Fan Deposits } Alluvial Aquifer
▩ Natural reducing zone in fluvial deposits (estimated beneath river and marsh)
🟥 Hyporheic Zone
⬛ Upland
▼ Water Table
→ Groundwater Flow Direction
① Observation Point

① Fluvial aquifer =
Naturally elevated TOC, Fe, Mn, and As

②

Hyporheic Zone*		
Groundwater	**Average Conc (µg/L)**	**Conc Range (µg/L)**
Cr(VI)	<0.2	<0.2
Mn	983	500 ~ 2,400
Fe	3,613	549 ~ 16,800
As	not analyzed	not analyzed
TOC	4,330	2,290 ~ 5,880
ORP (mV)	-162	-231 ~ 46

③
- River flow = ~6.8 million gallons per minute
- River water is saturated with dissolved oxygen
- 100,000x more oxygen available than that required to oxidize all of the potential influent reduced metals**
- Abundance of iron in river sediments provides excess capacity for co-precipitation of As (Fe:As of 800:1***)

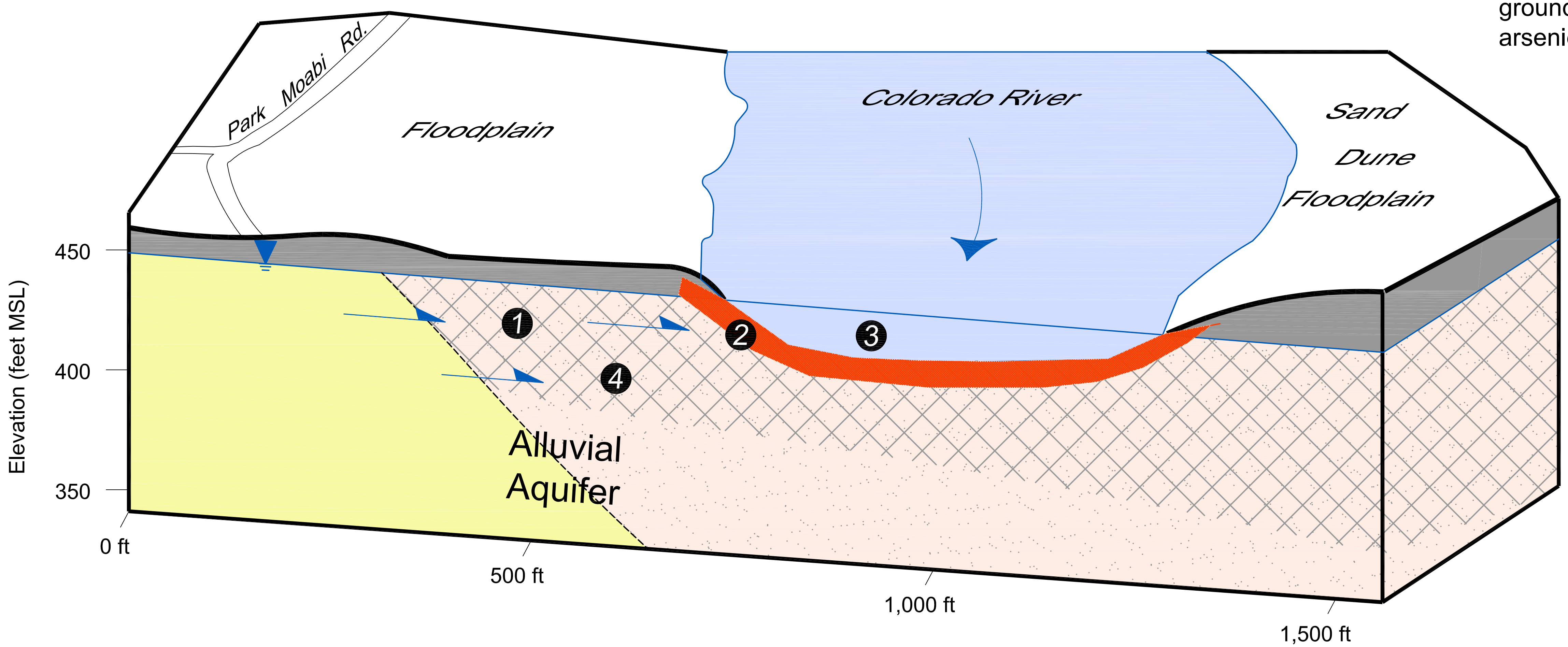
④ Pockets of less reducing conditions along groundwater flowpath =
arsenic sorption onto aquifer

NOTES:

* Data collected from sediments at a depth of six feet below the bottom of river; 10 samples.

** Oxygen demand calculated based upon oxygen required to oxidize the maximum concentration of dissolved iron and manganese.

*** Fe:As ratio based upon iron detected in porewater and assuming highest concentration of As measured in floodplain.



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Natural Conditions at Groundwater/River Interface

Corrective Measures Study/Feasibility Study Report
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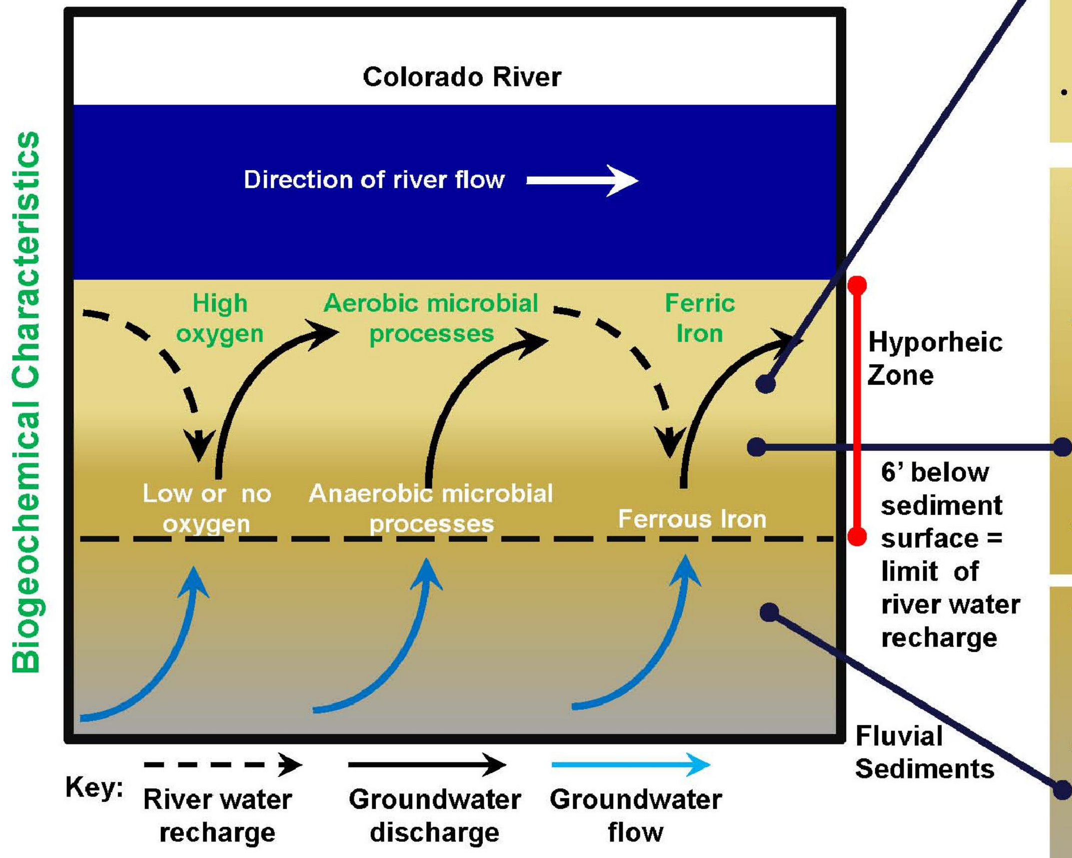
Appendix G: *In-situ* Reactive Zone Treatment Design Elements

PGE Topock Facility
Needles, California

DATE: 12/10/09

FIGURE
G7



- Oxidation of ferrous iron by dissolved oxygen and precipitation of ferric (hydr)oxides.
- Manganese oxidation by dissolved oxygen and aerobic microbial processes.
- Arsenic oxidation and co-precipitation with ferric iron.

- Redox transition zone (oxidation during river recharge and reduction during ground-water discharge).
- Oxidation of ferrous iron by dissolved oxygen; creation of mixed-valent iron (hydr)oxides and oxides.
- Sorption of manganese and arsenic to iron minerals.
- Oxidation of manganese by dissolved oxygen.

- Anoxic reducing zone; reduction of Cr(VI) to Cr(III), with precipitation of very low solubility Cr(III) minerals.
- Accumulation of iron sulfides, co-precipitation of arsenic with iron sulfides or mixed valence iron oxides.
- Precipitation of Mn as $MnCO_3$; sorption on mixed valence iron oxides.

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Detail of the Biogeochemical Processes in the Hyporheic Zone

Corrective Measures Study/Feasibility Study Report
for Chromium in Groundwater
Appendix G: *In-situ* Reactive Zone Treatment Design Elements

PGE Topock Facility
Needles, California

DATE: 11/06/2009

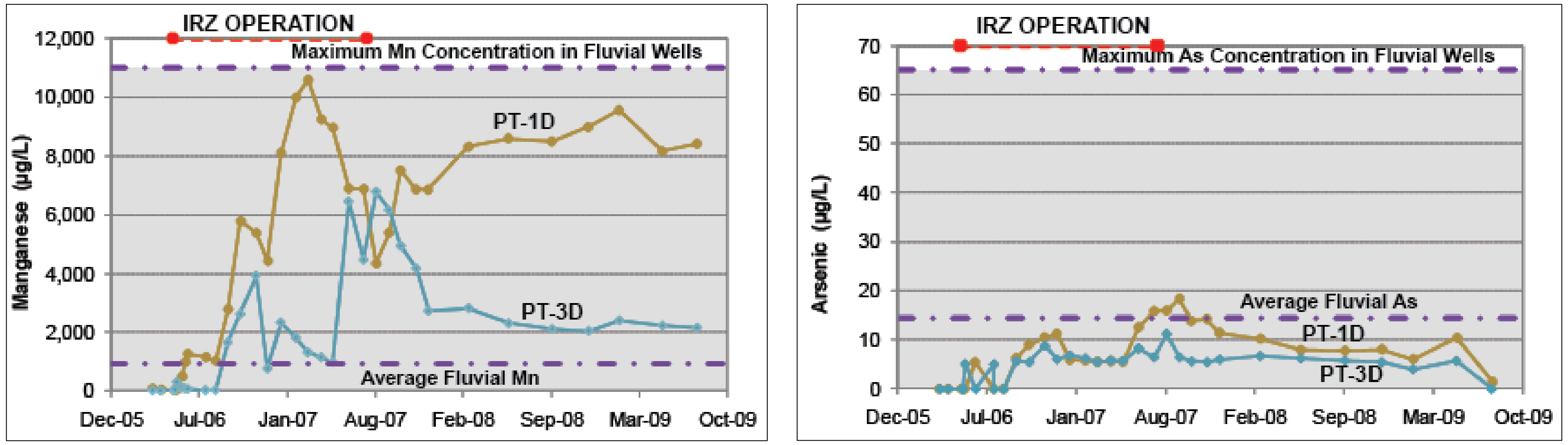
FIGURE
G8

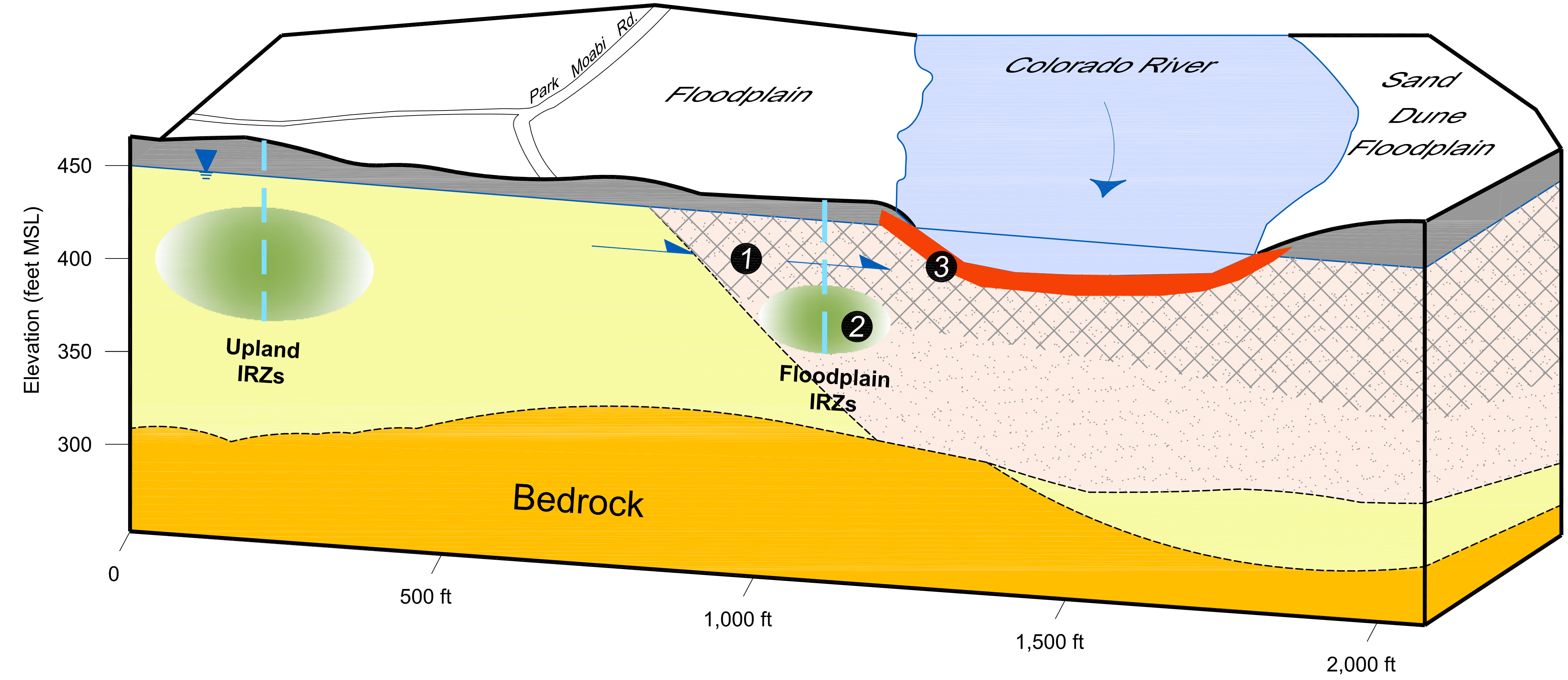
LEGEND

- ░ Fluvial Deposits of Colorado River } Alluvial Aquifer
- 🟨 Older Alluvial Fan Deposits } Alluvial Aquifer
- ▨ Natural reducing zone in fluvial deposits (estimated beneath river and marsh)
- 🟧 Bedrock (Conglomerate and Igneous/Metamorphic Rocks)
- 🟥 Hyporheic Zone
- ⬛ Upland
- ▼ Water Table
- → Groundwater Flow Direction
- ❶ Observation Point

Optimizing TOC during IRZ formation keeps manganese and arsenic concentrations in the IRZ below baseline fluvial conditions

❷ Shaded areas in the folllowing charts show range of baseline concentrations for Mn and As





❶ Dissolved metals sorb, co-precipitate, and diffuse naturally under aerobic and anaerobic conditions along flow path

❸ Natural oxidation of Mn, Fe, As occurs at groundwater/river interface

Date\Time : Thu, 10 Dec 2009 - 9:17am
Path\Name : K:\Misc. Tasks\PG&E\For_Monica\CAD\Schematic_Diagram_200912b.dwg

Acad Version : R17.0s (LMS Tech)
User Name : jchen

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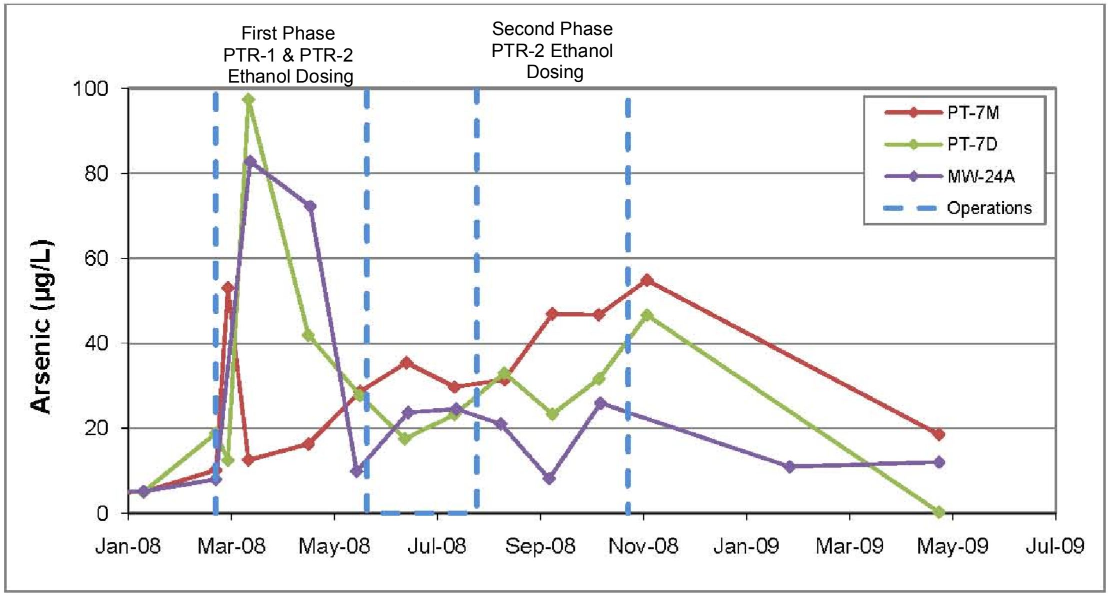
Chemical Conditions Created by IRZs

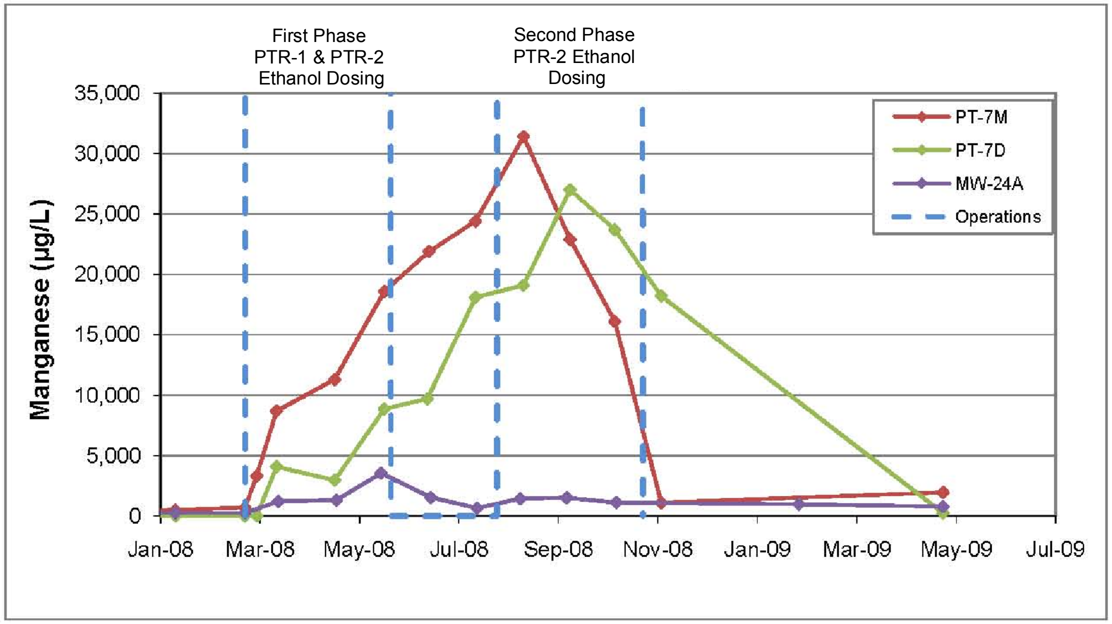
Corrective Measures Study/Feasibility Study Report
for Chromium in Groundwater
Appendix G: *In-situ* Reactive Zone Treatment Design Elements

PGE Topock Facility
Needles, California

DATE: 12/10/09

FIGURE
G9





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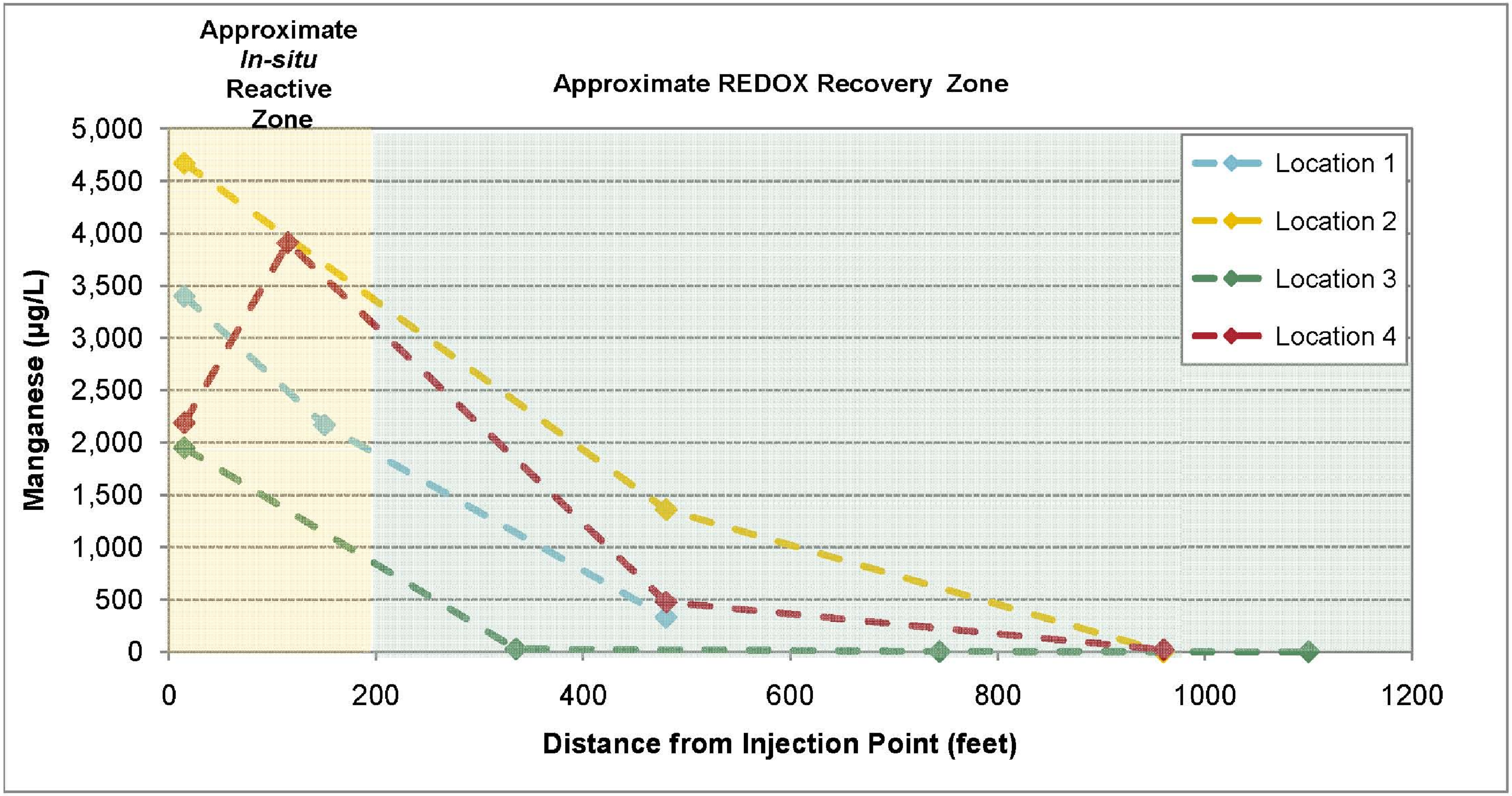
Manganese and Arsenic Generated in the Upland pilot test

Corrective Measures Study/Feasibility Study Report
for Chromium in Groundwater
Appendix G: *In-situ* Reactive Zone Treatment Design Elements

PGE Topock Facility
Needles, California

DATE: 11/06/2009

FIGURE
G10



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Downgradient Control on Manganese in the IRZ (Hinkley Central Area IRZ)

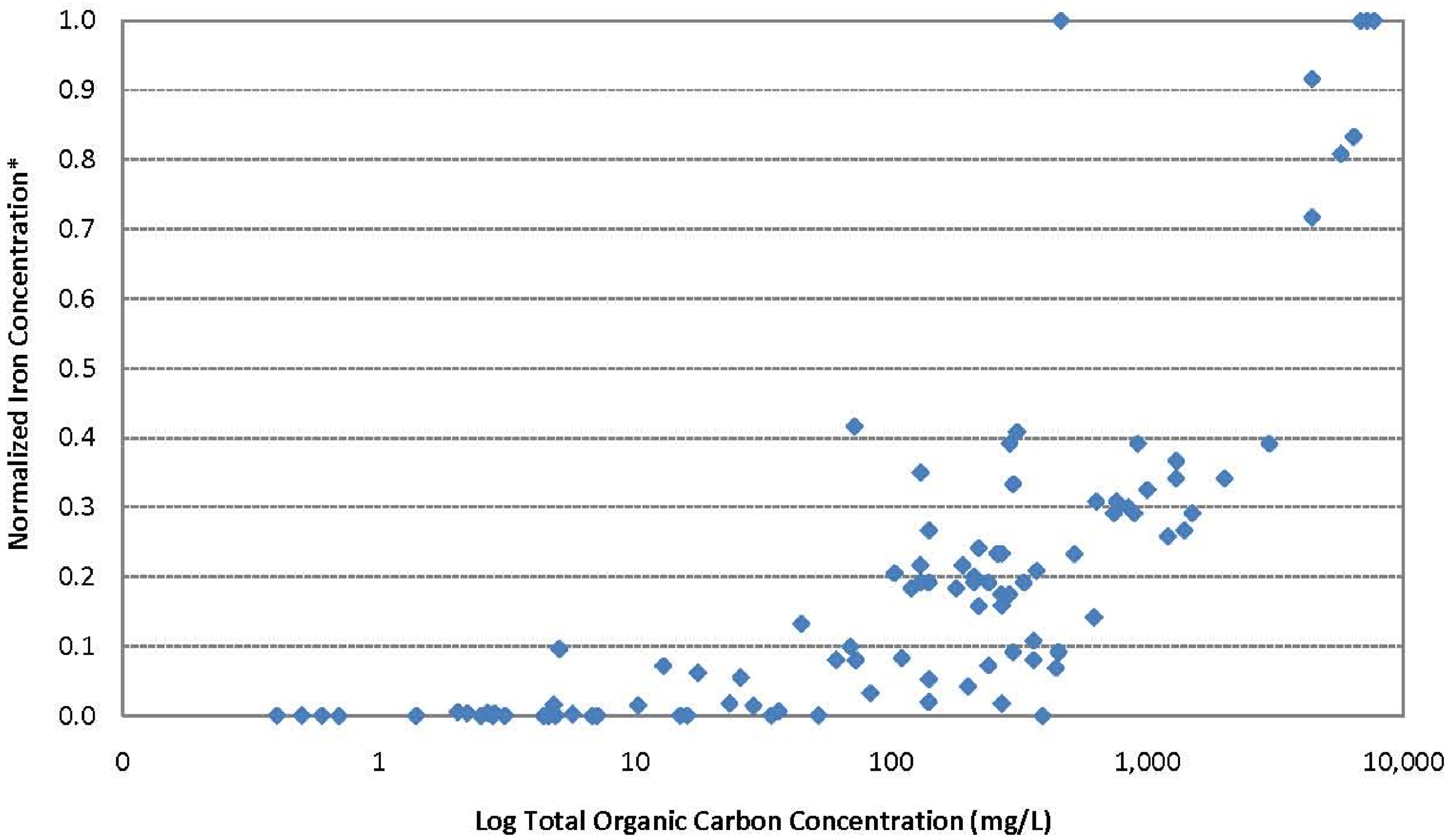
Corrective Measures Study/Feasibility Study Report
for Chromium in Groundwater
Appendix G: *In-situ* Reactive Zone Treatment Design Elements

PGE Topock Facility
Needles, California

DATE: 11/06/2009

FIGURE

G11



Notes:
*Normalized relative to maximum concentration

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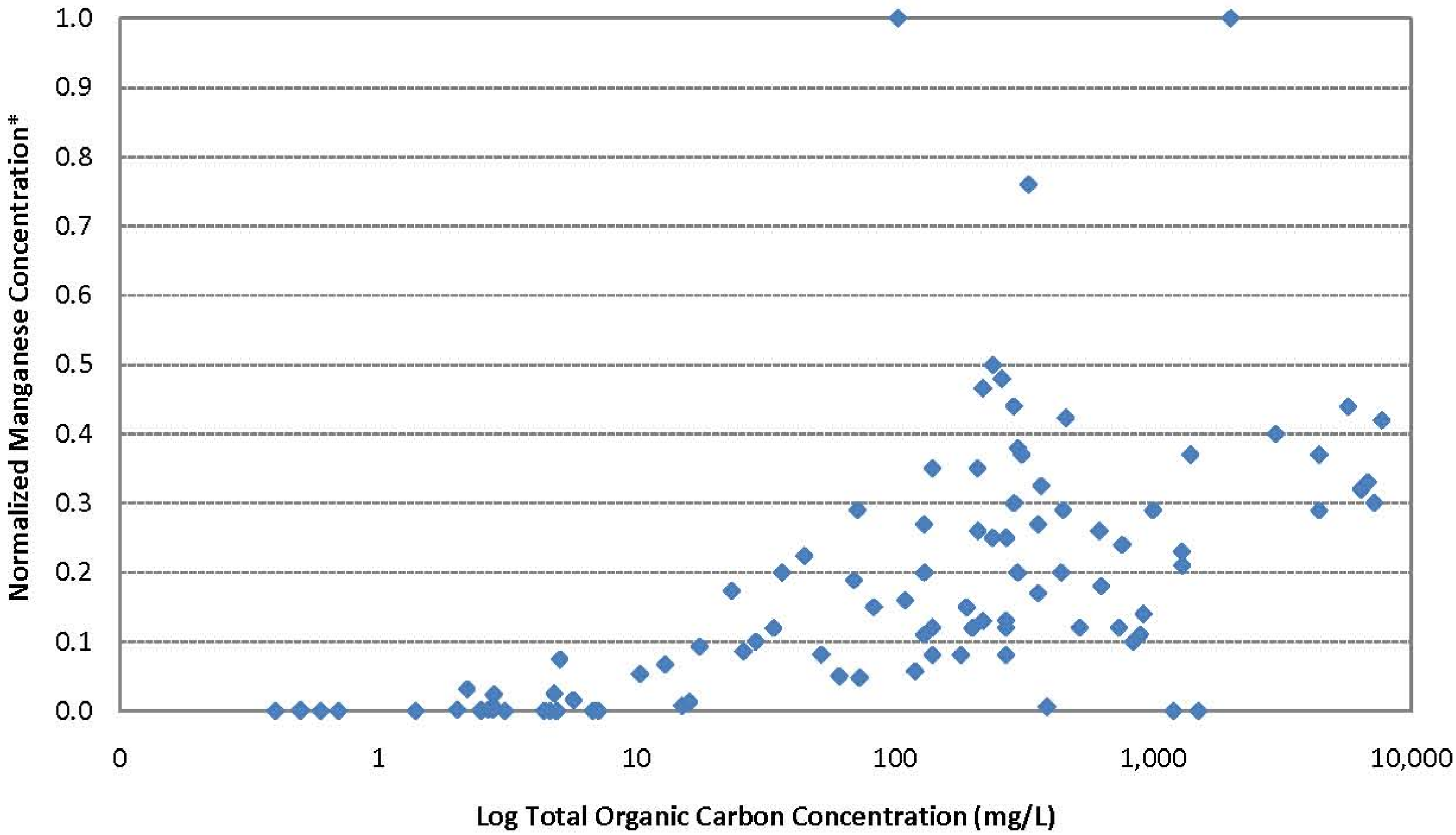
Correlation of Dissolved Iron with Total Organic Carbon

Corrective Measures Study/Feasibility Study Report
for Chromium in Groundwater
Appendix G: *In-situ* Reactive Zone Treatment Design Elements

PGE Topock Facility
Needles, California

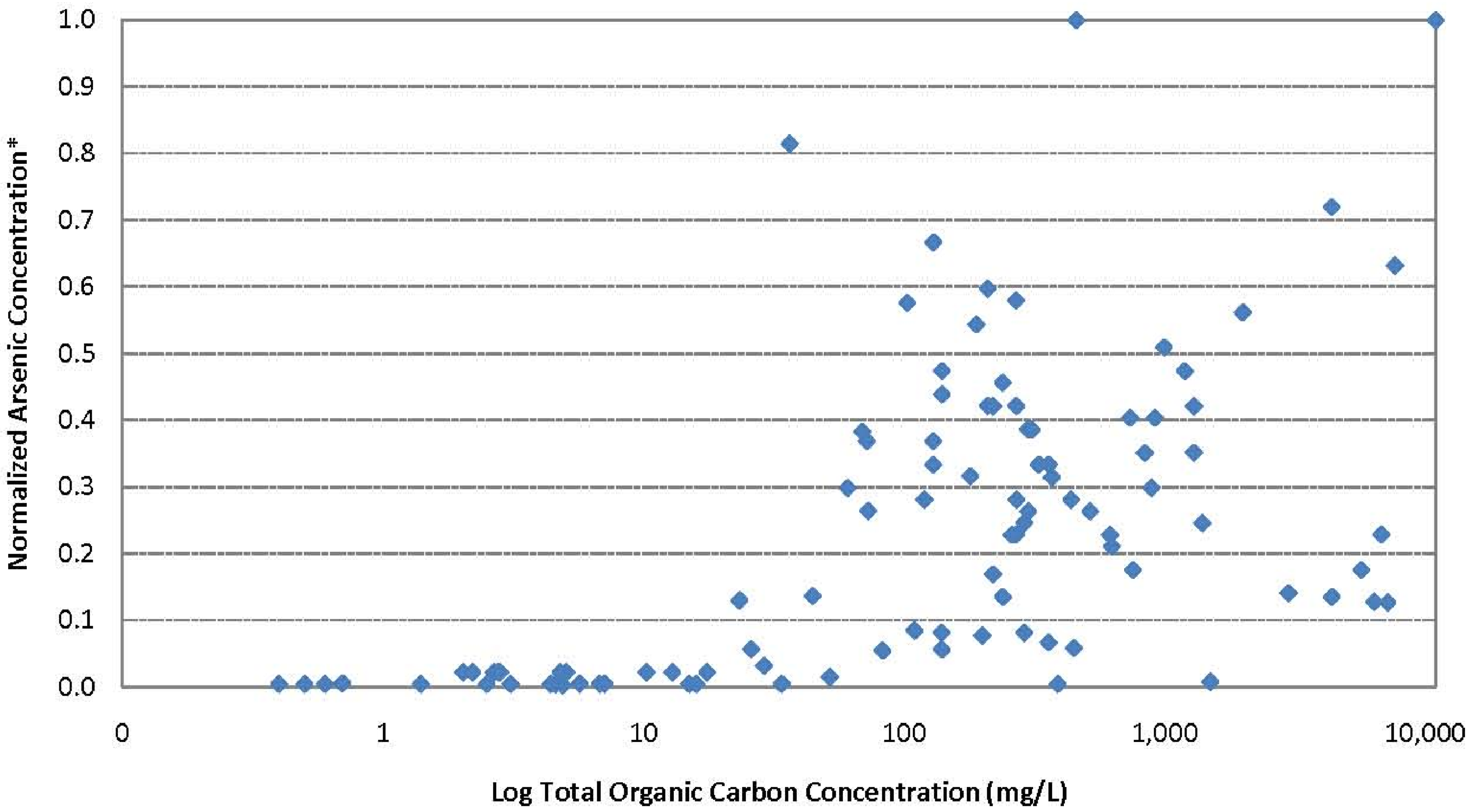
DATE: 11/06/2009

FIGURE
G12



Notes:
*Normalized relative to maximum concentration

Program Manager Lisa Cope Project Manager Lisa Kellog Task Manager Janis Lutrick Technical Review Jeff Gillow	ARCADIS 630 Plaza Drive, Suite 100 Highlands Ranch, Colorado 80129 Tel: 720-344-3500 Fax: 720-344-3535 www.arcadis-us.com	Correlation of Dissolved Manganese with Total Organic Carbon Corrective Measures Study/Feasibility Study Report for Chromium in Groundwater Appendix G: *In-situ* Reactive Zone Treatment Design Elements PGE Topock Facility Needles, California	DATE: 11/06/2009 FIGURE G13



Notes:
*Normalized relative to maximum concentration

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Correlation of Dissolved Arsenic with Total Organic Carbon

Corrective Measures Study/Feasibility Study Report
for Chromium in Groundwater
Appendix G: *In-situ* Reactive Zone Treatment Design Elements

PGE Topock Facility
Needles, California

DATE: 11/06/2009

FIGURE

G14

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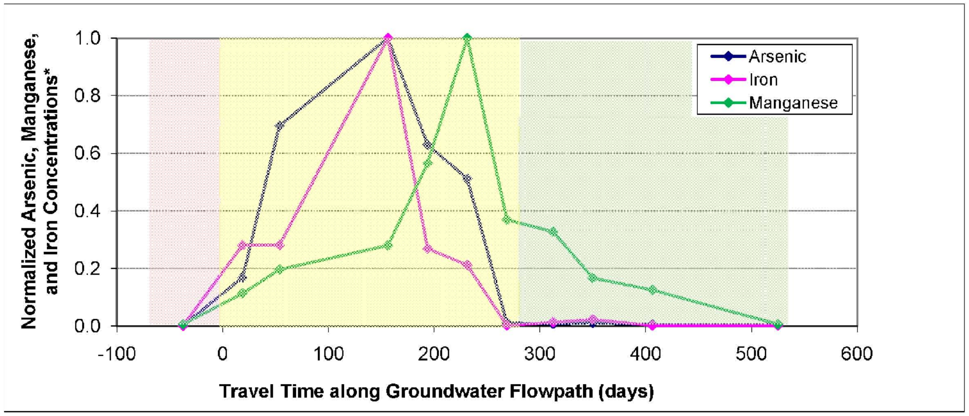
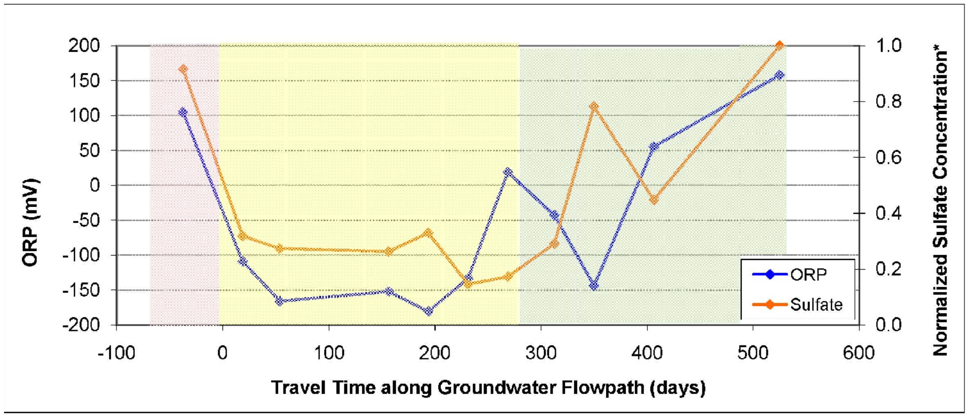
Stratified glacial outwash, primarily coarse sand and gravel

Groundwater velocity = 1 ft/day

Snapshot of data along groundwater flow path at a point after 4.5 years of operation



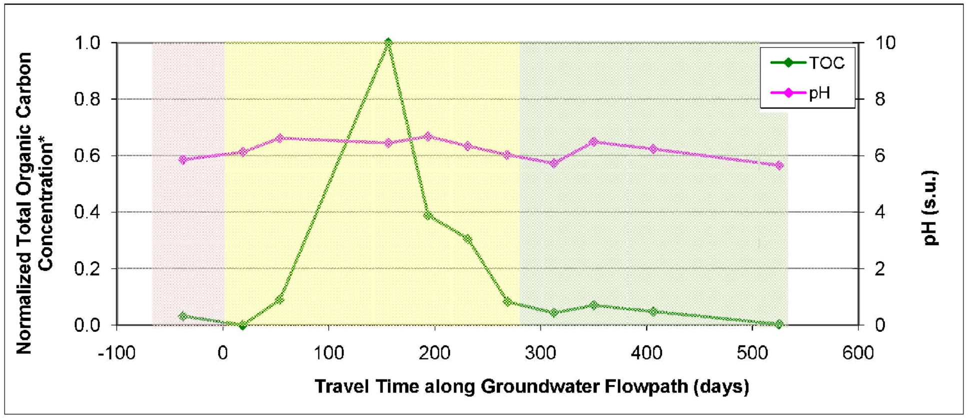


Legend

🟪 Upgradient Zone

🟨 In Situ Reactive Zone

🟩 Downgradient Redox Zone



Notes:
*Normalized relative to maximum concentration
Data taken from an anaerobic IRZ location other than Topock

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Fate of Metals in an Anaerobic IRZ

Corrective Measures Study/Feasibility Study Report
for Chromium in Groundwater
Appendix G: *In-situ* Reactive Zone Treatment Design Elements

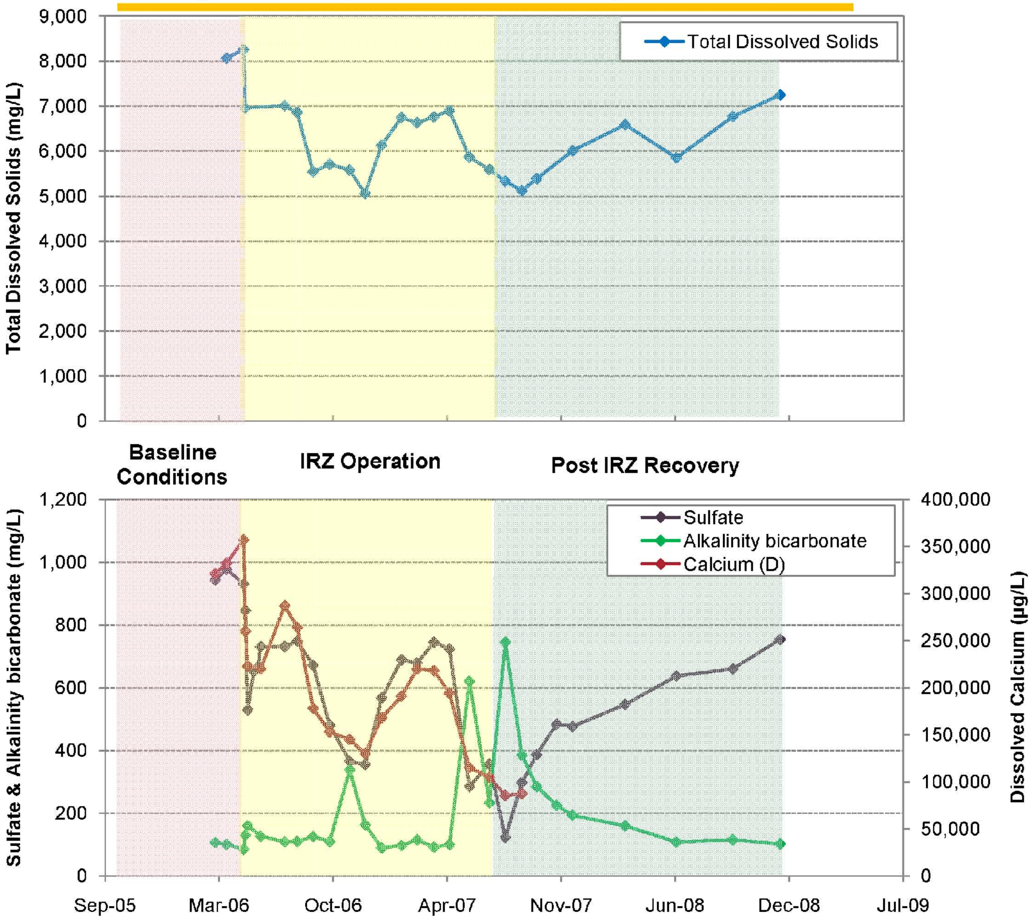
PGE Topock Facility
Needles, California

DATE: 11/06/2009

FIGURE

G15

No significant change in concentrations during or after IRZ operation



Legend

🟪 Upgradient Zone

🟨 In Situ Reactive Zone

🟩 Downgradient Redox Zone

Dilution (due to injections), creation of alkalinity through carbon metabolism - this causes calcite precipitation. Sulfate is biologically reduced.

Natural recovery; no longer generating alkalinity. Calcite precipitation and sulfate reduction stop.

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TDS in Floodplain Pilot Test Monitoring Well PT-1D

Corrective Measures Study/Feasibility Study Report
for Chromium in Groundwater
Appendix G: *In-situ* Reactive Zone Treatment Design Elements

PGE Topock Facility
Needles, California

DATE: 11/06/2009

FIGURE

G16

__________. 1999. *Use of Monitored Natural Attenuation at Superfund, RCRA Corrective Action, and Underground Storage Tank Sites*. EPA Office of Solid Waste and Emergency Response Directive 9200.4-17P. April.

__________. 2000. *A Guide to Developing and Documenting Cost Estimates During the Feasibility Study*. EPA 540-R-00-002. July.

__________. 2001a. *A Citizen's Guide to Pump and Treat*. December.

__________. 2001b. *A Citizen's Guide to Permeable Reactive Barriers*. April.

__________. 2004. *Handbook of Groundwater Protection and Cleanup Policies for RCRA Corrective Action*. EPA530_R_04-030. April.

__________. 2008. *Green Remediation: Incorporating Sustainable Environmental Practices into Remediation of Contaminated Sites*. EPA 542-R-08-002. April.

__________. USEPA Office of Transportation and Air Quality data: http://www.epa.gov/OMS/climate/420f05004.htm.

United States Fish and Wildlife Services (USFWS). 1999.Havasu National Wildlife Refuge. Havasu General Regulations Brochure. http://www.fws.gov/southwest/refuges/Arizona/havasu/index.html

APPENDIX NOP

Notice of Preparation

NOTICE OF PREPARATION
FOR A DRAFT ENVIRONMENTAL IMPACT REPORT

Date: May 2, 2008

To: Responsible Agencies, Trustee Agencies, and Interested Organizations and Individuals

Subject: Notice of Preparation

Lead Agency: California Department of Toxic Substances Control

Contact:
Mr. Aaron Yue, Project Manager
California Department of Toxic Substances Control
5796 Corporate Avenue
Cypress, CA 90630
Phone: (714) 484-5439
E-mail: ayue@dtsc.ca.gov

Prepared by:
EDAW
2022 J Street
Sacramento, CA 95811
Heather Halsey, Project Manager
(916) 414-5800

PROJECT TITLE

PG&E Topock Compressor Station Environmental Investigation and Cleanup Project

PROJECT LOCATION

Needles, California

PURPOSE OF THE NOTICE OF PREPARATION

The California Environmental Quality Act (CEQA) specifies that a public agency must prepare an environmental impact report (EIR) for any project that it proposes to carry out or approve that may have a significant direct or indirect impact on the environment (Public Resources Code Section 21100[a]). The California Department of Toxic Substances Control (DTSC) is the lead agency for the Pacific Gas and Electric Company (PG&E) Topock Compressor Station, Environmental Investigation and Cleanup Project. DTSC has determined that this project may have a significant impact on the environment and has therefore decided to prepare an EIR.

A Notice of Preparation (NOP) is a procedural document used to initiate interagency and public dialogue to determine the scope of an EIR. The purpose of the scoping process is to engage Responsible Agencies[1], Trustee

---

[1] In accordance with Title 14, Section 15381 of the California Code of Regulations, "Responsible Agency" means a public agency which proposes to carry out or approve a project, for which a Lead Agency is preparing or has prepared an EIR or Negative Declaration. For the purposes of CEQA, the term "Responsible Agency" includes all public agencies other than the Lead Agency which have discretionary approval power over the project.

Agencies[2], federal agencies, and interested organizations and individuals in order to identify concerns to be addressed in the EIR. The principal goal of this NOP is to inform agencies and the public about issues related to the project and to solicit recommendations and develop information regarding the scope, focus, and content of the proposed EIR. DTSC encourages recipients of this notice to inform others with an interest in or responsibility related to the proposed project that this NOP is available for review.

PROVIDING COMMENTS ON THE NOTICE OF PREPARATION

Responsible Agencies, Trustee Agencies, federal agencies and interested organizations and individuals are encouraged to submit comments regarding the scope and content of the environmental information to be contained in the draft EIR for DTSC's consideration. To provide greater opportunity for input on the scope of the EIR, this NOP is being circulated an additional 30 days beyond the required 30-day comment period for a total of 60 days. Comments should be submitted as soon as possible and must be received no later than July 1, 2008.

Please send written comments to Mr. Aaron Yue, DTSC Project Manager, at the address listed above. When submitting comments, please identify a contact person to answer any questions regarding your comments.

DEADLINE FOR SUBMITTING COMMENTS

Comments on this NOP must be received no later than 5:00 p.m. on July 1, 2008.

Documents related to the proposed project are available for review at the project repositories listed below, on the internet at http://www.dtsc.ca.gov/SiteCleanup/Projects/PGE_Topock.cfm, and at the DTSC address listed above.

Information Repository Locations and Contact Information

Needles Public Library
1111 Bailey Avenue
Needles, CA 92363
Kristin Mouton: 760-326-9255

Chemehuevi Indian Reservation
2000 Chemehuevi Trail
Havasu Lake, CA 92363
Gilbert Parra: 760-858-1140

Golden Shores/Topock Library Station
13136 Golden Shores Parkway
Topock, AZ 86436
Avis McKinnon: 928-768-2235

Lake Havasu City Library
1770 McCulloch Blvd.
Lake Havasu City, AZ 86403
Audrey Lacomarre: 928-453-0718

Colorado River Indian Tribes Public Library
2nd Avenue and Mojave Road
Parker, AZ 85344
Amelia Flores: 928-669-1285

Parker Public Library
1001 Navajo Avenue
Parker, AZ 85344
Jana Ponce: 928-669-262

California Department of Toxic Substances Control
5796 Corporate Avenue
Cypress, CA 90630
Julie Johnson: 714-484-5337
9am-Noon, 1pm-4pm, Monday –Friday
Please call for an appointment

---

[2] In accordance with Title 14, Section 15386 of the California Code of Regulations, Trustee Agency" means a state agency having jurisdiction by law over natural resources affected by a project which are held in trust for the people of the State of California. Trustee Agencies include: the California Department of Fish and Game, the State Lands Commission, the State Department of Parks and Recreation, and the University of California.

DTSC will be hosting several scoping meetings to give the Responsible Agencies, Trustee Agencies, federal agencies and interested organizations and individuals an opportunity to appear and comment on the scope and content of the draft EIR. These professionally facilitated scoping meetings will consist of introductions, a project overview, a CEQA process overview and an opportunity for meeting participants to comment orally on the scope and content of the EIR. A reasonable amount of time will be allotted to allow all participants who wish to speak to do so. Written comments will also be accepted at the meetings. Scoping meetings have been scheduled at the following locations and times:

Public Scoping Meetings

City	Address	Date	Time
Palm Desert, CA	City of Palm Desert City Council Chamber Palm Desert, CA 92260	Tuesday, May 27	1:30-4:30 p.m.
Yuma, AZ	Gila Ridge High School Auditorium 7150 E. 24th Street Yuma, AZ 85365	Wednesday, May 28	1:30–4:30 p.m.
Needles, CA	Needles Elks Lodge 1000 Lillyhill Dr. Needles, CA 92363-3432	Thursday, May 29	5:30–8:30 p.m.
Lake Havasu City, AZ	City Council Chamber 2360 McCulloch Blvd. North Lake Havasu City, AZ 86403	Monday, June 2	2:00-5:00 p.m.
Big River, CA	Big River Development Enterprises 150313 Rio Vista Drive Big River, CA 92242	Thursday, June 5	5:00-7:00 p.m.

CONTACT

If you have any questions or wish to discuss the project, please contact Aaron Yue, DTSC Project Manager, at (714) 484-5439 or email: ayue@dtsc.ca.gov or Jeanne Matsumoto, DTSC Public Participation Specialist, at (714) 484-5338, toll free at (866) 495-5651 or email: jmatsumo@dtsc.ca.gov. For media inquiries, please contact the DTSC Public Information Officer, Jeanne Garcia, at (818) 717-6573 or email: jgarcia1@dtsc.ca.gov.

INFORMATION FOR THE DISABLED AND HEARING IMPAIRED

The meeting rooms for the scoping meetings are accessible to people with disabilities. If translation services are needed or if additional accommodations for the disabled are needed, please notify Susan Callery at (818) 717-6567 scallery@dtsc.ca.gov no later than one week before the meeting. TDD users can obtain additional information by using the California Relay Service at 1-(888)-877-5378 to reach DTSC's Project Manager Aaron Yue at (714) 484-5439.

1 PROJECT DESCRIPTION

1.1 INTRODUCTION AND PROJECT OVERVIEW

DTSC is the Lead Agency for the environmental investigation and cleanup of contamination at the PG&E Topock Compressor Station (Station). The proposed project includes the development of a final remedy under the California Hazardous Waste Control Law for corrective action. A "final remedy" is a final cleanup action proposed for dealing with contaminants at a site. Under California law, owners or operators of facilities that treat, store, or dispose of hazardous waste must undertake corrective actions to clean up releases and spills of hazardous wastes or constituents resulting from their operation. The final remedy will address both soil and groundwater contamination at the Station, which is located in eastern San Bernardino County, California. DTSC will be preparing a Programmatic EIR which would allow DTSC to identify and analyze project-wide alternatives and environmental effects while including detailed analysis of all approved actions. Any subsequent activities would then be examined in light of the Programmatic EIR to determine whether a supplemental environmental document must be prepared.

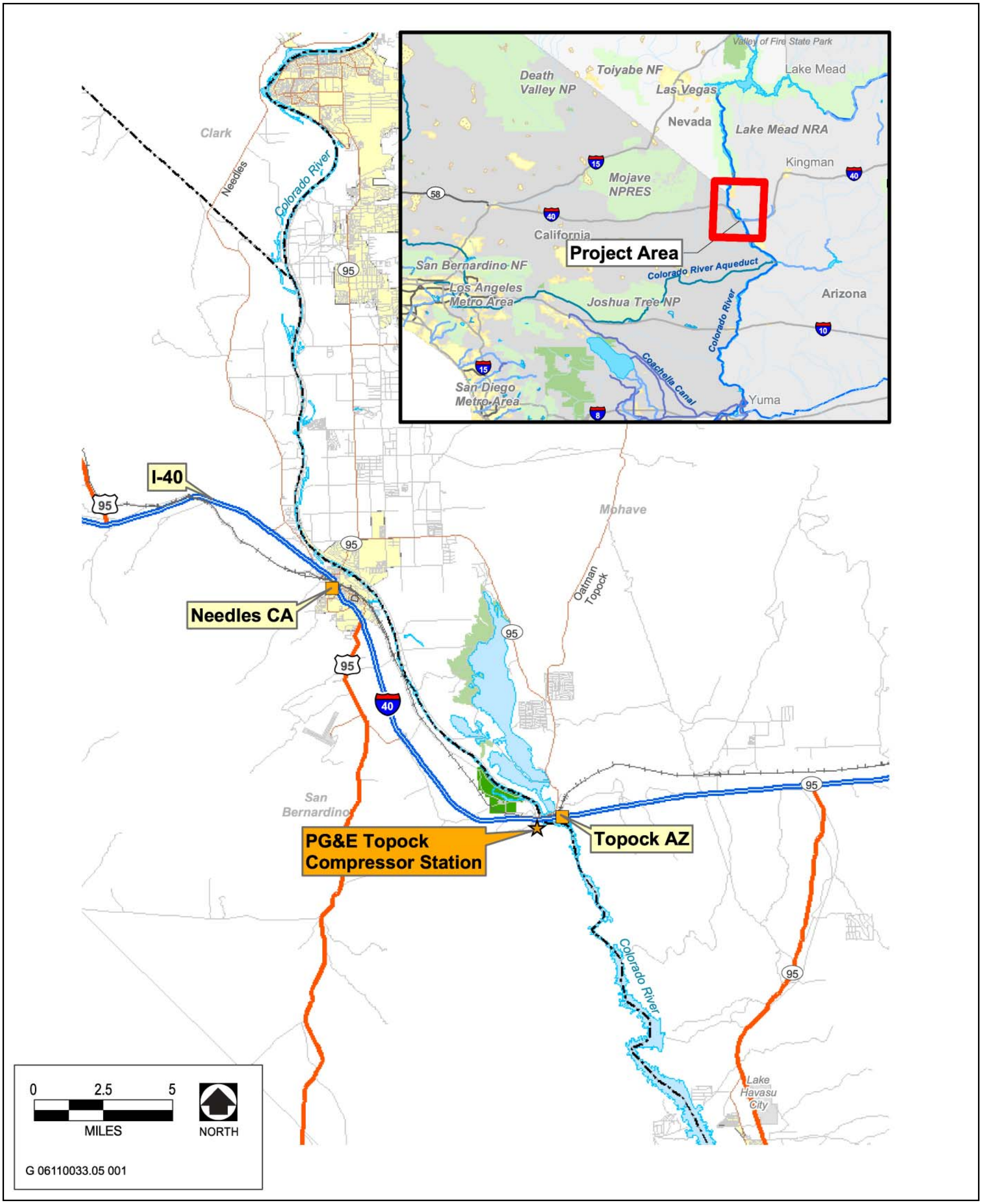
The goal of the final remedy for groundwater and soil is to contain, control, and/or eliminate the mobility, toxicity, and other risks of all Chemicals of Concern (COCs) identified by meeting the Remedial Action Objectives developed for the site. Hexavalent chromium [Cr(VI)] is the principal COC with regard to human health and environmental impacts at this site. The U.S. Department of Health and Human Services has determined that certain chromium compounds [e.g., Cr(VI)] are known to cause cancer in humans. Cr(VI) is generally soluble in water. Based on current investigation and historic wastewater discharges at the Station, other constituents that ultimately may become COCs in groundwater are copper, nickel, lead, zinc, pH, total dissolved solids, and petroleum hydrocarbons. Other COCs in groundwater may be identified as ongoing investigations are completed.

Cr(VI) was used as an additive to the cooling water at the Station from 1951 to 1985 to inhibit corrosion to the equipment and minimize scaling. From 1951 to 1964, a portion of the cooling water was discharged to a dry wash adjacent to the Station. As a result, Cr(VI) has been detected in the groundwater and soil in the vicinity of the Station, although there is currently no evidence that human or ecological receptors are being exposed to Cr(VI) from the contaminated groundwater. Human and ecological receptors could be affected if contaminated groundwater were to reach drinking water wells or the Colorado River. The final remedy will be designed to protect potential receptors against exposures in the future.

In 2002, PG&E submitted a Draft Corrective Measures Study/Feasibility Study Work Plan (CMS/FS Work Plan) to DTSC. After comments were received from various public agencies, a revised CMS/FS Work Plan was issued in June 2007. The 2007 Draft CMS/FS Work Plan has been commented on and a final revision, dated March 2008, is pending agency approval.

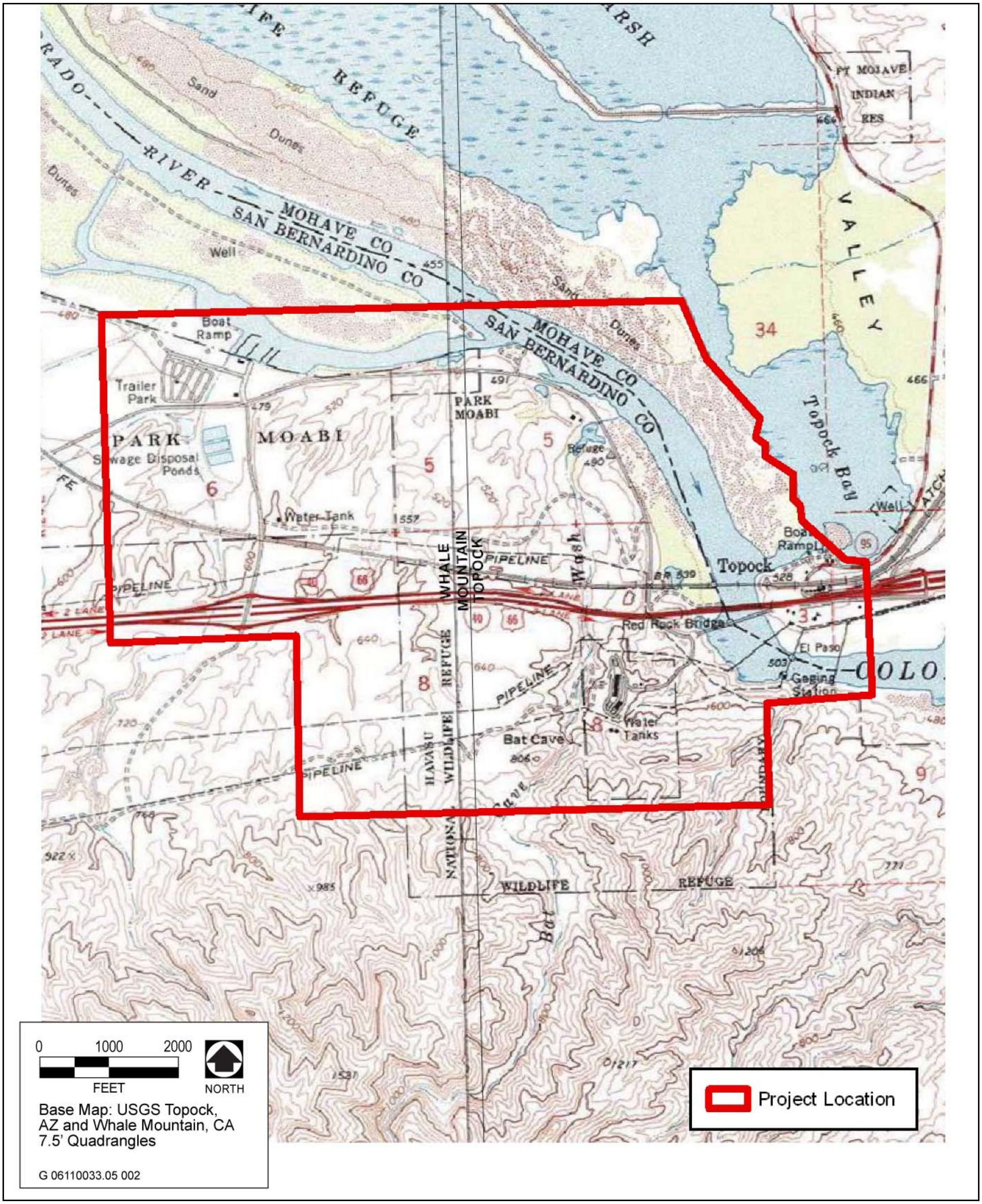
1.2 PROJECT LOCATION

The Station is located in the Mojave Desert approximately 12 miles southeast of the city of Needles, California, and 1 mile southeast of the Moabi Regional Park in California. The Station is one-half mile west of the community of Topock, Arizona, which is situated directly across the Colorado River from the Station, and 5 miles south of Golden Shores, Arizona. The Station is one-half mile west of the Colorado River and south of Interstate 40 (see Exhibits 1-1 and 1-2, and 2-1) and occupies approximately 65 acres of land owned by PG&E. However, the study area for the corrective action activities covers additional surrounding land owned and managed by a number of private entities and government agencies, including the Havasu National Wildlife Refuge managed by the U.S. Fish and Wildlife Service (USFWS), lands managed by the Department of Interior (DOI), U.S. Bureau of Land Management (BLM), rights of way for the Burlington Northern Santa Fe Railroad and California Department of Transportation, and land owned by the Metropolitan Water District of Southern California (see Exhibits 1-1 1-2, and 1-3).



Source: Data provided by CH2M Hill in 2007 and adapted by EDAW in 2008

Project Vicinity **Exhibit 1-1**



Base Map: USGS Topock, AZ and Whale Mountain, CA 7.5' Quadrangles

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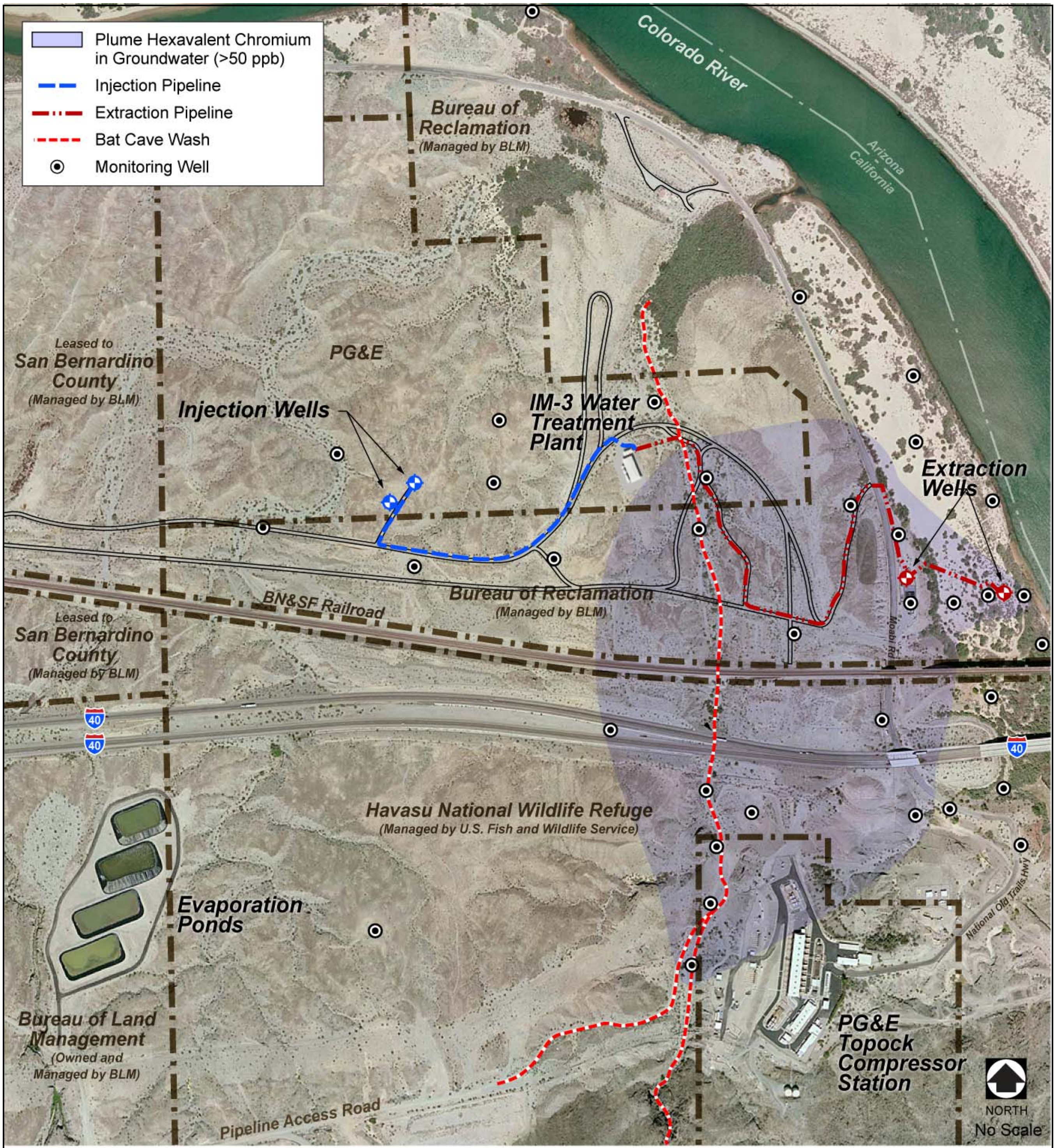
Source: Data provided by ESRI in 2007 and adapted by EDAW in 2008

Project Location **Exhibit 1-2**



G 06110033.05 005

Site Map Showing Topock Maze and Groundwater Plume **Exhibit 1-3**

2 REMEDIAL ACTION ALTERNATIVES

2.1 REASONABLE RANGE OF ALTERNATIVES

CEQA requires an EIR to include a discussion of a reasonable range of alternatives, including the “no project” alternative. Specifically, an EIR must “describe a range of reasonable alternatives to the project or to the location of the project, which would feasibly attain most of the basic objectives of the project but would avoid or substantially lessen any of the significant effects of the project, and evaluate the comparative merits of the alternatives.”[3] The lead agency is responsible for selecting a range of project alternatives for examination and must publicly disclose its reasoning for selecting those alternatives.

The Topock EIR will analyze the potential environmental impacts associated with the implementation of the Final Remedy. Although the Corrective Measure Study/Feasibility Study (CMS/FS) Work Plan has not yet been approved, and preparation of the individual CMS/FS reports for groundwater and soil have not begun, DTSC anticipates that the Final Remedy will include the use of one or more of the following remedial action technologies identified in the draft CMS/FS Work Plan:

Groundwater Remediation Technologies

Monitored natural attenuation
Impermeable barrier wall
Permeable reactive barrier
Groundwater extraction and on-site treatment
Groundwater extraction and off-site treatment
Reactive *in-situ* treatment zones
Passive *in-situ* treatment zones

Soil Remediation Technologies

Excavation and offsite disposal
Excavation and onsite treatment
Soil washing
Chemical reduction/oxidation
Soil flushing
In-situ reduction
Phytoremediation
Solidification/stabilization
Capping in place

2.2 ENVIRONMENTAL EFFECTS TO BE EXAMINED IN THE EIR

The purpose of an EIR is to examine a project for potentially significant environmental effects and to identify measures that can reduce, avoid, or mitigate potential adverse impacts[4]. Based upon consultation with other agencies and environmental assessments conducted in and around the site, it has been determined that the proposed project may have a significant impact on Biological Resources and Cultural Resources. Because DTSC believes additional adverse impacts could exist, the EIR also will examine potential effects in the following areas:

Aesthetics
Air Quality
Agricultural Resources
Geology and Soils
Hazardous Materials and Public Health
Hydrology and Water Quality
Land Use
Noise
Population and Housing
Public Services
Recreation
Transportation and Circulation
Utilities and Service Systems

---

[3] Section 15126.6[e][1] of the California Code of Regulations

[4] According to the *CEQA Guidelines Section 15382* a “significant effect on the environment” means a substantial, or potentially substantial, adverse change in any of the physical conditions within the area affected by the project, including land, air, water, minerals, flora, fauna, ambient noise, and objects of historic or aesthetic significance.

APPENDIX AQ

Air Quality

Urbemis 2007 Version 9.2.4

Detail Report for Summer Construction Unmitigated Emissions (Pounds/Day)

File Name: C:\Documents and Settings\weirichj\Desktop\Topock 06110033.01\topockpump and treat construction.urb924

Project Name: Topock Compressor Station Impact Analysis

Project Location: San Bernadino County

On-Road Vehicle Emissions Based on: Version : Emfac2007 V2.3 Nov 1 2006

Off-Road Vehicle Emissions Based on: OFFROAD2007

CONSTRUCTION EMISSION ESTIMATES (Summer Pounds Per Day, Unmitigated)

	ROG	NOx	CO	SO2	PM10 Dust	PM10 Exhaust	PM10 Total	PM2.5 Dust	PM2.5 Exhaust	PM2.5 Total	CO2
Time Slice 5/2/2011-12/30/2011 Active Days: 175	**10.54**	**79.52**	**49.30**	**0.02**	**213.67**	**4.45**	**218.12**	**44.63**	**4.09**	**48.72**	**9,884.34**
Building 05/01/2011-01/31/2012	4.48	29.34	22.33	0.01	0.05	1.89	1.94	0.02	1.74	1.75	3,585.40
Building Off Road Diesel	4.03	25.19	15.64	0.00	0.00	1.72	1.72	0.00	1.58	1.58	2,335.71
Building Vendor Trips	0.33	3.93	2.85	0.01	0.03	0.16	0.18	0.01	0.14	0.15	781.64
Building Worker Trips	0.12	0.22	3.85	0.00	0.02	0.01	0.04	0.01	0.01	0.02	468.05
Mass Grading 05/01/2011-05/30/2014	6.06	50.18	26.96	0.01	213.62	2.56	216.18	44.62	2.35	46.97	6,298.94
Mass Grading Dust	0.00	0.00	0.00	0.00	213.60	0.00	213.60	44.61	0.00	44.61	0.00
Mass Grading Off Road Diesel	5.87	48.73	23.69	0.00	0.00	2.50	2.50	0.00	2.30	2.30	5,761.24
Mass Grading On Road Diesel	0.10	1.29	0.47	0.00	0.01	0.05	0.06	0.00	0.05	0.05	197.20
Mass Grading Worker Trips	0.09	0.16	2.80	0.00	0.02	0.01	0.03	0.01	0.01	0.01	340.51

Time Slice 1/2/2012-1/31/2012 Active Days: 22	9.93	73.87	47.41	**0.02**	**213.67**	4.07	217.74	**44.63**	3.74	48.37	9,883.50
Building 05/01/2011-01/31/2012	4.17	27.47	21.42	0.01	0.05	1.74	1.79	0.02	1.60	1.62	3,584.93
Building Off Road Diesel	3.75	23.76	15.25	0.00	0.00	1.59	1.59	0.00	1.46	1.46	2,335.71
Building Vendor Trips	0.30	3.51	2.62	0.01	0.03	0.14	0.17	0.01	0.13	0.14	781.68
Building Worker Trips	0.11	0.20	3.56	0.00	0.02	0.01	0.04	0.01	0.01	0.02	467.54
Mass Grading 05/01/2011-05/30/2014	5.76	46.40	25.99	0.01	213.62	2.33	215.95	44.62	2.14	46.76	6,298.57
Mass Grading Dust	0.00	0.00	0.00	0.00	213.60	0.00	213.60	44.61	0.00	44.61	0.00
Mass Grading Off Road Diesel	5.60	45.11	22.98	0.00	0.00	2.27	2.27	0.00	2.09	2.09	5,761.24
Mass Grading On Road Diesel	0.09	1.14	0.42	0.00	0.01	0.04	0.05	0.00	0.04	0.04	197.20
Mass Grading Worker Trips	0.08	0.15	2.59	0.00	0.02	0.01	0.03	0.01	0.01	0.01	340.14
Time Slice 2/1/2012-12/31/2012 Active Days: 239	5.76	46.40	25.99	0.01	213.62	2.33	215.95	44.62	2.14	46.76	6,298.57
Mass Grading 05/01/2011-05/30/2014	5.76	46.40	25.99	0.01	213.62	2.33	215.95	44.62	2.14	46.76	6,298.57
Mass Grading Dust	0.00	0.00	0.00	0.00	213.60	0.00	213.60	44.61	0.00	44.61	0.00
Mass Grading Off Road Diesel	5.60	45.11	22.98	0.00	0.00	2.27	2.27	0.00	2.09	2.09	5,761.24
Mass Grading On Road Diesel	0.09	1.14	0.42	0.00	0.01	0.04	0.05	0.00	0.04	0.04	197.20
Mass Grading Worker Trips	0.08	0.15	2.59	0.00	0.02	0.01	0.03	0.01	0.01	0.01	340.14
Time Slice 1/1/2013-12/31/2013 Active Days: 261	5.46	43.02	25.11	0.01	213.62	2.14	215.76	44.62	1.96	46.58	6,298.25
Mass Grading 05/01/2011-05/30/2014	5.46	43.02	25.11	0.01	213.62	2.14	215.76	44.62	1.96	46.58	6,298.25
Mass Grading Dust	0.00	0.00	0.00	0.00	213.60	0.00	213.60	44.61	0.00	44.61	0.00
Mass Grading Off Road Diesel	5.31	41.88	22.35	0.00	0.00	2.09	2.09	0.00	1.92	1.92	5,761.24
Mass Grading On Road Diesel	0.08	1.01	0.37	0.00	0.01	0.04	0.04	0.00	0.03	0.04	197.20
Mass Grading Worker Trips	0.07	0.14	2.39	0.00	0.02	0.01	0.03	0.01	0.01	0.02	339.81

Time Slice 1/1/2014-5/30/2014 Active Days: 108	5.15	39.03	24.35	0.01	213.62	1.90	215.52	44.62	1.75	46.36	6,297.96
Mass Grading 05/01/2011-05/30/2014	5.15	39.03	24.35	0.01	213.62	1.90	215.52	44.62	1.75	46.36	6,297.96
Mass Grading Dust	0.00	0.00	0.00	0.00	213.60	0.00	213.60	44.61	0.00	44.61	0.00
Mass Grading Off Road Diesel	5.02	38.02	21.82	0.00	0.00	1.86	1.86	0.00	1.71	1.71	5,761.24
Mass Grading On Road Diesel	0.07	0.88	0.33	0.00	0.01	0.03	0.04	0.00	0.03	0.03	197.20
Mass Grading Worker Trips	0.06	0.12	2.20	0.00	0.02	0.01	0.03	0.01	0.01	0.02	339.53

Phase Assumptions

Phase: Mass Grading 5/1/2011 - 5/30/2014 - Well Installation, Roads, Pipelines, Utilities

Total Acres Disturbed: 106.86

Maximum Daily Acreage Disturbed: 10.68

Fugitive Dust Level of Detail: Default

20 lbs per acre-day

On Road Truck Travel (VMT): 46.53

Off-Road Equipment:

1 Bore/Drill Rigs (291 hp) operating at a 0.75 load factor for 8 hours per day

1 Excavators (168 hp) operating at a 0.57 load factor for 6 hours per day

1 Graders (174 hp) operating at a 0.61 load factor for 4 hours per day

1 Off Highway Trucks (479 hp) operating at a 0.57 load factor for 4 hours per day

1 Rollers (95 hp) operating at a 0.56 load factor for 4 hours per day

1 Rubber Tired Dozers (357 hp) operating at a 0.59 load factor for 4 hours per day

1 Scrapers (313 hp) operating at a 0.72 load factor for 4 hours per day

2 Tractors/Loaders/Backhoes (108 hp) operating at a 0.55 load factor for 7 hours per day

1 Trenchers (63 hp) operating at a 0.75 load factor for 4 hours per day

1 Water Trucks (189 hp) operating at a 0.5 load factor for 4 hours per day

Phase: Building Construction 5/1/2011 - 1/31/2012 - Treatment Plant, Other Pads

Off-Road Equipment:

1 Aerial Lifts (60 hp) operating at a 0.46 load factor for 8 hours per day

2 Air Compressors (106 hp) operating at a 0.48 load factor for 8 hours per day

1 Excavators (168 hp) operating at a 0.57 load factor for 4 hours per day

1 Forklifts (145 hp) operating at a 0.3 load factor for 4 hours per day

1 Generator Sets (49 hp) operating at a 0.74 load factor for 8 hours per day

1 Graders (174 hp) operating at a 0.61 load factor for 4 hours per day

1 Rubber Tired Dozers (357 hp) operating at a 0.59 load factor for 4 hours per day

1 Tractors/Loaders/Backhoes (108 hp) operating at a 0.55 load factor for 4 hours per day

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Urbemis 2007 Version 9.2.4

Summary Report for Annual Emissions (Tons/Year)

File Name: C:\Documents and Settings\weirichj\Desktop\Topock 06110033.01\topockpump and treat construction.urb924

Project Name: Topock Compressor Station Impact Analysis

Project Location: San Bernadino County

On-Road Vehicle Emissions Based on: Version : Emfac2007 V2.3 Nov 1 2006

Off-Road Vehicle Emissions Based on: OFFROAD2007

CONSTRUCTION EMISSION ESTIMATES

	ROG	NOx	CO	SO2	PM10 Dust	PM10 Exhaust	PM10	PM2.5 Dust	PM2.5 Exhaust	PM2.5	CO2
2011 TOTALS (tons/year unmitigated)	0.92	6.96	4.31	0.00	18.70	0.39	19.09	3.91	0.36	4.26	864.88
2012 TOTALS (tons/year unmitigated)	0.80	6.36	3.63	0.00	27.88	0.32	28.20	5.82	0.30	6.12	861.40
2013 TOTALS (tons/year unmitigated)	0.71	5.61	3.28	0.00	27.88	0.28	28.16	5.82	0.26	6.08	821.92
2014 TOTALS (tons/year unmitigated)	0.28	2.11	1.32	0.00	11.54	0.10	11.64	2.41	0.09	2.50	340.09

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Urbemis 2007 Version 9.2.4

Detail Report for Summer Operational Unmitigated Emissions (Pounds/Day)

File Name: C:\Documents and Settings\weirichj\Desktop\Topock 06110033.01\topockpump and treat operational.urb924

Project Name: Topock Pump and Treat Operational

Project Location: San Bernadino County

On-Road Vehicle Emissions Based on: Version : Emfac2007 V2.3 Nov 1 2006

Off-Road Vehicle Emissions Based on: OFFROAD2007

OPERATIONAL EMISSION ESTIMATES (Summer Pounds Per Day, Unmitigated)

Source	ROG	NOX	CO	SO2	PM10	PM25	CO2
General light industry	0.33	0.49	0.85	0.00	0.03	0.02	141.02
TOTALS (lbs/day, unmitigated)	0.33	0.49	0.85	0.00	0.03	0.02	141.02

Does not include correction for passby trips

Does not include double counting adjustment for internal trips

Analysis Year: 2011 Temperature (F): 80 Season: Summer

Emfac: Version : Emfac2007 V2.3 Nov 1 2006

Summary of Land Uses

Land Use Type	Acreage	Trip Rate	Unit Type	No. Units	Total Trips	Total VMT
General light industry		0.13	1000 sq ft	45.00	5.85	90.09
					5.85	90.09

Vehicle Fleet Mix

Vehicle Type	Percent Type	Non-Catalyst	Catalyst	Diesel
Light Auto	45.0	0.9	98.9	0.2
Light Truck < 3750 lbs	8.5	2.0	94.0	4.0

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Vehicle Fleet Mix

Vehicle Type	Percent Type	Non-Catalyst	Catalyst	Diesel
Light Truck 3751-5750 lbs	17.7	0.5	99.5	0.0
Med Truck 5751-8500 lbs	8.2	0.9	99.1	0.0
Lite-Heavy Truck 8501-10,000 lbs	0.0	0.0	80.0	20.0
Lite-Heavy Truck 10,001-14,000 lbs	0.0	0.0	42.9	57.1
Med-Heavy Truck 14,001-33,000 lbs	1.0	0.0	20.0	80.0
Heavy-Heavy Truck 33,001-60,000 lbs	17.6	0.0	0.0	100.0
Other Bus	0.0	0.0	0.0	100.0
Urban Bus	0.0	0.0	0.0	0.0
Motorcycle	2.0	63.4	36.6	0.0
School Bus	0.0	0.0	0.0	100.0
Motor Home	0.0	0.0	92.3	7.7

Travel Conditions

	Residential			Commercial		
	Home-Work	Home-Shop	Home-Other	Commute	Non-Work	Customer
Urban Trip Length (miles)	12.7	7.0	9.5	13.3	7.4	8.9
Rural Trip Length (miles)	25.0	25.0	25.0	15.4	9.6	12.6
Trip speeds (mph)	30.0	30.0	30.0	30.0	30.0	30.0
% of Trips - Residential	90.0	1.0	9.0			
% of Trips - Commercial (by land use)						
General light industry				100.0	0.0	0.0

Operational Changes to Defaults

The urban/rural selection has been changed from Urban to Rural

Home-based work rural trip length changed from 17.6 miles to 25 miles

Home-based shop rural trip length changed from 12.1 miles to 25 miles

Home-based other rural trip length changed from 14.9 miles to 25 miles

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Urbemis 2007 Version 9.2.4

Summary Report for Annual Emissions (Tons/Year)

File Name: C:\Documents and Settings\weirichj\Desktop\Topock 06110033.01\topockpump and treat operational.urb924

Project Name: Topock Pump and Treat Operational

Project Location: San Bernadino County

On-Road Vehicle Emissions Based on: Version : Emfac2007 V2.3 Nov 1 2006

Off-Road Vehicle Emissions Based on: OFFROAD2007

OPERATIONAL (VEHICLE) EMISSION ESTIMATES

	ROG	NOx	CO	SO2	PM10	PM2.5	CO2
TOTALS (tons/year, unmitigated)	0.05	0.09	0.15	0.00	0.00	0.00	25.28

SUM OF AREA SOURCE AND OPERATIONAL EMISSION ESTIMATES

	ROG	NOx	CO	SO2	PM10	PM2.5	CO2
TOTALS (tons/year, unmitigated)	0.05	0.09	0.15	0.00	0.00	0.00	25.28

APPENDIX BIO

Biological Resources

Final

Programmatic Biological Assessment for Pacific Gas and Electric Topock Compressor Station Remedial and Investigative Actions

Prepared for

Pacific Gas and Electric Company

January 2007

CH2MHILL
155 Grand Avenue, Suite 1000
Oakland, CA 94612

Contents

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Appendices

Acronyms and Abbreviations

APE	Area of Potential Effects
ATV	all-terrain vehicle
BLM	United States Bureau of Land Management
BNSF	Burlington Northern-Santa Fe Railroad
USBR	United States Bureau of Reclamation
CDFG	California Department of Fish and Game
CERCLA	Comprehensive Environmental Response, Compensation, and Liability Act
CMP	compliance monitoring program
COPC	chemicals of potential concern
DOI	United States Department of Interior
DTSC	Department of Toxic Substances Control
ESA	Endangered Species Act
GMP	groundwater monitoring program
GPS	global positioning system
HNWR	Havasu National Wildlife Refuge
IM	Interim Measure
IMPM	Interim Measures Performance Monitoring
msl	mean sea level
PBA	programmatic biological assessment
PG&E	Pacific Gas and Electric Company
PMP	performance monitoring program
RCRA	Resource Conservation and Recovery Act
RFI	RCRA facility investigation
RI	CERCLA Remedial Investigation
SWCA	Steven W. Carothers and Associates

SWFL	southwestern willow flycatcher
USFWS	United States Fish and Wildlife Service

1.0 Introduction

Pacific Gas and Electric Company (PG&E) is conducting a Remedial Investigation (RI) and a RCRA Facility Investigation (RFI) to investigate the release of hazardous substances and hazardous wastes at or from the Topock Compressor Station. The RI is being performed under the oversight of the United States Department of Interior (DOI), the United States Bureau of Land Management (BLM), the United States Fish and Wildlife Service (USFWS), and the United States Bureau of Reclamation (USBR) (collectively "the Federal agencies") in accordance with a Consent Agreement entered between the Federal agencies and PG&E pursuant to the Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA). The RFI is being performed under the oversight of the California Environmental Protection Agency, Department of Toxic Substances Control (DTSC) in accordance with corrective action orders entered pursuant to State law. This programmatic biological assessment (PBA) has been prepared to determine any potential effect on species protected under the federal Endangered Species Act (ESA) resulting from past, present, or planned remedial and investigative activities. The Topock Compressor Station site is located in eastern San Bernardino County, California, about 15 miles southeast of Needles (Figure 1).

Activities relate to investigation and remediation of soil, sediments, surface water, and groundwater resulting from historic operations at the Topock Compressor Station. As described further in Section 2.0, historic operations primarily involved the use of chromium in the compressor station cooling water. Subsequent discharge of the cooling water resulted in chromium entering the groundwater aquifer. The activities addressed in this PBA include all RI and RFI activities taken prior to the selection and implementation of a final remedial action and corrective action to address chromium in groundwater, as well as other chemicals of potential concern (COPC) in all environmental media related to historical operations. PG&E is requesting ESA coverage for these activities through the end of 2012. Selection and implementation of a final remedial action/corrective action will be the subject of additional analysis and ESA consultation at a future date.

The action area, also generally referred to here as the Area of Potential Effects (APE), includes lands under the jurisdiction of the Federal agencies and private lands potentially affected by released hazardous substances requiring RI/RFI actions (Figure 2). The "action area" is "all areas to be affected directly or indirectly by the federal action and not merely the immediate area involved in the action (50 CFR 402.02). Because of the federal nexus, activities undertaken pursuant to the investigative remedial program that require discretionary federal review and approval are evaluated for potential project effects to species listed under the ESA.

This PBA serves as supportive documentation by the Bureau of Land Management Lake Havasu Field Office as the lead federal agency, under the provisions of Title 50 Code of Federal Regulations Part 402, the ESA of 1973, as amended, for the evaluation of Project effects to listed species and resulting determinations.

1.1 Consultation to Date

Consultation to date has occurred on a project specific basis. In January 2000, PG&E was issued a no-jeopardy biological opinion for ongoing maintenance activities on the PG&E gas pipeline system in the California desert on lands managed by the BLM and the pipeline's effects on the desert tortoise and its critical habitat. That biological opinion specifically addressed maintenance of the gas pipeline and is not considered applicable to past, present, or planned remedial and investigative activities within the APE.

In September 2004, the BLM Lake Havasu Office initiated informal consultation with the USFWS Ventura Office on behalf of PG&E regarding potential impacts to the desert tortoise and southwestern willow flycatcher (SWFL) related to a time-critical removal action/interim measure within the APE. The anticipated biological impacts were addressed in the *Final Biological Resources Investigations for Interim Measures No. 3: Topock Compressor Station Expanded Groundwater Extraction and Treatment System San Bernardino County, California* (CH2M HILL, 2004b). Based on the proposed activities, which included a proposed groundwater treatment system, a "no effect" determination was considered appropriate for that project. To date, Interim Measure (IM) No. 3 has been working under this determination with no effect on listed species.

In addition, a biological assessment and Section 7 ESA informal consultation was completed in December 2005 related to construction of the PE-1 groundwater pipeline and implementation of the floodplain *in-situ* pilot study, both located on the floodplain of the Colorado River. The applicable *Biological Assessment for the Pacific Gas and Electric Topock Compressor Station Remedial and Investigative Actions* (CH2M HILL, 2005j) was completed in November 2005. The subsequent consultation resulted in a determination of "may affect, not likely to adversely affect" the SWFL, and a "no effect" finding for all other listed species potentially occurring in the APE.

In 2006, informal consultation was conducted for the *Site Access and Sampling Procedures for Groundwater Monitoring Wells Located Near Potential Southwestern Willow Flycatcher Habitat, Revision 3, Topock Compressor Station (Technical Memorandum, April 20, 2006)* (CH2M HILL, 2006b). A determination of "may affect, but not likely to adversely affect" was concurred upon by the USFWS. These access and sampling procedures are currently being implemented and will be carried forward in subsequent years. They are included within the scope of this PBA, which covers activities through the end of 2012.

As part of the interim measures on federal lands, Action Memoranda were issued by the Federal Agencies pursuant to Section 104 of the CERCLA. These Action Memoranda include general mitigation measures (outlined in Section 3.4) to manage biological resources. In addition, several measures were subsequently specified or clarified (e.g., migratory bird dates, SWFL dates, access routes) to address the management of ESA-listed species and their habitats.

1.2 Content and Scope

At the direction of the DTSC and DOI, activities are ongoing in the APE and are expected to continue, and in some cases expand, prior to the selection of a final remedy. As such, the

BLM and PG&E believe that it is prudent to pursue programmatic ESA coverage for ongoing, as well as future, RI/RFI activities that are anticipated to occur in the APE prior to the selection and implementation of the final remedy.

The scope of this PBA will address past, present, and planned activities up to the selection and implementation of the final remedy. ESA coverage of the activities described in this PBA is requested through the end of 2012. It is anticipated that this PBA and associated Section 7 consultation will also lay a foundation for a separate Section 7 consultation that will occur prior to implementation of the final remedy.

The content of a biological assessment is at the discretion of the federal agency and depends on the nature of the action for which consultation is requested. The term "action" refers to discretionary activities or programs that are authorized, funded, or carried out, in whole or in part, by federal agencies. In coordination with PG&E, BLM is initiating consultation with USFWS to comply with agency responsibilities to consider the effects of activities to ESA-listed species within the APE. This request for consultation includes information in several basic areas encompassing the nature and scope of the action, the action area, species and habitat description, effects of the action, and relevant reports.

This consultation does not preclude future consultations or additional management restrictions by the BLM or USFWS beyond the measures presented in this document, nor authorize final ESA coverage on current or future response or corrective actions. The primary purpose of this PBA is to put into context the status and management of ESA species within or near the APE and to better evaluate the effects of current and future proposed activities on those species and habitats. It is anticipated that subsequent ESA evaluations/consultations will move more efficiently through the work plan review/approval process as project-specific proposals come forward.

Under the scope of this PBA, ESA consultation will be applied to species and habitat located within or near the APE. If future activities are proposed to occur outside the APE, consultation will be required to be reinitiated with the USFWS.

"Action area" refers to all lands directly or indirectly affected by the action and not merely the immediate area involved in the action. Past, present and planned response activities take place on BLM- and USFWS-managed lands. The action area also applies to related activities on nonfederal lands.

"Species" and "habitat description" refers to all potentially affected listed species, or species proposed to be listed, and the habitat to be considered. Several federally-listed species that are known to or may occur within or near the action area have been identified.

"Effects of the action" include direct and indirect effects of an action on the species or critical habitat, together with the effects of other activities that will be added to the environmental baseline. The environmental baseline includes the past and present impacts of all federal, state, or private actions and other human activities in the action area; the anticipated impacts of all proposed federal projects in the action area that have already undergone Section 7 consultation; and the impact of state or private actions that are contemporaneous with the consultation in process. The environmental baseline does not include future or ongoing response or other investigative or interim activities in the APE. For purposes of this PBA, these activities are assessed for their potential effect on species listed under the ESA.

“Indirect effects” are those that are caused by the proposed action and are later in time, but are still reasonably certain to occur. For example, an action that results in subsequent changes to land use patterns would be considered an indirect effect.

“Cumulative effects” are those effects of future state or private activities that are reasonably certain to occur within the action area of the federal action subject to consultation.

“Direct effects” include the direct or immediate effect of the action on the species or it’s habitat.

“Relevant reports” include any available information on the action, action area, affected listed species, or critical habitat. The Reference Section of this document includes a list of works cited—specific references to relevant reports are provided throughout this PBA. In addition, Appendix E of this PBA includes a series of biological reports and analyses prepared specifically for these activities.

2.0 Background

In December 1951, the Topock Compressor Station began operations to compress natural gas supplied from the southwestern United States for transport through pipelines to PG&E's service territory in central and northern California. The compressor station is still active and is anticipated to remain an active facility into the foreseeable future. The operations at the compressor station consist of six major activities: water conditioning, compressing natural gas, cooling compressed natural gas and compressor lubricating oil, wastewater treatment, facility and equipment maintenance, and miscellaneous operations. Facility operations involve treatment of cooling water.

From 1951 to 1985 chromium-based products were added to cooling water to inhibit corrosion, minimize scale, and control biological growth. From 1951 to 1964 untreated wastewater ("blowdown") containing chromium was discharged to Bat Cave Wash. Beginning in 1964, PG&E began to treat the wastewater. At about this time, PG&E also constructed a percolation bed in the wash by creating soil berms that impounded the discharged wastewater and allowed it to percolate into the ground and/or evaporate. Beginning in May 1970, the majority of treated wastewater was discharged to an injection well located on PG&E property. In 1973, PG&E discontinued use of this injection well, and wastewater was discharged exclusively to a set of four, single-lined evaporation ponds, located about 1,600 feet west of the compressor station.

PG&E replaced the chromium-based cooling water treatment products with phosphate-based products in 1985, at which time PG&E discontinued operation of the wastewater treatment system. Use of the four, single-lined evaporation ponds continued from 1985 to 1989. In 1989, the single-lined ponds were replaced with four new, Class II (double-lined) ponds on BLM-managed lands. The wastewater treatment system and the single-lined ponds were physically removed and "clean-closed" between 1988 and 1993. The four Class II double-lined ponds are still in use and are operated under the jurisdiction of the Colorado River Basin Regional Water Quality Control Board.

In 1996, PG&E entered into a Corrective Action Consent Agreement with DTSC to govern the investigation and remediation of the Topock Compressor Station site under California state law. DTSC is the California state lead agency charged with directing investigative activities in the action area in accordance with the Resource Conservation and Recovery Act (RCRA). In July 2005, PG&E and the Federal Agencies entered into a Consent Agreement that outlined the process by which PG&E would comply with CERCLA requirements during the investigation and remediation of the action area. Activities under both agreements proceeded with active stakeholder input, facilitated through the Topock Consultative Workgroup. PG&E, and DTSC, have also made commitments to engage in consultation with interested tribes. The BLM will consult with potentially affected tribes in accordance with applicable laws, regulations and policies.

Additional activities that pre-date current interim measures include prior RFI wells installed to identify and monitor groundwater conditions at the compressor station. Between 1997 and 2004, such activities included the installation of monitoring wells at 32 locations within the APE. In addition, approximately 300 soil samples were collected and analyzed. Since 2004, interim investigative and remedial actions have continued and include the installation of additional monitoring wells throughout the site and construction and operation of a temporary water treatment system (IM No. 3). Where applicable, ESA consultation for these activities has occurred on a project-specific basis as identified in Section 1.1.

Under the purview of the DTSC and DOI, PG&E is in the process of finalizing the RI/RFI. This report will comprehensively characterize the nature and extent of hazardous substance contamination in the affected area and provide the basis for formulating alternative remedial actions/corrective measures to be considered for the final remedy. The Feasibility Study/Corrective Measure Study will follow the RI/RFI Report, culminating in a proposed final remedy to remediate chromium (and potentially other hazardous substances) to appropriate cleanup levels. As noted above, it is expected that additional consultation with USFWS will occur pursuant to Section 7 of the ESA prior to selection and implementation of the final remedy.

3.0 Description of Activities

3.1 Area of Potential Effects (APE)

The action area is generally defined by the approximately 1,528-acre APE (Figure 2) and includes lands in both California and Arizona. The APE was originally defined by the BLM and DTSC to facilitate a cultural resources assessment (Applied Earthworks, 2005). An identical boundary was subsequently used to define the area in which annual protocol surveys are conducted for listed species (CH2M HILL, 2005b). The approximately 1.6-mile reach of the Colorado River within the APE generally defines the boundary between California and Arizona.

The Topock Compressor Station occupies approximately 65 acres of PG&E-owned land within the APE. PG&E also owns a 100-acre parcel located about 0.25 mile north of the compressor station, which was purchased to facilitate interim remedial measures. The area surrounding these parcels within the APE includes land owned and/or managed by a number of government agencies including the BLM, USFWS, and USBR.

The APE lies within a larger cultural landscape of significance to federally recognized tribes. In addition, the Colorado River itself is of spiritual and cultural importance to local tribes in the region. The continued contemporary traditional and spiritual use of the area and the management of the land, animals, plants, and water are of great importance to the tribes.

Primary access to the California portion of the APE is provided by Park Moabi Road and National Trails Highway, a two-lane paved roadway extending for approximately 2 miles across the APE. Park Moabi Road connects with Interstate 40 in the western portion of the APE and extends to Moabi Regional Park in the northwest. At Moabi Regional Park, the roadway connects to National Trails Highway, which extends eastward and then southward along the Colorado River to the Topock Compressor Station. Various unnamed roadways traverse the APE, including abandoned segments of former Historic U.S. Route 66 and National Old Trails Road.

Access to the Havasu National Wildlife Refuge (HNWR) in Arizona is provided from Interstate 95. The levee road along the eastern shore of the Colorado River provides access to the northeast portion of the APE. The Topock Marina to the south is accessed from Interstate 40. Land use in the APE is primarily open space with several prominent exceptions. Interstate 40 and the Burlington Northern-Santa Fe (BNSF) railway run east-west, roughly bisecting the APE. The compressor station and associated evaporation ponds are located in the southern portion of the APE. Moabi Regional Park in the northwestern portion of the APE includes numerous mobile home sites, boat docks, and associated infrastructure. The Topock Marina is located on the Arizona side of the river, north of the railway. The Topock Marina and nearby lands encompass approximately 29 acres of private land north and south of Interstate 40 Arizona (see Figure 2). Various gas transmission pipelines traverse the APE. These are primarily subsurface pipelines, with occasional surface expressions (e.g., to bridge ravines or the river).

Developed facilities associated with interim measures and time critical removal actions include numerous groundwater wells and an interim groundwater treatment system (IM No. 3). Between Park Moabi Road and the Colorado River floodplain is an approximately 1-acre area, referred to as the MW-20 bench (see Figure 2), which has been the site of past and present interim measures/removal actions. These activities are described further in Section 3.2.

Land ownership and management in the APE is depicted on Figure 2. The BLM manages the federally owned land north of the BNSF railway and west of the Colorado River. This includes lands managed on behalf of the USBR. The USFWS manages the HNWR located in California immediately north, south, west, and east of the Topock Compressor Station. The HNWR is also located in the southern and eastern portions of the APE and includes most lands located on the Arizona-side of the Colorado River. Outside of the APE, the 37,515-acre HNWR extends for approximately 26 miles along the Colorado River, from Needles, California, to Lake Havasu City, Arizona.

Recreational activities within the HNWR include sightseeing, boating, bird watching, fishing, hunting, and camping. Prior damming and channelization of the Colorado River have significantly altered the aquatic, marsh, and riparian habitats associated with the river. These water control and diversion actions have also contributed to increased housing development along the river and facilitated an increase in the intensity of river-related recreation (including watercraft, fishing, and hunting) (BOR, 1996, 2000, 2002, 2004).

The Colorado River flows southeast between California and Arizona and provides the primary aquatic habitat within the APE. The river is approximately 700 to 900 feet wide and 8 to 15 feet deep through the APE. The adjacent river floodplain averages about 500 feet in width but narrows at the Topock Gorge, approximately 4 miles south of the APE. The topography of the floodplain in California is relatively flat with a gentle slope toward the river. The Arizona floodplain is more mound-like creating a low divide between the Colorado River and the wetlands of the Topock Marsh

The Colorado River has been stocked with various game fish that have been linked to predation of native listed fish species (BOR, 2004). The invasion of salt cedar along the Colorado River has significantly altered riparian habitat. This exotic tree dominates and displaces native plant communities. The BOR is responsible for managing the river and has consulted with USFWS on its actions (BOR, 1996, 2000, 2002, 2004). Several biological opinions have been issued to the BOR (USFWS, 1997a-b, 2002, 2005a). A Multi-Species Conservation Plan (MSCP) and Multi-Species Habitat Conservation Plan (MSHCP) recently have been developed for the Colorado River (BOR, 2004).

The terrestrial portions of the APE are characterized by arid conditions (precipitation averages less than 5 inches/year) and high temperatures (routinely exceeding 110 degrees Fahrenheit in the summer) typical to the Mojave Desert. The landscape in the California portion of the APE is considerably eroded by natural processes resulting from the effects of wind and water erosion. The result in part is land forms characterized by alluvial terraces and incised drainage channels. One of the largest incised channels is Bat Cave Wash, which runs from the Chemehuevi Mountains in the south toward the Colorado River in the north. Terraces occurring onsite are homogeneous, comprised of rocky soils with very sparse vegetation. Of tribal concern and spiritual importance, these terraces are also where the physical evidence of the Maze is most observable. Elevations in the APE range from about 450 feet mean sea level (msl) at the river floodplain to 550 feet msl at the compressor station. The area north of Topock Marina in the Arizona portion of the APE is within the HNWR; the landscape in this area is dominated by dredge spoils and bordered by the Colorado River to the west and the Topock Marsh to the east.

The local geology consists of recent and older river deposits progressing westward to older alluvial deposits associated with the local mountains. Sand, gravel, and cobblestone dominate these deposits, comprising the principal groundwater aquifer at the site. The main surface water drainage channel from the APE toward the Colorado River is Bat Cave Wash and a large unnamed desert wash with several tributaries located to the west. These ephemeral desert washes are dry most of the year, but during heavy precipitation events the washes can have surface flow.

Structurally diverse vegetation is primarily limited to the Colorado River floodplain and ephemeral washes near the river. The uplands consist primarily of a sparse creosote bush scrub community, whereas the floodplains on the California and Arizona shorelines are composed of sandy soils with tamarisk (*Tamarix* sp.), mesquite (*Prosopis* sp.), palo verde (*Cercidium* sp.), and arrowweed (*Pluchea sericea*). A more detailed description of the flora and fauna in the APE, including species listed under the federal ESA, are described in Section 4.0.

3.2 Past and Present Activities

Past and present activities have been limited to the California portion of the APE and the Colorado River. These activities include the installation and sampling of numerous groundwater monitoring wells, as well as Interim Measure (IM) No. 1, IM No. 2, and IM No. 3, which generally involve plume characterization and control including pumping and treating impacted groundwater. For each of the IM's, activities on federal land were authorized as CERCLA time-critical removal actions pursuant to Action Memoranda issued by the BLM.

Additional activities which pre-date current interim measures include prior RFI wells and wells installed to monitor groundwater conditions at the compressor station. Between 1997 and 2004, RFI activities included the installation of monitoring wells at 32 locations within the APE. In addition, approximately 300 soil samples were collected and analyzed at locations within and surrounding the Topock Compressor Station, and impacted soil was removed during removal of former wastewater treatment structures within the compressor station. The locations of the previously constructed RFI well facilities, compressor station monitoring wells, and those associated with IM Nos. 1 through 3, are shown on Figure 3.

Past and present activities discussed below have been authorized by BLM and/or the HNWR. Informal consultation with the USFWS occurred in September 2004, prior to the approval by BLM of the IM No. 3 activities occurring on federal land (CH2M HILL, 2004b). In addition, the PE-1 pipeline project and floodplain *in-situ* pilot study was the subject of a biological assessment (CH2M HILL, 2005j) and subsequent consultation with USFWS in November 2005. Completion reports addressing the implementation of several of the past projects discussed below have documented no known take of any species listed under the ESA (CH2M HILL, 2005c, d, g, and 2006a).

3.2.1 General Activity Categories

Past and present response and investigative activities have occurred throughout the California portion of the APE and have typically comprised one or more of the following categories of activity:

1. Well installation, maintenance, and operation. This includes access to injection, extraction, and monitoring well sites for surveys, drilling, installation of wellheads, pumps and equipment, monitoring, testing, well maintenance, and sampling. The number of required staff and duration of these activities is provided in the sections that follow.
2. Pipeline installation, maintenance, and operation. This includes above- and belowground piping and appurtenances to and from wells, water treatment, and water and waste management facilities.
3. Facility installation, maintenance, and operation. This includes water treatment facilities, such as IM No. 2 batch treatment plant and the IM No. 3 treatment facility and related injection wells, water and waste management facilities, and *in-situ* treatment operations.
4. Colorado River and soil sampling. This includes open water sample collection from shore and by boat, as well as pore water sampling using techniques including, but not limited to, those described for the Pore Water Sample Study (see Section 3.2.7). Also includes sediment and soil sampling, and seismic surveys.
5. Road maintenance. This includes maintenance of roads and/or paths to project facilities (wells, pipelines, and treatment facilities) within the APE on public and private land.
6. Restoration and mitigation activities. This includes biological restoration or revegetation activities to restore ecological values to areas where project activities/facilities are no longer necessary or have been removed.

3.2.2 Topock Compressor Station Wells

Groundwater monitoring wells have been installed in the vicinity of the existing and former evaporation ponds associated with the Topock Compressor Station. These wells are not associated with corrective actions but are used to monitor operation of the existing ponds. The locations of Topock Compressor Station wells are included on Figure 3. These facilities and the associated activities fall within Category No. 1 described in Section 3.2.1.

3.2.3 Groundwater and Surface Water Monitoring Program

Routine groundwater and surface water monitoring activities were initiated in 1998 as a continuation of the RFI, through the ongoing groundwater monitoring program (GMP). The number of groundwater well and surface water sampling locations, as well as the frequency of sampling from each location, have varied since the GMP inception and will continue to be refined in the future as data needs are evaluated. As of September 2006, monitoring occurs semiannually, quarterly, monthly, biweekly, and biennially, as follows:

- Fourteen groundwater wells are sampled semiannually.
- Sixty-two groundwater wells are sampled quarterly.
- Twelve groundwater wells on the floodplain are sampled monthly.
- Four groundwater wells on the floodplain are sampled biweekly.
- One extraction well, one injection well, and two inactive supply wells are sampled biennially.
- Nine shoreline surface water stations along the Colorado River are sampled monthly.
- Nine depth-specific sampling stations within the Colorado River channel are sampled quarterly (except during winter low-river stage conditions, when the stations are sampled monthly).

The locations of the GMP wells are included on Figure 3. The sampling frequency of wells currently included in the program is in the process of being evaluated by DTSC. The more frequent GMP events focus on wells located on the Colorado River floodplain.

Access to monitoring wells typically occurs via a pickup truck or all-terrain vehicle (ATV) with a trailer. On average, two field personnel are engaged in sampling activities for each individual well. Sampling procedures require purging the wells before sampling can be conducted. Depending on the well characteristics, between 15 and 200 gallons of water are typically purged and subsequently transported to the IM No. 3 treatment facility. Pumping of purge water often involves the use of a portable generator to power a well pump. Several wells on the Colorado River floodplain have dedicated pumps installed that are powered from an electrical power source at the PE-1 wellhead. The time frame to complete field sampling activities at an individual well ranges from approximately 15 minutes to 1 hour. Several monitoring sites include clusters of two to three wells sampled at different groundwater depths. The total time frame to complete a sampling event ranges from 2 days for biweekly events to 7 days for a biennial event.

Vehicles traveling throughout the APE use existing roads and/or predetermined routes to access each of the monitoring wells.

Further details of the GMP program are provided in Appendix A1.

The facilities and the associated activities discussed above fall mainly within Category No. 1 and partially within Category No. 4 (surface water sampling), as described in Section 3.2.1.

3.2.3.1 Floodplain Sampling Procedures

In June 2005, modified sampling procedures were developed due to concerns regarding the potential affects to the SWFL. Floodplain sampling and access procedures during the 2005 SWFL nesting season were modified to include limited use of ATVs and staging of equipment and tanks within specified areas for the purpose of reducing potential impacts to SWFL. These procedures to avoid any potential effects to SWFL comprised a “no effect” avoidance strategy.

In April 2006, PG&E proposed modifications to the floodplain sampling procedures implemented during the SWFL nesting season (May 1 through September 30). The modified procedures include the use of lower-noise ATVs, dedicated well pumps, electrical power supply outlets on the floodplain in lieu of portable generators, reduced sampling frequencies at certain wells, use of 4-inch "lay-flat" hose to purge water outside of potentially sensitive areas, and additional staging areas to limit equipment movement. These procedures are detailed in the *Site Access and Sampling Procedures for Groundwater Monitoring Wells Located Near Potential Southwestern Willow Flycatcher Habitat, Rev. 3* (CH2M HILL, 2006b) provided to the BLM on April 20, 2006.

Based on the above-referenced technical memo and the biological analysis provided therein, BLM and HNWR initiated informal consultation with the USFWS. In a letter dated April 28, 2006, USFWS provided their concurrence with the BLM determination that the proposed sampling procedure modification "may affect, but not likely to adversely affect" the SWFL. The USFWS also concurred with the BLM determination that implementation of these sampling procedures would have "no effect" to the razorback sucker, bonytail chub, Colorado pikeminnow, desert tortoise, and Yuma clapper rail. The sampling procedures described in the April 20, 2006, technical memorandum were subsequently approved by BLM in a letter dated May 1, 2006, and by HNWR in a letter dated May 11, 2006. Figure 4 depicts the approved ATV access routes and staging areas to be used during the SWFL nesting season. No take has been reported to date as a result of implementing these access and sampling procedures.

It is PG&E's intent to carry these or similar access and sampling procedures forward and to consider them as general management measures through 2012.

3.2.3.2 Surface Water Sampling

Sampling procedures for surface water sampling on the Colorado River involve the use of a motorized boat and a global positioning system (GPS) device. At each sample location, river samples are taken from 1 foot off the river bottom, at the mid-point of the water column, and 1 foot below the river surface. Shoreline surface water samples are taken at a depth of approximately 6 inches below the water surface from the shoreline or from a boat. To date, these activities have occurred with no known take of listed species.

The facilities and the associated activities discussed above fall mainly within Category No. 1 and partially within Category No. 4 (surface water sampling), as described in Section 3.2.1.

3.2.4 Interim Measures No. 1

The IM No. 1 project was authorized in March 2004 and provided for additional groundwater monitoring wells at eight locations to complement the existing network of monitoring wells in the APE (see Appendices A2 and A3). IM No. 1 also included several potential extraction wells. However, the extraction portion of IM No. 1 was subsequently supplanted by IM No. 2 (Section 3.2.5), which provided a more comprehensive program to extract, treat, and haul groundwater containing chromium. In early 2005, a second phase of IM No. 1 was implemented involving the development of groundwater wells at five additional locations on the Colorado River floodplain (see Appendices A4 through A6). An assessment of the land used during the second phase of IM No. 1 construction activities was prepared for BLM and USFWS HNWR, per stipulations provided in their approval. That analysis is provided in Appendix A7.

Typical well installation activities involved the use of a rotosonic drilling rig, forklift, and support vehicle for equipment and material transfer to each drill site. Materials temporarily stored at well sites included drilling equipment and well construction materials (casing, sand, bentonite, cement grout). Drill cuttings generated from drilling were transferred by forklift to lined steel rolloff soil bins. The water produced from drilling was temporarily stored in 55-gallon steel drums placed on pallets or portable storage tanks at each drill site. After installation, the injection and monitoring wells were developed by a combination of surging, bailing, and pumping to remove sediment from the well casing. All waste generated was disposed of at a permitted disposal facility.

Well installation activities involved an average of three drill crew members, two to three staff specialists to collect and record core samples, one biologist, and one archaeologist (if required). The amount of time to install a well varies depending on whether the facility is a single well or well cluster. On average, about 15 days are required to install and develop a well cluster. Well development time may vary, depending on whether conducted by the drill crew or other dedicated staff immediately subsequent to the drilling activity.

Authorization for IM No. 1 was provided by BLM via an Action Memorandum in March 2004 (Appendix A3). To date, these activities have occurred with no known take of listed species.

Monitoring wells installed under IM No. 1 included wells used for both the Groundwater Monitoring Program (see Section 3.2.3) and Performance Monitoring Program (see Section 3.2.6.1). The facilities and activities discussed above fall within Category No. 1, as described in Section 3.2.1.

3.2.5 Interim Measures No. 2

IM No. 2 was authorized by BLM and DTSC in March 2004 and in May 2004. IM No. 2 involved the extraction, treatment, and hauling of treated water to an offsite disposal facility (see Appendices B1 and B2). Groundwater was extracted at rates of up to approximately 90 gallons per minute and pumped into a series of Baker tanks. A batch treatment process to remove chromium occurred within the Baker tanks, resulting in a 99 percent reduction in the volume of hazardous waste (see Appendices B3 and B4). The treated water was pumped into tanker trucks for disposal at a permitted treatment facility in Los Angeles. Groundwater treatment operations at IM No. 2 were phased out in July 2005 following commencement of groundwater treatment at the IM No. 3 plant. Groundwater extraction and hauling of brine continues at the same site as a part of IM No. 3, discussed in Section 3.2.6.

The extraction, treatment, and truck-loading facilities and operations were limited to an approximately 1-acre area on BLM land (referred to as the MW-20 bench) due to the proximity to monitoring well MW 20. This area is bounded by Park Moabi Road to the west and the Colorado River floodplain to the east. This site was selected based on various factors that included proximity to Park Moabi Road, available space, lack of vegetation/habitat, existing groundwater wells, and flat topography. The MW-20 bench and IM No. 2 project area are shown on Figure 3.

The facilities and activities discussed above fall within Category No. 3, as described under Section 3.2.1. Two extraction wells (TW-2S and TW-2D) were installed on the MW-20 bench as part of IM No. 2, and installation of these wells falls within Category 1, as described under Section 3.2.1. Details of the IM No. 2 program and related federal authorizations, including applicable biological stipulations, are provided in Appendix B. Authorization for IM No. 2 was provided by BLM via an Action Memorandum in March 2004 (Appendix B2) and a subsequent Action Memorandum provided in May 2004 (Appendix B4). To date, these activities have occurred with no known take of listed species.

3.2.6 Interim Measures No. 3

IM No. 3 was designed to provide greater groundwater extraction and management capacity to maintain hydraulic control of groundwater near the Colorado River. Under IM No. 3, the pumped water is treated in a treatment plant on property owned by PG&E, with treated water also managed onsite, through re-injection into the groundwater aquifer. IM No. 3 operations provide a significantly higher rate of extraction and treatment than IM No. 2. Details of the IM No. 3 project are described in the work plans provided in Appendices C1 through C3. The BLM approval, including biological stipulations, is provided in Appendix C4.

IM No. 3 facilities include extraction, treatment, conveyance, injection, and monitoring facilities, shown on Figure 3. Construction of IM No. 3 commenced in September 2004 and was completed in July 2005. An analysis of IM No. 3 construction and the total area used by IM No. 3 is provided in Appendix C5. Prior consultation between BLM and USFWS regarding IM No. 3 construction and operation resulted in a determination of no effect to the desert tortoise, a species listed as threatened under the federal ESA. The biological investigation of the IM No. 3 project is provided in Appendix C6. Following construction, a report of IM No. 3 construction and operation was prepared (Appendix C7). This document includes the applicable approvals and stipulations provided by BLM.

Access to IM No. 3 is provided by roads extending from the east and west off Park Moabi Road and National Trails Highway. These access roads have been improved to facilitate effective transportation to the treatment plant and to protect key cultural resources. The roads will continue to require maintenance several times each year to repair storm damage and control dust. This will require the use of graders, backhoes, and water trucks (for example) to complete the maintenance. The IM No. 3 treatment plant occupies an approximately 1-acre site. Double-walled influent conveyance piping is subsurface and generally follows the eastern access road. Effluent piping from the treatment system to the injection wells is mostly located aboveground, along the shoulder of the western IM No. 3 access road. The subsurface and aboveground piping extend for approximately 3,000 and 1,900 feet, respectively.

There are four existing extraction wells available for operation of IM No. 3. Currently, the system operates using two wells: TW-3D located on the MW-30 bench, and PE-1 located on the floodplain. Construction of the pipeline between the PE-1 site and the MW-20 bench was recently completed, and extraction operations began in January 2006 (see Figure 3 and Section 3.2.6.3). Installation of TW-3D was completed in late 2005 and extraction operations began in December 2005 (see Figure 3 and Section 3.2.6.4). The other two extraction wells (TW-2S and TW-2D) were installed on the MW-20 bench as part of IM No. 2 and are available for backup, but are not currently in operation. The injection wellfield consists of two wells (IW-02 and IW-03) located on PG&E property west of the treatment plant, installed in 2004. Construction and development of the extraction and injection wells was similar to the typical well installation activities described above in Section 3.2.4

Operation of IM No. 3 commenced in late July 2005. Continuing operations require one to two operations staff to manage and monitor IM No. 3 functions 24 hours per day, primarily at the IM No. 3 treatment plant. The operations staff drives to the injection well area and the extraction well locations several times each day to monitor the condition of the wells and conveyance piping. In addition to the operations staff, a security company has been employed to provide 24-hour-a-day patrolling of the IM No. 3 project area.

Periodic maintenance activities include routine repairs, waste removal, and deliveries of supplies and treatment compounds. Maintenance activities may also involve enhancement of existing facilities to optimize operations (e.g., upgrading or replacing equipment). Delivery of supplies and materials occurs several times per week. Repair activity includes recent repairs to the IM No. 3 access road. These repairs mainly involved the installation of sufficiently sized culverts to convey stormwater below the roadway and the addition of fill material to eroded sections. As part of the BLM mitigation for HR66, which is the primary access route to IM-3, approximately 5 inches of road base must be maintained over the original HR66 surface to protect the historic landmark from potential vehicular impacts.

During IM No. 3 operations, brine wastewater from the water treatment process is pumped back to the MW-20 bench and trucked to an offsite disposal facility. Currently, the offsite disposal facility receiving the brine wastewater is located in Los Angeles, California. Approximately 24 trucks per week are required to haul brine waste at the extraction rate of 135 gallons per minute. The required trucking activity varies throughout the year as the flow rate requirements change. In the future, the brine may be hauled to the existing Topock Compressor Station evaporation ponds currently utilized for compressor station operations. These operations would continue but would also involve discharge of IM No. 3 brine waste in the compressor station ponds in lieu of transport to an offsite facility. Alternatively, in the future, brine wastewater may be disposed at an offsite disposal facility in Nevada, Arizona, or alternate location in California.

In September 2004, BLM initiated informal Section 7 consultation with USFWS related to implementation of IM No. 3. Specifically, the consultation addressed potential effects to the Desert Tortoise and SWFL during construction and operation of this project. The anticipated biological impacts of the project, including potential impacts to sensitive species, were assessed in the *Biological Resources Investigation for Interim Measures No. 3* (CH2M HILL, 2004b) provided in Appendix C6. Based on this analysis and the consultation between BLM and USFWS, a "no effect" determination was provided for IM No. 3. The 2004 Action Memorandum providing BLM authorization to implement IM No. 3 included numerous biological stipulations (see Appendix C4). To date, the project has been working under the "no effect" determination with no take of listed species. A report documenting the completion of IM No. 3 construction activities (CH2M HILL, 2005d) is provided in Appendix C7.

These facilities and activities fall within Category Nos. 1, 3, and 5, as described in Section 3.2.1.

3.2.6.1 Performance Monitoring Program

The performance monitoring program (PMP) involves monitoring, data evaluation, reporting, and response actions associated with the IM No. 3 pumping, treatment, transport, and disposal of extracted groundwater near the floodplain area. The network of groundwater wells used for performance monitoring includes the monitoring and extraction wells in the floodplain and adjoining area, as shown on Figure 3. The network of groundwater wells used for performance monitoring includes monitoring wells in the floodplain, the MW-20 bench/Park Moabi Road area, and the upland interior plume area.

As part of the PMP, a network of pressure transducers are maintained and operated to continuously monitor water levels and assess hydraulic gradients (horizontal and vertical) in the floodplain area. The transducer data are downloaded biweekly to the PMP database. Manual water levels are measured periodically at the monitoring wells, river locations, and extraction wells to calibrate and supplement the pressure transducer data. The majority of the PMP wells used for hydraulic data and groundwater sampling are clusters consisting of two or three individual wells installed at one monitoring location. The PMP activities and standard operating procedures are detailed further in Appendix C2.

The PMP uses existing monitoring wells, equipped with transducers and data loggers. To the extent that the PMP is a component of the IM No. 3 project, it is included in the prior Section 7 ESA consultation for IM No. 3 described above.

The facilities and activities discussed above fall within Category No. 1, as described in Section 3.2.1.

3.2.6.2 Compliance Monitoring Program

The compliance monitoring program (CMP) monitors the aquifer in the IM No. 3 injection well area to ensure that injection of treated groundwater is not causing an adverse effect on the aquifer water quality. Groundwater levels are measured in the vicinity of the injection wells, and groundwater samples are collected and analyzed. Groundwater analyses are performed to ensure that the distribution and concentrations of constituents of concern remain consistent with the baseline sampling results. The CMP monitoring well network consists of both observation wells and compliance monitoring wells. The CMP plan is provided in Appendix C3.

The December 2004 BLM letter of approval (Appendix A5) for the CMP facilities makes reference to prior authorization provided under the March 2004 IM No. 1/2 Action Memorandum and applies all stipulations included in the September 2004 IM No. 3 Action Memorandum.

The facilities and activities discussed above fall within Category No. 1, as described under Section 3.2.1.

3.2.6.3 PE-1 Pipeline

IM No. 3 operation was planned to process groundwater influent from extraction well PE-1, located approximately 400 feet east of the MW-20 bench on the Colorado River floodplain (Figure 3). The PE-1 extraction well was installed in March 2005. Construction of a double-walled conveyance pipeline to connect the PE-1 extraction well with existing conveyance pipeline at the MW-20 bench was completed in January 2006. The pipeline alignment extends for approximately 500 feet between PE-1 and the MW-20 bench (Figure 3). The alignment also includes power conduit for use during activities in the floodplain, including the well sampling program. The PE-1 extraction well is currently operational. The *Design Plan Conveyance Piping and Power Supply for Extraction Well PE-1* (CH2M HILL, 2005e) is provided in Appendix C8.

Potential biological impacts associated with this facility were covered under the *Biological Assessment for the Pacific Gas and Electric Topock Compressor Station Remedial and Investigative Actions* (CH2M HILL, 2005j) prepared in November 2005 and an ESA Section 7 consultation process completed in December 2005. The result of that consultation was a finding of "may affect, not likely to adversely affect" for the SWFL, and a "no effect" finding for all other listed species. As documented in the completion report for PE-1 (CH2M HILL, 2006a), the construction activities were completed with no take of any listed species.

The facilities and activities discussed above fall within Category No. 2, as described in Section 3.2.1.

3.2.6.4 Well TW-3D

An additional IM No. 3 extraction well was installed at the MW-20 bench site in late 2005 and is currently in operation. This well is referred to as TW-3D, and is located approximately 15 feet west of the TW-2D extraction well, which was originally installed as the primary extraction well for IM No. 2. The work plan detailing installation of extraction well TW-3D is provided in Appendix C9.

Construction and development of this well was similar to the typical well installation activities described above in Section 3.2.4. In addition, approximately 50 feet of underground piping were constructed to connect TW-3D to the existing IM No. 3 groundwater conveyance system. TW-3D construction activities occurred entirely within the MW-20 bench.

The October 2005 BLM letter of approval for TW-3D indicated that the facilities were authorized via the IM No. 3 Action Memo of September 2004 (Appendix C4).

These facilities and activities fall within Category Nos. 1 and 2, as described in Section 3.2.1.

3.2.6.5 Interim Measures Performance Monitoring Wells

In 2005, DTSC requested the installation of eight groundwater well clusters within and in the vicinity of the Colorado River floodplain to further characterize the nature and extent of the chromium plume in this area and to assess the performance of interim measures. The *Well Installation Work Plan for Interim Measures Performance Monitoring Program,* describing the installation and operation of five well clusters on the river floodplain and three well clusters immediately upland from the floodplain, is provided in Appendix A10. The eight well cluster locations are included on Figure 3.

BLM and HNWR approval of the eight Interim Measures Performance Monitoring (IMPM) well clusters was provided in a letter dated February 21, 2006, pursuant to prior authorization provided by the September 2004 Action Memorandum related to IM No. 3 activities. Construction of the IMPM well clusters commenced in February 2006 and concluded in May 2006. Construction and development of these wells was similar to the typical well installation activities described above in Section 3.2.

These facilities and activities fall within Category No. 1 described above in Section 3.2.1.

3.2.7 Pore Water Study and Seismic Survey

The pore water study focused on water within pore spaces in sediments immediately beneath the Colorado River. Samples from the river were taken along approximately 16 transects—eight downstream of the groundwater plume and eight upstream of the groundwater plume. Pore water transects within the APE are shown on Figure 3. Approximately four samples were taken at each transect. In addition, approximately 10 core samples of river sediment were taken. Sampling depths ranged from 2 to 6 feet below the riverbed. The *Pore Water and Seepage Study Work Plan* detailing project activities is provided in Appendix A8.

Prior to implementation of the pore water study, the United States Geologic Survey (USGS) conducted a seismic survey within the Colorado River to better understand bedrock characteristics below the riverbed. This survey involved the use of a small watercraft utilizing equipment similar to a fish finder to conduct the seismic bedrock survey.

Prior review and approval by the USFWS HNWR concluded that no effect to sensitive fish species would result from implementation of the pore water study (USFWS 2005e). Authorization and approval for the pore water study provided by the USFWS HNWR on November 15 included a prohibition on take of any wildlife, particularly threatened and/or endangered species.

The pore water study sampling activities were planned to coincide with low water levels within the river, which generally occur in the months of December and January. The study field activities commenced in December 2005 and were completed in early January 2006. Further details regarding the pore water study are described in the work plan, provided in Appendix A8.

These activities fall within Category No. 4, as described in Section 3.2.1.

3.2.8 *In-situ* Floodplain Pilot Study

The *in-situ* floodplain pilot study activities involve injection of food-grade compounds into the groundwater aquifer and measurement of the reduction of chromium levels. The pilot study is located on the floodplain within an approximately 0.25-acre area 300 feet east of the MW-20 bench. Facilities at the site include one injection well cluster and six monitoring well nests. The permanent nested well structures have a surface expression of less than 500 square feet (0.01 acre). The floodplain pilot study project wells are included on Figure 3.

The *In-situ Hexavalent Chromium Reduction Pilot Test Work Plan, Floodplain Reductive Zone Enhancement* (MWH, 2005a) is provided in Appendix A9.

The pilot study wells were installed in early 2006, prior to the SWFL nesting season. Construction of the injection and monitoring wells occurred over approximately 2 months. Typical well installation activities associated with the pilot study are similar to those described above in Section 3.2.4.

Beyond the project wells, no other permanent equipment or facilities are required for *in-situ* pilot study operations; temporary hoses connect the injection well to temporary containers during injection activities. Operations commenced in April 2006, and involve injection of reagents at up to four separate times over the 8-month operation period and groundwater monitoring. Groundwater monitoring occurs as frequently as daily over the first week of operations, and then weekly to monthly until the end of the study, anticipated to be late 2006. Monitoring activities are similar to those described above for the GMP project. Details of the *in-situ* floodplain pilot study are described in the work plans for these activities, provided in Appendix A9.

Potential biological impacts associated with these activities were covered under the *Biological Assessment for the Pacific Gas and Electric Topock Compressor Station Remedial and Investigative Actions* (CH2M HILL, 2005j) prepared in November 2005 and an ESA Section 7 consultation process completed in December 2005. The result of that consultation was a finding of “may affect, not likely to adversely affect” for the SWFL, and a “no effect” finding for all other listed species. As documented in the completion report for these facilities (CH2M HILL, 2006a), the construction activities were completed with no take of any listed species.

These facilities and activities fall within Category Nos. 1 and 3, as described in Section 3.2.1.

3.2.9 Restoration

To date, restoration activities primarily have involved revegetation of the area affected by installation of monitoring well MW-43, and decommissioning of the IM-2 batch treatment system at the MW-20 bench. Restoration at MW-43 involved the planting of approximately 100 mesquite trees along the approximately 250-foot access corridor to MW-43. Decommissioning of the IM No. 2 batch treatment system to date has involved cleaning tanks and associated containment structures, removal of support facilities (including the field trailer, field laboratory, generator, ice machine and potable water tanks, etc.), securing batch treatment pumps, piping and appurtenances, and modifying the security fencing to reduce the footprint of the secured area. Decommissioning of the MW-20 bench is being performed in phases, as described in the *MW-20 Bench Decommissioning Work Plan,* submitted to BLM on August 8, 2005 (CH2M HILL 2005g).

These restoration activities fall under Category No. 6 described above in Section 3.2.1. Additional and future restoration efforts are currently in planning, as discussed in Section 3.3.8.

3.3 Planned Activities

Various investigative and remedial activities are currently planned prior to implementation of the final remedy. It is expected that DTSC and DOI will require additional investigatory and/or response activities as part of the RI/RFI prior to the selection of the final remedy, which is currently unspecified. Such activities are likely to fall within the general activity categories described below. Where information is currently available, specific planned activities are also described. Table 1 provides a list of planned activities and a summary of the area estimated to be used during implementation. Overall, future activities are anticipated to be substantially similar to past and current activities, particularly those conducted since 2004.

3.3.1 Planned Activity Categories

The planned investigative and remedial activities occur throughout the APE and may comprise any one or more of the following activity types listed below. Where necessary, staging of equipment and materials will typically occur at the MW-20 bench, an area approximately 1,200 feet to the north between Park Moabi Road and the MW-35 well, and/or at the Topock Compressor Station. Further details regarding equipment, personnel, and time frames are provided as available for the planned activities described below in Sections 3.3.2 through 3.3.8.

1. Well installation, maintenance, operation, and decommissioning. Includes access to existing and future injection, extraction, and monitoring well sites for surveys, drilling, installation of well heads, pumps and equipment, aquifer testing, monitoring, well maintenance, retro-fitting, decommissioning (e.g., well abandonment), and sampling. Approximately 30 new well clusters may be installed throughout the APE. Also includes related improvements such as dedicated well pumps to facilitate well sampling activities. Access to well locations would use existing access roads and/or pre-defined travel corridors wherever possible.

2. Pipeline installation, maintenance, and operation. Includes above- and belowground piping and appurtenances to and from wells, water treatment, and water and waste management facilities. Potential pipelines include a connection from the MW-20 bench to the Topock Compressor Station to convey brine waste from the IM No. 3 treatment plant operations.

3. Facility maintenance and operation. Includes water treatment facilities, such as IM No. 2 batch treatment, IM No. 3 treatment facilities, water and waste management facilities, and *in-situ* treatment operations. Periodic maintenance activities include routine repairs, well maintenance, waste removal, and deliveries of supplies and treatment compounds.

4. Colorado River and soil sampling. Includes open water sample collection from shore and by boat, as well as pore water sampling using techniques including, but not limited to, those and similar techniques as described in the Pore Water Sample Study (see Section 3.2). This category also includes soil sampling activities via a number of collection methods including, but not limited to: boring, augers, trenching, and such sampling methods conducted via track- and truck-mounted apparatus. Other sampling

activities may include seismic studies and/or bedrock sampling using drilling equipment. Non-intrusive test methods (i.e., geophysical methods) may also be employed if useful data can be collected by such means. Access to soil sampling locations would use existing access roads and/or pre-defined travel corridors wherever possible.

5. Road maintenance. Includes maintenance of roads and/or paths to project facilities (wells, pipelines, and treatment facilities) within the APE on public and private land. Examples include regrading and/or re-paving of existing access routes, and the installation of stormwater culverts to limit roadway erosion during storm events.
6. Restoration and mitigation activities. Includes activities to restore spiritual, cultural, ecological, aesthetic, or other values to areas where project activities/facilities are no longer necessary or have been removed. Also includes revegetation and removal of debris located within the APE (e.g., scrap metal, wood, brick, plastic, or similar materials). Some restoration sites will require removal or addition of soil and rocks to re-contour the landscape and drainage ditches that may require barriers and irrigation facilities. Reasonably foreseeable planned restoration areas are shown on Figure 5. Other additional restoration and mitigation areas may be identified by BLM and USFWS, including restoration outside of the APE as investigative and response activities continue at a 2:1 ratio (restored:lost).
7. Emergency activities. Includes any activity that cannot be reasonably foreseen but, due to public health/safety concerns, requires immediate response and/or corrective action. Examples of such activity include, but are not limited to, response of police, fire, ambulance or other personnel to the site, and subsequent work, in the event of explosion, fire, vehicle accident, spill, natural disaster, equipment failure, chemical reaction, heat illness, heart attack, or other medical emergencies.

3.3.2 IM No. 3 Discharge Options

Treated water effluent from the IM No. 3 treatment plant is currently re-injected into the groundwater aquifer. Brine waste resulting from the treatment process is currently transported offsite to a facility located in Los Angeles, California. Potential changes to IM No. 3 operations include (1) transporting brine waste to the Topock Compressor Station ponds, (2) transporting brine waste to an alternate offsite disposal facility in Nevada, Arizona or elsewhere in California, and (3) using treated IM No. 3 water in the compressor station cooling towers.

Current IM No. 3 operations involve the transport of brine waste via truck from the MW-20 bench to an offsite disposal facility located in Los Angeles, California. Approximately 26 truckloads of brine waste per week are generated. Potential changes to IM No. 3 operations include transport of the brine waste along National Trails Highway to the compressor station evaporation ponds. This transfer can be accomplished by trucking the brine waste to compressor station tank facilities and commingling the brine waste with cooling water blowdown, which is subsequently piped to the evaporation ponds.

The potential transport of brine waste offsite to an alternate offsite disposal facility would involve little or no change in the onsite operations to access Interstate 40.

Potential use of treated IM No. 3 water in the compressor station cooling towers would partially offset, but not completely replace, existing potable water usage. The treated water would be hauled from the MW-20 bench to the compressor station and pumped into existing cooling water tank facilities. After use in the cooling towers, the treated water would ultimately be discharged to the existing evaporation ponds.

Implementation of both the brine waste and treated water options involve the transport of approximately 300 truckloads per week of treated water and brine waste from the MW-20 bench to the Topock Compressor Station. In addition, both of these options would require the construction of a small transfer facility at the discharge point to ensure proper management of brine waste and treated water pumping operations. Activities associated with the transport and use of brine water and treated water at the compressor station would be conducted within a predominantly industrial setting and would not require any expansion of the footprint of the existing industrial facilities.

In lieu of trucking brine waste and/or treated water from the MW-20 bench to the Topock Compressor Station described above, a conveyance pipeline may be constructed in National Trails Highway. PG&E maintains an existing agreement with the County of San Bernardino to construct such facilities within the existing roadway right-of-way. Use of a pipeline to transport brine waste and treated water would also require construction and operation of a pump station at the MW-20 bench. The conceptual pipeline alignment would follow the brine waste haul route shown on Figure 5 between the MW-20 bench and the entry to the Topock Compressor Station.

Details regarding potential pipeline installation activities are not currently specified, but could involve up to 12 construction staff over a period of 2 to 3 months. Typical equipment would include a backhoe, excavator, roller, and smaller support vehicles. Following pipeline installation, National Trails Highway would be repaved to pre-construction conditions.

These activities generally fall under Category Nos. 2, 3 and 5, as described in Section 3.3.1.

3.3.3 Soil Sampling

Several soil sampling programs are planned to further characterize COPCs in soil resulting from historic operations at the Topock Compressor Station and/or to characterize back ground soil conditions, as described below. Soil sampling is expected to primarily occur in the upland areas, but may involve some sampling in the Colorado River floodplain. Further soil sampling is expected to be required by DTSC and DOI to support site characterization or remedy selection and design. Details of currently planned sampling methods are provided in Appendix D1 and outlined further below. The activities described below fall under Category No. 4, as described in Section 3.3.1.

3.3.3.1 IM No. 3 Soil Sampling

The primary objective of the IM No. 3 soil sampling program is to determine naturally-occurring background concentrations of metals, including hexavalent chromium, total chromium, and other inorganic compounds in soil in the direct vicinity of the IM No. 3 system. As part of future IM No. 3 closure activities, or in the event of a release of wastewater and/or treatment chemicals from the treatment system or pipelines during operation, such baseline data would be used to assess impacts associated with the release, assess the appropriate level of site restoration, and guide remediation, if necessary.

Approximately 21 sample locations have been preliminarily identified, primarily along the pipeline alignment and Bat Cave Wash, as shown on Figure 5. Within the upland and Bat Cave Wash areas, approximately three samples will be taken from each location between 0 to 6 feet below ground surface. Within the floodplain area, approximately five samples will be taken from each location between 0 and 20 feet below ground surface. Mechanized sampling would use a Bobcat-mounted auger rig to drill and sample a borehole. This technique would involve two field personnel. Hand digging would occur with a hand auger, posthole digger, shovel, or pry bar and would require two to four field personnel. Field sampling activities for all of the locations shown on Figure 5 are expected to be completed in about 3 days.

Additional details of the IM No. 3 soil sampling, including proposed sampling methods, are described in the work plan provided in Appendix D1.

3.3.3.2 RCRA Facility Investigation/CERCLA Remedial Investigation Soil Sampling

The Final RI/RFI Report, Volume 1 (Site Background and History) recommends soil sampling at 27 locations in the vicinity of the Topock Compressor Station to collect additional data needed to verify past closure activities, or to complete the RFI objectives of defining the nature and extent of contamination, characterize risks to human health and the environmental, and gather information for the Corrective Measures Study/Feasibility Study (CH2M HILL 2006d). Of these 27 locations, 17 are within the fence line of the compressor station. The remaining locations are on PG&E property surrounding the fenced area, or on HNWR property north, east, and west of the PG&E property. The areas of soil sampling are shown on Figure 5. Multiple samples will be taken at each of the 27 locations. In addition, future activities will include implementation of a background soil sampling program to assess naturally occurring concentrations of inorganic constituents in soil. Samples collected for the background study will be collected in areas removed from the sources of potential contamination at the compressor station.

Sampling activities would be similar to the IM No. 3 baseline soil sampling described above and could occur via a number of collection methods including, but not limited to, boring, augers, and trenching. Depending on the location, sampling activities may be conducted via track- and truck-mounted apparatus or using hand equipment. Approximately 200 soil samples would be obtained at multiple depths via the sampling methods described above for the RFI soil sampling and IM No. 3 baseline soil sampling. If substantial soil contamination is encountered during sampling activities, soil may be hauled off-site to an appropriate permitted disposal facility, in lieu of leaving or returning the soil in place.

3.3.4 Future Wells and Related Activities

3.3.4.1 California and Arizona Floodplain Monitoring Wells

In 2005, DTSC requested the installation of five groundwater well clusters on the Colorado River floodplain in California to further characterize the nature and extent of the chromium plume in this area and to assess the performance of interim measures, as described in Section 3.2.6.5. Installation of these well facilities was completed in May 2006.

Approximately 15 additional floodplain well clusters may be installed prior to the final remedy. While the precise location of additional wells has not yet been identified, additional well clusters could be located in both the California and Arizona portions of the APE.

Typical well construction activities would be substantially similar to past activities, as described above under Section 3.2.4 (Interim Measures No. 1) and as documented in the construction completion report provided in Appendix A7 that addresses prior well installation activities in the APE (CH2M HILL, 2005c). Modifications to future well construction may include "slant drilling" where the mast of the drill rig is set to an angle off vertical, resulting in a boring that penetrates at a similar angle. This approach may be taken so that samples can be collected beneath a surface obstruction (e.g., the Colorado River). The surface expression of slant drilling activities is substantially similar to that associated with vertical drilling activities.

Sampling of future floodplain wells would occur per the existing GMP program, discussed in Section 3.2.3. As noted, due to potential concerns regarding the SWFL, floodplain sampling and access procedures were originally modified during the 2005 SWFL nesting season. Recent approvals provided by BLM and USFWS updated the sampling procedures implemented during the SWFL nesting season. These procedures include the use of lower-noise ATVs, dedicated well pumps, and electrical power supply sources, as described above in Section 3.2.3.1 and as shown on Figure 4. The current 2006 sampling procedures will be carried forward for implementation during future SWFL nesting seasons.

In addition to the monitoring wells discussed above, planned activities include the installation of slant wells below the Colorado River. A proposed drill site is located immediately south of Interstate 40 on the western shore of the Colorado River in California. This slant drill site is shown on Figure 5. In addition, a seismic survey of the Colorado River would precede the well installation activities to obtain additional detail regarding bedrock characteristics below the river. These proposed activities were addressed in a separate project-specific Biological Assessment (CH2M HILL 2006e) and ESA consultation.

The facilities and activities discussed above fall within Category No. 1, as described in Section 3.3.1.

3.3.4.2 Upland Monitoring Wells

Additional monitoring wells may be required at upland locations throughout the APE. Recent construction activities completed in May 2006 involved the installation of three additional well clusters at upland locations in the APE (see Appendix A10). These three well locations are included on Figure 3. No other well facilities or locations have currently been specified by DTSC or DOI. However, approximately 15 additional well clusters may be installed within the upland portion of the APE, based on future monitoring well results and changing data needs. The potential locations include areas within both the California and Arizona portions of the APE.

Typical well installation activities would be substantially similar to past activities, as described above under Section 3.2.4 (IM No. 1) and as documented in the construction completion report provided in Appendix A7, which addresses prior well installation activities in the APE (CH2M HILL, 2005c). Given the typical management measures to be applied at the site (see Section 3.4), including those associated with cultural resources, potential impacts to sensitive species such as the desert tortoise would also tend to be minimized.

Existing groundwater monitoring wells are located in the vicinity of the existing and former evaporation ponds associated with the Topock Compressor Station. These wells are not associated with corrective actions but are used to monitor closure of the former evaporation ponds and operation of the existing ponds. In the future, these wells may be sampled as part of the ongoing corrective action process.

The facilities and activities discussed above fall within Category No. 1, as described in Section 3.3.1.

3.3.4.3 California and Arizona Floodplain Monitoring Well Improvements

Additional facilities may be constructed to support ongoing groundwater monitoring on the river floodplain. The purpose of these improvements would be to further limit noise and activity associated with the GMP, similar to past improvements described above in Section 3.2.3.1 (e.g., electrical power sources, dedicated well pumps, etc.). Approximately five additional dedicated well pumps would be installed in monitoring wells located in California on the Colorado River floodplain. The well sites have not yet been identified. Well site selection will be based on proximity to potentially-sensitive nesting habitat and frequency of sampling. Similar improvements may also be installed at future wells sites in Arizona.

These facilities fall under Category No. 1, as described in Section 3.3.1.

3.3.4.4 Compliance Monitoring Wells

The IM No. 3 project included the construction of four compliance well (CW) clusters to monitor groundwater in the vicinity of the injection wellfields. The existing CW-1 through CW-4 clusters may be enhanced to include additional shallow-depth wells. Drilling at these four locations would involve the typical well installation activities described in Section 3.3.3.1. The work plan describing these activities is provided in Appendix D2. The well installation activities would occur directly adjacent to the existing CW clusters, in areas previously used for well installation activities.

The facilities and activities discussed above fall within Category No. 1, as described in Section 3.3.1.

3.3.4.5 Well Decommissioning

Additional planned well activities include the decommissioning of well PGE-6 located north of the compressor station and south of Interstate 40 in an area referred to as the MW-24 bench, within the HNWR. This well is located within an area that has been previously graded and very sparsely vegetated. The associated activities involve the removal of the upper portion of the well casing, and filling of the well casing with inert materials. The well surface would be restored to the original grade.

The decommissioning work could be accomplished in 2 to 3 days. Because of the short duration of the work and the relatively small amount of materials needed, there will be no need for an equipment or materials staging area. It may be necessary to locate some pallets of cement or sand at the work site during the decommissioning work. Buried gas pipelines cross PG&E property just outside the north gate of the Compressor Station. An earthen berm will need to be placed over top of these pipelines to allow the safe passage of heavy vehicles across them. This berm would be removed at the completion of the decommissioning work. The planned decommissioning of well PGE-6 is detailed in the work plan provided in appendix D3. Other wells within the APE may also be decommissioned by PG&E, if required.

The facilities and activities discussed above fall within Category No. 1, as described in Section 3.3.1.

3.3.4.6 Well Maintenance and Testing

Planned activities include retrofitting and/or testing at existing monitoring wells PGE-7, PGE-8 and MW-48. PGE-8 is located within the compressor station. PGE-7 is located at the southern end of the MW-24 bench on the HNWR, and MW-48 is located northeast of the compressor station on the HNWR. A work plan will be prepared to describe retrofitting of PGE-7, performing a flow meter survey and/or spinner logging within PGE-7 and PGE-8 to evaluate vertical hydraulic gradients, and conducting aquifer testing in PGE-7, PGE-8 and MW-48 to further characterize the hydraulic properties of the aquifer. Aquifer testing involves pumping water at a controlled rate to measure aquifer properties. This testing requires temporary water containment tanks at the well location for storage prior to transport to IM-3 for treatment.

Retrofitting and testing at PGE-7, PGE-8 and MW-48 will occur over approximately 4 weeks. PG&E may conduct similar activities at other existing or future wells in the APE, if required.

The facilities and activities discussed above fall within Category No. 1, as described in Section 3.3.1.

3.3.4.7 Seismic Studies

Additional seismic studies may be conducted to advance knowledge of bedrock conditions under the Colorado River. Similar to prior seismic studies (see Section 3.2.7), the survey would typically involve a small watercraft equipped with a measuring device similar to a recreational fish finder. The watercraft would move along the surface of the river only. No sub-surface activity is required.

The facilities and activities discussed above fall within Category No. 4, as described in Section 3.3.1.

3.3.5 *In-situ* Upland Pilot Study

A work plan for an *in-situ* upland pilot study has been drafted and is provided in Appendix D. This work plan has been submitted to regulatory agencies, but it is likely that specifics of the work could be modified in the future by oversight agencies or other requirements, and in such case, changes to the implementation activities described in this section would be necessary.

Information collected from the uplands pilot study will complement information provided by the *in-situ* floodplain pilot study currently underway on the Colorado River floodplain. Similar to the floodplain pilot study, the upland pilot study involves the injection of reductant compounds into the groundwater aquifer and measurement of the reduction of chromium levels. The upland pilot study would be conducted within an area of approximately 0.25 acre. The proposed study site is located within the HNWR north of the Topock Compressor Station, south of Interstate 40, and east of Bat Cave Wash in an area referred to as the MW-24 bench (see Figure 5).

Planned facilities include two recirculation wells with pumps, wellhead vaults, and pump controls. These wells will provide circulation of the groundwater and reductant, thereby facilitating the reduction of hexavalent chromium concentrations. In addition, three new monitoring well clusters would be developed. Pilot study operations may use existing monitoring wells at the site to collect data. These existing well facilities include MW-24, MW-11, and MW-38. Once constructed, the new pilot study well structures would have a surface expression of less than 500 square feet (0.01 acre).

The wells will be drilled using rotosonic techniques. The rotosonic drill rig will be equipped with drilling casing with an outside diameter of approximately 10 inches for the recirculation and monitoring well boreholes. Rotosonic drilling provides continuous highly representative, core samples that can be recovered in all formations without the use of air, water, or additives, thus minimizing the waste produced. Recirculation wells will be 6 inches in diameter and will be spaced approximately 150 feet apart. The monitoring well nests will be located between and in the vicinity of recirculation wells to monitor coverage of the injected reagents and the circulation between the wells. The monitoring well nests will consist of three separate 2-inch well completions in a single boring (if feasible). Activities and equipment required for well construction are similar to those described above under Section 3.2.4 (IM No. 1) and as documented in the construction completion report provided in Appendix A7 that addresses prior well installation activities in the APE (CH2M HILL, 2005c).

Pilot study implementation may require maintenance of an existing access road extending from the northern portion of the Topock Compressor Station to the MW-24 bench and pilot study site. Road maintenance would primarily involve minor grading. Construction of the upland pilot study recirculation and monitoring wells will last approximately 2 months.

Following construction, the proposed pilot test will be conducted by introducing a food-grade carbon source to be used by indigenous microbes coupled with the available electron acceptors in the aquifer to provide a reducing environment in the aquifer. Ethanol (denatured by methanol) is the preferred carbon substrate due to its solubility, low viscosity, and minimized potential for well biofouling. A total of 38,000 gallons of 40 percent ethanol solution will be injected in two recirculation wells in 6 months. Reagent tanks will be temporarily placed adjacent to each injection well during the pilot test. No other permanent aboveground equipment will be employed during the pilot test. Diluted ethanol (and for the first month, a dye tracer) will be kept in double-contained reagent tanks temporarily located at each well head. The reagent tanks (sized 3,000 gallons or less) will be refilled approximately once a month.

Concurrent with the pilot test injection, a tracer test will also be initiated to better understand the flow conditions in the pilot test area. The tracer study will be conducted with each injection well receiving its own tracer (e.g., fluorescein and rhodamine). These dyes will be introduced at a target concentration of 1 milligram per liter in the injection water and will be continuously injected for the first month of circulation. Approximately 12 pounds of each dye will be injected in the respective wells during the 1-month dye injection period.

Monitoring of reagent flow (rate and volume) into the injection well and water levels in nearby monitoring wells will be conducted as proposed in the work plan or in accordance with other requirements, if more stringent. The work plan proposes daily monitoring throughout the first week of injection until the injection system is operating routinely. Thereafter, weekly monitoring visits will record volumes of reagent injected. Groundwater chemistry monitoring will be conducted to evaluate the effectiveness of the reagent introduction to the aquifer. Monitoring wells will be sampled twice prior to the initial injection event and on a phased schedule post-injection (weekly for the first month, bi-weekly for next 3 months, and monthly for the next 5 months). Monitoring will continue for a minimum of 9 months. Depending on the results obtained, post-test monitoring may continue beyond the 9-month time frame.

These facilities and activities fall within Category Nos. 1 and 3, as described in Section 3.3.1.

3.3.6 Maintenance and Other Activities

Ongoing and future activities include maintenance and operation of the IM No. 3 system, and groundwater monitoring well network. This includes routine maintenance and any required repairs to the treatment system, injection, extraction, pipelines, and monitoring wells. Maintenance activities may also involve enhancement of existing facilities to optimize IM No. 3 operations (e.g., upgrading or replacing equipment). Such maintenance/optimization activities would occur primarily in areas where existing facilities are located. In addition, road repairs will be periodically required to ensure adequate access to investigative and remedial facilities throughout the APE. This may include paving of an existing roadway on PG&E property extending from the west side of the Topock Compressor Station into Bat Cave Wash. Paving this roadway would reduce or eliminate the need for other maintenance activities such as grading, which is regularly required to ensure adequate access to facilities near the Topock Compressor Station.

Periodic maintenance of the IM No. 3 injection wells involves backwashing approximately every 8 weeks. Associated equipment includes a pickup truck mounted with an air compressor to remove water and accumulated sediments from the well casing. Water is collected in tanks and transported back to the IM No. 3 treatment plant. Maintenance of the IM No. 3 extraction wells involves periodically replacing the pumps, using an approximately 1-ton truck with a hoist to lift and replace the well pump. Such maintenance is typically completed within 1 day.

Potential structural IM No. 3 enhancements outside of the existing project footprint include enhanced spill control structures such as containment berms and truck loading pads. At the MW-20 bench, spill containment berms may be installed around the IM No. 3 water/brine tanks. In addition, the truck-loading area at the MW-20 bench would be improved with a concrete spill pad and surrounding moat to minimize potential impacts in case of a spill. Additional improvements at the MW-20 bench may include the replacement of the existing water/brine tanks (six blue tanks and three brown tanks). Up to four new concrete tanks would replace these tanks. Each concrete tank would have a capacity of approximately 100,000 gallons, and measure about 35 feet in diameter and 20 feet in height. Alternatively, the three existing brown tanks may remain in place, and could be augmented by relocation of several of the existing blue tanks. Any remaining blue tanks not required for IM No. 3 operations would be removed. In addition, connective pipe and pumps may be installed at the MW-20 bench to provide for water transfer among the tanks, and between the tanks and tanker trucks.

A concrete spill containment pad structure may also be installed at the existing loading facility on the eastern side of the IM No. 3 Treatment Plant. The loading area is currently a permeable gravel surface; installation of a concrete pad and moat would serve to contain any potential spills and avoid or limit release to the environment. In addition, a second clarifier may be added to the IM No. 3 treatment system. Installation of a second clarifier would involve the construction of a concrete pad measuring about 20 feet by 15 feet. The new clarifier would be mounted on the concrete pad directly adjacent to the existing clarifier and outside of the existing sun shade structure. The new clarifier would be similar in height as the existing clarifier (about 20 feet).

Other activities include possible actions that require immediate corrective action. This includes repairs to existing facilities or emergency cleanup operations following a potential spills or releases. The *Emergency Notification Binder* (CH2M HILL, 2005f) covers investigative and interim remedial activities in the APE and provides site personnel contact information in the event of an emergency that requires immediate reporting. Reporting covers internal and external entities and may include site management personnel, PG&E management, emergency response personnel, regulatory agencies, other agencies, and/or landowners.

IM No. 3 activities are specifically subject to defined emergency response procedures described in the *Hazardous Materials Management Business Plan* (HMMP) (PG&E, 2006), which addresses hazardous substances handled at the IM No. 3 Treatment Plant. Emergency situations covered in the HMMP include spills, leaks, fire, explosion, equipment failure, vehicle accident, a chemical reaction, natural disaster and employee exposure, accident, injury, or incident. Procedures presented in the HMMP give, in order, the basic steps to be followed for the emergency actions. For example, the procedure for a non-transportation-related spill, with no water contact, gives direction on how to:

- Assess and evaluate the (potential) hazard.
- Isolate and stop the flow the material.
- Apply proper absorbent or other material and contain waste generated during cleanup.
- Complete a scene-management checklist.
- Decontaminate and cleanup equipment used.
- Properly dispose any waste generated.

The HMMP also states that site personnel assessing and responding to emergency situations should make every effort to minimize impact to the surrounding environment.

These activities fall within Category Nos. 2, 3, 5, and 7 described in Section 3.3.1.

3.3.7 Unspecified Actions and Interim Measures

Additional studies and/or responses or corrective actions not identified in the actions specified above may occur prior to implementation of the final remedy. It is anticipated that these actions would be very similar to activities that have already occurred for investigative and response activities and would generally fall into any one or a combination of Category Nos. 1 through 7, as described in Section 3.3.1.

Preferably, construction and operation of these unidentified or unspecified activities would occur within areas that provide existing access, are already disturbed (e.g., those sites already impacted by investigative and response actions), and are limited to topographically flat sites to avoid or minimize additional landscape disturbances. Such activities may include, but are not necessarily limited to, new pipeline alignments, soil sampling and/or new extraction or injection wells. In addition, contingency activities may involve re-starting the IM No. 2 plant including associated batch treatment facilities and operations (e.g., storage tanks, trucking) focused on the MW-20 bench. These activities are described above in Section 3.2.5 and detailed further in Appendices B3 and B4.

To the maximum extent possible, such facilities and their associated activities would be designed, constructed, and implemented within previously-used areas. The project intent will be to avoid or minimize additional effects to listed species and all biological resources. It is estimated that an additional 4 acres (2 acres on the floodplain and 2 acres on the uplands) may be required to construct or implement unspecified/unidentified facilities and activities. Habitat loss is defined as the removal of trees and perennial shrubs. Therefore, of the estimated 4 acre total, the acreage of habitat lost would be substantially less due to the siting of activities within previously used areas and/or areas with little or no vegetation.

As with all future activities subject to this PBA and related Section 7 consultation, to avoid and/or minimize effects to listed species and their habitats, aggregate habitat loss thresholds of 2.5 acres for the floodplain and 3 acres for the uplands are hereby established to preclude any adverse effects to listed species. As noted above, habitat loss is defined as the removal of trees and perennial shrubs, and does not include trimming of vegetation. If the respective acreages are exceeded, consultation with the USFWS will be reinitiated to reassess the potential effects to listed species and consider possible mitigation. The above acreages do not imply project coverage or approval at the risk of other resources (e.g., cultural resources).

Unanticipated or currently unspecified activities not adequately described and assessed in this PBA may require additional Section 7 ESA consultation as determined by BLM and USFWS. The expected format of the required information would be similar to the technical memorandum provided previously that addressed the 2006 floodplain sampling procedures during the SWFL nesting season (CH2M HILL, 2006b). Specifically, subject field activities will be designed to minimize biological impacts, particularly those involving sensitive species listed under the Federal ESA.

ESA consultation will occur by applying the concept and practice of adaptive management, which accounts for uncertainties through a process of information feedback and subsequent adjustments to management practices. Future activities not adequately specified in this PBA will integrate any new or updated information related to APE biology. All approvals by BLM and/or USFWS, including ESA clearance, will account for any new information and provide for additional management or mitigation measures as needed.

3.3.8 Restoration / Mitigation Activities

In accordance with agency conditions and direction, various restoration activities are planned throughout the APE. As investigative and response activities continue, additional restoration/mitigation measures may be required by the BLM or USFWS, should new information require the addition of these measures.

Restoration involves return of a project site or sites to prior topographic conditions and/or reestablishment of native vegetation in areas which were cleared for remedial or investigative activities. The cultural landscape is also considered. Restoration is anticipated to occur in four major areas, in addition to other offsite restoration activities and general debris removal throughout the APE. The approximate locations of these major restoration areas within the APE are shown on Figure 5. Restoration areas associated with the IM No. 3 project are considered priorities for implementation.

- IM No. 2 Batch Treatment Plant Decommissioning: Planned decommissioning of batch treatment facilities associated with IM No. 2. Limited earthwork is anticipated. Activities primarily involve the removal of existing facilities. The affected area is about 1.3 acres.
- IM No. 3 Staging Area: Restoration of topographic features and revegetation to replicate conditions prior to IM No. 3 implementation at the construction staging area and other areas used during construction. Restoration at the IM No. 3 construction staging area specifically will include fill removal and soil contouring to restore preconstruction topographic contours and drainage patterns. The affected area is about 0.9 acre.
- East Mesa and West Mesa: These two IM No. 3 injection wellfield areas will be restored to conditions occurring prior to injection well drilling. Primary restoration activities involve revegetation with limited earthwork required. The acreage of the East and West Mesa is about 1.4 and 0.6 acres, respectively.
- City of Needles Electric Areas: Restoration of areas affected by offroad access in March 2005 (not shown on Figure 5). Little or no earthmoving activities are involved in these efforts.
- Potential cleanup of debris located within the APE (e.g., removal of scrap metal, wood, brick, plastic, or similar materials) in accordance with the RFI/RI (these areas are not shown on Figure 5).

If the amount of habitat disturbance for project implementation or restoration exceeds a total of 2.5 acres on the floodplain and 3 acres on the uplands, consultation with the USFWS will be reinitiated to reassess the potential effects to listed species.

These activities fall within Category No. 6, as described in Section 3.3.1.

3.4 General Project Management Measures

Similar to the approval of past activities within the APE, approval of planned future activities are expected to be consistent with the substantive intent of current mitigation measures applied by BLM and USFWS to investigative and interim measures/removal actions as stipulated in BLM Action Memorandum dated Sept. 17, 2004. In addition to the measures noted below, project activities could also be subject to other regulatory requirements including, but not necessarily limited to, California Fish and Game Code Section 1600 et seq. and the requirements of the California Endangered Species Act. Further, prior to the approval of field activities, the BLM and/or USFWS will engage in consultation with the Native American community. The consultation typically includes nine local tribes.

To clarify existing BLM mitigation measures, March 15 through September 30 was established to delineate the migratory bird nesting season and May 1 through September 30 was established to signify the nesting period for the SWFL. During these periods, a biological monitor would be in the field to conduct preconstruction surveys for nesting birds and USFWS-approved surveys would be conducted annually for the presence of SWFLs. In addition, February 1 through May 31 is established as conservation dates to identify the up/down river migration and spawning period for razorback suckers and bonytail chubs.

General management measures, also referred to as “Mitigation Measures, Lake Havasu Field Office” will apply to future field activities are listed below:

1. All project activities will be conducted in a manner that avoids take of a federally listed species. Take is defined to include any harm or harassment , including significant habitat modification or degradation potentially kill or injure listed wildlife by significantly impairing essential behavioral patterns, including breeding, feeding, or sheltering. Should a listed species enter the project site or become harmed or killed by project activities, the project shall be shut down and the USFWS, BLM, and CDFG shall be consulted. Impacts to habitat will also be minimized to the maximum possible extent.

2. PG&E shall designate a field contact representative (FCR) who will be responsible for overseeing compliance with the mitigation measures. The FCR must be onsite during all construction activities. The FCR shall have authority to halt activities that are in violation of the mitigation measures and/or pose a danger to listed species. The FCR will have a copy of the mitigation measures when work is being conducted on the site. The FCR may be a project manager, PG&E representative, or a biologist.

3. PG&E shall have a qualified biologist responsible for assisting crews in compliance with the mitigation measures, performing surveys in front of the crew as needed to locate and avoid listed species, and monitoring compliance. Preconstruction surveys by a biologist shall be implemented for special-status wildlife species in impact areas immediately prior to initiation of ground-disturbing activities. The inspection shall provide 100 percent coverage of the area within the project limits. Any desert tortoise burrows and pallets outside of, but near, the project footprint shall be flagged at that time so that they may be avoided during work activities. At conclusion of work activities, all flagging shall be removed.

4. Listed species, including the desert tortoise, shall not be handled or harassed. Encounters with a listed species shall be reported to the project biologist and BLM Lake Havasu biologists. These biologists will maintain records of all listed species encountered during project activities. This information will include for each individual: the locations (narrative, vegetation type, and maps) and dates of observations; general conditions and health; any apparent injuries and state of healing; and diagnostic markings.

5. All PG&E employees and the contractors involved with the proposed project shall be required to attend PG&E's threatened and endangered species education program prior to initiation of activities. New employees shall receive training prior to working onsite.

6. To the maximum extent possible, facilities (treatment facility, pipelines, injection wells, and access routes) shall be sited within an existing right–of-way (ROW) and previously disturbed or barren areas to limit new surface disturbance.

7. Existing routes of travel to and from the proposed project site shall be used. Cross-country vehicle and equipment use shall be prohibited.

8. Trash and food items shall be contained in closed containers and removed daily to reduce attractiveness to opportunistic predators such as common ravens (*Corvus corax*), coyotes (*Canis latrans*), and feral dogs.

9. To minimize effects, lights shall be angled toward the ground, reduced in intensity to levels compatible with safety concerns, and limited in duration of usage. The hue of lighting shall be that which is most compatible with and least disturbing to wildlife.

10. Employees shall not bring pets to the project site.

11. Firearms shall be prohibited from the project site, except as required for security employees.

12. Employees shall be required to check under their equipment or vehicle before it ismoved. If a desert tortoise or other wildlife is encountered under vehicles or equipment, the vehicle shall not be moved until the animal has voluntarily moved to another location, or to a safe distance from the parked vehicle.13. Upon project completion, all unused material and equipment shall be removed from the site. This condition does not apply to fenced sites.

13. Upon completion, all unused material and equipment shall be removed from the site. This condition does not apply to fenced areas.

14. Palo verde, ocotillo, mesquite, cat-claw, smoke tree, and cacti species are considered sensitive by the BLM. To the extent practicable, these species shall be avoided. If avoidance is not possible, these species shall be transplanted when practical. Should any of the aforementioned plants be destroyed, they shall be replaced.

15. The area of disturbance shall be confined to the smallest practical area, considering topography, placement of facilities, location of burrows, nesting sites or dens, public health and safety, and other limiting factors. As needed, work area boundaries shall be

delineated with flagging or other marking to minimize surface disturbance associated with vehicle straying.

16. Activities shall be restricted to a pre-determined corridor. If unforeseen circumstances require project expansion, the potential expanded work areas shall be surveyed for listed species prior to use of the area. All appropriate mitigation measures shall be implemented within the expanded work areas based on the judgment of the agencies and the project biologist. Work outside of the original ROW shall proceed only after receiving written approval from the BLM, Fish and Wildlife Service (Service) and CDFG describing the exact location of the expansion.

17. PG&E has the option of erecting desert tortoise fencing in lieu of inspection open trenches If the trench is short, personnel may monitor the trench. All open holes and trenches shall be inspected for trapped desert tortoises at the beginning, middle, and end of the work day, at a minimum. During excavation of trenches or holes, earthen ramps shall be provided to facilitate the escape of any wildlife species that may inadvertently become entrapped. If desert tortoises are trapped, the project biologist shall be notified immediately. The desert tortoise shall be allowed to escape before work continues in that location. A final inspection of the open trench segment shall also be made immediately before back filling. All open pipe segments shall be covered when work activity is not occurring at the site.

18. All construction vehicles and equipment shall be periodically checked to ensure proper working condition and to ensure that there is no potential for fugitive emissions of oil, hydraulic fluid, or other hazardous products. The BLM shall be informed of any hazardous spills.

19. Workers shall exercise caution when traveling to and from the APE. To minimize the likelihood for vehicle strikes of listed species, speed limits when commuting to project areas on ROW roads shall not exceed 20 miles per hour.

20. Intentional killing or collection of either plant or wildlife at construction sites and surrounding areas shall be prohibited. The BLM shall be notified of any such occurrences.

21. For emergency situations involving a pipeline leak or spill or any other immediate safety hazard, PG&E shall notify the BLM within 48 hours. As a part of this emergency response, the BLM may require specific measures to protect listed species. During cleanup and repair, the agencies may also require measures to recover damaged habitats.

22. Once the treatment facility is no longer needed, PG&E shall restore disturbed areas in a manner that will assist in the reestablishment of biological values within the disturbed ROW. Methods of such restoration shall include the reduction of erosion, re-spreading of top two inches of soil, planting with appropriate native shrubs, and scattering of bladed vegetation and rocks across the ROW, depending upon the appropriateness or effectiveness in a given area.

23. Within 60 days of completion of construction activities, the FCR and biologist shall prepare a brief report for the BLM documenting the effectiveness and practicality of the mitigation measure and making recommendations for modifying the measures to enhance species protection. The report will also provide information on survey and monitoring activities, observed listed species, and the actual acreage disturbed by the project.

24. Any future construction during August for most birds, will require preconstruction surveys for nesting pairs, nests and eggs. These preconstruction surveys shall occur in areas proposed for any vegetation removal and active nesting areas flagged. If nesting birds are detected, vegetation removal be avoided during the nesting season. All construction activity within 200 feet of active nesting areas will be prohibited until the nesting pair/young have vacated the nests.

25. All areas within the proposed action areas, subject to operations and maintenance activities, and within the potential impact of the action, shall be monitored annually during the active period for tortoise by a biologist knowledgeable of desert tortoise ecology. Surveys shall be completed throughout the duration of the action to verify the presence or absence of desert tortoise and reports shall be provided to the biologists in the BLM Lake Havasu Field Office on an annual basis.

26. Riparian areas surrounding the proposed action site and subject to influence of operations and maintenance activities shall be surveyed for southwestern willow flycatcher according to the protocol established by the USFWS. These surveys shall be completed each year by a biologist permitted by the USFWS to carry out flycatcher surveys until the action has been completed and all facilities have been removed. Reports shall be provided to the biologists in the BLM Lake Havasu Field Office on an annual basis.

27. Upon locating an individual of a dead or injured listed species, PG&E shall make initial notification to the BLM and US Fish and Wildlife (Service) within three working days of its finding. The notification must be made by telephone and writing to the Lake Havasu BLM Office (2610 Sweetwater Avenue, Lake Havasu City, Arizona 86406, 928-505-1200) and the Phoenix Fish and Wildlife Office (2321 West Royal Palm Road, Suite 103, Phoenix, AZ 85021, 602-242-0210). The report will include the date and time of the finding or incident (if known), location of the carcass, a photograph, cause of death (if known), and other pertinent information. Animals injured through PG&E activities shall be transported to a qualified veterinarian for treatment at the expense of PG&E. If an injured animal recovers, the CDFG and the BLM shall be contacted for final disposition of the animal.

28. PG&E will immediately notify the BLM Lake Havasu Field Manager (or his designated representative) of any cultural resources (prehistoric/historic sites or objects) and/or paleontological resources (fossils) encountered during permitted operations and will maintain the integrity of such resources pending subsequent investigation. All operations in the immediate area of the discovery must be suspended until written authorization from BLM to proceed is issued. An evaluation of the discovery shall be

made by a qualified archaeologist or paleontologist to determine appropriate actions to prevent the loss of significant cultural or scientifically important paleontological values.

29. No permanent improvements that affect the integrity of the bridge/culvert over Bat Cave Wash on historic Route 66 shall be implemented.

30. Actions that result in impacts to archaeological or historical resources are subject to the provisions of the Archaeological Resources Protection Act of 1979, as amended, and the Federal Land Policy and Management Act of 1976.

4.0 Biological Setting and Environmental Baseline

This section describes the biological setting and environmental baseline in the APE. The information in this section was obtained from several sources that may be found in Section 7.0.

4.1 Biological Setting

The APE is located approximately 15 miles to the southeast of the City of Needles along Interstate 40 in the easternmost portion of San Bernardino County, California (see Figure 1). Agriculture and public lands dominate the surrounding area. The APE includes areas within both California and Arizona (see Figure 2). The state boundary is located within the Colorado River, as shown on Figure 2. West of the Colorado River, the topography is abrupt, rising from around 450 feet msl at the river to over 1,200 feet above msl within 1 mile to the south and southwest. Slopes encountered west of the Colorado River reflect a series of ancient river terraces. East of the Colorado River within the HNWR (see Figure 2), dredge spoils rise approximately rise 30 feet above the river surface forming a mound of sand and tamarisk that gradually slopes back to water level and emergent vegetation at the Topock Marsh further east.

The Colorado River is the primary aquatic habitat located approximately 1,300 feet east of the Topock Compressor Station. The river is approximately 700 to 900 feet wide and 8 to 15 feet deep at this location (E&E 2000). Flood Insurance Rate Mapping is available on the Arizona-side of river (Panel No. 040058215C). However, mapping on the California side of the river (Panel No. 06071C5725) is not available. The interpretation of this limited information is that the 100-year floodplain elevation in the vicinity of the APE is approximately 460 feet msl based on information from the Flood Insurance Rate Mapping map that indicates a Zone A 100-year flood elevation in the Topock Marsh of 460 feet (Matt Johns, CH2M HILL, personal communication, 2006). Within the APE, the 460-foot contour is generally located on the Colorado River floodplain within approximately 30 feet of the river channel. However, in the vicinity of the BNSF Railway and Interstate 40 bridge crossings, the 460-foot contour extends approximately 300 feet from the river channel as evidenced by the dense vegetation in this area. East of the River, the 100-year floodplain encompasses the majority of the Topock Marsh.

Little to no submergent vegetation exists within the Colorado River. Small patches of emergent vegetation along the banks consist of common reed (*Phragmites communis*), cattails (*Typha* sp.), sedges (*Carex* sp.), and bulrush (*Scirpus* sp.). Several of these wetland patches are located at the confluence of Bat Cave Wash, near Moabi Regional Park, and the mouth to Topock Marsh. Larger wetlands and marshes exist along the eastern bank of the peninsula north of the Topock Marina. The Topock Marsh, extending northeast of the APE within the HNWR, provides important aquatic marsh and riparian habitat in the local vicinity. The

Colorado River functions as an important corridor for fish and migratory birds (CH2M HILL, 2004b, 2005a-d, g, i, 2006a-b; E&E, 2000).

Terrestrial habitats, typical of Mojave Desert uplands, in the APE consist of creosote bush scrub, Mojave wash, desert riparian, and tamarisk thicket. The dominant upland plant community is creosote bush scrub. The area is sparsely vegetated with widely distributed creosote bushes (*Larrea tridentata*). Other plant species that occur within this plant community include burrobush (*Ambrosia dumosa*), allscale (*Atriplex polycarpa*), split grass (*Schismus* sp.), spineflower (*Chorizanthe* sp.), desert trumpet (*Eriogonum inflatum*), beavertail cactus (*Opuntia basilaris*), golden cholla (*Opuntia echinocarpa*), brittlebush (*Encelia farinosa*), cheesebush (*Hymenoclea salsola*), dalea (*Dalea mollisma*), red barrel cactus (*Ferocactus pilosus*), sweetbush (*Bebbia juncea*), and ratany (*Krameria erecta*) (CH2M HILL, 2004b, 2005a-d, g, i, 2006a-b; E&E, 2000). The creosote bush and salt bush scrub plant communities comprise approximately 974 acres within the APE (Figure 6).

West of the Colorado River, the Mojave Wash habitat type is comprised of Bat Cave Wash and the other unnamed washes in the area. Bat Cave Wash is an ephemeral drainage that extends from the Chemehuevi Mountains to the Colorado River approximately 3,500 feet north of the Topock Compressor Station. Although this wash may periodically flood during stormwater runoff events, it remains dry throughout most of the year due to arid desert conditions. The wash floor is relatively barren of vegetation and consists of sand, gravel, and cobblestone substrate. Although the drainages occur within the creosote bush scrub plant community, several native tree species are associated with the washes including palo verde (*Cercidium* sp.), acacia (*Acacia greggii*), mesquite (*Prosopis* sp.), and smoke tree (*Dalea spinosa*). Desert riparian vegetation is predominately present at the confluence of Bat Cave Wash and the Colorado River. This plant community consists of scattered mesquite, palo verde, and salt cedar (*Tamarix* sp.) (CH2M HILL, 2004b, 2005a-d, g, i, 2006a-b; E&E, 2000). The salt cedar and mesquite combination plant community comprises approximately 3 acres within the APE on the California side of the River (Figure 6).

East of the Colorado River, the APE is a sand and salt cedar environment very similar to that found of the floodplain on the California side. North of the Topock Marina is an approximately 120-acre peninsula bordered by water to the west, south, and east. This area is within the HNWR and is also the southern portion of the Topock Marsh. The Topock Marsh is an extensive wetland community that extends from approximately the BNSF Rail northward for about 10 miles beyond the APE to the Fort Mojave Indian Reservation.

South of the Topock Marsh and the HNWR is the Topock Marina and other private property totaling approximately 30 acres. Development on the property includes the marina, multiple trailer sites, a restaurant, and residential dwellings. Also crossing this property is the BNSF railroad tracks, the Interstate 40, and natural gas transmission lines. The marina, restaurant and trailer sites are located near the mouth to the Topock Marsh. The residential dwellings and gas transmission lines are located just south of the Interstate 40. The habitat ranges from riverine to dry uplands and is highly altered to facilitate human occupation, transportation and energy transmission needs. Land use in the area is discussed in more detail in Section 3.1.

Salt cedar (also referred to as tamarisk) thicket is the dominant plant community along the Colorado River floodplain. This invasive, exotic plant species has displaced native plant species. This plant community consists of dense monotypic stands of salt cedar with an understory of arrowweed (*Pluchea sericea*). The salt cedar and arrowweed plant communities comprise approximately 349 acres within the APE (Figure 6).

The aquatic habitat of the Colorado River supports several game fish species including striped bass (*Morone saxatillis*), largemouth bass (*Micropterus salmoides*), bluegill (*Lepomis macrochirus*), white crappie (*Pomoxis annularis*), flathead catfish (*Pylodictis olivaris*), and channel catfish (*Ictalurus punctatus*) (CH2M HILL, 2004b, 2005a-d, g, i, 2006a-b; E&E, 2000).

Avian species commonly associated with the river include American coot (*Fulica americana*), mallard (*Anas platyrhynchos*), pied-billed grebe (*Podilymbus podiceps*), great egret (*Casmerodius albus*), great blue heron (*Ardea herodias*), northern rough-winged swallow (*Stegidopteryx serripennis*), and belted kingfisher (*Ceryle alcyon*). Other avian species found in the upland areas include red-tailed hawk (*Buteo jamencensis*), Gambel’s quail (*Callipepla gambelii*), mourning dove (*Zenaida macroura*), common raven (*Corvus corax*), song sparrow (*Melospiza melodia*), Canyon wren (*Catherpes mexicanus*), brewer’s blackbird (*Euphagus cyanocephalus*), great-tailed grackle (*Quiscalus mexicanus*), turkey vulture (*Cathartes aura*), greater roadrunner (*Geococcyx californianus*), lesser nighthawk (*Chordeiles acutipennis*), and rock dove (*Columba livia*) (CH2M HILL, 2004b, 2005a-d, g, i, 2006a-b; E&E, 2000).

Mammals that may occur in the APE include deer mouse (*Peromyscus maniculatus*), Merriam kangaroo rat (*Dipodomys merriami*), whitetail antelope squirrel (*Ammospermophilus leucurus*), desert woodrat (*Neotoma lepida*), California ground squirrel (*Spermophilus beecheyi*), desert cottontail (*Sylvilagus audubonii*), and black-tailed hare (*Lepus californicus*), coyote (*Canis latrans*), desert kit fox (*Vulpes macrotis*), American badger (*Taxidea taxus*), bobcat (*Lynx rufus*), stripped skunk (*Mephitis mephitis*), beaver (*Castor canadensis*), and raccoon (*Procyon lotor*) (CH2M HILL, 2004b, 2005a-d, g, i, 2006a-b; E&E, 2000).

Reptiles that may occur in the area include chuckwalla (*Sauromalus obesus*), side-blotched lizard (*Uta stansburiana*), western whiptail lizard (*Cnemidophorus tigris*), zebra-tailed lizard (*Callisaurus draconoides*), desert iguana (*Dipsosaurus dorsalis*), coachwhip (*Masticophis flagellum*), gopher snake (*Pituophis melanoleucus*), and western diamondback rattlesnake (*Crotalus atrox*) (CH2M HILL 2004b, 2005a-d, g, i, 2006a-b; E&E 2000).

4.2 Environmental Baseline

The APE lies within a larger area of significant cultural and sacred tribal resources. In addition, the Colorado River itself is of spiritual and cultural importance to local tribes (Applied Earthworks, 2004; CH2M HILL, 2004a). Over time, the Colorado River corridor has undergone many changes influenced by past and present federal, state, or private actions, which comprise the environmental baseline. The environmental baseline includes the past and present impacts of all Federal, State, or private actions and other human activities in the action area, the anticipated impacts of all proposed Federal projects in the action area that have already undergone formal or early Section 7 consultation, and the impact of State or private actions which are contemporaneous with the consultation process (50 CFR 402.02). However, for purposes of this PBA, ongoing activities discussed under Section 3.2 (Past and Present Activities) are assessed for potential impacts to listed species and are included in the related ESA consultation.

By 1852, the first steamboat traveled up the Colorado River to resupply Fort Yuma. This marked the beginning of the steamboat trade that would have profound effects on the mature riparian areas along the river (Lingenfelter, 1978). The Colorado River Gold Rush began in 1862 (Lingenfelter, 1978). The gold rush fueled steamboat trade along the lower Colorado River. Initially, downed, dried cottonwood, willow, and mesquite trees were used as fuel for the steamboats (Ives, 1861). Increased river traffic soon used all of the available wood debris, and crews began cutting down large quantities of cottonwoods, willows, and mesquites. By 1890, most of the large cottonwood-willow stands and mesquite bosques had been cut down (Ohmart et al., 1988; Grinnell, 1914). The railroad crossing at Needles by the Atlantic and Pacific Railroad in 1883 resulted in the end of steamboat trade along the lower Colorado River (LaRue, 1916).

By the late 1800s, salt cedar was introduced into the United States as an ornamental tree and soon it escaped cultivation. Expansion of its range was rapid by the early 1900s (DeLoach, 1989). By 1920, salt cedar appeared along the mainstem of the Colorado River (Ohmart et al., 1988). This species adapted to the altered riverine ecosystem and displaced native riparian species throughout the lower Colorado River. Important wildlife habitats, including the cottonwood-willow gallery forests, have all but disappeared from the Colorado River and have been replaced by the less desirable salt cedar (Anderson and Ohmart, 1984).

In 1910, Joseph Grinnell led a 3-month expedition from Needles to Yuma to collect data on mammals, birds, and associated habitats. The expedition provided one of first detailed accounts of the flora and fauna of the lower Colorado River. Grinnell documented the loss of riparian habitat to agriculture during his expedition (Grinnell, 1914).

Starting in the 1930s, federal actions consisted of the channelization of the Colorado River and the construction of several dams, including the Hoover Dam, Parker Dam, and Davis Dam. The changes to the natural river flows significantly altered available fish habitats and reduced the river’s ability to meander and create or destroy backwaters and marshes. Alleviating the threat of floods also allowed for conversion of riparian areas to agricultural uses. In addition, USBR implemented intermittent riverbank stabilization and dredging programs from 1951 to today. As part of the mitigation for the various river control projects, USBR has undertaken to improve and enhance backwater and marsh areas (USBR, 1996, 2000, 2002, 2004).

Specific to the APE, several past activities have occurred within or adjacent to the site. In the southern section of the APE, PG&E owns and operates a compressor station and gas transmission line (Figure 2). A biological opinion was obtained to cover the operations and maintenance of this facility and associated pipelines (USFWS, 2000a). Ongoing and planned investigative and remedial activities are related to an existing chromium plume in groundwater (Figure 2). As described in Section 3.2.6, a groundwater treatment facility was recently constructed on land owned by PG&E (Figure 3), along with associated groundwater wells within the upland and floodplain (see IM No. 3 discussion in Section 3.2.6 and Appendix C for additional details). Near the treatment facility, there is evidence of an old abandoned quarry pit and World War II-era military training exercises. A major gas utility and travel corridor are located between the compressor station and treatment facility. The corridor includes Interstate 40, BNSF railroad, and four natural gas transmission lines (Figure 2). A substantial amount of train and vehicular traffic and associated noise and air emissions are generated along this corridor. Also intersecting the APE are several alignments of Historic Route 66, which attracts tourists to the APE and vicinity. Moabi Regional Park, managed by San Bernardino County, is located in the far northern section of the APE. This regional park contains facilities for mobile homes, campers, and boaters. A marina leads into the park from the Colorado River. The small town of Topock, with several mobile homes, a restaurant, and marina, is located along the southeastern section of the APE in Arizona (Figure 2).

The proposed project is within the HNWR. Recreational activities within the HNWR include sightseeing, boating, bird watching, fishing, hunting, and camping. Prior damming and channelization of the Colorado River have significantly altered the aquatic, marsh, and riparian habitats associated with the river. These water control and diversion actions have also contributed to increased housing development along the river and facilitated an increase in the intensity of river-related recreation (including watercraft, fishing, and hunting) (USBR, 1996, 2000, 2002, 2004).

The Colorado River has been stocked with various game fish that have been linked to predation of native listed fish species (USBR, 2004). The invasion of salt cedar along the Colorado River has significantly altered riparian habitat. This exotic tree dominates and displaces native plant communities. The USBR is responsible for managing the river and has consulted with USFWS on its actions (USBR, 1996, 2000, 2002, 2004). Several biological opinions have been issued to the USBR (USFWS, 1997a-b, 2002, 2005a). A Multi-Species Conservation Plan (MSCP) and Multi-Species Habitat Conservation Plan (MSHCP) recently have been developed for the Colorado River (USBR, 2004).

5.0 Species and Habitat Description, Effects of the Action, and Relevant Reports

5.1 Introduction

This section describes the status, natural history, distribution, and abundance of federally listed species that may occur or are known to occur within or near the APE. This section also analyzes the potential effects to each species and its critical habitat resulting from on-going and future investigative and interim remedial activities that may occur prior to the implementation of the final remedy. Table 1 provides a list of planned activities and a summary of the area estimated to be used during implementation. A background search of available documents and databases was performed in preparation for this PBA and the information in this section was obtained from several sources (AGFD, 2004; USBR, 1996, 1999, 2000, 2002, 2004; CNDDB, 2003; CDFG, 2003; CH2M HILL, 2004b, 2005 a-h, 2006a-c; E&E, 2000; USFWS, 2004; USFWS, 2005a).

In March 2005, a work plan was produced and submitted to USFWS, BLM, and California Department of Fish and Game representatives describing proposed surveys within suitable habitat for the SWFL, Mojave desert tortoise, and Yuma clapper rail within the APE (Figure 7) (CH2M HILL, 2005a). Surveys were proposed according to USFWS-approved protocols (Sogge et al., 1997; USFWS 1990c; USFWS 2000b). The 2005 and 2006 flycatcher and tortoise surveys were conducted in accordance with these protocols (GANDA, 2005a-b and 2006a-b), and a brief summary of the survey results are included in this section. Based on prior discussions, PG&E received a letter from USFWS HNWR staff in January 2005 requesting that protocol surveys for clapper rail not be performed because HNWR staff were interested in avoiding duplication of prior USFWS survey efforts and were concerned with potential added stress to the clapper rail (USFWS, 2005c). Accordingly, PG&E did not perform surveys for this species. The USFWS stated that it would share data collected from the 2004 and 2005 surveys with PG&E. The USFWS data results are briefly summarized in this section (USFWS, 2005d; Fitzpatrick, 2006). The 2005 work plan and survey reports are attached to this PBA as Appendix E. Overall the management measures identified in Section 3.4 are intended to avoid, reduce, or mitigate potential direct, indirect, and cumulative effects to these species and habitats.

5.2 Terrestrial

5.2.1 Southwestern Willow Flycatcher (*Empidonax traillii extimus*)

5.2.1.1 Status

The SWFL (*Empidonax traillii extimus*) was listed as federally endangered on February 27, 1995 (USFWS, 1995). Critical habitat was designated on October 19, 2005 (USFWS, 2005b). The SWFL Recovery Plan was released on March 5, 2003 (USFWS, 2003). The SWFL was listed as endangered by the state of California in 1991.

Several factors have caused the decline in SWFL populations. Extensive areas of suitable riparian habitat have been lost due to river regulation and channelization, agricultural and urban development, mining, road construction, and overgrazing (Tibbitts et al., 1994). As a result of habitat fragmentation, cowbird (*Molothrus ater*) nest parasitism has increased. The invasion of the exotic tamarisk has also altered the riparian ecosystem in the Southwest. Willow flycatcher nesting has been documented in tamarisk stands along the Colorado River. Many of the observations of SWFL since 1993 have occurred in habitat dominated by tamarisk (Koronkiewicz et al., 2005). This provides strong evidence that successful breeding is occurring in tamarisk on the Lower Colorado River. Because of low population numbers rangewide, identifying and conserving SWFL breeding sites is thought to be crucial to the recovery of the species (USFWS, 2003).

5.2.1.2 Natural History, Distribution, Abundance and Habitat

The SWFL is one of four subspecies of willow flycatcher. *Empidonax* flycatchers are noted for their physical similarities and the difficulty in identifying individuals in the field. This species is a small bird, approximately 14.6 centimeters (5.75 inches) long, with a grayish-green back and wings, whitish throat, light grey-olive breast, and pale yellowish body. Two white wing bars are visible. The upper mandible is dark, the lower is light. The most distinguishable taxonomic characteristic of the SWFL is the absent or faintly visible eye ring. This willow flycatcher can be differentiated from other species by its distinctive “fitz-bew” song. As an insectivore, it forages within and above dense riparian vegetation taking insects on the wing and gleaning them from the foliage. It also forages along water edges, backwaters, and sandbars adjacent to nest sites (Tibbitts et al, 1994). The current estimate of the rangewide SWFL population is between 1,100 and 1,200 pairs/territories (Koronkiewicz et al., 2005). From 1997 to 2004, breeding populations of SWFL were documented at seven study areas along the Virgin and Lower Colorado Rivers and tributaries (Koronkiewicz et al., 2005).

The SWFL breeds in dense riparian habitats in all or part of seven southwestern states, from sea level in California to over 2,600 meters (8,550 feet) in Arizona and southwestern Colorado (Sogge et al., 1997). This particular species breeds only in dense riparian vegetation near surface water or saturated soil. Along the Colorado River , they may typically nest in riparian habitat characterized by a dense stand of intermediate-sized shrubs or trees, such as willows (especially *Salix gooddingii*), *Baccharis*, or arrowweed (*Pluchea sericea*), usually with an overstory of scattered larger trees, such as cottonwoods (*Populus fremontii*). Occupied habitat always has dense vegetation in the patch interior regardless of the plant composition and height. These dense patches are often interspersed with small openings, open water, or sparser vegetation, creating a mosaic that is not uniformly dense (Sogge et al., 1997).

Riparian patches used by breeding flycatchers vary in size and may be a relatively dense, linear, contiguous stand or an irregularly shaped mosaic of dense vegetation with open areas. SWFLs are known to nest in patches as small as 0.8 hectare (2 acres) to as large as several hundred hectares (Sogge et al, 1997). The mean size of flycatcher breeding habitat patches is 8.5 hectares (21.2 acres) (Sogge et al, 1997; USFWS, 2003). Habitat patches as small as 0.5 hectare (1.23 acres) may support one or two nesting pairs (USFWS, 1995). Sogge et al. (1993) found territorial flycatchers in habitat patches ranging from 0.5 to 1.2 hectares (1.23 to

2.96 acres). However, this species has not been observed nesting in narrow, linear riparian habitats that are less than 10 meters (30 feet) wide, although they may use such linear habitats during migration (Sogge et al., 1997; USFWS, 2003). In the southwest, several willow flycatcher breeding territories are found within small breeding sites containing five or fewer territories; only two sites are known to have 50 or more territories (Gila and Rio Grande). The Hoover to Parker Management Unit that includes the Topock Marsh contains approximately 21 territories (Sogge et al., 2003).

Nesting habitat almost always contains or is adjacent to water or saturated soil. With the loss of preferred habitat throughout the southwest, SWFL have been observed using tamarisk thickets for nesting. Nearly 50 percent of willow flycatcher territories occur in mixed native/exotic habitat, and 25 percent are at sites where tamarisk is dominant (Sogge et al., 1997). Flycatchers nest in tamarisk at many river sites and, in many cases, use tamarisk even if native willows are present. Tamarisk eradication can be detrimental to willow flycatchers in mixed and exotic habitats, especially in or near occupied habitat or where restoration is unlikely to be successful. Risks to the flycatcher increase if the tamarisk control projects are implemented in the absence of a plan to restore suitable native riparian plant species or if site conditions preclude the reestablishment of native plant species of equal or higher functional value. Threats also increase if the eradication projects are large-scale, thus possibly setting the stage for large-scale habitat loss (USFWS, 2005a).

Migrant SWFLs may occur in nonriparian habitats and riparian habitats unsuitable for breeding. These migration stopover areas, even though not used for breeding, may be critically important sites affecting local and regional flycatcher productivity and survival (Sogge et al., 1997). One of the last long-distance, neo-tropical migrants to arrive in North America during spring migration, willow flycatchers have a short (approximately 100-day) breeding season, with individuals typically arriving in May or June and departing in late August. All four subspecies of willow flycatchers spend the non-breeding season in portions of southern Mexico, Central America, and northwestern South America. Willow flycatchers have been recorded on the wintering grounds from central Mexico to southern Central America as early as mid-August, and wintering resident individuals have been recorded in southern Central America as late as the end of May.

5.2.1.3 Recent Findings

The APE is located between two SWFL study areas—the Topock Marsh and Topock Gorge. In 2004, USBR contracted Steven W. Carothers and Associates (SWCA) to perform surveys for SWFL at these study areas. During this survey, SWCA recorded 65 and three SWFL individuals within Topock Marsh and Topock Gorge, respectively (Koronkiewicz et al., 2005).

Nesting and migratory habitat for the SWFL exists within and near the APE. The nesting and migratory period for SWFLs occurs May (arrival) through September (departure). Tamarisk and arrowweed are the dominant vegetation types within the portion of the APE that is associated with the Colorado River floodplain. The dense tamarisk thickets are considered suitable nesting, roosting and foraging habitat for willow flycatchers.

East of the river, suitable nesting habitat exists in the Topock Marsh where nesting pairs of SWFLs have been documented within 4 miles of the APE. Along the northeastern edge of the APE exists a contiguous band of suitable habitat (approximately 42 acres) that could support a nesting pair of SWFLs (Figure 7). However, the annual protocol surveys conducted in 2005 and 2006 have not documented SWFLs nesting in this area. The topography along this peninsula from west to east consists of rolling sand dunes increasing in elevation from the levee road to an additional 20 feet and decreasing to tamarisk thicket and eventually to marsh habitat.

Within the APE and west of the Colorado River, less suitable SWFL nesting habitat exists that may be used for roosting and foraging during migration. These thickets are concentrated below the BNSF Railway and Interstate 40 bridge (approximately 6 acres), near the Bat Cave Wash and Colorado River confluence (approximately 5 acres), near the unnamed wash and Colorado River confluence directly northwest of Bat Cave Wash (approximately 3 acres), and near Park Moabi Marina (approximately 7 acres) as shown on Figure 7. Each of these tamarisk thickets constitute a very small portion of the total APE, ranging from about 0.5 percent to 2.0 percent of the APE as shown in Table 2. These patches tend to be fragmented and subject to human disturbance, two factors that may decrease the habitat value for the species (GANDA, 2005b).

While tamarisk thicket habitat exists in the APE, this species is not expected to nest within or directly adjacent to the APE based on past USBR annual surveys that indicate flycatchers are selecting the higher-quality habitat at the Topock Marsh and Gorge (Koronkiewicz et al., 2005). Although tamarisk habitat exists within the APE, the vegetation density, habitat structure, and patch-size of thickets are sparser, smaller, and more fragmented in comparison to observed/known breeding habitat within the Topock Marsh. Additionally, SWFLs are not known to nest in mesquite, palo verde, and acacia trees (Sogge et al., 1997), which are the other tree species in the APE. Furthermore, there is no known breeding habitat within the APE where flycatcher reproductive success and survivorship has resulted in a stable or growing population.

To assess SWFL presence or absence, PG&E contracted GANDA in 2005 and 2006 to perform USFWS protocol surveys of potential suitable habitat within the APE. (Figure 7; CH2M HILL, 2005b; GANDA, 2005b). The methodology followed the protocol for project related surveys that recommends five surveys be conducted during three survey periods, with three surveys occurring during the last survey period. These periods are from May 15 to 31, June 1 to 21, and June 22 to July 17 (Sogge et al., 1997; USFWS, 2000b). On June 7, 2005, one possible willow flycatcher was detected near Moabi Regional Park. Although the bird was visually identified as a willow flycatcher, the distinctive “fitz-bew” call required for positive identification was not heard. This bird was possibly a transient since there were no subsequent detections of this species (GANDA, 2005b). Other than this single observation, no other willow flycatchers were seen or heard during the 2005 protocol survey of the APE. (Appendix E).

In 2006, the protocol surveys for the SWFL were repeated within the APE. The methodology was identical to the survey conducted in 2005. Results of the survey reported no detection of SWFLs within the APE during this period (GANDA, 2006b).

Additionally, biological monitors have logged several hundred hours in performing preactivity surveys on the California floodplain in compliance with the mitigation measures detailed in Section 3.4 and the revised well sampling procedures. These surveys required that a qualified biologist monitor a 200-foot circle for migratory bird nests around the work area prior to construction related activities. This monitoring occurs from March 15 – September 30. To date, no active nests of any migratory birds have been documented.

5.2.1.4 Direct Effects

Direct effects are those that are caused by the proposed action and occur at the same time and place. Specific actions occurring within or adjacent to suitable habitat in the floodplain have the potential to affect the species. This includes the floodplain groundwater monitoring programs, IM No. 3 floodplain operations, floodplain soil sampling, floodplain well installations, floodplain in-situ pilot study, seismic bedrock studies, slant drilling, activities similar to the pore water study, and floodplain restoration.

The following activities are not expected to have an effect to this species due to unsuitable habitat at the specific project location: IM No. 2 decommissioning, IM No. 3 upland operations, upland soil sampling, *in-situ* upland pilot study, and upland restoration including the MW-20 bench and IM No. 3 staging area. These sites are located within the upland that does not support the riparian vegetation and other characteristics commonly associated with flycatcher habitat.

The project activities proposed by PG&E will occasionally involve the use of heavy equipment including, but not limited to, backhoes and drill rigs that may be used to remove vegetation, grade the ground surface, and drill groundwater monitoring wells within the floodplain. This equipment can create substantial ground disturbance and noise.

Operational activities associated with monitoring the wells include personnel collecting water samples weekly, biweekly, or monthly. A small hand-held generator may be used for power to activate the submersible pumps during water collection. The generators' noise output is minimal enough that a conversation can occur. If these activities are performed within or adjacent to suitable flycatcher habitat, this action may lead to alterations of SWFL behavior. However, the lack of SWFL presence within the APE suggests that the probability of negatively altering SWFL behavior during operations and any future construction-related activities would be low. Further, the magnitude of project effects may be difficult to discern from other potentially impacting transportation activities (i.e., the Interstate-40 and the BNSF Railroad) and recreational activities (e.g., watercraft) that occur with regularity within the APE.

The Colorado River may function as a migration corridor for the SWFL. During migration periods, this species may briefly stop to roost and/or forage within or adjacent to the APE. Potential roosting and foraging habitats include the tamarisk patches located at Bat Cave Wash and an adjacent unnamed wash, under the BNSF railroad and Interstate 40 overpasses, near Park Moabi Regional Park, and the eastern edge of the APE (Figure 6) (CH2M HILL, 2005a-b). Because flycatchers may potentially use the habitat in the APE for roosting and foraging during the spring and fall migration seasons, it is possible that operational activities could alter the behavior of migrating individuals, but as discussed, the potential for impact is considered low. The greatest potential for direct effects to SWFL would be within the short migratory period during arrival (May – June) and departure (July

– September) when individuals could be passing through the APE to/from more suitable nesting locations.

Potentially suitable habitat for SWFL nesting exists within the 42 acres along the eastern edge of the APE located on the HNWR in Arizona. Habitat elements such as patch size, shrub density and the presence and/or location of water provide the appropriate habitat structure and features to allow for this behavior. However, annual surveys conducted in 2005 and 2006 have not documented any nesting or presence of SWFLs utilizing this habitat patch within the APE. Potential sites for additional monitoring wells include the levee road near the eastern shore of the Colorado River, approximately 230 feet from the edge of this suitable habitat. The 10- to 20-foot elevation increase of the topography between the wells and this habitat eliminates any direct line-of-sight and provides a buffer from project activities. Based on the combination of annual survey results, distances of wells to habitat, topography between wells to habitat and the application of conservation measures, any direct effects to nesting or migratory SWFLs would be low to none.

In May 2006, the well access and monitoring procedures were refined to further minimize any potential impacts to this species and reduce the amount of time in the field for sampling techniques due to human health and safety concerns, while maintaining quality control requirements for sample collection (CH2M HILL, 2006b). The duration of the modified sampling procedures is from May 1 through September 30, 2006, during the flycatcher breeding season. Several conservation measures were outlined as part of the revised procedures and will be carried forward under the scope of this PBA. A biologist is assigned to the well sampling teams during the SWFL period. The biologist is responsible for awareness training, preactivity surveys, compliance monitoring, and reporting. In response to informal consultation regarding the revised procedures, a USFWS letter dated 28 April 2006 concurred with a "may affect, not likely to adversely affect" determination made by the BLM for the SWFL (USFWS, 2006).

Project-related construction and operational activities will not occur within cottonwood-willow stands and therefore will have no effect upon the Colorado River's overall balance of remaining cottonwood-willow stands that historically were the native habitat for this species. Over time, tamarisk acreage resulting from human population growth in the Colorado River corridor has significantly increased along the Colorado River and the larger thickets are known to serve as SWFL breeding habitat. Several individual and small stands of tamarisk are expected to be affected as a result of the proposed actions (Table 2). To avoid and minimize habitat disturbance, sparsely vegetated areas within the floodplain have typically been selected in the past and the intent is to continue this practice for implementing future actions. In addition, every effort will be made to avoid dense contiguous stands of tamarisk greater than 1.0 acre and any associated vegetation. Limited riparian vegetation, primarily smaller patches or individual plants of tamarisk and arrowweed, may be crushed or trimmed as a result of the proposed actions. A 2.5-acre disturbance threshold will be followed in an attempt to lessen the potential effects to the species and habitat. Exceeding the 2.5-acre threshold will require consultation with the USFWS and may require possible mitigation.

5.2.1.5 Indirect Effects

Indirect effects are those that are caused by the proposed action and are later in time, but reasonably certain to occur. The possible actions that may occur will more than likely be extensions of current projects such as the installation and burying of groundwater conveyance pipeline; creation of additional access roads; and construction of additional well sites. These activities would require heavy equipment, trucks, materials, and crews to implement. Any indirect effects are considered to be low.

The decommissioning of the IM No. 3 facilities may begin within the time frame of this PBA (i.e., before the end of 2012). This action will require the use of heavy equipment, trucks and personnel to teardown and remove building material. This is primarily an upland activity and any indirect effect would be low to none.

No changes in land use patterns are foreseen.

5.2.1.6 Cumulative Effects

Cumulative effects include future state and private activities, excluding federal activities, that are reasonably certain to occur within the action area. The interim and remedial actions that may occur within the APE focus on the cleanup of soil and groundwater. It is reasonably certain that additional investigative and remedial activities very similar to the actions that have been implemented to date will occur. The level and use of equipment, materials and personnel will be similar as well. However, the loss or manipulation of floodplain habitat is expected to be required to conduct these and future unspecified activities. This loss may be sufficient enough to reduce the habitat value and thus alter SWFL use and behavior. Habitat loss is defined as the removal of trees and perennial shrubs. The trimming of vegetation is not considered habitat loss.

Future state and private actions separate from PG&E that are reasonably certain to occur within the project vicinity include continued recreational activities associated with the Colorado River such as boating, camping, and fishing. Additionally, operations and maintenance of existing infrastructure such as the gas pipelines, railroad, Interstate 40 and other nearby roads and utilities are anticipated.

5.2.1.7 Critical Habitat Effects Determination

The nearest critical habitat for the SWFL is located at Big Sandy River located approximately 50 miles east of the APE (USFWS, 2005b). PG&E’s activities are located outside designated critical habitat for the SWFL. An effects determination of “no effect” to critical habitat is concluded.

5.2.1.8 Effects Determination

There has been no positive identification of a SWFL during the 2005 and 2006 protocol surveys of the APE (GANDA, 2005b and 2006b). Although the results from two protocol surveys may be limited to determining presence/absence, it does provide the best available science specific to SWFLs within the APE. To date, no take of SWFLs (or any other migratory birds) has occurred within the APE from project activities.

The best opportunity for nesting SWFLs in the APE would occur in the tamarisk thickets along the eastern edge of the APE in Arizona. However, the distance from potential well locations near the levee road along the eastern shore of the Colorado River in conjunction with the 20 foot increase in the topography would provide a buffer from activities if SWFLs were inclined to attempt to nest in this location. These buffer features would allow for migratory activity to occur unimpeded. Additionally, annual and pre-project surveys will be conducted to identify the presence of SWFLs and adapt operations to minimize any potential for effects. Further, if project activities (primarily those utilizing heavy equipment for the construction and development of wells) occurred before the March 15 migratory bird dates, any potential effects would be a non-issue.

Nesting of SWFLs is considered unlikely west of the Colorado River within the California portion of the APE. This can be attributed to the lack of appropriate vegetation composition, habitat structure, microclimate, and presence of water or moist soils. Negative effects to nesting SWFLs are not anticipated to occur.

Seasonal migratory use of habitat on the floodplains of California and Arizona can be anticipated to occur along the Colorado River as SWFLs move to and from other known breeding locations. Project activities therefore could influence activity during this period. To further the knowledge of SWFLs within the APE and to help guide in the conservation of this species, annual USFWS protocol surveys will be conducted to determine presence or absence of SWFLs and pre-construction surveys will be conducted during the migratory/nesting season by biological monitors.

Future project activities, under guidance of the identified mitigation measures presented in Section 3.21 will help to avoid, reduce, and mitigate operational impacts to the biological environment within the APE. It is estimated that additional Tamarisk habitat may be lost, removed, or manipulated to conduct activities. This may be sufficient to reduce habitat value and alter SWFL behavior. Under this PBA the following conservation measures, not replacing those already identified, will be imposed.

1. The intent of PG&E will be to minimize the net increase of disturbed habitat in the APE.
2. Construction and development activities that use heavy equipment should be completed prior to March 15. The use of any heavy equipment in or near SWFL habitat after March 15 will be required to be reassessed and additional conservation measures considered. Preferably such activities would occur from Oct 1 to March 15.
3. To the extent feasible, future project activities within the sensitive areas identified on Figure 8 (i.e., potential SWFL habitat, wetlands, 100-year floodplain, and a 60-foot buffer from the Colorado River) should be avoided. Further, if greater than 2.5 acres of floodplain habitat is lost or manipulated, specific project consultation with the USFWS will be required and possible mitigation may be required. Habitat loss is defined as the removal of trees and perennial shrubs. The trimming of vegetation is not considered habitat loss.
4. The previously consulted upon modified well access and sampling procedures implemented in 2006 in SWFL habitat will be used under this PBA and will be implemented from May 1 – September 30.

Southwestern willow flycatcher use of the APE cannot be rejected and future project activities are anticipated to occur on the Arizona and California floodplains in or near suitable nesting/migratory habitat along the Colorado River and within the Topock Marsh on the HNWR. However, based on the location of project activities and distance from recorded SWFL nesting habitat; the non-conducive distribution, composition and structure of habitat conditions in or adjacent to the APE; the non-documentation of nesting and/or migratory SWFLs obtained from annual surveys in potentially suitable habitat; and accompanied with the application of the above conservation measures identified in this section, the effects of project activities to the SWFL could not be meaningfully measured, detected or evaluated and are not expected to occur. Therefore, any potential direct or indirect effects from project activities are either insignificant or discountable. An effects determination of "may affect, but not likely to adversely affect" is concluded for this species.

5.2.2 Mojave Desert Tortoise (*Gopherus agassizii*)

5.2.2.1 Status

The desert tortoise was listed as federally threatened on April 2, 1990 (USFWS, 1990b). Critical habitat was designated on February 8, 1994 (USFWS, 1994b). The Desert Tortoise Recovery Plan was released on June 28, 1994 (USFWS, 1994a). The desert tortoise was listed as threatened by the state of California in 1989.

The decline in the desert tortoise population is primarily due to habitat loss, degradation, and fragmentation resulting from increased human population and urbanization in the desert and arid regions of the southwestern United States. The increase in urbanization, collection of tortoises for pets, overgrazing, landfills, subsidized predation, highway mortality, vandalism, agriculture, fire, drought, and offroad vehicle use have all contributed to the decline of the tortoise in the wild. Another important reason for the tortoise decline in the western Mojave Desert is the introduction of an upper respiratory tract disease into many of the wild populations (USFWS, 1990b, 1994a).

5.2.2.2 Natural History, Distribution, Abundance, and Habitat

The desert tortoise is a large herbivorous terrestrial reptile. It has a high-domed shell that can reach a length of 36 centimeters (14 inches). The animal has stocky, elephant-like limbs and a short tail. The carapace (upper shell) is brown, and the plastron (lower shell) is yellow—both exhibiting prominent growth lines. Adult males can be distinguished from females by the concavity toward the rear of their plastron. Adult males also have larger chin glands and a longer tail and gular horn than females (Stebbins, 1985).

The adult desert tortoise is active from mid-March or April to November and, during the winter months, is dormant in underground burrows (Luckenbach, 1982). Desert tortoises will congregate in winter dens during colder weather, and then spread out to nearby areas during moderate weather in the spring and fall and retreat into short individual burrows or under shrubs during more extreme heat in summer (Woodbury and Hardy, 1940). During the summer active period, desert tortoises have home ranges from 12.7 to 72.1 hectares (5-29 acres) (O'Conner et al., 1994). During active periods, tortoises feed on a wide variety of herbaceous plants, including cactus, grasses, and annual flowering plants (USFWS, 1994a).

Desert tortoises may live beyond 80 years and have a relatively slow rate of reproduction. Sexual maturity is reached at 15 to 20 years of age. Mating generally occurs in the spring (mid-March to late-May), with nesting and egg-laying occurring from May to July (Rostral et al., 1994). The female tortoise lays her eggs in a hole approximately 7 to 10 centimeters (2.7 to 3.9 inches) deep dug near the mouth of a burrow (Woodbury and Hardy, 1948). Following egg-laying, the female covers the eggs with soil. Clutch size ranges from 2 to 14 eggs, with an average of 5 to 6 eggs (Luckenbach, 1982). Desert tortoise eggs typically hatch from August through October. These hatchlings are provided a food source in the form of an egg yolk that is assimilated into the underside of the shell. This yolk sac will sustain the animal for up to 6 months. The hatchling desert tortoise will go into hibernation in the late fall but can be active on warm sunny or rainy days (Luckenbach, 1982).

The desert tortoise can be found in desert and arid regions from southern Nevada and extreme southwestern Utah to northern Sinaloa, Mexico, southwestern Arizona west to the Mojave Desert, and eastern side of the Salton Basin, California (Stebbins, 1985). The desert tortoise can be divided into two distinct races, the Mojave and Sonoran, based on morphological and genetic characteristics.

The Mojave race is associated with the Mojave Desert in California, Nevada, and Utah, as well as a portion of Arizona. This race is primarily associated with flats and bajadas (shallow slopes that lie at the base of rocky hills), with soils ranging from sand to sandy-gravel but firm enough for the tortoise to construct burrows. In California, this desert tortoise is most commonly found in association with creosote bush scrub, with inter-shrub space for growth of herbaceous plants (USFWS, 1994a).

The Sonoran race is associated with the Sonoran Desert in Arizona. This race is found predominantly on steep rocky slopes of mountain ranges or sloping foothills primarily in Arizona upland vegetation dominated by palo verde and saguaro cactus (USFWS, 1990b).

5.2.2.3 Recent Findings

In 2004, 2005, and 2006 PG&E contracted CH2M HILL and GANDA to perform USFWS protocol presence/absence surveys for the desert tortoise. No live desert tortoises were detected within the survey area. However, three disarticulated desert tortoise carcasses were observed. Two carcasses were associated with ephemeral drainages. The third carcass was observed on a mesa top. Each carcass was estimated to be more than 4 years old. The carcasses observed in the drainages may have washed in from outside the survey area during a rainstorm. This interpretation is based on the location of the finds, surrounding topography, and the lack of any other desert tortoise sign within the survey area. The desert tortoise carcasses may indicate historical use of the area, however, no live desert tortoises, scats, tracks, or other evidence of recent use was observed. Burrows with entrances large enough to accommodate a desert tortoise were also observed during the surveys. The possible desert tortoise burrows had no scat, tracks, or other signs within or surrounding the burrows and were likely created by a black-tailed jackrabbit or other burrowing mammal species (CH2M HILL, 2005b; GANDA, 2005a, 2006a). The annual reports documenting the desert tortoise survey results may be referenced within Appendix E.

Based on the survey results, desert tortoises were concluded to be absent in the APE. Despite the absence of live tortoise observations, there is a possibility that desert tortoises could enter the survey area. While it is possible that the desert tortoise could enter the APE from the west, the quality of the present creosote bush scrub habitat is poor, typically lacking of annual vegetation for forage and burrows for shelter. Combined with the presence of steep rocky slopes of the Chemehuevi Mountains and associated deep drainages, these conditions make permanent occupation of the survey area unlikely. Additionally, past disturbances and fragmentation by pipeline corridors, roads, Interstate 40, the BNSF railroad, Topock Compressor Station, evaporation ponds, and other manmade facilities further degrade the habitat (CH2M HILL, 2005b; GANDA, 2005a, 2006a).

5.2.2.4 Direct Effects

Direct effects are those that are caused by the proposed action and occur at the same time and place. Specific actions occurring within suitable habitat in upland areas have the potential to affect this species. These include upland groundwater monitoring programs, IM No. 3 upland operations, upland soil sampling, upland well installations, *in-situ* upland pilot study, and upland restoration activities.

The following activities, associated with the floodplain, are not expected to have an effect to this species due to unsuitable habitat at the specific project location: IM No. 2 decommissioning, pore water study, seismic bedrock studies, slant drilling, floodplain soil sampling, floodplain well installations, and floodplain restoration.

A large portion of the APE (approximately 988 acres) is located on the uplands within desert habitat that is referred to as creosote bush scrub (Figure 6). Although the area is considered poor desert tortoise habitat, a transient could enter the site. It is intended that project-related construction and operational activities will be designed to have a minimal effect on the creosote bush scrub plant community. No more than 3 acres of creosote bush scrub are expected to be affected by the proposed actions. Under additional protection measures of tribal cultural resources in the uplands, any direct effects to the habitat or landscape will be closely evaluated and minimized.

The project activities proposed by PG&E on the uplands will occasionally involve the use of heavy equipment including but not limited to graders, backhoes, drill rigs, and water trucks that may be used to remove vegetation, grade the ground surface including dirt roads, extract soil samples, drill monitoring wells, and install other facilities. This equipment can create substantial ground disturbance and noise. The project also includes the continued operations of IM No. 1 and IM No. 3 involving vehicles traveling on dirt roads to access sites and associated human activity. Existing routes will be utilized wherever possible. Any direct effects to the creosote bush scrub habitat would be low.

Operational activities associated with monitoring the wells include personnel collecting water samples biweekly, weekly, or monthly. A small hand-held generator typically is used for power to activate the submersible pumps during water collection. The generator's noise output is minimal but may distract this species. These activities will be performed within suitable but poor habitat. The potential for direct effects to the desert tortoise involves the possibility of a transient entering the APE. However, based on past survey findings and a full-time biological monitor onsite conducting preactivity surveys, the probability of potential impact is considered low. Additionally, negative affects to tortoises may be further complicated by nearby natural and manmade barriers such as the Chemehuevi

Mountains, Colorado River, BNSF railroad, and I-40 Interstate fragmenting the landscape. Any direct effects associated resulting from operational activities would be insignificant and discountable.

As with construction and maintenance actions, there is a risk of altering individual tortoise behavior from the restoration of degraded sites (Figure 5). This will involve recontouring, removing structures, driving trucks, using bobcats, and replanting native vegetation, for example. Once established, the restoration will improve the quality of the creosote bush scrub habitat for this species and other wildlife species. Any direct effects associated with restoration will be beneficial to this species and habitat.

5.2.2.5 Indirect Effects

Indirect effects are those that are caused by the proposed action and are later in time, but reasonably certain to occur. The possible actions that may occur will more than likely be the extension of projects such as the installation and burying of groundwater conveyance pipeline; creation of additional access roads; and construction of additional well sites. These activities would require heavy equipment, trucks, materials and crews to implement. The decommissioning of the IM No. 3 facilities may begin within the time frame of this PBA (i.e., before the end of 2012). This action will require the use of heavy equipment, trucks and personnel to teardown and remove building material.

No changes in land use patterns are foreseen.

5.2.2.6 Cumulative Effects

Cumulative effects are of those future state and private activities, excluding federal activities, that are reasonably certain to occur within the action area of the federal action subject to consultation. Any future investigative and remedial actions that may occur within the APE are focused at the cleanup of hexavalent chromium within the groundwater. It is reasonably certain that future investigative and remedial activities beyond, but similar to, those actions that have been implemented to date will occur. The level and use of equipment, materials and personnel will be similar as well. The loss of up to 3.0 acres of creosote bush scrub upland habitat is estimated to be required to conduct these activities. Habitat loss is defined as the removal of trees and perennial shrubs. The trimming of vegetation is not considered habitat loss.

Future state and private actions separate from PG&E that are reasonably certain to occur within the project vicinity include continued recreational activities associated with the Colorado River such as boating, camping, and fishing. Additionally, operations and maintenance of existing infrastructure such as the gas pipelines, railroad, Interstate 40 and other nearby roads and utilities are anticipated.

5.2.2.7 Critical Habitat Effects Determination

The nearest critical habitat for the Mojave desert tortoise is located within the Chemehuevi Valley located approximately 9 miles west of the APE (USFWS, 1994b). PG&E's activities are located outside designated critical habitat for the Mojave Desert tortoise. An effects determination of "no effect" to critical habitat is concluded.

5.2.2.8 Effects Determination

Recent evidence of desert tortoise presence was not detected during the 2004, 2005, and 2006 protocol surveys of the APE (CH2M HILL, 2005b; GANDA, 2005a, 2006a). However, remains of desert tortoises have been documented in the APE. These remains are highly aged and are not understood to be from those of recent occupation by the desert tortoise. There has been no reported take of this species resulting from investigative and remedial activities to date.

The upland landscape is considered poor habitat for the desert tortoise. It is estimated that no more than 3 acres of creosote bush scrub upland habitat would be affected by future proposed actions. The intent of PG&E will be to use those areas already disturbed by project activities so as to minimize the net increase of affected habitat. It should also be noted that this PBA does not imply the approval of actions and/or the degradation of the landscape at the expense or risk to other resources (e.g., cultural resources).

Under this PBA the following conservation measures, not replacing those already identified, will be imposed.

1. The intent of PG&E will be to minimize the net increase of disturbed habitat in the APE.
2. If future activities require the loss or manipulation of greater than 3.0 acres of upland creosote bush scrub habitat, specific project consultation with the USFWS will need to occur and possible mitigation may be required. Habitat loss is defined as the removal of trees and perennial shrubs. The trimming of vegetation is not considered habitat loss.
3. PG&E is to have a USFWS-certified desert tortoise handler available if and when a tortoise visits the APE and requires relocation.

The documentation of aged desert tortoise remains and the presence of two possible burrows within the APE, although difficult to interpret, do suggest that an individual may have and could potentially visit the APE in the future. However, based on the non-presence of tortoises documented by 3 years of protocol surveys within the APE; the low suitability of tortoise habitat within the APE; the location of project activities and distance from known suitable habitat and tortoise presence; and accompanied by mitigation measures presented in Section 3.4 and in addition to the landscape level protection afforded to Tribal cultural resources, the effects of project activities to the Mohave Desert tortoise could not be meaningfully measured, detected, or evaluated and are not expected to occur. Therefore any potential direct or indirect effects from project activities are either insignificant or discountable. An effects determination of "may affect, but not likely to adversely affect" is concluded for this species.

5.3 Marsh

5.3.1 Yuma Clapper Rail (*Rallus longirostris yumanensis*)

5.3.1.1 Status

The Yuma clapper rail was listed as a federally endangered species on March 11, 1967, under endangered species legislation enacted in 1966. Critical habitat has not been designated for this species. The Yuma Clapper Rail Recovery Plan was released on

February 4, 1983 (USFWS, 1983). The Yuma clapper rail is a fully protected species in California and was listed as threatened by the state in 1978.

Much of the decline of the Yuma clapper rail can be attributed to altered seasonal flow regimes and lost marsh habitat due to the construction of hydro facilities and dredging on the Lower Colorado River. Population changes on a local level have been documented, but these changes may be based on changes in habitat quality. In turn, a decline in habitat quality may be the result of the aging of existing cattail stands to a less suitable condition for rail occupancy. Historically, the marshes seldom accumulated large amounts of dead vegetative material because of floods and changes to the river channel, which washed away cattail stands on a repeating cycle (USBR, 2004).

5.3.1.2 Natural History, Distribution, and Abundance and Habitat

The Yuma clapper rail is a chicken-shaped marsh bird with a long down-curved beak. Both sexes are slate brown above, with light cinnamon underparts and barred flanks. This subspecies is slightly lighter in color and slightly thinner than other clapper rails. The bird measures 14 to 16 inches long once it is fully grown (Eddleman,1989).

Yuma clapper rails are found in emergent wetland vegetation such as dense or moderately dense stands of cattails (*Typha latifolia* and *T. domingensis*) and bulrush (*Scirpus californicus*) (Eddleman, 1989; Todd, 1986). They can also occur, in lesser numbers, in sparse cattail-bulrush stands or in dense reed (*Phragmites australis*) stands (Rosenberg et al., 1991). The most productive clapper rail areas consist of a mosaic of uneven-aged marsh vegetation interspersed with open water of variable depths (Conway et al., 1993). Annual fluctuation in water depth and residual marsh vegetation are important factors in determining habitat use by Yuma clapper rails (Eddleman, 1989).

Yuma clapper rails may begin exhibiting courtship and pairing behavior as early as February. Nest building and incubation can begin by mid-March, with the majority of nests being initiated between late April and late May (Eddleman, 1989). The rails build their nests on dry hummocks, on or under dead emergent vegetation and at the bases of cattail or bulrush. Sometimes they weave nests in the forks of small shrubs that lie just above moist soil or above water that is up to about 2 feet deep. The incubation period is approximately 28 days so the majority of clapper rail chicks should be fledged by August (Eddleman, 1989). Yuma clapper rails nest in a variety of different micro habitats within the emergent wetland vegetation type, with the only common denominator being a stable substrate. Nests can be found in shallow water near shore or in the interior of marshes over deep water. Nests usually do not have a canopy overhead as surrounding marsh vegetation provides protective cover (Eddleman, 1989).

Crayfish (*Procambarus clarki*) are the preferred prey of Yuma clapper rails. Crayfish comprise as much as 95 percent of the diet of some Yuma clapper rail populations (Ohmart and Tomlinson 1977). Availability of crayfish may be a limiting factor in clapper rail populations and is believed to be a factor in the migratory habits of the rail (Rosenberg et al., 1991). However, Eddleman (1989) found that crayfish populations in some areas remain high enough to support clapper rails all year and that seasonal movement of clapper rails cannot be correlated to crayfish availability. New information suggests that selenium levels in crayfish may be high enough to cause reproductive effects. However, due to the species' secretive nature, nests are difficult to find and reproductive effects are difficult to assess. No adverse effects have been documented (USFWS, 2005a).

5.3.1.3 Recent Findings

The eastern edge of the APE is located within a USFWS study site near the Topock Marina. Several call stations have been surveyed annually for Yuma clapper rail by the USFWS along the South Dike that is located within the HNWR. In past years, this species has been detected south of the new South Dike and north of the Topock Marina (Figure 7) (USFWS, 2005d). A 2004 survey map and data are included in Appendix E. In 2005, seven Yuma clapper rails were detected along the South Dike transect (Fitzpatrick, 2006). Suitable emergent habitat is located approximately 400 feet from potential well locations near the eastern shoreline of the Colorado River, and extends the full length of the northeastern edge of the APE. The emergent habitat type is buffered from the nearest well by a 400-foot distance of tamarisk and a 10- to 20-foot elevation increase of the floodplain to the west and suitable habitat to the east.

On the California-side, there is a small wetland associated with the Colorado River within the APE that is approximately 3 acres in size, located in the vicinity of the Interstate-40 bridge. This wetland is within the HNWR boundary. No reports of rails have been documented at this location and at the request of the USFWS, PG&E has not conducted any rail surveys of this area.

5.3.1.4 Direct Effects

Direct effects are those that are caused by the proposed action and occur at the same time and place. Specific actions occurring within or adjacent to marsh habitat within the APE located south of the Interstate 40 bridge and along the eastern boundary of the APE have the potential to affect the species. This includes floodplain groundwater monitoring programs, IM No. 3 floodplain operations, floodplain soil sampling, floodplain well installations, slant drilling, seismic bedrock studies, activities similar to the pore water study, and floodplain restoration.

The following activities are expected not to affect this species due to unsuitable upland habitat at the specific project location: upland groundwater monitoring programs, IM No. 2 decommissioning, IM No. 3 upland operations, *in-situ* upland pilot study, upland soil sampling, and upland restoration activities.

Marsh habitat conditions and the associated riparian communities are essential habitat elements for the Yuma clapper rail. PG&E's activities are designed to avoid marshes and wetlands if at all possible. Dense salt cedar adjacent to marshes functions as a cover and buffer element to protect nests from predators (Fitzpatrick, 2006). Approximately 200 feet of dense salt cedar (and an additional 200 feet of open floodplain) would buffer the marsh habitat on the eastern edge of the APE from well construction, development and monitoring on the Arizona floodplain. The salt cedar habitat near the marsh on the California floodplain is also under the modified access and sampling procedures applied for the SWFL from May 1 to September 30.

Operational activities associated with monitoring the wells within the salt cedar habitat include personnel collecting water samples biweekly, weekly, or monthly. A small hand-held generator typically is used for power to activate the submersible pumps during water collection. The generator's noise output is minimal; however, it may distract this species.

5.3.1.5 Indirect Effects

Indirect effects are those that are caused by the proposed action and are later in time, but reasonably certain to occur. The possible actions that may occur will more than likely be the extension of projects such as the installation and burying of groundwater conveyance pipeline; creation of additional access roads; and construction of additional well sites. These activities would require heavy equipment, trucks, materials and crews to implement.

It is not anticipated that any additional facilities or buildings will be required to be built. But the decommissioning of the IM No. 3 facilities in time may begin within the time frame of this PBA (i.e., before 2012). This action will require the use of heavy equipment, trucks and personnel to teardown and remove building material. This activity may increase vehicle traffic to the main compressor station on the road overlooking the wetland.

No changes in land use patterns are foreseen.

5.3.1.6 Cumulative Effects

Cumulative effects are those of future state and private activities, excluding federal activities, that are reasonably certain to occur within the action area of the federal action subject to consultation. The actions that may occur within the APE are focused at the cleanup of hexavalent chromium within the groundwater. It is reasonably certain that additional investigative and response activities beyond, yet similar to, the actions that have been implemented to date will occur. The level and use of equipment, materials and personnel will be similar as well.

Future state and private actions separate from PG&E that are reasonably certain to occur within the project vicinity include continued recreational activities associated with the Colorado River such as boating, camping, and fishing. Additionally, operations and maintenance of existing infrastructure such as the gas pipelines, railroad, Interstate 40 and other nearby roads and utilities are anticipated.

5.3.1.7 Critical Habitat Effects Determination

Critical habitat has not been designated for the Yuma clapper rail. An effects determination of "no effect" for critical habitat is concluded for this species.

5.3.1.8 Effects Determination

Yuma clapper rails have been documented in suitable nesting habitat along the northeastern boundary of the APE on the HNWR in Arizona. Potential monitoring well locations include the floodplain of the Colorado River in Arizona near the existing levee road. This area is approximately 60 feet from the Colorado River and 400 feet from known occupied habitat (Figure 7). Project activities in this area would be buffered from suitable nesting habitat by approximately 200 feet of tamarisk (about 42 acres total) vegetation and 200 feet of open floodplain, as well as a 10 to 20 foot increase in topography.

There is also 3 acres of potentially suitable habitat under (below/near) the Interstate 40 bridge. However, no Yuma clapper rails have been documented at this location. Past investigative and response activities have occurred in the tamarisk dominated zone near this wetland. Currently, a slant drilling project to directionally test for potential contaminants under the Colorado River is being proposed. This slant drilling activity will be addressed under a separate biological assessment (CH2M HILL 2006e) prior to the finalization of the PBA. The slant drilling activity is scheduled to be completed before March 15. As well, project activities occurring in this location are limited to well monitoring on a monthly schedule and subject to the 2006 modified well access and sampling procedures consulted upon for the SWFL (USFWS 2006).

Under this PBA the following conservation measures, not replacing those already identified, will be imposed.

1. The intent of PG&E will be to avoid investigative or response actions in or near marshes or wetlands, if at all possible.
2. If future actions are proposed to occur within 300 feet of wetlands or marshes (specifically the eastern boundary of the APE on the Arizona floodplain), project specific review will occur to ensure compliance with this PBA and associated USFWS consultation.
3. Specific to the Arizona portion of the APE, all construction and development activities should be completed prior to March 15. Preferably, such activities would occur from October 1 to March 15.
4. Where feasible, actions should not be proposed within the tamarisk habitat under the Interstate 40 and the BNSF railway bridges that occur on the HNWR unless otherwise agreed to by the USFWS.
5. No more than 2.5 acres of floodplain habitat can be impacted without triggering additional ESA consultation requirements.

Suitable habitat conditions and documented presence of nesting individuals do increase the level of awareness of project activities negatively effecting Yuma clapper rails primarily along the eastern boundary of the APE. However, the distances and locations of potential well sites from occupied habitat; as well as the topographical features and tamarisk densities between potential wells and suitable habitat will provide sufficient cover to buffer this species from any effects caused by project activities. In addition with the application of the above conservation measures, the effects of project activities to the Yuma clapper rail could not be meaningfully measured, detected or evaluated and are not expected to occur. Therefore, any potential direct or indirect effects of project activities are either insignificant or discountable. An effects determination of “may affect, but not likely to adversely affect” is concluded for this species.

5.4 Aquatic

5.4.1 Colorado Pikeminnow (*Ptychocheilus lucius*)

5.4.1.1 Status

The Colorado pikeminnow was listed as a federally endangered species in 1967 and came under protection of the ESA in 1973. The Colorado Pikeminnow Recovery Plan was released in 1991 (USFWS, 1991) and was supplemented with the Colorado Pikeminnow Recovery Goals in 2001 (USFWS, 2001a). The Colorado pikeminnow is a fully protected species in California and was listed as endangered by the state in 1971. It is considered to be extirpated from the lower Colorado River (Minckley, 1973).

5.4.1.2 Natural History, Distribution, Abundance and Habitat

The Colorado pikeminnow is considered the world's largest minnow, reaching lengths up to 5 feet. It has a large long head, somewhat pike-like, with a terminal mouth. It was, historically, the top predator fish in the Colorado River. This species is the only member of the genus *Ptychocheilus* endemic to the Colorado River Basin.

This species was formerly widespread in the Colorado River basin from Wyoming to Arizona and California. Now, native populations are restricted to the upper basin in Wyoming, Colorado, Utah, and New Mexico in the Green, Yampa, White, Gunnison, and Colorado Rivers. Critical habitat was designated for Colorado pikeminnow in the upper basin effective April 20, 1994. No critical habitat was designated in Arizona.

5.4.1.3 Direct Effects

No direct effects will occur.

5.4.1.4 Indirect Effects

No indirect effects will occur.

5.4.1.5 Cumulative Effects

No cumulative effects will occur.

5.4.1.6 Critical Habitat Effects Determination

Critical habitat has not been designated for the Colorado pikeminnow. An effect determination of "no effect" for critical habitat is concluded for this species.

5.4.1.7 Effects Determination

Due to the extirpation of the Colorado pikeminnow in the Lower Colorado River, an effect determination of "no effect" is concluded for this species.

5.4.2 Razorback Sucker (*Xyrauchen texanus*)

5.4.2.1 Status

The razorback sucker was listed as a federally endangered species on October 23, 1991, with an effective date of November 22, 1991. The Razorback Sucker Recovery Plan was released in 1998 (USFWS, 1998). The recovery plan was supplemented with the Upper Colorado River Endangered Fish Recovery Program (USFWS, 2001a) and the Razorback Sucker Recovery Goals (USFWS, 2001b). The razorback sucker is a fully protected species in California and was listed as endangered by the state in 1974.

Critical habitat was designated in 15 river reaches in the historic range of the razorback sucker on March 21, 1994, with an effective date of April 20, 1994 (USFWS, 1994c). This includes Lake Mead to its full pool elevation, the Colorado River and its 100-year floodplain between Hoover Dam and Davis Dam including Lake Mohave to its full pool elevation, and the Colorado River and its 100-year floodplain from Parker Dam to Imperial Dam (USFWS, 1994c).

The trend for the razorback sucker is for a continued rangewide decrease in wild populations due to lack of sufficient recruitment of young adults, with the loss of old adults due to natural mortality. The primary limiting factor for the razorback sucker appears to be non-native fish predation of the early life stages (USFWS, 2005a).

5.4.2.2 Natural History, Distribution, Abundance and Habitat

The razorback sucker is a large fish, measuring over 2 feet long and weighing 8 pounds. Sexual dimorphism is present, with males being smaller, slimmer, and having larger fins than females. During the breeding season males have nuptial tubercles covering posterior fins and portions of the body. Females tend to be larger, heavier-bodied, and have fins that are somewhat smaller in proportion to their body size (Minckley, 1973).

The razorback sucker is endemic to large rivers of the Colorado River Basin from Wyoming to Mexico. Present distribution of natural populations is limited to Lake Mohave, Green River Basin, and the Upper Colorado River Basin. Historically razorback suckers inhabited the Colorado, Gila, Salt, Verde, and San Pedro rivers.

Presently, natural adult populations exist only in Lake Mohave, Lake Mead, and Lake Havasu. This species uses a variety of habitat types from mainstem channels to slow backwaters of medium and large streams and rivers, sometimes around cover. In impoundments they prefer depths of 1 meter or more over sand, mud, or gravel substrates. (AGFD, 2002b). Early explorers report the fish as extremely abundant (Gilbert and Scofield, 1898). In central Arizona it was abundant enough to be commercially harvested for human and animal food and for fertilizer in the late 1800s. Similar abundances have been noted for the upper basin (Bestgen, 1990). Today the species occupies only a small portion of its historical range, and most occupied areas have very low numbers of fish. Between Davis Dam and Lake Havasu, observations of razorback suckers are extremely rare (USBR, 2004).

Spawning occurs from late winter through spring along gravelly shorelines or bays. Evidence suggests that suckers migrate from larger rivers to smaller tributaries prior to spawning. A single female is attended by 2 to 12 males, and the group moves in tight circles over the bottom. The eggs are adhesive and attach to the interstitial spaces within the gravel substrate. The young hatch in a few days and live along the shoreline for a time. Females will spawn repeatedly with several males. Hatching success is highly dependant on water temperature with complete mortality in temperatures less than 10 degrees Celsius (50 degrees Fahrenheit) (AGFD, 2002b).

5.4.2.3 Recent Findings

The Lower Colorado River supports the largest remaining populations of razorback sucker. The population consists primarily of subadults. In 2005, razorback suckers were documented near Needles, California. In 2006, 236 suckers were captured and released at that spawning site. The likelihood of this species being in the area around Park Moabi and Topock Marina is very high (Fitzpatrick, 2006).

Extinction of the species in the wild throughout the historic range is being forestalled by stocking of subadult fish into the remaining wild populations (USBR, 2002). Where natural recruitment is occurring (i.e., spawning and survival of young), it is not known whether the current level of recruitment will sustain the existing population levels. Where natural recruitment is not occurring, loss of the remaining wild populations is expected.

Stocking efforts in the Upper Colorado River Basin and in Lakes Mohave and Havasu and the Lower Colorado River below Parker Dam are ongoing, with the 30,000-fish requirement for Lake Havasu completed in 2001. The most critical of these efforts is the replacement of the Lake Mohave population using wild-caught larvae from the lake. By the end of 2001, the initial goal to stock 50,000 subadult fish into Lake Mohave was achieved. The Lake Mohave efforts will continue to meet the second goal, which is to establish a population of 50,000 adults.

5.4.2.4 Direct Effects

Direct effects are those that are caused by the proposed action and occur at the same time and place. Activities that may occur in the Colorado River include seismic bedrock studies and pore water studies. The 2005 pore water study was issued a no effect determination (USFWS, 2005e).

Activities that may occur within the 100-year floodplain include floodplain groundwater monitoring programs, IM No. 3 floodplain operations, flood plain soil sampling, slant drilling, floodplain well installations, activities similar to the pore water study, and floodplain restoration.

Seismic studies will be similar to the 2005 pore water study that was issued a no effect determination by the USFWS (USFWS, 2005e). The seismic studies involve a small boat that will be used to submerge the seismic equipment within a portion of the Colorado River. The equipment that will be used for the study creates an acoustical pulse that is similar to that used by a recreational fish finder. The seismic studies will be performed during the winter season and completed before February 1, when feasible. Up river migration, spawning, and down river migration of adult and fry razorback suckers are expected to occur between February 1 and May 31; therefore, seismic studies between June 1 and January 31 will have no affect upon this species (Adams, 2006). Conversely, activities within the Colorado River that are conducted during the spawning and migration period may affect this species.

The project activities proposed by PG&E will occasionally involve the use of heavy equipment including but not limited to backhoes and drill rigs that may be used to remove vegetation, grade the ground surface, and drill groundwater monitoring wells within the floodplain. Smaller equipment such as bobcats and quad-runners are also used to transport personnel and well sampling tools. This equipment can create disturbance to the ground and vegetation that may reduce the function of the riparian zone to contribute nutritional attributes to the river. However, the magnitude of riparian function that may be reduced by the proposed action is not expected to impact the razorback sucker due to limited project-related activities and associated minor footprints directly adjacent to the Colorado River. Additionally, a 2.5 acre floodplain vegetation removal threshold has been established to minimize any reduced function of the riparian zone.

5.4.2.5 Indirect effects

Indirect effects are those that are caused by the proposed action and are later in time, but reasonably certain to occur. All proposed activities will take place outside the Colorado River with the exception of activities similar to the prior pore water study, which in 2005 received a no effect determination (USFWS, 2005e). No changes in land use patterns are foreseen. No indirect effects are anticipated.

5.4.2.6 Cumulative Effects

Cumulative effects are of those future state and private activities, excluding federal activities, that are reasonably certain to occur within the action area of the federal action subject to consultation. The interim and remedial actions that may occur within the APE are focused at the cleanup of hexavalent chromium within the groundwater. It is reasonably certain that additional investigative and remedial activities beyond, but similar to, those actions that have been implemented to date will occur.

These actions will occur within the 100-year floodplain and involve heavy equipment including but not limited to backhoes and drill rigs that may be used to remove vegetation, grade the ground surface, and drill groundwater monitoring wells on the California and Arizona floodplains within the APE. Smaller equipment such as bobcats and quad-runners are also used to transport personnel and well sampling tools. This equipment can create disturbance to the ground and vegetation that may reduce the function of the riparian zone to contribute nutritional attributes to the river. However, the magnitude of riparian function that may be reduced by the proposed action is not expected to impact the razorback sucker due to limited project-related activities and associated minor footprints directly adjacent to the Colorado River. Additionally, a 2.5 acre floodplain vegetation removal threshold has been established to minimize any reduced function of the riparian zone.

Future state and private actions separate from PG&E that are reasonably certain to occur within the project vicinity include continued recreational activities associated with the Colorado River such as boating, camping, and fishing. Additionally, operations and maintenance of existing infrastructure such as the gas pipelines, railroad, Interstate 40 and other nearby roads and utilities are anticipated.

No changes in land use or water use are foreseen.

5.4.2.7 Critical Habitat Effects Determination

Critical habitat for the razorback sucker does not occur within the APE. An effect determination of "no effect" for critical habitat is concluded for this species.

5.4.2.8 Effects Determination

Under this PBA the following conservation measures, not replacing those already identified, will be imposed.

1. The intent of PG&E will be to minimize the net increase of disturbed habitat in the APE.
2. If greater than 2.5 acres of habitat within the general and 100-year floodplain is destroyed or manipulated, specific project consultation with the USFWS will be required and possible mitigation may be required.
3. If additional actions are proposed within the Colorado River beyond those described for the pore water study, consultation will be required to be reinitiated at that time.
4. Proposed project activities within the Colorado River should preferably occur between June 1 and January 31. Project activities that differ from the pore water study and which are proposed to occur between February 1 and May 31 will require further consultation.
5. In the event an emergency situation (e.g., a spill into the Colorado River), where actions to abate the problem are to occur along the shoreline/river interface or in the water, a negative impact to this species may occur. Those actions which may adversely affect this species and constitute a taking, are not covered within this scope of this determination in this PBA. If an emergency situation occurs, immediate consultation with the USFWS will be required.

Razorback suckers have been documented north of the APE near Needles, California. There is a high likelihood for this species to utilize the mainstem Colorado River as will as the backwater areas of Park Moabi and the Topock Marina. Future project activities are anticipated to occur in the Colorado River and within the 100-year floodplain. However, the light magnitude of small scale projects in the River; the minimal amount of riparian habitat altered in the 100-year floodplain; and accompanied by the conservation measures described above, the effects of project activities to the razorback sucker could not be meaningfully measured, detected or evaluated and are not expected to occur. Therefore, any potential direct or indirect effects from project activities are either insignificant or discountable. An effects determination of "may effect, but not likely to adversely affect" is concluded for this species.

5.4.3 Bonytail Chub (*Gila elegans*)

5.4.3.1 Status

The bonytail chub was listed as a federally endangered species on April 24, 1980, with an effective date of May 23, 1980. The Bonytail Chub Recovery Plan was updated in 1990 (USFWS, 1990a). The recovery plan was supplemented with the Upper Colorado River Endangered Fish Recovery Program (USFWS, 2001a) and the Bonytail Chub Recovery goals (SWCA, 2001). The bonytail chub was listed as endangered by the state of California in 1974.

Critical habitat was designated in six river reaches in the historic range of the bonytail chub on March 21, 1994, with an effective date of April 20, 1994, in designated portions of the Colorado, Green, and Yampa Rivers in the Upper Basin and the Colorado River in the Lower Basin (USFWS, 1994c). In relation to the APE, critical habitat includes the Colorado River and the 100-year floodplain (see Figure 8) from Parker Dam to the northern boundary of the HNWR just south of Needles, CA.

The trend for the bonytail chub is for a continued rangewide decrease in wild populations due to lack of sufficient recruitment of young adults with the loss of old adults due to natural mortality. Like the razorback sucker, the primary limiting factor for bonytail appears to be nonnative fish predation of the early life stages (USFWS, 2005a).

5.4.3.2 Natural History, Distribution, Abundance and Habitat

In appearance, bonytail are gray to gray-green on the dorsal, with silvery sides fading to a white ventral surface. The fish is elongated and somewhat laterally compressed with a narrow caudal peduncle. Adults are from 11 to 13 inches in length, although larger individuals (up to 24 inches) are occasionally identified. A smooth predorsal hump is present in the adult form. Breeding males can be distinguished by reddish marks on the paired fins and the presence of tubercles anterior on the body (Vanicek, 1967).

In Lake Mohave, spawning has been observed during the month of May, while in the upper Green River, spawning occurs in June and July at water temperatures of about 18 degrees Celsius (64 degrees Fahrenheit) (Minckley, 1973). Eggs are scattered over the bottom; no parental care occurs. Cold water released below dams precludes successful hatching of eggs (Bagley, 1989).

The bonytail was once widely distributed throughout the Colorado River and its main tributaries, to include the Green River in Utah and Wyoming, and the Colorado, Gila, Salt, and Verde rivers in Arizona. Currently, this species is found only in isolated populations in the Yampa River, Green River, Colorado River at the Colorado/Utah border, and at the confluence of the Green and Colorado Rivers. In the lower basin, the bony tail is found only in Lake Mohave with possible individuals between Parker Dam and Davis Dam (AGFD, 2001). They were still abundant in Lake Mead after the completion of Hoover Dam; however, by 1950 they were considered rare. By the time concern was raised for this fish, it had disappeared from much of its range. Loss of the extant wild populations is expected.

Extinction of this fish in the wild throughout its historic range is being forestalled by the stocking of subadult fish into the Upper Colorado River Basin and Lakes Mohave and Havasu in the Lower Colorado River (USFWS, 2005a). These stockings are intended to create populations of young adults that may be expected to persist for 40 to 50 years. While it is expected that these young adults will reproduce, the successful recruitment of wild born young fish to the population may not occur without additional management of habitat and biological factors. Management and research on these populations will be critical to provide for the survival and recovery of the species. Of vital importance to the stocking program is maintenance and enhancement of the existing bonytail broodstock (USFWS, 2005a).

5.4.3.3 Recent Findings

A portion of APE is within the 100-year floodplain of the Colorado River that delineates critical habitat for the bonytail chub (Figure 8). From south to north, this area extends from a river-associated wetland (described in the Yuma clapper rail section 5.3.1) to a deep sand and drier environment of dredge spoils deposited by the Army Corps of Engineers from excavating the river channel. The gradient ranges from river level to possibly 20 feet created by the dredge spoils. The dredge spoils environment can be described as sand, tamarisk and arrowweed. This is detailed in greater depth within the SWFL section 5.2.1. The mouths of the washes have channels and bridges that would allow water to flood these areas if a larger event was to occur. The lower ends of the washes are composed of tamarisk and water. Normally, except for isolated rain events, there is no overland flow connectivity to the river.

The Lower Colorado River supports the largest remaining populations of bonytail chub. The populations consist primarily of sub-adults. In 2005, eight individuals were captured and released near Park Moabi (Fitzpatrick, 2006), increasing the likelihood of individuals being present in the APE.

5.4.3.4 Direct Effects

Direct effects are those that are caused by the proposed action and occur at the same time and place. Activities that may occur in the Colorado River include seismic bedrock studies and pore water studies. The 2005 pore water study was issued a no effect determination (USFWS, 2005e).

Activities that may occur within the 100-year floodplain and critical habitat include floodplain groundwater monitoring programs, IM No. 3 floodplain operations, floodplain soil sampling, slant drilling, floodplain well installations, activities similar to the pore water study, and floodplain restoration.

Seismic studies will be similar to the 2005 pore water study that was issued a no effect determination by the USFWS (USFWS, 2005e). The seismic studies involve a small boat that will be used to submerge the seismic equipment within a portion of the Colorado River. The equipment that will be used for the study creates an acoustical pulse that is similar to that used by a recreational fish finder. The seismic studies will be performed during the winter season and completed before February 1 when feasible. Up river migration, spawning, and down river migration of adult and fry bonytail chubs are expected to occur between February 1 and May 31; therefore, seismic studies between June 1 and January 31 will have no affect upon this species (Adams, 2006). Conversely, activities within the Colorado River that are conducted during the spawning and migration period may affect this species.

The project activities proposed by PG&E will occasionally involve the use of heavy equipment including but not limited to backhoes and drill rigs that may be used to remove vegetation, grade the ground surface, and drill groundwater monitoring wells within the general and 100-year floodplain. Smaller equipment such as bobcats and quad-runners are also used to transport personnel and well sampling tools. This equipment can create disturbance to the ground and vegetation that may reduce the function of the riparian zone to contribute nutritional attributes to the river. However, the magnitude of riparian function that may be reduced by the proposed action is not expected to impact the bonytail chub due to limited project-related activities and associated minor footprints directly adjacent to the Colorado River. Additionally, a 2.5 acre floodplain vegetation removal threshold has been established to minimize any reduced function of the riparian zone.

5.4.3.5 Indirect Effects

Indirect effects are those that are caused by the proposed action and are later in time, but reasonably certain to occur. All proposed activities will take place outside the Colorado River with the exception of activities similar to the prior pore water study, which in 2005 received a no effect determination (USFWS, 2005e). No changes in land use patterns are foreseen. No indirect effects are anticipated.

5.4.3.6 Cumulative Effects

Cumulative effects are of those future state and private activities, not involving federal activities, that are reasonably certain to occur within the action area of the federal action subject to consultation. It is expected that all the activities will take place outside the Colorado River with the exception of those similar to the prior pore water study, which in 2005 received a no effect determination (USFWS, 2005e).

The project actions that may occur within the APE are focused at the cleanup of hexavalent chromium within the groundwater. It is reasonably certain that additional investigative and remedial activities beyond, yet similar to, those actions that have been implemented to date will occur. These actions will occur within the 100-year floodplain, designated as critical habitat, and involve heavy equipment including but not limited to backhoes and drill rigs that may be used to remove vegetation, grade the ground surface, and drill groundwater monitoring wells on the California and Arizona floodplains. Smaller equipment such as bobcats and quad-runners are also used to transport personnel and well sampling tools. This equipment can create disturbance to the ground and vegetation that may reduce the function of the riparian zone to contribute nutritional attributes to the river. However, the magnitude of riparian function that may be reduced by the proposed action is not expected to impact the bonytail chub due to limited project-related activities and associated minor footprints directly adjacent to the Colorado River. Additionally, a 2.5 acre floodplain vegetation removal threshold has been established to minimize any reduced function of the riparian zone.

Future state and private actions separate from PG&E that are reasonably certain to occur within the project vicinity include continued recreational activities associated with the Colorado River such as boating, camping, and fishing. Additionally, operations and maintenance of existing infrastructure such as the gas pipelines, railroad, Interstate 40 and other nearby roads and utilities are anticipated.

No changes in land use or water use patterns are foreseen.

5.4.3.7 Critical Habitat Effects Determination

Critical habitat in relationship to the APE includes the 100-year floodplain of the Colorado River (see Figure 8) from Parker Dam to the northern boundary of the HNWR south of Needles, CA. Project activities will be occurring within this designation. However, based on the small footprint of project activities; the limited amount of vegetation removal within the

100-year floodplain; and accompanied by the below conservation measures, no appreciable diminishment to critical habitat function is expected nor could be meaningfully measured, detected or evaluated. Therefore, any potential direct or indirect effects of project activities to critical habitat for the bonytail chub are either insignificant or discountable. An effects determination of "may affect, but not likely to adversely affect" is concluded for critical habitat of this species.

5.4.3.8 Effects Determination

Under this PBA the following conservation measures, not replacing those already identified, will be imposed.

1. The intent of PG&E will be to minimize the net increase of disturbed habitat in the APE.
2. If greater than 2.5 acres of habitat within the general and 100-year floodplain is destroyed or manipulated, specific project consultation with the USFWS will be required and possible mitigation may be required.
3. If additional actions are proposed within the Colorado River beyond those described for the pore water study, consultation will be required to be reinitiated at that time.
4. Proposed project activities within the Colorado River should preferably occur between June 1 and January 31. Project activities that differ from the pore water study and which are proposed to occur between February 1 and May 31 will require further consultation.
5. In the event an emergency situation (such as a spill into the Colorado River), where actions to abate the problem are to occur along the shoreline/river interface or in the water, a negative impact to this species may very well occur. Those actions that may adversely affect this species and constitute a taking, are not covered within this scope of this determination in this PBA. If an emergency situation occurs, immediate consultation with the USFWS will be required.

Bonytail chubs have been captured and released near Park Moabi making the likelihood for this species to utilize the mainstem Colorado River and backwater areas (near Park Moabi and Topock Marina) within and near the APE a possibility. Future project activities are anticipated to occur in the Colorado River and within the 100-year floodplain. However, the light magnitude of the small scale projects in the River; the minimal amount of riparian habitat altered in the 100-year floodplain; and accompanied by the conservation measures described above, the effects of project activities to the bonytail chub could not be meaningfully measured, detected, or evaluated and are not expected to occur. Therefore, any potential direct or indirect effects from project activities are either insignificant or discountable. An effects determination of "may affect, but not likely to adversely affect" is concluded for this species.

6.0 Effects Determination Summary

6.1 Southwestern Willow Flycatcher

An effects determination of “may affect, but not likely to adversely affect” is concluded for the southwestern willow flycatcher.

A critical habitat effects determination of “no effect” is concluded for this species.

6.2 Mojave Desert Tortoise

An effects determination of “may affect, but not likely to adversely affect” is concluded for the Mojave desert tortoise.

A critical habitat effects determination of “no effect” is concluded for this species.

6.3 Yuma Clapper Rail

An effects determination of “may affect, but not likely to adversely affect” is concluded for the Yuma clapper rail.

A critical habitat effects determination of “no effect” is concluded for this species.

6.4 Colorado Pikeminnow

An effects determination of “no effect” is concluded for the Colorado pikeminnow.

A critical habitat effects determination of “no effect” is concluded for this species.

6.5 Razorback Sucker

An effects determination of “may affect, but not likely to adversely affect” is concluded for the razorback sucker.

A critical habitat effects determination of “no effect” is concluded for this species.

6.6 Bonytail Chub

An effects determination of “may affect, but not likely to adversely affect” is concluded for the bonytail chub.

A critical habitat effects determination of “may affect, but not likely to adversely affect” is concluded for this species.

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Tables

TABLE 1
Planned Remedial and Investigative Actions in the APE

Planned Actions [a]	Estimated Short-Term Area Affected (Acres) [b]	Estimated Long-Term Area Affected (Acres) [b]
Soil Sampling [c]	0.5	0.00
Groundwater Wells [d]	4.5	<0.1
In Situ Pilot Study (Upland)	0.25	<0.1
Maintenance and Other	<1.0	<1.0
Unspecified	6.0	4.0
Pipelines	2.0	<1.0
Restoration Activities [e]	10.0	0.0

Notes:

[a] Access to planned activity areas will occur mainly along existing access routes and/or preapproved travel corridors.

[b] Because planned activities will be sited in previously used areas to the extent possible, total impacts to vegetation communities would be less than the affected acreage noted above; no more than 2.5 acres of salt cedar (on the floodplain) and 3 acres of creosote bush scrub (in uplands) are anticipated to be impacted by planned activities.

[c] Up to 200 samples, each within a 10-foot-diameter area.

[d] Up to 30 groundwater well clusters installed, each requiring a 0.15-acre area during construction and occupying 100 square feet thereafter (CH2M HILL, 2005c, 2005d, 2005h).

[e] Restoration activities will restore designated areas to preconstruction conditions.

TABLE 2
Salt Cedar Thickets

Location	Contiguous Acreage	Percent of APE [a]
BNSF Railway and I-40	5.8	0.4
Bat Cave Wash	5.1	0.4
Unnamed Wash	2.7	0.2
Park Moabi Marina	6.9	0.5
Arizona Portion of HNWR	30.7	2.2

[a] Percent of APE does not include aquatic habitats (e.g., Colorado River) in total area.

Figures

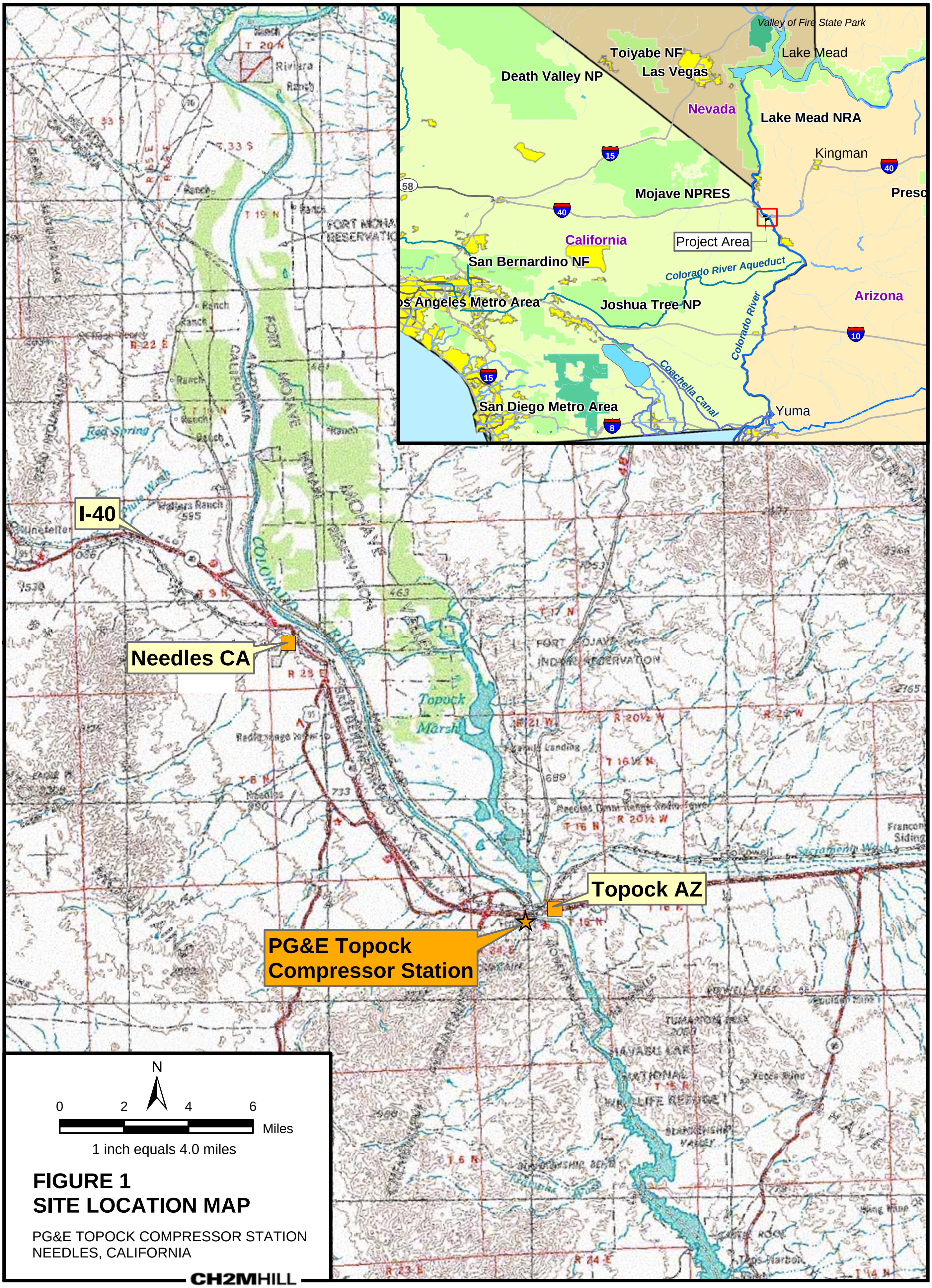

FIGURE 1
SITE LOCATION MAP

PG&E TOPOCK COMPRESSOR STATION
NEEDLES, CALIFORNIA

CH2MHILL

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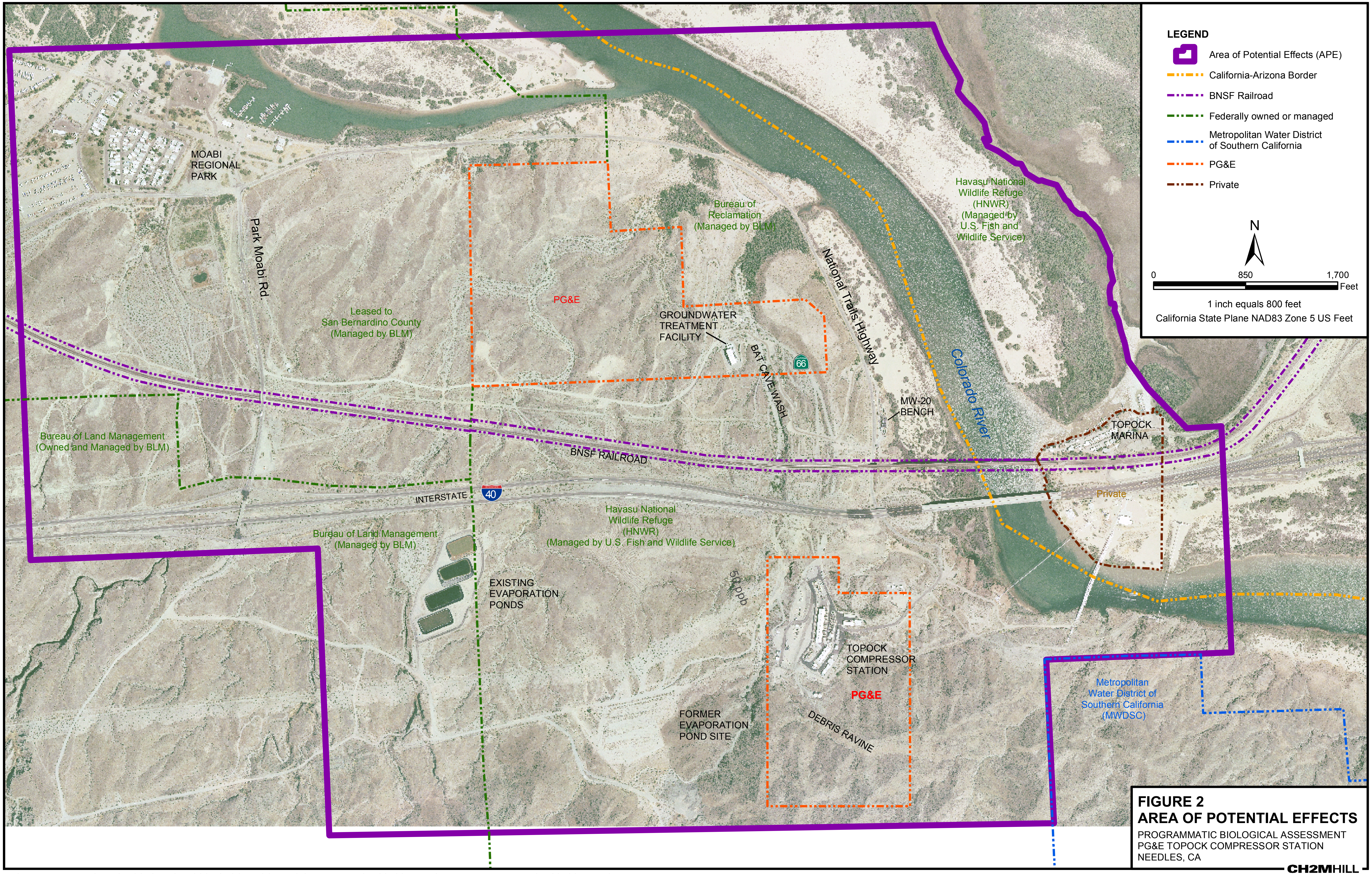

FIGURE 2
AREA OF POTENTIAL EFFECTS

PROGRAMMATIC BIOLOGICAL ASSESSMENT
PG&E TOPOCK COMPRESSOR STATION
NEEDLES, CA

CH2MHILL

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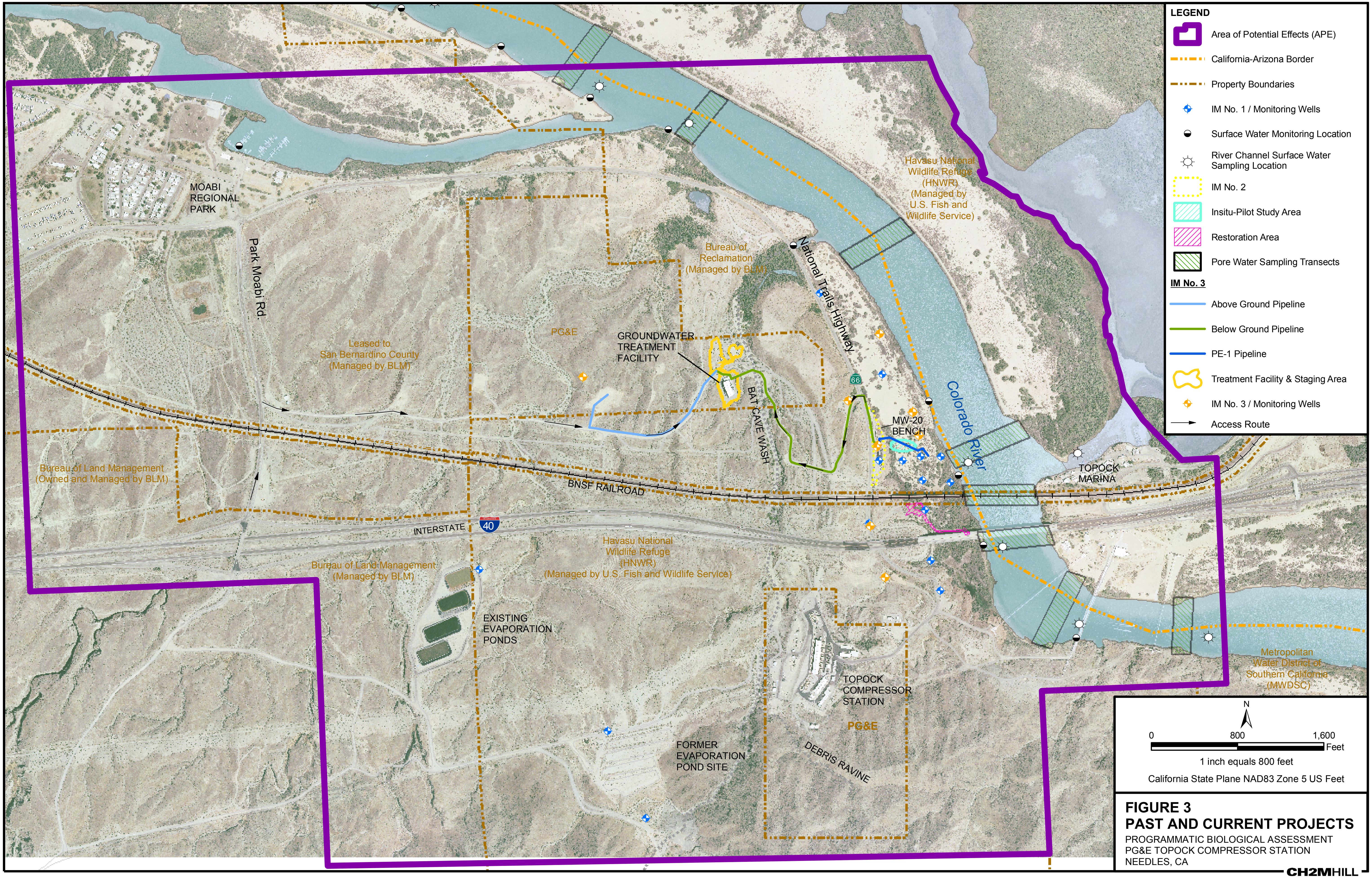

FIGURE 3
PAST AND CURRENT PROJECTS

PROGRAMMATIC BIOLOGICAL ASSESSMENT
PG&E TOPOCK COMPRESSOR STATION
NEEDLES, CA

CH2MHILL

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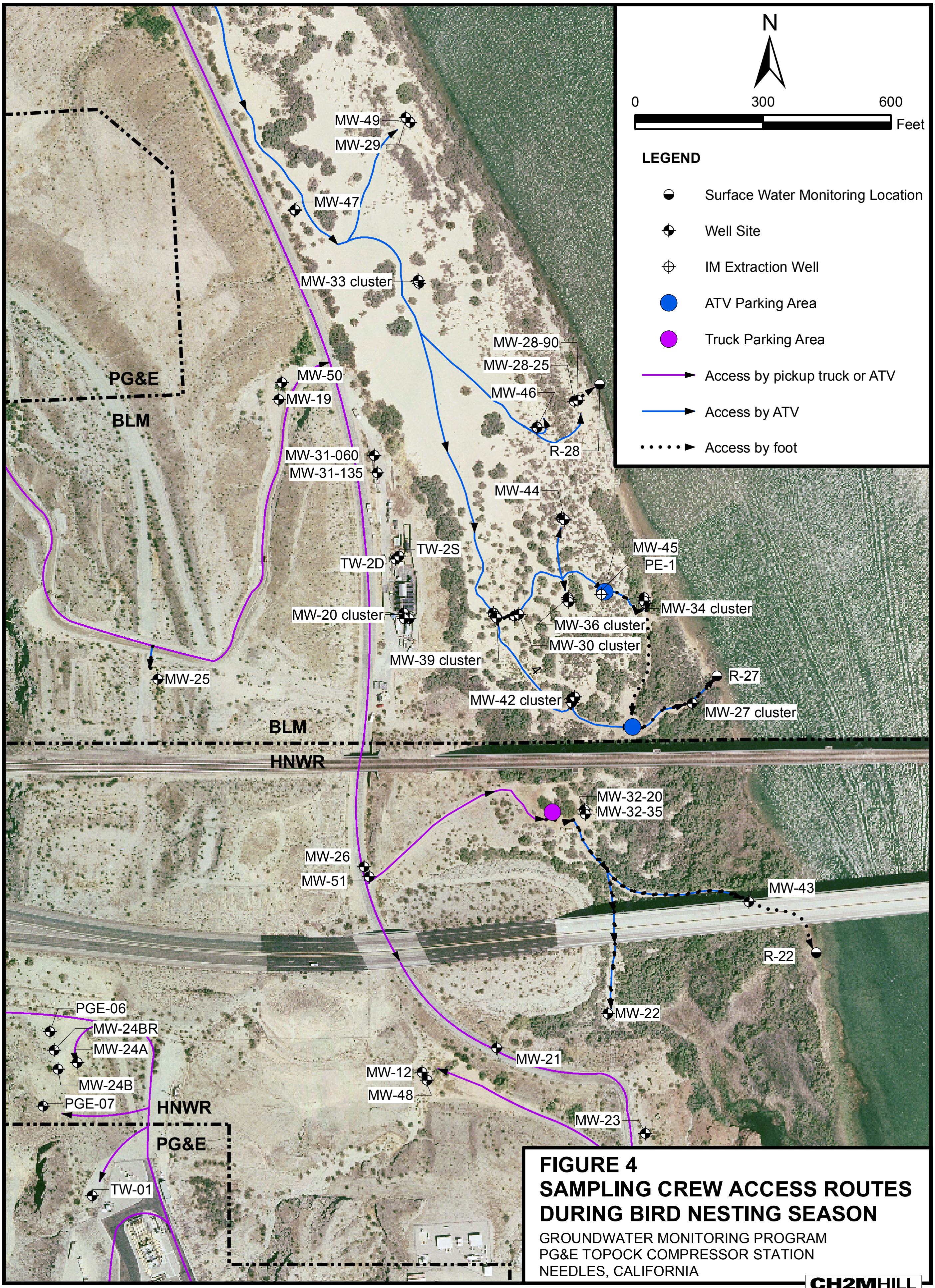

FIGURE 4
SAMPLING CREW ACCESS ROUTES DURING BIRD NESTING SEASON

GROUNDWATER MONITORING PROGRAM
PG&E TOPOCK COMPRESSOR STATION
NEEDLES, CALIFORNIA

CH2MHILL

BAO \\ZINFANDEL\PROJ\PACIFICGASELECTRICCO\TOPOCKPROGRAM\GIS\MXD\2006\IM3_CORRECTIVE_MEASURES_ACCESS_ROADS.MXD
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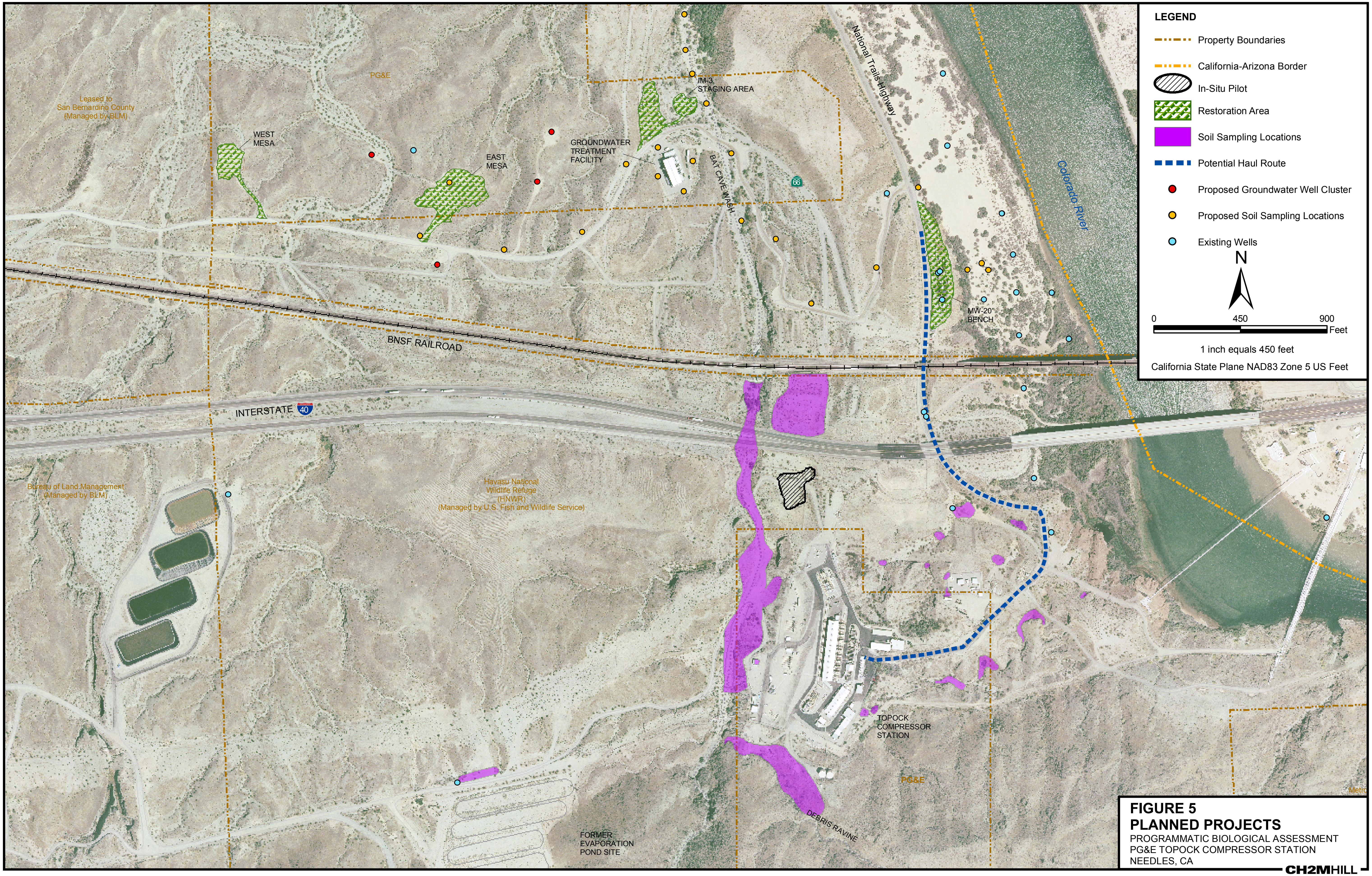
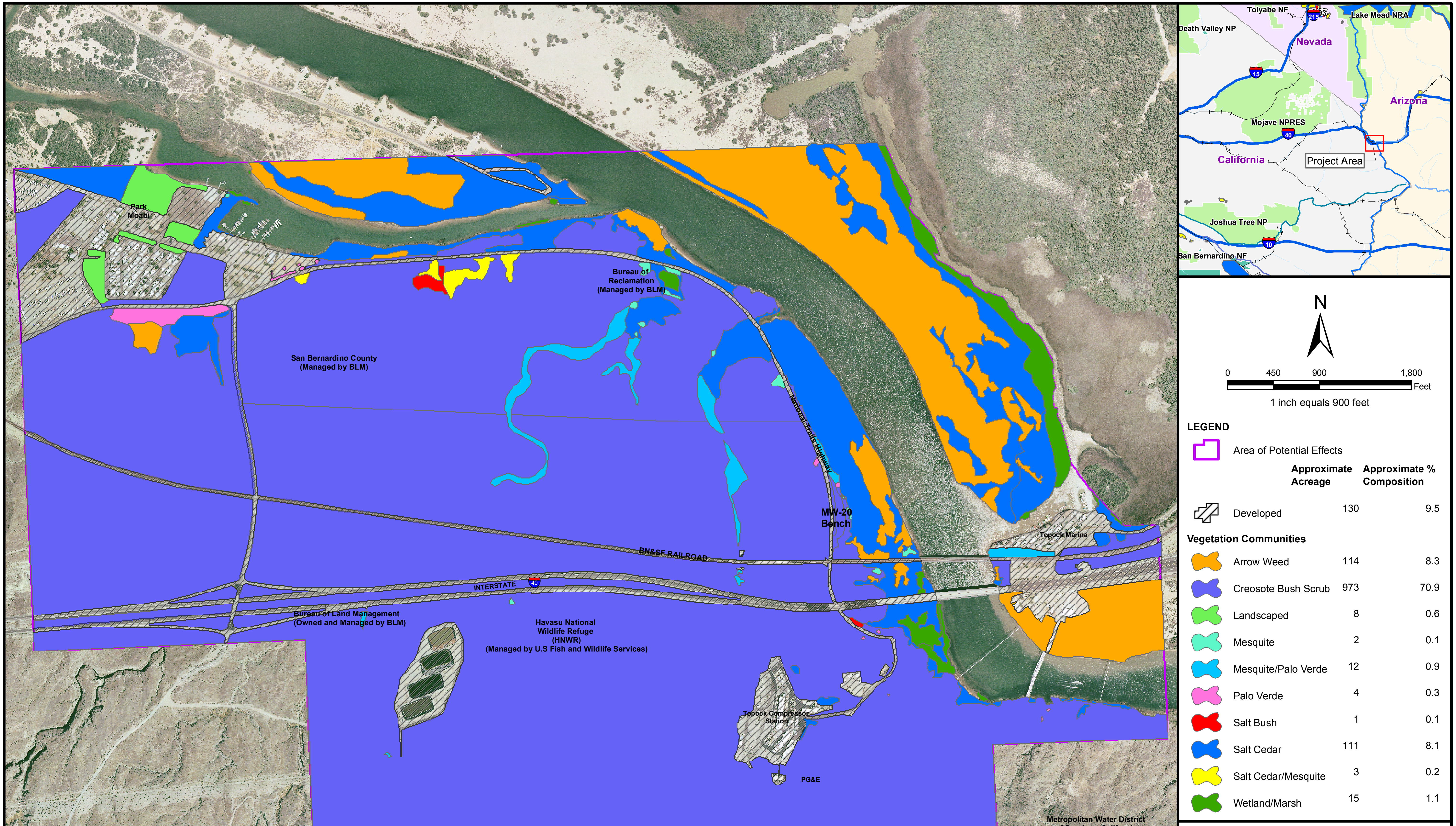


FIGURE 5
PLANNED PROJECTS

PROGRAMMATIC BIOLOGICAL ASSESSMENT
PG&E TOPOCK COMPRESSOR STATION
NEEDLES, CA

BAO \\ZINFANDEL\PROJ\PACIFICGASELECTRICCO\TOPOCKPROGRAM\GIS\MXD\2006\BIO_ASSESSMENT_PLANNEDPROJECTS.MXD BIO_ASSESSMENT_PLANNEDPROJECTS.PDF 12/7/2006 09:54:35



LEGEND

		Approximate Acreage	Approximate % Composition
▭	Area of Potential Effects		
▨	Developed	130	9.5
	Vegetation Communities		
	Arrow Weed	114	8.3
	Creosote Bush Scrub	973	70.9
	Landscaped	8	0.6
	Mesquite	2	0.1
	Mesquite/Palo Verde	12	0.9
	Palo Verde	4	0.3
	Salt Bush	1	0.1
	Salt Cedar	111	8.1
	Salt Cedar/Mesquite	3	0.2
	Wetland/Marsh	15	1.1

FIGURE 6
TOPOCK VEGETATION COMMUNITIES, MAY 2006

PROGRAMMATIC BIOLOGICAL ASSESSMENT
PG&E TOPOCK COMPRESSOR STATION
NEEDLES, CALIFORNIA

CH2MHILL

BAO \\ZINFANDEL\PROJ\PACIFICGASELECTRICCO\TOPOCKPROGRAM\GIS\MXD\2006\BIO_ASSESSMENT_VEG_COMMUNITIES.MXD BIO_ASSESSMENT_VEG_COMMUNITIES.PDF 12/6/2006 15:24:30

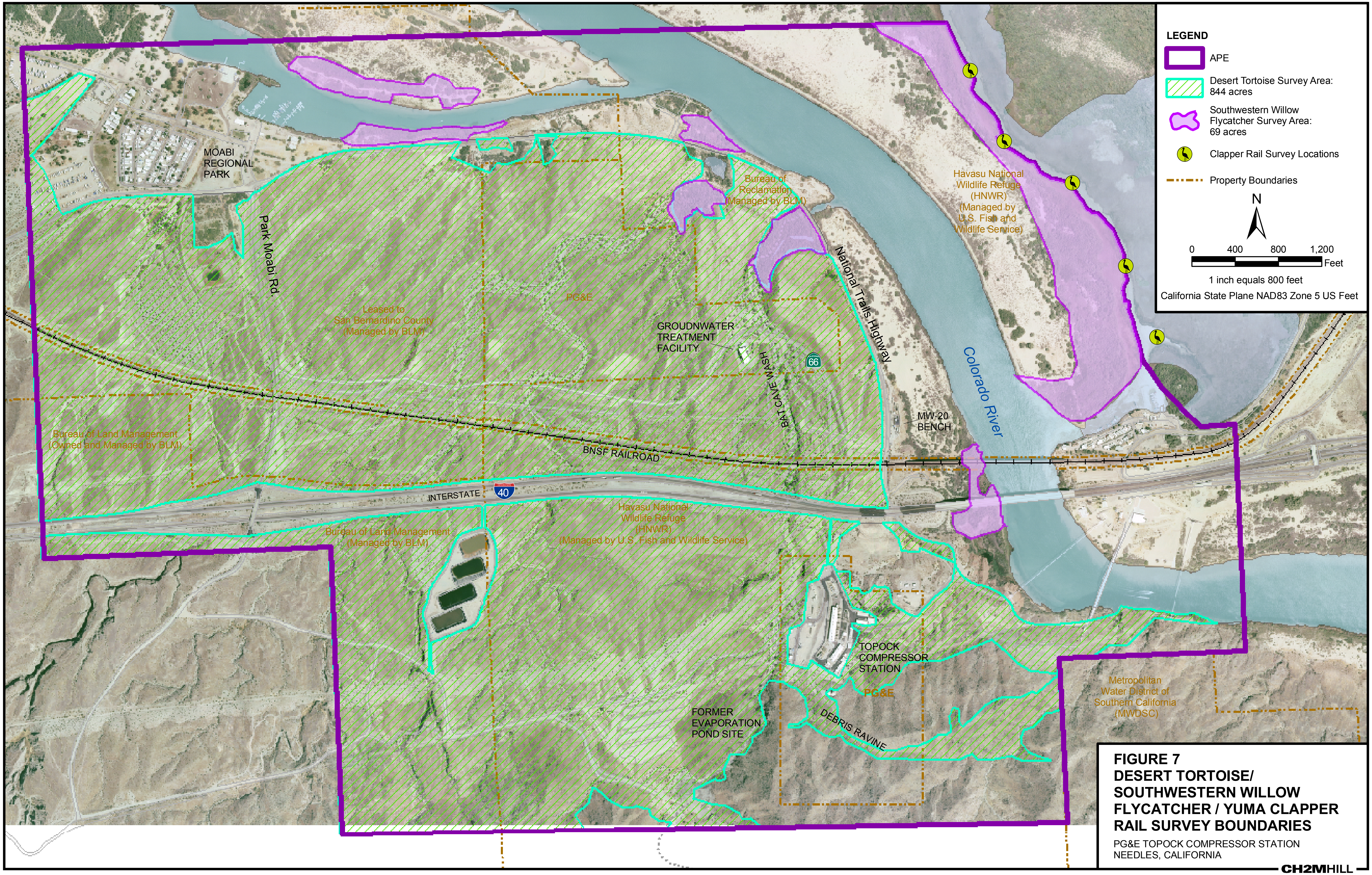


FIGURE 7
DESERT TORTOISE/ SOUTHWESTERN WILLOW FLYCATCHER / YUMA CLAPPER RAIL SURVEY BOUNDARIES

PG&E TOPOCK COMPRESSOR STATION
NEEDLES, CALIFORNIA

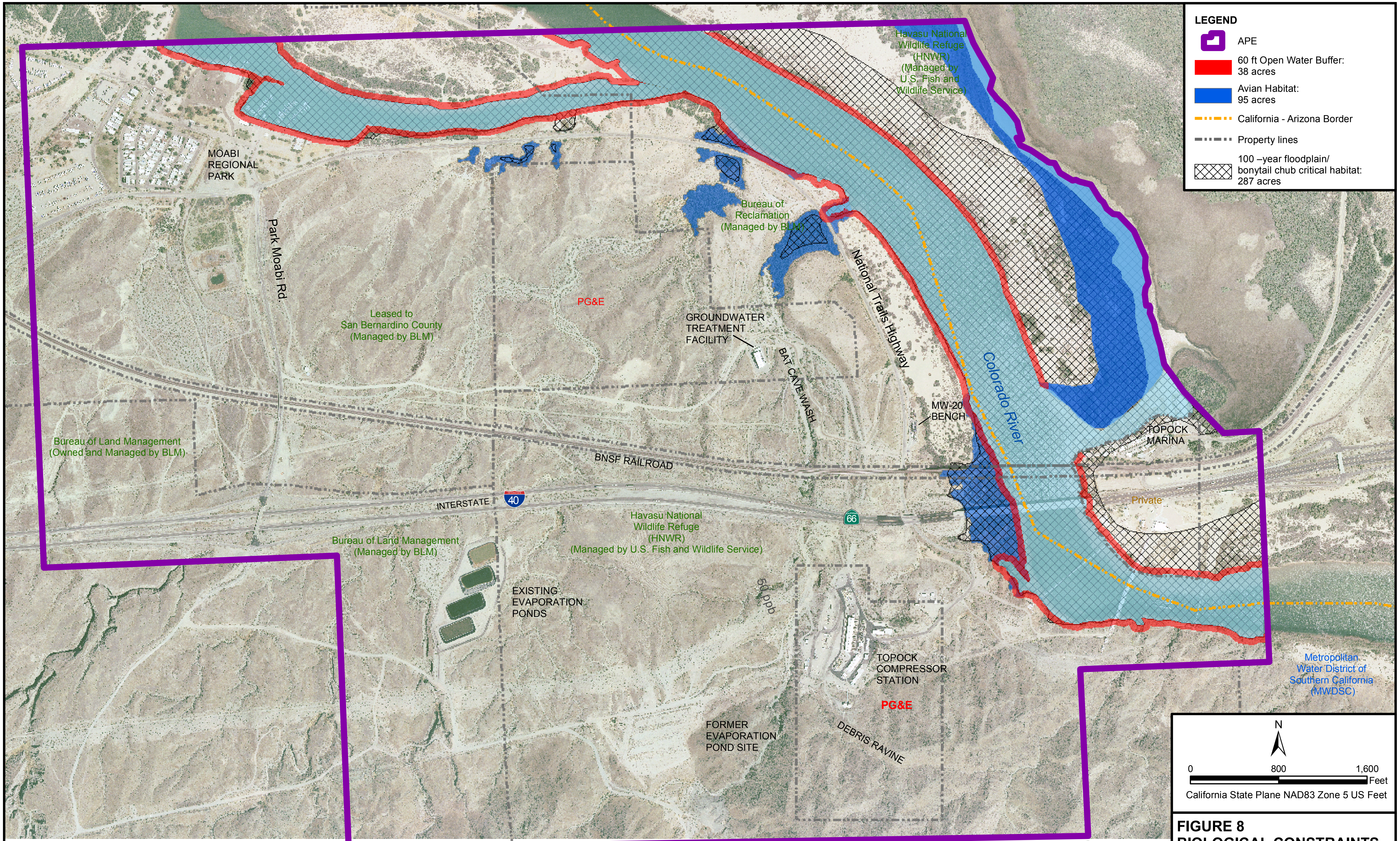


FIGURE 8
BIOLOGICAL CONSTRAINTS
PROGRAMMATIC BIOLOGICAL ASSESSMENT
PG&E TOPOCK COMPRESSOR STATION
NEEDLES, CA

CH2MHILL

BAO \\ZINFANDEL\PROJ\PACIFICGASELECTRICCO\TOPOCKPROGRAM\GIS\MXD\2006\BIO_ASSESSMENT_SENSITIVE_AREAS.MXD BIO_ASSESSMENT_SENSITIVE_AREAS.PDF 12/11/2006 10:23:33

APPENDIX WQ

Hydrology and Water Quality

Table 1
Summary of Surface Water Sampling Results – Chromium, Other Metals, Specific Conductance, and pH, July 1997 through October 2007

	Hexavalent Chromium (µg/L)		Dissolved Total Chromium (µg/L)		Dissolved Copper (µg/L)		Dissolved Nickel (µg/L)		Dissolved Zinc (µg/L)		Dissolved Lead (µg/L)		Specific Conductance (µS/cm)		pH (pH Units)	
Chemical-Specific ARAR[1]	11		50		23		132		297		8		900-1600		6.5-8.5	
Station ID[2]	**Frequency of Detection[3] (Number of Detects/Number of Samples) and Average Concentration[4]**															
Shoreline Surface Water Locations																
Needles Gauge	0 \ 2	ND	0 \ 2	ND	0 \ 0	---	0 \ 0	---	0 \ 0	---	0 \ 0	---	0 \ 0	---	0 \ 0	---
NR-3	0 \ 41	ND	0 \ 42	ND	0 \ 2	ND	0 \ 2	ND	1 \ 2	166	0 \ 0	---	15 \ 15	1000	14 \ 14	8.20
NR-2	0 \ 43	ND	1 \ 44	0.65	0 \ 2	ND	0 \ 2	ND	1 \ 2	54.7	0 \ 0	---	15 \ 15	1010	14 \ 14	8.22
NR-1	0 \ 43	ND	1 \ 44	0.627	0 \ 2	ND	0 \ 2	ND	1 \ 2	51.1	0 \ 0	---	15 \ 15	1020	14 \ 14	8.20
A-Dock	0 \ 6	ND	0 \ 6	ND	2 \ 4	5.42	0 \ 4	ND	4 \ 4	9.25	0 \ 1	ND	4 \ 4	944	4 \ 4	8.02
CON	0 \ 70^	ND	6 \ 71	3.42	12 \ 28	5.85	10 \ 28	7.82	22 \ 28	47.1	1 \ 3	2.33	38 \ 38	1130	37 \ 37	8.09
Seasonal Wetlands	0 \ 8	ND	0 \ 8	ND	5 \ 8	11.4	2 \ 8	23.8	5 \ 8	9.97	1 \ 1	2.60	8 \ 8	4800	8 \ 8	7.97
RRB	0 \ 57^	ND	8 \ 58	3.47	7 \ 22	5.85	11 \ 22	9.28	19 \ 22	102	1 \ 1	2.00	30 \ 30	1100	29 \ 29	8.06
R-19	0 \ 1	ND	0 \ 1	ND	0 \ 1	ND	0 \ 1	ND	0 \ 1	ND	0 \ 0	---	1 \ 1	888	1 \ 1	7.43
R-19-B	0 \ 2	ND	0 \ 2	ND	1 \ 2	4.75	0 \ 2	ND	0 \ 2	ND	0 \ 0	---	2 \ 2	896	2 \ 2	7.79
R-19-C	0 \ 2	ND	0 \ 2	ND	0 \ 2	ND	0 \ 2	ND	1 \ 2	3.20	0 \ 0	---	2 \ 2	892	2 \ 2	7.84
R-28	0 \ 62^	ND	7 \ 63	3.49	6 \ 22	5.38	11 \ 22	8.80	18 \ 22	96.4	0 \ 0	---	32 \ 32	1020	31 \ 31	8.20
R-20	0 \ 1	ND	0 \ 1	ND	0 \ 1	ND	0 \ 1	ND	0 \ 1	ND	0 \ 0	---	1 \ 1	902	1 \ 1	7.95
R-20-B	0 \ 2	ND	0 \ 2	ND	1 \ 2	5.65	1 \ 2	12.3	1 \ 2	5.90	0 \ 0	---	2 \ 2	893	2 \ 2	7.84
R-20-C	0 \ 2	ND	0 \ 2	ND	0 \ 2	ND	0 \ 2	ND	1 \ 2	3.05	0 \ 0	---	2 \ 2	891	2 \ 2	7.77
R-27	0 \ 65^	ND	6 \ 66	2.84	8 \ 22	5.95	9 \ 22	7.07	19 \ 22	57.2	0 \ 0	---	32 \ 32	958	31 \ 31	8.18
R-22	0 \ 64^	ND	7 \ 65	2.85	11 \ 22	13.2	11 \ 22	8.58	19 \ 22	54.0	0 \ 0	---	32 \ 32	972	32 \ 32	8.21
I-3	0 \ 65^	ND	7 \ 66	3.33	12 \ 26	5.47	7 \ 26	7.73	20 \ 26	38.3	0 \ 3	ND	37 \ 37	951	35 \ 35	8.18
In-Channel Surface Water Locations																
C-NR4	0 \ 52	ND	0 \ 52	ND	0 \ 0	---	0 \ 0	---	0 \ 0	---	0 \ 0	---	30 \ 30	1030	30 \ 30	8.34
C-NR3	0 \ 52	ND	0 \ 52	ND	0 \ 0	---	0 \ 0	---	0 \ 0	---	0 \ 0	---	30 \ 30	1030	30 \ 30	8.34
C-NR1	0 \ 52	ND	0 \ 52	ND	0 \ 0	---	0 \ 0	---	0 \ 0	---	0 \ 0	---	30 \ 30	1030	30 \ 30	8.34
C-CON	0 \ 52	ND	0 \ 52	ND	0 \ 0	---	0 \ 0	---	0 \ 0	---	0 \ 0	---	30 \ 30	1050	30 \ 30	8.15
C-MAR	0 \ 26	ND	0 \ 26	ND	0 \ 0	---	0 \ 0	---	0 \ 0	---	0 \ 0	---	13 \ 13	1110	13 \ 13	7.97
C-R27	0 \ 47	ND	0 \ 47	ND	0 \ 0	---	0 \ 0	---	0 \ 0	---	0 \ 0	---	26 \ 26	1000	26 \ 26	8.19
C-R22	1 \ 59	0.119	0 \ 59	ND	0 \ 0	---	0 \ 0	---	0 \ 0	---	0 \ 0	---	30 \ 30	999	30 \ 30	8.19
C-I-3	0 \ 52	ND	0 \ 52	ND	0 \ 0	---	0 \ 0	---	0 \ 0	---	0 \ 0	---	30 \ 30	995	30 \ 30	8.19
C-TAZ	0 \ 49	ND	0 \ 52	ND	0 \ 0	---	0 \ 0	---	0 \ 0	---	0 \ 0	---	30 \ 30	993	30 \ 30	8.20
Pore Water Study Surface Water Locations																
SW-1B	0 \ 1	ND	0 \ 1	ND	0 \ 0	---	0 \ 0	---	0 \ 0	---	0 \ 0	---	1 \ 1	1000	1 \ 1	8.15
SW-2B	0 \ 1	ND	0 \ 1	ND	0 \ 0	---	0 \ 0	---	0 \ 0	---	0 \ 0	---	1 \ 1	999	1 \ 1	8.16
SW-3B	0 \ 1	ND	0 \ 1	ND	0 \ 0	---	0 \ 0	---	0 \ 0	---	0 \ 0	---	1 \ 1	980	1 \ 1	8.12
SW-4B	0 \ 1	ND	0 \ 1	ND	0 \ 0	---	0 \ 0	---	0 \ 0	---	0 \ 0	---	1 \ 1	1000	1 \ 1	8.10
SW-5B	0 \ 1	ND	0 \ 1	ND	0 \ 0	---	0 \ 0	---	0 \ 0	---	0 \ 0	---	1 \ 1	998	1 \ 1	8.14
SW-6B	0 \ 1	ND	0 \ 1	ND	0 \ 0	---	0 \ 0	---	0 \ 0	---	0 \ 0	---	1 \ 1	992	1 \ 1	8.11
SW-7B	0 \ 1	ND	0 \ 1	ND	0 \ 0	---	0 \ 0	---	0 \ 0	---	0 \ 0	---	1 \ 1	1000	1 \ 1	7.96

Table 1
Summary of Surface Water Sampling Results – Chromium, Other Metals, Specific Conductance, and pH, July 1997 through October 2007

	Hexavalent Chromium (µg/L)		Dissolved Total Chromium (µg/L)		Dissolved Copper (µg/L)		Dissolved Nickel (µg/L)		Dissolved Zinc (µg/L)		Dissolved Lead (µg/L)		Specific Conductance (µS/cm)		pH (pH Units)	
Chemical-Specific ARAR[1]	11		50		23		132		297		8		900-1600		6.5-8.5	
Station ID[2]	**Frequency of Detection[3] (Number of Detects/Number of Samples) and Average Concentration[4]**															
SW-8B	0 \ 1	ND	0 \ 1	ND	0 \ 0	---	0 \ 0	---	0 \ 0	---	0 \ 0	---	1 \ 1	995	1 \ 1	8.20
SW-9B	0 \ 1	ND	0 \ 1	ND	0 \ 0	---	0 \ 0	---	0 \ 0	---	0 \ 0	---	1 \ 1	1010	1 \ 1	8.11
SW-10B	0 \ 1	ND	0 \ 1	ND	0 \ 0	---	0 \ 0	---	0 \ 0	---	0 \ 0	---	1 \ 1	1010	1 \ 1	8.06
SW-11B	0 \ 1	ND	0 \ 1	ND	0 \ 0	---	0 \ 0	---	0 \ 0	---	0 \ 0	---	1 \ 1	1000	1 \ 1	8.13
SW-12B	0 \ 1	ND	0 \ 1	ND	0 \ 0	---	0 \ 0	---	0 \ 0	---	0 \ 0	---	1 \ 1	999	1 \ 1	8.16
SW-13B	0 \ 1	ND	0 \ 1	ND	0 \ 0	---	0 \ 0	---	0 \ 0	---	0 \ 0	---	1 \ 1	1000	1 \ 1	8.09
SW-14B	0 \ 1	ND	0 \ 1	ND	0 \ 0	---	0 \ 0	---	0 \ 0	---	0 \ 0	---	1 \ 1	998	1 \ 1	8.16
SW-15B	0 \ 1	ND	0 \ 1	ND	0 \ 0	---	0 \ 0	---	0 \ 0	---	0 \ 0	---	1 \ 1	1000	1 \ 1	8.14
SW-16B	0 \ 1	ND	0 \ 1	ND	0 \ 0	---	0 \ 0	---	0 \ 0	---	0 \ 0	---	1 \ 1	1010	1 \ 1	7.79

Notes:

ND	not detected
^	According to the data quality review for the June 2002 monitoring, the results were determined to be false positive due to unidentified interference for these samples, and no action should be taken or project decisions made based on the results. These results were not included in the statistical analyses.
µS/cm	microsiemens per centimeter
µg/L	micrograms per liter
---	not analyzed

At each of the river channel surface water locations, depth specific samples were collected at shallow (1 foot from water surface), middle, and deep depths (1 foot from river bottom). Results for each location summarize the samples collected at depth.

At locations R-19B, R-19C and R-20B, multiple samples were collected at surface, 5-foot, and 10-foot depths and locations. Results for each location summarized the samples collected at depth.

Refer to Appendix H for complete analytical data for surface water sampling.

1 Surface water chemical-specific ARARs. See Table 4.

2 Surface water locations are listed in order of their position on the river, from north to south.

3 Results listed for number of detections for primary samples collected during RFI, July 1997 through October 2007.

4 Average concentrations of all results (including estimated concentrations) in micrograms per liter, with half the reporting limit used for non detects. Detected results are the maximum concentrations from primary or duplicate samples.

Source: RCRA Facility Investigation/Remedial Investigation (Volume 2); PG&E Topock Compressor Station, Needles, California

Table 2
Surface Water Sampling Results - October 2006 through October 2007

Station ID	Sample Date	Hexavalent Chromium (µg/L)	Total Chromium (µg/L)	Specific Conductance (µS/cm)	pH (pH units)
Shoreline Surface Water Locations					
CON	10/04/2006	ND (0.2)	ND (1.0)	1010	8.01 R
CON	11/15/2006	ND (0.2)	ND (1.0)	---	---
CON	12/20/2006	ND (0.2)	ND (1.0)	927	8.17
CON	01/22/2007	ND (0.2)	ND (1.0)	---	---
CON	03/14/2007	ND (0.2)	ND (1.0)	949	8.25
CON	05/09/2007	ND (0.2)	ND (1.0)	949	8.23
CON	09/12/2007	ND (0.2)	ND (1.0)	1400	8.17 J
CON	09/14/2007	ND (0.2)	ND (1.0)	---	---
CON	09/26/2007	ND (0.2)	ND (1.0)	---	---
CON	10/03/2007	ND (0.2)	ND (1.0)	---	---
I-3	10/04/2006	ND (0.2)	ND (1.0)	1040	8.37 R
I-3	11/15/2006	ND (0.2)	ND (1.0)	---	---
I-3	12/20/2006	ND (0.2)	ND (1.0)	987	8.28
I-3	01/22/2007	ND (0.2)	ND (1.0)	---	---
I-3	03/13/2007	ND (0.2)	ND (1.0)	908	8.34
I-3	05/08/2007	ND (0.2)	ND (1.0)	957	8.29
I-3	09/11/2007	ND (0.2)	ND (1.0)	943	8.25 J
I-3	09/13/2007	ND (0.2)	ND (1.0)	---	---
I-3	09/25/2007	ND (0.2)	ND (1.0)	---	---
I-3	10/02/2007	ND (0.2)	ND (1.0)	---	---
NR-1	10/04/2006	ND (0.2)	ND (1.0)	1020	7.79 R
NR-1	11/15/2006	ND (0.2)	ND (1.0)	---	---
NR-1	12/20/2006	ND (0.2)	ND (1.0)	947	8.18
NR-1	01/22/2007	ND (0.2)	ND (1.0)	---	---
NR-1	03/14/2007	ND (0.2)	ND (1.0)	958	8.33
NR-1	05/09/2007	ND (0.2)	ND (1.0)	952	8.32
NR-1	09/12/2007	ND (0.2)	ND (1.0)	1330	8.08 J
NR-1	09/14/2007	ND (0.2)	ND (1.0)	---	---
NR-1	09/26/2007	ND (0.2)	ND (1.0)	---	---
NR-1	10/03/2007	ND (0.2)	ND (1.0)	---	---
NR-2	10/04/2006	ND (0.2)	ND (1.0)	1020	8.03 R
NR-2	11/15/2006	ND (0.2)	ND (1.0)	---	---
NR-2	12/20/2006	ND (0.2)	ND (1.0)	922	8.36
NR-2	01/22/2007	ND (0.2)	ND (1.0)	---	---
NR-2	03/14/2007	ND (0.2)	ND (1.0)	945	8.30
NR-2	05/09/2007	ND (0.2)	ND (1.0)	952	8.29
NR-2	09/12/2007	ND (0.2)	ND (1.0)	1390	8.07 J
NR-2	09/14/2007	ND (0.2)	ND (1.0)	---	---
NR-2	09/26/2007	ND (0.2)	ND (1.0)	---	---
NR-2	10/03/2007	ND (0.2)	ND (1.0)	---	---

Table 2
Surface Water Sampling Results - October 2006 through October 2007

Station ID	Sample Date	Hexavalent Chromium (µg/L)	Total Chromium (µg/L)	Specific Conductance (µS/cm)	pH (pH units)
Shoreline Surface Water Locations					
NR-3	10/04/2006	ND (0.2)	ND (1.0)	1020	8.11 R
NR-3	11/15/2006	ND (0.2)	ND (1.0)	---	---
NR-3	12/20/2006	ND (0.2)	ND (1.0)	925	8.35
NR-3	01/22/2007	ND (0.2)	ND (1.0)	---	---
NR-3	03/14/2007	ND (0.2)	ND (1.0)	942	8.30
NR-3	05/09/2007	ND (0.2)	ND (1.0)	950	8.27
NR-3	09/12/2007	ND (0.2)	ND (1.0)	1320	8.02 J
NR-3	09/14/2007	ND (0.2)	ND (1.0)	---	---
NR-3	09/26/2007	ND (0.2)	ND (1.0)	---	---
NR-3	10/03/2007	ND (0.2)	ND (1.0)	---	---
R-22	10/04/2006	ND (1.0)	ND (1.0)	1020	7.68
R-22	11/15/2006	ND (0.2)	ND (1.0)	---	---
R-22	12/20/2006	ND (0.2)	ND (1.0)	928	8.19
R-22	01/22/2007	ND (0.2)	ND (1.0)	---	---
R-22	03/13/2007	ND (0.2)	ND (1.0)	928	8.30
R-22	05/08/2007	ND (0.2)	ND (1.0)	958	8.30
R-22	09/11/2007	ND (0.2)	ND (1.0)	938	8.27 J
R-22	09/13/2007	ND (0.2)	ND (1.0)	---	---
R-22	09/25/2007	ND (0.2)	ND (1.0)	---	---
R-22	10/02/2007	ND (0.2)	ND (1.0)	---	---
R-27	10/04/2006	ND (0.2)	ND (1.0)	1020	8.45 R
R-27	11/15/2006	ND (0.2)	ND (1.0)	---	---
R-27	12/20/2006	ND (0.2)	ND (1.0)	911	8.21
R-27	01/22/2007	ND (0.2)	ND (1.0)	---	---
R-27	03/13/2007	ND (0.2)	ND (1.0)	956	8.31
R-27	05/08/2007	ND (1.0)	ND (1.0)	967	8.28
R-27	09/11/2007	ND (0.2)	ND (1.0)	934	8.30 J
R-27	09/13/2007	ND (0.2)	ND (1.0)	---	---
R-27	09/26/2007	ND (0.2)	ND (1.0)	---	---
R-27	10/02/2007	ND (0.2)	ND (1.0)	---	---
R-28	10/04/2006	ND (0.2)	ND (1.0)	1010	8.25 R
R-28	11/15/2006	ND (0.2)	ND (1.0)	---	---
R-28	12/20/2006	ND (0.2)	ND (1.0)	896	8.16
R-28	01/22/2007	ND (0.2)	ND (1.0)	---	---
R-28	03/14/2007	ND (0.2)	ND (1.0)	914	8.16
R-28	05/09/2007	ND (0.2)	ND (1.0)	951	8.27
R-28	09/12/2007	ND (0.2)	ND (1.0)	1240	8.20 J
R-28	09/13/2007	ND (0.2)	ND (1.0)	---	---
R-28	09/26/2007	ND (0.2)	ND (1.0)	---	---
R-28	10/03/2007	ND (0.2)	ND (1.0)	---	---

Table 2
Surface Water Sampling Results - October 2006 through October 2007

Station ID	Sample Date	Hexavalent Chromium (µg/L)	Total Chromium (µg/L)	Specific Conductance (µS/cm)	pH (pH units)
Shoreline Surface Water Locations					
RRB	10/04/2006	ND (0.2)	ND (1.0)	1070	7.90 R
RRB	11/15/2006	ND (0.2)	ND (1.0)	---	---
RRB	12/20/2006	ND (1.0)	ND (1.0)	3870	7.73
RRB	01/22/2007	ND (0.2)	ND (1.0)	---	---
RRB	03/14/2007	ND (0.2)	ND (1.0)	929	8.18
RRB	05/09/2007	ND (0.2)	ND (1.0)	947	8.13
RRB	09/12/2007	ND (0.2)	ND (1.0)	1310	7.92 J
RRB	09/14/2007	ND (0.2)	ND (1.0)	---	---
RRB	09/26/2007	ND (0.2)	ND (1.0)	---	---
RRB	10/03/2007	ND (0.2)	ND (1.0)	---	---
In-Channel Surface Water Locations					
C-CON-S	10/03/2006	ND (0.2)	ND (1.0)	955	8.00
C-CON-M	10/03/2006	ND (0.2)	ND (1.0)	953	8.02
C-CON-D	10/03/2006	ND (0.2)	ND (1.0)	956	8.04
C-CON-S	11/16/2006	ND (0.2)	ND (1.0)	---	---
C-CON-M	11/16/2006	ND (0.2)	ND (1.0)	---	---
C-CON-D	11/16/2006	ND (0.2)	ND (1.0)	---	---
C-CON-S	12/19/2006	ND (0.2)	ND (1.0)	912	8.14
C-CON-M	12/19/2006	ND (0.2)	ND (1.0)	903	8.24
C-CON-D	12/19/2006	ND (0.2)	ND (1.0)	892	8.14
C-CON-S	01/22/2007	ND (0.2)	ND (1.0)	---	---
C-CON-M	01/22/2007	ND (0.2)	ND (1.0)	---	---
C-CON-D	01/22/2007	ND (0.2)	ND (1.0)	---	---
C-CON-D	02/20/2007	ND (0.2)	ND (1.0)	---	---
C-CON-S	03/14/2007	ND (0.2)	ND (1.0)	932	8.28
C-CON-M	03/14/2007	ND (0.2)	ND (1.0)	930	8.30
C-CON-D	03/14/2007	ND (0.2)	ND (1.0)	939	8.26
C-CON-S	05/09/2007	ND (0.2)	ND (1.0)	948	8.25
C-CON-M	05/09/2007	ND (0.2)	ND (1.0)	951	8.27
C-CON-D	05/09/2007	ND (0.2)	ND (1.0)	949	8.25
C-CON-S	09/12/2007	ND (0.2)	ND (1.0)	1370	8.09 J
C-CON-M	09/12/2007	ND (0.2)	ND (1.0)	1350	8.10 J
C-CON-D	09/12/2007	ND (0.2)	ND (1.0)	1610	8.07 J
C-CON-S	09/14/2007	ND (0.2)	ND (1.0)	---	---
C-CON-M	09/14/2007	ND (0.2)	ND (1.0)	---	---
C-CON-D	09/14/2007	ND (0.2)	ND (1.0)	---	---
C-CON-S	09/26/2007	ND (0.2)	ND (1.0)	---	---
C-CON-M	09/26/2007	ND (0.2)	ND (1.0)	---	---
C-CON-D	09/26/2007	ND (0.2)	ND (1.0)	---	---
C-CON-S	10/03/2007	ND (0.2)	ND (1.0)	---	---
C-CON-M	10/03/2007	ND (0.2)	ND (1.0)	---	---

Table 2
Surface Water Sampling Results - October 2006 through October 2007

Station ID	Sample Date	Hexavalent Chromium (µg/L)	Total Chromium (µg/L)	Specific Conductance (µS/cm)	pH (pH units)
In-Channel Surface Water Locations					
C-CON-D	10/03/2007	ND (0.2)	ND (1.0)	---	---
C-I-3-S	10/03/2006	ND (0.2)	ND (1.0)	962	8.11
C-I-3-M	10/03/2006	ND (0.2)	ND (1.0)	953	8.12
C-I-3-D	10/03/2006	ND (0.2)	ND (1.0)	943	8.12
C-I-3-S	11/15/2006	ND (0.2)	ND (1.0)	---	---
C-I-3-M	11/15/2006	ND (0.2)	ND (1.0)	---	---
C-I-3-D	11/15/2006	ND (0.2)	ND (1.0)	---	---
C-I-3-S	12/19/2006	ND (0.2)	ND (1.0)	942	8.22
C-I-3-M	12/19/2006	ND (0.2)	ND (1.0)	905	8.29
C-I-3-D	12/19/2006	ND (0.2)	ND (1.0)	901	8.23
C-I-3-S	01/23/2007	ND (0.2)	ND (1.0)	---	---
C-I-3-M	01/23/2007	ND (0.2)	ND (1.0)	---	---
C-I-3-D	01/23/2007	ND (0.2)	ND (1.0)	---	---
C-I-3-D	02/20/2007	ND (0.2)	ND (1.0)	---	---
C-I-3-S	03/13/2007	ND (0.2)	ND (1.0)	945	8.29
C-I-3-M	03/13/2007	ND (0.2)	ND (1.0)	931	8.30
C-I-3-D	03/13/2007	ND (0.2)	ND (1.0)	920	8.25
C-I-3-S	05/08/2007	ND (0.2)	ND (1.0)	953	8.28
C-I-3-M	05/08/2007	ND (0.2)	ND (1.0)	952	8.24
C-I-3-D	05/08/2007	ND (0.2)	ND (1.0)	950	8.32
C-I-3-S	09/11/2007	ND (0.2)	ND (1.0)	948	8.19 J
C-I-3-M	09/11/2007	ND (0.2)	ND (1.0)	945	8.18 J
C-I-3-D	09/11/2007	ND (0.2)	ND (1.0)	936	8.14 J
C-I-3-S	09/13/2007	ND (0.2)	ND (1.0)	---	---
C-I-3-M	09/13/2007	ND (0.2)	ND (1.0)	---	---
C-I-3-D	09/13/2007	ND (0.2)	ND (1.0)	---	---
C-I-3-S	09/25/2007	ND (0.2)	ND (1.0)	---	---
C-I-3-M	09/25/2007	ND (0.2)	ND (1.0)	---	---
C-I-3-D	09/25/2007	ND (0.2)	ND (1.0)	---	---
C-I-3-S	10/02/2007	ND (0.2)	ND (1.0)	---	---
C-I-3-M	10/02/2007	ND (0.2)	ND (1.0)	---	---
C-I-3-D	10/02/2007	ND (0.2)	ND (1.0)	---	---
C-MAR-M	10/03/2006	ND (0.2)	ND (1.0)	985	7.84
C-MAR-M	11/16/2006	ND (0.2)	ND (1.0)	---	---
C-MAR-M	12/19/2006	ND (0.2)	ND (1.0)	1830	7.85
C-MAR-D	01/23/2007	ND (0.2)	ND (1.0)	---	---
C-MAR-D	02/20/2007	ND (0.2)	ND (1.0)	---	---
C-MAR-S	03/13/2007	ND (0.2)	ND (1.0)	1030	8.04
C-MAR-D	03/13/2007	ND (0.2)	ND (1.0)	1030	8.06
C-MAR-S	05/09/2007	ND (0.2)	ND (1.0)	951	8.24
C-MAR-D	05/09/2007	ND (0.2)	ND (1.0)	929	8.08

Table 2
Surface Water Sampling Results - October 2006 through October 2007

Station ID	Sample Date	Hexavalent Chromium (µg/L)	Total Chromium (µg/L)	Specific Conductance (µS/cm)	pH (pH units)
In-Channel Surface Water Locations					
C-MAR-S	09/11/2007	ND (0.2)	ND (1.0)	1010	7.81
C-MAR-D	09/11/2007	ND (0.2)	ND (1.0)	1000	7.88
C-MAR-S	09/13/2007	ND (0.2)	ND (1.0)	---	---
C-MAR-D	09/13/2007	ND (0.2)	ND (1.0)	---	---
C-MAR-S	09/26/2007	ND (0.2)	ND (1.0)	---	---
C-MAR-D	09/26/2007	ND (0.2)	ND (1.0)	---	---
C-MAR-S	10/02/2007	ND (0.2)	ND (1.0)	---	---
C-MAR-D	10/02/2007	ND (0.2)	ND (1.0)	---	---
C-NR1-S	10/04/2006	ND (0.2)	ND (1.0)	1000	8.20
C-NR1-M	10/04/2006	ND (0.2)	ND (1.0)	995	8.18
C-NR1-D	10/04/2006	ND (0.2)	ND (1.0)	986	8.19
C-NR1-S	11/16/2006	ND (0.2)	ND (1.0)	---	---
C-NR1-M	11/16/2006	ND (0.2)	ND (1.0)	---	---
C-NR1-D	11/16/2006	ND (0.2)	ND (1.0)	---	---
C-NR1-S	12/19/2006	ND (0.2)	ND (1.0)	909	8.04
C-NR1-M	12/19/2006	ND (0.2)	ND (1.0)	911	8.24
C-NR1-D	12/19/2006	ND (0.2)	ND (1.0)	923	8.20
C-NR1-S	01/22/2007	ND (0.2)	ND (1.0)	---	---
C-NR1-M	01/22/2007	ND (0.2)	ND (1.0)	---	---
C-NR1-D	01/22/2007	ND (0.2)	ND (1.0)	---	---
C-NR1-D	02/20/2007	ND (0.2)	ND (1.0)	---	---
C-NR1-S	03/14/2007	ND (0.2)	ND (1.0)	935	8.27
C-NR1-M	03/14/2007	ND (0.2)	ND (1.0)	934	8.22
C-NR1-D	03/14/2007	ND (0.2)	ND (1.0)	942	8.30
C-NR1-S	05/09/2007	ND (0.2)	ND (1.0)	957	8.32
C-NR1-M	05/09/2007	ND (0.2)	ND (1.0)	952	8.31
C-NR1-D	05/09/2007	ND (0.2)	ND (1.0)	951	8.29
C-NR1-S	09/12/2007	ND (0.2)	ND (1.0)	1280	8.15 J
C-NR1-M	09/12/2007	ND (0.2)	ND (1.0)	1300	8.12 J
C-NR1-D	09/12/2007	ND (0.2)	ND (1.0)	1230	8.14 J
C-NR1-S	09/14/2007	ND (0.2)	ND (1.0)	---	---
C-NR1-M	09/14/2007	ND (0.2)	ND (1.0)	---	---
C-NR1-D	09/14/2007	ND (0.2)	ND (1.0)	---	---
C-NR1-S	09/26/2007	ND (0.2)	ND (1.0)	---	---
C-NR1-M	09/26/2007	ND (0.2)	ND (1.0)	---	---
C-NR1-D	09/26/2007	ND (0.2)	ND (1.0)	---	---
C-NR1-S	10/03/2007	ND (0.2)	ND (1.0)	---	---
C-NR1-M	10/03/2007	ND (0.2)	ND (1.0)	---	---
C-NR1-D	10/03/2007	ND (0.2)	ND (1.0)	---	---

Table 2
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Station ID	Sample Date	Hexavalent Chromium (µg/L)	Total Chromium (µg/L)	Specific Conductance (µS/cm)	pH (pH units)
In-Channel Surface Water Locations					
C-NR3-S	10/04/2006	ND (0.2)	ND (1.0)	975	8.17
C-NR3-M	10/04/2006	ND (0.2)	ND (1.0)	981	8.19
C-NR3-D	10/04/2006	ND (0.2)	ND (1.0)	987	8.16
C-NR3-S	11/16/2006	ND (0.2)	ND (1.0)	---	---
C-NR3-M	11/16/2006	ND (0.2)	ND (1.0)	---	---
C-NR3-D	11/16/2006	ND (0.2)	ND (1.0)	---	---
C-NR3-S	12/19/2006	ND (0.2)	ND (1.0)	935	8.03
C-NR3-M	12/19/2006	ND (0.2)	ND (1.0)	906	8.08
C-NR3-D	12/19/2006	ND (0.2)	ND (1.0)	901	8.15
C-NR3-S	01/22/2007	ND (0.2)	ND (1.0)	---	---
C-NR3-M	01/22/2007	ND (0.2)	ND (1.0)	---	---
C-NR3-D	01/22/2007	ND (0.2)	ND (1.0)	---	---
C-NR3-D	02/20/2007	ND (0.2)	ND (1.0)	---	---
C-NR3-S	03/14/2007	ND (0.2)	ND (1.0)	931	8.31
C-NR3-M	03/14/2007	ND (0.2)	ND (1.0)	944	8.30
C-NR3-D	03/14/2007	ND (0.2)	ND (1.0)	945	8.27
C-NR3-S	05/09/2007	ND (0.2)	ND (1.0)	957	8.27
C-NR3-M	05/09/2007	ND (0.2)	ND (1.0)	955	8.31
C-NR3-D	05/09/2007	ND (0.2)	ND (1.0)	952	8.28
C-NR3-S	09/12/2007	ND (0.2)	ND (1.0)	1310	8.16 J
C-NR3-M	09/12/2007	ND (0.2)	ND (1.0)	1340	7.86 J
C-NR3-D	09/12/2007	ND (0.2)	ND (1.0)	1260	8.00 J
C-NR3-S	09/14/2007	ND (0.2)	ND (1.0)	---	---
C-NR3-M	09/14/2007	ND (0.2)	ND (1.0)	---	---
C-NR3-D	09/14/2007	ND (0.2)	ND (1.0)	---	---
C-NR3-S	09/26/2007	ND (0.2)	ND (1.0)	---	---
C-NR3-M	09/26/2007	ND (0.2)	ND (1.0)	---	---
C-NR3-D	09/26/2007	ND (0.2)	ND (1.0)	---	---
C-NR3-S	10/03/2007	ND (0.2)	ND (1.0)	---	---
C-NR3-M	10/03/2007	ND (0.2)	ND (1.0)	---	---
C-NR3-D	10/03/2007	ND (0.2)	ND (1.0)	---	---
C-NR4-S	10/04/2006	ND (0.2)	ND (1.0)	995	8.09
C-NR4-M	10/04/2006	ND (0.2)	ND (1.0)	983	8.16
C-NR4-D	10/04/2006	ND (0.2)	ND (1.0)	970	8.17
C-NR4-S	11/16/2006	ND (0.2)	ND (1.0)	---	---
C-NR4-M	11/16/2006	ND (0.2)	ND (1.0)	---	---
C-NR4-D	11/16/2006	ND (0.2)	ND (1.0)	---	---
C-NR4-S	12/20/2006	ND (0.2)	ND (1.0)	915	8.29
C-NR4-M	12/20/2006	ND (0.2)	ND (1.0)	915	8.25
C-NR4-D	12/20/2006	ND (0.2)	ND (1.0)	922	8.15
C-NR4-S	01/22/2007	ND (0.2)	ND (1.0)	---	---

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Station ID	Sample Date	Hexavalent Chromium (µg/L)	Total Chromium (µg/L)	Specific Conductance (µS/cm)	pH (pH units)
In-Channel Surface Water Locations					
C-NR4-M	01/22/2007	ND (0.2)	ND (1.0)	---	---
C-NR4-D	01/22/2007	ND (0.2)	ND (1.0)	---	---
C-NR4-D	02/20/2007	ND (0.2)	ND (1.0)	---	---
C-NR4-S	03/14/2007	ND (0.2)	ND (1.0)	943	8.28
C-NR4-S FD	03/14/2007	ND (0.2)	ND (1.0)	941	8.24
C-NR4-M	03/14/2007	ND (0.2)	ND (1.0)	947	8.31
C-NR4-D	03/14/2007	ND (0.2)	ND (1.0)	946	8.30
C-NR4-S	05/09/2007	ND (0.2)	ND (1.0)	954	8.22
C-NR4-M	05/09/2007	ND (0.2)	ND (1.0)	950	8.21
C-NR4-D	05/09/2007	ND (0.2)	ND (1.0)	957	8.25
C-NR4-S	09/12/2007	ND (0.2)	ND (1.0)	1250	8.17 J
C-NR4-M	09/12/2007	ND (0.2)	ND (1.0)	1250	8.14 J
C-NR4-D	09/12/2007	ND (0.2)	ND (1.0)	1280	8.09 J
C-NR4-S	09/14/2007	ND (0.2)	ND (1.0)	---	---
C-NR4-M	09/14/2007	ND (0.2)	ND (1.0)	---	---
C-NR4-D	09/14/2007	ND (0.2)	ND (1.0)	---	---
C-NR4-S	09/26/2007	ND (0.2)	ND (1.0)	---	---
C-NR4-M	09/26/2007	ND (0.2)	ND (1.0)	---	---
C-NR4-D	09/26/2007	ND (0.2)	ND (1.0)	---	---
C-NR4-S	10/03/2007	ND (0.2)	ND (1.0)	---	---
C-NR4-M	10/03/2007	ND (0.2)	ND (1.0)	---	---
C-NR4-D	10/03/2007	ND (0.2)	ND (1.0)	---	---
C-R22-S	10/03/2006	ND (0.2)	ND (1.0)	946	8.16
C-R22-M	10/03/2006	ND (0.2)	ND (1.0)	975	8.16
C-R22-D	10/03/2006	ND (0.2)	ND (1.0)	964	8.15
C-R22-S	11/15/2006	ND (0.2)	ND (1.0)	---	---
C-R22-M	11/15/2006	ND (0.2)	ND (1.0)	---	---
C-R22-D	11/15/2006	ND (0.2)	ND (1.0)	---	---
C-R22-S	12/19/2006	ND (0.2)	ND (1.0)	940	8.15
C-R22-M	12/19/2006	ND (0.2)	ND (1.0)	892	8.03
C-R22-D	12/19/2006	ND (0.2)	ND (1.0)	927	8.31
C-R22-S	01/23/2007	ND (0.2)	ND (1.0)	---	---
C-R22-M	01/23/2007	ND (0.2)	ND (1.0)	---	---
C-R22-D	01/23/2007	ND (0.2)	ND (1.0)	---	---
C-R22-D	02/20/2007	ND (0.2)	ND (1.0)	---	---
C-R22-S	03/13/2007	ND (0.2)	ND (1.0)	937	8.18
C-R22-M	03/13/2007	ND (0.2)	ND (1.0)	934	8.30
C-R22-D	03/13/2007	ND (0.2)	ND (1.0)	941	8.25
C-R22-S	05/08/2007	ND (0.2)	ND (1.0)	963	8.29
C-R22-M	05/08/2007	ND (0.2)	ND (1.0)	960	8.28
C-R22-D	05/08/2007	ND (0.2)	ND (1.0)	960	8.30

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Station ID	Sample Date	Hexavalent Chromium (µg/L)	Total Chromium (µg/L)	Specific Conductance (µS/cm)	pH (pH units)
In-Channel Surface Water Locations					
C-R22-S	09/11/2007	ND (0.2)	ND (1.0)	936	8.17 J
C-R22-M	09/11/2007	ND (0.2)	ND (1.0)	932	8.20 J
C-R22-D	09/11/2007	0.40 J	ND (1.0)	941	8.22 J
C-R22-S	09/12/2007	ND (1.0)	ND (1.0)	---	---
C-R22-M	09/12/2007	ND (0.2)	ND (1.0)	---	---
C-R22-D	09/12/2007	ND (0.2)	ND (1.0)	---	---
C-R22-D-East	09/12/2007	ND (0.2)	ND (1.0)	---	---
C-R22-D-North	09/12/2007	ND (0.2)	ND (1.0)	---	---
C-R22-D-South	09/12/2007	ND (0.2)	ND (1.0)	---	---
C-R22-D-West	09/12/2007	ND (1.0)	ND (1.0)	---	---
C-R22-S	09/13/2007	ND (0.2)	ND (1.0)	---	---
C-R22-M	09/13/2007	ND (0.2)	ND (1.0)	---	---
C-R22-D	09/13/2007	ND (0.2)	ND (1.0)	---	---
C-R22-S	09/25/2007	ND (0.2)	ND (1.0)	---	---
C-R22-M	09/25/2007	ND (0.2)	ND (1.0)	---	---
C-R22-D	09/25/2007	ND (0.2)	ND (1.0)	---	---
C-R22-S	10/02/2007	ND (0.2)	ND (1.0)	---	---
C-R22-M	10/02/2007	ND (0.2)	ND (1.0)	---	---
C-R22-D	10/02/2007	ND (0.2)	ND (1.0)	---	---
C-R27-S	10/03/2006	ND (0.2)	ND (1.0)	931	8.10
C-R27-M	10/03/2006	ND (0.2)	ND (1.0)	944	8.11
C-R27-D	10/03/2006	ND (0.2)	ND (1.0)	946	8.11
C-R27-S	11/16/2006	ND (0.2)	ND (1.0)	---	---
C-R27-D	11/16/2006	ND (0.2)	ND (1.0)	---	---
C-R27-M	12/19/2006	ND (0.2)	ND (1.0)	873	8.25
C-R27-S	01/23/2007	ND (0.2)	ND (1.0)	---	---
C-R27-M	01/23/2007	ND (0.2)	ND (1.0)	---	---
C-R27-D	01/23/2007	ND (0.2)	ND (1.0)	---	---
C-R27-D	02/20/2007	ND (0.2)	ND (1.0)	---	---
C-R27-S	03/13/2007	ND (0.2)	ND (1.0)	949	8.31
C-R27-M	03/13/2007	ND (0.2)	ND (1.0)	953	8.34
C-R27-D	03/13/2007	ND (0.2)	ND (1.0)	948	8.33
C-R27-S	05/08/2007	ND (1.0)	ND (1.0)	962	8.27
C-R27-M	05/08/2007	ND (1.0)	ND (1.0)	960	8.26
C-R27-D	05/08/2007	ND (0.2)	ND (1.0)	963	8.25
C-R27-S	09/11/2007	ND (0.2)	ND (1.0)	944	8.21 J
C-R27-M	09/11/2007	ND (0.2)	ND (1.0)	942	8.19 J
C-R27-D	09/11/2007	ND (0.2)	ND (1.0)	934	8.18 J
C-R27-S	09/13/2007	ND (0.2)	ND (1.0)	---	---
C-R27-M	09/13/2007	ND (0.2)	ND (1.0)	---	---
C-R27-D	09/13/2007	ND (0.2)	ND (1.0)	---	---

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Station ID	Sample Date	Hexavalent Chromium (µg/L)	Total Chromium (µg/L)	Specific Conductance (µS/cm)	pH (pH units)
In-Channel Surface Water Locations					
C-R27-S	09/25/2007	ND (0.2)	ND (1.0)	---	---
C-R27-M	09/25/2007	ND (0.2)	ND (1.0)	---	---
C-R27-D	09/25/2007	ND (0.2)	ND (1.0)	---	---
C-R27-S	10/02/2007	ND (0.2)	ND (1.0)	---	---
C-R27-M	10/02/2007	ND (0.2)	ND (1.0)	---	---
C-R27-D	10/02/2007	ND (0.2)	ND (1.0)	---	---
C-TAZ-S	10/03/2006	ND (0.2)	ND (1.0)	956	8.14
C-TAZ-M	10/03/2006	ND (0.2)	ND (1.0)	955	8.15
C-TAZ-D	10/03/2006	ND (0.2)	ND (1.0)	926	8.15
C-TAZ-S	11/15/2006	ND (0.2)	ND (1.0)	---	---
C-TAZ-M	11/15/2006	ND (0.2)	ND (1.0)	---	---
C-TAZ-D	11/15/2006	ND (0.2)	ND (1.0)	---	---
C-TAZ-S	12/19/2006	ND (0.2)	ND (1.0)	897	8.30
C-TAZ-M	12/19/2006	ND (0.2)	ND (1.0)	886	8.24
C-TAZ-D	12/19/2006	ND (0.2)	ND (1.0)	920	8.13
C-TAZ-S	01/23/2007	ND (0.2)	ND (1.0)	---	---
C-TAZ-M	01/23/2007	ND (0.2)	ND (1.0)	---	---
C-TAZ-D	01/23/2007	ND (0.2)	ND (1.0)	---	---
C-TAZ-D	02/20/2007	ND (0.2)	ND (1.0)	---	---
C-TAZ-S	03/13/2007	ND (0.2)	ND (1.0)	922	8.31
C-TAZ-M	03/13/2007	ND (0.2)	ND (1.0)	941	8.35
C-TAZ-D	03/13/2007	ND (0.2)	ND (1.0)	936	8.33
C-TAZ-S	05/08/2007	ND (0.2)	ND (1.0)	950	8.31
C-TAZ-M	05/08/2007	ND (0.2)	ND (1.0)	951	8.32
C-TAZ-D	05/08/2007	ND (0.2)	ND (1.0)	947	8.30
C-TAZ-S	09/11/2007	ND (0.2)	ND (1.0)	938	8.12 J
C-TAZ-M	09/11/2007	ND (0.2)	ND (1.0)	941	8.09 J
C-TAZ-D	09/11/2007	ND (0.2)	ND (1.0)	935	8.06 J
C-TAZ-S	09/13/2007	ND (0.2)	ND (1.0)	---	---
C-TAZ-M	09/13/2007	ND (0.2)	ND (1.0)	---	---
C-TAZ-D	09/13/2007	ND (0.2)	ND (1.0)	---	---
C-TAZ-S	09/25/2007	ND (0.2)	ND (1.0)	---	---
C-TAZ-M	09/25/2007	ND (0.2)	ND (1.0)	---	---
C-TAZ-D	09/25/2007	ND (0.2)	ND (1.0)	---	---
C-TAZ-S	10/02/2007	ND (0.2)	ND (1.0)	---	---
C-TAZ-M	10/02/2007	ND (0.2)	ND (1.0)	---	---
C-TAZ-D	10/02/2007	ND (0.2)	ND (1.0)	---	---

Table 2
Surface Water Sampling Results - October 2006 through October 2007

Station ID	Sample Date	Hexavalent Chromium (µg/L)	Total Chromium (µg/L)	Specific Conductance (µS/cm)	pH (pH units)

Notes:

ND	not detected at listed reporting limit
J	concentration or reporting limit estimated by laboratory or data validation
R	result exceeded analytical criteria for precision and accuracy; should not be used for project decision-making
µS/cm	microsiemens per centimeter
µg/L	Dissolved metals concentrations in micrograms per liter
(---)	data not collected or available
FD	Field duplicate

Source: RCRA Facility Investigation/Remedial Investigation (Volume 2); PG&E Topock Compressor Station, Needles, California

Table 3
Summary of Surface Water Sampling Results–Additional Trace Metals, July 1997 Through October 2007

	Barium (µg/L)		**Iron (µg/L)**		**Manganese (µg/L)**		**Molybdenum (µg/L)**		**Vanadium (µg/L)**	
Chemical-Specific ARAR[1]	1,000		300		50		NA		NA	
Station ID[2]	**Frequency of Detection[3] (Number of Detects/Number of Samples) and Average Concentration[4]**									
Shoreline Surface Water Locations										
Needles Gauge	0 \ 0	---	0 \ 0	---	0 \ 0	---	0 \ 0	---	0 \ 0	---
NR-3	0 \ 0	---	0 \ 0	---	0 \ 0	---	0 \ 0	---	0 \ 0	---
NR-2	0 \ 0	---	0 \ 0	---	0 \ 0	---	0 \ 0	---	0 \ 0	---
NR-1	1 \ 1	140	0 \ 1	ND	0 \ 1	ND	0 \ 0	---	0 \ 0	---
A-Dock	1 \ 1	110	0 \ 0	---	0 \ 1	ND	0 \ 1	ND	0 \ 1	ND
CON	3 \ 4	143	0 \ 1	ND	2 \ 4	65.0	2 \ 3	4.93	2 \ 3	3.47
Seasonal Wetlands	1 \ 1	120	0 \ 0	---	1 \ 1	8.00	1 \ 1	5.00	0 \ 1	ND
RRB	1 \ 1	120	0 \ 0	---	1 \ 1	5.00	1 \ 1	7.00	0 \ 1	ND
R-19	0 \ 0	---	0 \ 0	---	0 \ 0	---	0 \ 0	---	0 \ 0	---
R-19-B	0 \ 0	---	0 \ 0	---	0 \ 0	---	0 \ 0	---	0 \ 0	---
R-19-C	0 \ 0	---	0 \ 0	---	0 \ 0	---	0 \ 0	---	0 \ 0	---
R-28	0 \ 1	ND	0 \ 3	ND	0 \ 3	ND	1 \ 1	5.40	1 \ 1	253
R-20	0 \ 0	---	0 \ 0	---	0 \ 0	---	0 \ 0	---	0 \ 0	---
R-20-B	0 \ 0	---	0 \ 0	---	0 \ 0	---	0 \ 0	---	0 \ 0	---
R-20-C	0 \ 0	---	0 \ 0	---	0 \ 0	---	0 \ 0	---	0 \ 0	---
R-27	0 \ 1	ND	0 \ 3	ND	0 \ 3	ND	0 \ 0	---	0 \ 0	---
R-22	0 \ 0	---	0 \ 0	---	0 \ 0	---	0 \ 0	---	0 \ 0	---
I-3	4 \ 5	150	0 \ 2	ND	3 \ 5	54.1	3 \ 3	4.73	2 \ 3	3.20

Notes:

ND	not detected
µg/L	micrograms per liter
---	not analyzed

At locations R-19B, R-19C and R-20B, multiple samples were collected at surface, 5-foot, and 10-foot depths and locations. Results for each location summarized the samples collected at depth.

[1] Surface water chemical-specific ARARs. See Table 4.

[2] Surface water locations are listed in order of their position on the river, from north to south.

[3] Results listed for number of detections for primary samples collected during RFI, July 1997 through October 2007.

[4] Average concentrations of all results (including estimated concentrations) in micrograms per liter, with half the reporting limit used for nondetects. Detected results are the maximum concentrations from primary or duplicate samples.

Source: RCRA Facility Investigation/Remedial Investigation (Volume 2); PG&E Topock Compressor Station, Needles, California

Table 4
Chemical-specific ARARs for Surface Water

Constituents [a]	California Surface Water Standards [b]			Drinking Water Standards	
	Ecological Receptors		Human Receptors		
	Freshwater Aquatic Life		Human Health [c]	California Safe Drinking Water Act [d]	Federal Safe Drinking Water Act [e]
	µg/L	µg/L	µg/L	µg/L	µg/L
	Actue [f]	Chronic [g]			
Barium	NA	NA	NA	1,000	2,000
Hexavalent chromium	16 [i]	11 [i]	NA	NA	NA
Total chromium	NA	NA	NA	50	100
Copper	38 [h, i]	23 [h, i]	1,300	1,000 [j]	1,300 [k]
Iron	NA	NA	NA	300 [j]	300 [j]
Lead	209 [h, i]	8 [h, i]	NA	15 [k]	15 [k]
Manganese	NA	NA	NA	50 [j]	50 [j]
Molybdenum	NA	NA	NA	NA	NA
Nickel	1,186 [h, i]	132 [h, i]	610	100	NA
Vanadium	NA	NA	NA	NA	NA
Zinc	297 [h, i]	300 [h, i]	NA	5,000 [j]	5,000 [j]
Chloride	NA	NA	NA	250,000–500,000 [j]	250,000 [j]
Fluoride	NA	NA	NA	2,000	4,000
Nitrate as Nitrogen	NA	NA	NA	45,000	10,000
Specific Conductance	NA	NA	NA	900–1,600	NA
Sulfate	NA	NA	NA	250,000–500,000 [j]	250,000 [j]
Perchlorate	NA	NA	NA	6	NA
pH	NA	NA	NA	NA	6.5–8.5 [j]
Total Dissolved Solids	NA	NA	NA	500,000–1,000,000 [j]	500,000 [j]

Notes:

NA = Not Available

[a] Constituents detected in surface water samples, both upstream and downstream of Topock Compressor Station. General water quality parameters for which there are no ARARs are not included.

[b] Federal Water Pollution Control Act, 33 USC §§ 1251-1387, 40 CFR §133.38. Source: Appendix G.

[c] Protective of human health assuming ingestion of surface water and fish from the same surface water body at 1 x 10-6 cancer risk level.

[d] California Safe Drinking Water Act, Title 22, CCR, Div 4, Ch 15, §64431, §64444, §64449. Source: Appendix G.

[e] Federal Safe Drinking Water Act, 42 USC § 300 f, et seq., 40 CFR 141- Subpart F - Maximum Contaminant Level Goals (MCLGs), and 42 USC § 300 g-1, 40 CFR 141 - Subpart G - National Primary Drinking Water Regulations (MCLs). Source: Appendix G.

[f] Acute exposure criteria are not-to-exceed 1-hour maximum concentrations.

[g] Chronic exposure criteria are not-to-exceed 96 hour-average concentrations.

[h] Hardness dependent. Shown is criteria @ CaCO3 = 300 ppm.

[i] Dissolved concentration.

[j] Secondary MCL standard, where primary MCL not developed.

[k] Action level for copper and lead, if more than 10 percent of samples exceed action level.

Source: RCRA Facility Investigation/Remedial Investigation (Volume 2); PG&E Topock Compressor Station, Needles, California

Table 5
Summary of Cr(VI), Cr(T), Cu, Ni, Pb, and Zn Groundwater Results, July 1997 through October 2007

Parameter	Results Summary of RFI/RI Wells [1]						Background Comparison [2]					Chemical-specific ARAR [3]				
	Number of Wells Sampled	Number of Primary Samples	Number of Detects	Detection Frequency %	Average Concentration (µg/L)	Maximum Concentration (µg/L)	UTL Value (µg/L)	Number of Wells with Average Exceeding UTL	Number of Wells with Maximum Exceeding UTL	Frequency of UTL Exceedances		ARAR Value (µg/L)	Number of Wells with Average Exceeding ARAR	Number of Wells with Maximum Exceeding ARAR	Frequency of ARAR Exceedances	
Hexavalent chromium	164	1,807	1,111	61.5	772	15,700	31.8	53	67	667 / 1,807	(36.9%)	---	---	---	---	---
Chromium (total)	166	2,898	1,911	65.9	905	16,400	34.1	57	79	1,084 / 2,898	(37.4%)	50	53	73	1,033 / 2,898	(35.6%)
Copper	89	1,130	419	37.1	10.6	306	10.5	0	47	96 / 1,130	(8.5%)	1,000	0	0	0 / 1,130	(0.0%)
Nickel	89	1,130	541	47.9	11.5	500	10.6	3	40	128 / 1,130	(11.3%)	100	0	9	10 / 1,130	(0.9%)
Lead	85	486	65	13.4	2.36	76	1.91	1	35	44 / 486	(9.1%)	15	0	8	9 / 486	(1.9%)
Zinc	89	1,130	824	72.9	67.7	1,870	77.7	5	48	230 / 1,130	(20.4%)	5,000	0	0	0 / 1,130	(0.0%)

Notes:

[1] Wells Sampled is the number of wells sampled for each parameter. Number of Samples is the total number of primary samples analyzed for each parameter. Detection Frequency is the number of times each parameter was detected over the total number of samples analyzed. Average concentration is the average of all results using one-half the reporting limit for non detects.

[2] Site background concentration is the 95% upper tolerance limit (UTL) of the elevated percentile from the Steps 3 and 4 Groundwater Background Study Report (CH2M HILL, 2008), see Table 6-3. Number of Exceedances is the number of times each parameter was detected above the background concentration.

[3] Chemical-specific ARARs listed are the most stringent drinking water standard from regulatory standards, see Table 4

ARAR = applicable or relevant and appropriate requirements

µg/L = dissolved metals concentrations in micrograms per liter

--- = not assigned or not applicable

Source: RCRA Facility Investigation/Remedial Investigation (Volume 2); PG&E Topock Compressor Station, Needles, California

APPENDIX NO

Noise

Appendix Noise 1

Long-Term 24 Hour Continuous Noise Monitoring

Model Input Sheet

EDAW | AECOM

Project: Topock Comressor Station

Date: **December 10-11, 2008**

Site: Site A

Hour	Leq	Lmax	L50	L90
12:00	73.5	86.1	70	58
13:00	73.4	83.7	69	57
14:00	73.4	85.7	69	56
15:00	73.7	87.1	70	57
16:00	73.4	83.6	70	57
17:00	73.3	85.8	68	58
18:00	72.7	84.6	67	55
19:00	72.6	84.0	66	54
20:00	72.0	84.4	65	51
21:00	71.5	84.8	64	53
22:00	70.9	84.9	61	51
23:00	70.4	83.0	61	49
0:00	71.0	95.9	59	49
1:00	68.7	83.3	57	48
2:00	69.6	84.2	60	50
3:00	70.2	84.6	60	49
4:00	69.8	85.4	61	49
5:00	71.1	83.2	64	53
6:00	71.7	84.6	66	55
7:00	72.2	85.0	65	54
8:00	72.8	83.4	68	57
9:00	73.5	83.9	69	57
10:00	72.9	83.8	69	57
11:00	73.6	84.5	69	58

Averages

	Leq	Lmax	L50	L90
Daytime (7 a.m. - 10 p.m.)	73.0	84.7	68.0	56.0
Nighttime (10 p.m. - 7 a.m.)	70.4	85.4	60.9	50.3

Uppermost-Level

	Leq	Lmax	L50	L90
Daytime (7 a.m. - 10 p.m.)	73.7	87.1	69.9	58.2
Nighttime (10 p.m. - 7 a.m.)	71.7	95.9	65.5	55.5

Percentage of Energy

Daytime	75%
Nighttime	25%

Calculated L_{dn}, dBA
77.3

Appendix Noise 1

Long-Term 24 Hour Continuous Noise Monitoring

Model Input Sheet

EDAW | AECOM

Project: Topock Comressor Station

Date: **December 10-11, 2008**

Site: Site B

Hour	Leq	Lmax	L50	L90
13:00	66.1	88.6	37	30
14:00	66.5	88.1	37	30
15:00	66.1	90.6	38	31
16:00	56.3	77.5	43	34
17:00	66.8	89.6	45	34
18:00	60.1	79.9	45	34
19:00	57.8	80.9	45	31
20:00	66.1	88.0	44	33
21:00	66.2	89.3	44	30
22:00	67.8	89.3	42	31
23:00	69.8	88.9	44	33
0:00	58.0	78.0	43	30
1:00	65.2	89.8	42	31
2:00	70.4	88.9	47	38
3:00	69.5	90.7	45	35
4:00	69.5	89.2	46	38
5:00	64.7	89.1	46	39
6:00	68.9	91.1	48	41
7:00	64.3	87.8	46	37
8:00	69.2	88.8	48	40
9:00	68.6	88.6	42	34
10:00	61.1	80.6	39	34
11:00	60.3	85.8	40	33
12:00	69.0	89.5	39	33

Averages

	Leq	Lmax	L50	L90
Daytime (7 a.m. - 10 p.m.)	65.7	86.2	42.3	33.3
Nighttime (10 p.m. - 7 a.m.)	68.2	88.3	44.6	35.1

Uppermost-Level

	Leq	Lmax	L50	L90
Daytime (7 a.m. - 10 p.m.)	69.2	90.6	47.6	40.1
Nighttime (10 p.m. - 7 a.m.)	70.4	91.1	48.4	41.4

Percentage of Energy

Daytime	49%
Nighttime	51%

Calculated L_{dn}, dBA

74.3

Appendix Noise 1

Railroad Operation Noise Calculation

Input Sheet

Individual Train Events

1	102.62	29	93.37
2	99.62	30	100.66
3	98.71	31	93.74
4	98.51	32	103.91
5	100.97	33	100.79
6	92.04	34	102.08
7	89.99	35	99.59
8	89.78	36	98.33
9	92.86	37	90.85
10	93.46	38	92.09
11	100.13	39	102.05
12	91.6	40	100.23
13	89.23	41	101.33
14	98.32	42	94.97
15	99.83	43	100.37
16	93.16	44	93.65
17	91.52	45	98.57
18	92.99	46	102.76
19	94.33	47	100.39
20	100.74	48	99.5
21	95.88	49	99.12
22	99.74	50	98.8
23	92.32	51	91.94
24	99.81	52	94.97
25	99.88	53	91.6
26	93.14	54	95.62
27	102.72	55	92.48
28	98.27		

Number of Events	**Average SEL**	**Reference Distance**
55	99 dBA	104 feet

# Trains / day	**55**	
Neq	240.6	
Ldn	73.1	dBA
Ref. Distance	**104**	feet
60 dB Contour	780	feet
65 dB Contour	362	feet
70 dB Contour	168	feet

Date: December 10-11, 2008
Topock Compressor Station

Appendix Noise 1

Project-Generated Construction Source Noise Prediction Model

Topock Compressor Station

EDAW | AECOM

Location	Distance to Nearest Receiver in feet	Combined Predicted Noise Level (L_{eq} dBA)
San Bernadino Daytime Threshold*	1,548	55.0
San Bernadino Nightime Threshold*	4,896	45.0
Mojave County Daytime Threshold*	275	70.0
Mojave County Nighttime Threshold*	616	63.0
Single Family Res. - AZ	850	63.9
Topock Marina MHP	1,500	59.7
Moabi Regional Park	3,500	47.9
	200	72.8
	400	66.8
	450	65.7
	500	64.8
	550	64.0
	600	63.2

Assumptions:	Reference Emission Noise Levels (L_{max}) at 50 feet[1]	Usage Factor[1]
Excavator	85	0.4
Drill Rig Truck	84	0.2
Excavator	85	0.4

Ground Type	Hard
Source Height	8
Receiver Height	5
Ground Factor	0.00

Predicted Noise Level [2]	L_{eq} dBA at 50 feet[2]
Excavator	81.0
Drill Rig Truck	77.0
Excavator	81.0

Combined Predicted Noise Level (L_{eq} dBA at 50 feet)
84.8

Sources:

[1] Obtained from the FHWA Roadway Construction Noise Model, January 2006.

[2] Based on the following from the Federal Transit Noise and Vibration Impact Assessment, 2006.

L_{eq}(equip) = E.L.+10*log (U.F.) - 20*log (D/50) - 10*G*log (D/50)

Where: E.L. = Emission Level;

U.F.= Usage Factor;

G = Constant that accounts for topography and ground effects; and

D = Distance from source to receiver.

*Project specific threshold

Appendix Noise 4

Traffic Noise Prediction Model, (FHWA RD-77-108)

Model Input Sheet

Project Name : Topock Compressor Station
Project Number : 06110033.05
Modeling Condition : Existing
Ground Type : Soft
Metric (L_{eq}, L_{dn}, CNEL) : L_{dn}

K Factor :
Traffic Desc. (Peak or ADT) : ADT

Segment	Roadway	Segment From	Segment To	Traffic Vol.	Speed (Mph)	Distance to CL	% Autos	%MT	% HT	Day %	Eve %	Night %	Offset (dB)
1	Interstate 40	Junction SR 95	State Line	13900	65	100	46.3	5.8	47.9	75		25	
2	Moabi Park Road	I-40	National Old Trails Rd	382	35	100	97.45	0.05	2.5	87		13	

Appendix Noise 4

Traffic Noise Prediction Model, (FHWA RD-77-108)

Predicted Noise Levels

Project Name : Topock Compressor Station
Project Number : 06110033.05
Modeling Condition : Existing
Metric (Leq, Ldn, CNEL Ldn

		Segment		Noise Levels, dB Ldn				Distance to Traffic Noise Contours, Feet				
Segment	Roadway	From	To	Auto	MT	HT	Total	70 dB	65 dB	60 dB	55 dB	50 dB
1	Interstate 40	Junction SR 95	State Line	65.7	62.8	75.5	76.1	256	551	1187	2556	5508
2	Moabi Park Road	I-40	ational Old Trails R	43.8	20.6	42.8	46.4	3	6	12	27	57

Appendix Noise 4

Traffic Noise Prediction Model, (FHWA RD-77-108)

Model Input Sheet

Project Name : Topock Compressor Station
Project Number : 06110033.05
Modeling Condition : Construction/Decommissioing
Ground Type : Soft
Metric (L_{eq}, L_{dn}, CNEL) : L_{dn}

K Factor :
Traffic Desc. (Peak or ADT) : ADT

		Segment											
Segment	Alternative	From	To	Traffic Vol.	Speed (Mph)	Distance to CL	% Autos	%MT	% HT	Day %	Eve %	Night %	Offset (dB)
1	Pump and Treat	I-40	National Old Trails Rd	367	35	100	90.35	0.05	9.6	87		13	
2	Floodplain In Situ Barrier	I-40	National Old Trails Rd	356	35	100	93.75	0.05	6.2	87		13	
3	Upland In Situ Treatment	I-40	National Old Trails Rd	356	35	100	93.75	0.05	6.2	87		13	
4	Monitored Natural Attenuation	I-40	National Old Trails Rd	324	35	100	95.05	0.05	4.9	87		13	
5	Freshwater Flushing	I-40	National Old Trails Rd	468	35	100	95.35	0.05	4.6	87		13	
6	Monitoring of Groundwater Remediation	I-40	National Old Trails Rd	324	35	100	95.05	0.05	4.9	87		13	
7	IM-3 Decommissioning	I-40	National Old Trails Rd	336	35	100	93.85	0.05	6.1	87		13	

Appendix Noise 4

Traffic Noise Prediction Model, (FHWA RD-77-108)

Predicted Noise Levels

Project Name : Topock Compressor Station
Project Number : 06110033.05
Modeling Condition : Construction/Decommissioing
Metric (Leq, Ldn, CNEL) Ldn

EDAW | AECOM

		Segment		Noise Levels, dB Ldn				Distance to Traffic Noise Contours, Feet				
Segment	Alternative	From	To	Auto	MT	HT	Total	70 dB	65 dB	60 dB	55 dB	50 dB
1	Pump and Treat	I-40	National Old Trails Rd	43.3	20.4	48.5	49.6	4	9	20	44	95
2	Floodplain In Situ Barrier	I-40	National Old Trails Rd	43.4	20.3	46.4	48.2	4	8	16	35	76
3	Upland In Situ Treatment	I-40	National Old Trails Rd	43.4	20.3	46.4	48.2	4	8	16	35	76
4	Monitored Natural Attenuation	I-40	National Old Trails Rd	43.0	19.9	45.0	47.1	3	6	14	30	65
5	Freshwater Flushing	I-40	National Old Trails Rd	44.6	21.5	46.3	48.6	4	8	17	37	80
6	Monitoring of Groundwater Remediation	I-40	National Old Trails Rd	43.0	19.9	45.0	47.1	3	6	14	30	65
7	IM-3 Decommissioning	I-40	National Old Trails Rd	43.1	20.1	46.1	47.9	3	7	16	34	72

Appendix Noise 4

Traffic Noise Prediction Model, (FHWA RD-77-108)

Model Input Sheet

Project Name : Topock Compressor Station
Project Number : 06110033.05
Modeling Condition : Operations and Maintenance
Ground Type : Soft
Metric **(L_{eq}, L_{dn}, CNEL) :** L_{dn}

K Factor :
Traffic Desc. (Peak or ADT) : ADT

Segment	Alternative	Segment From	To	Traffic Vol.	Speed (Mph)	Distance to CL	% Autos	%MT	% HT	Day %	Eve %	Night %	Offset (dB)
1	Pump and Treat	I-40	National Old Trails Rd	333	35	100	93.75	0.05	6.2	87		13	
2	Floodplain In Situ Barrier	I-40	National Old Trails Rd	331	35	100	93.25	0.05	6.7	87		13	
3	Upland In Situ Treatment	I-40	National Old Trails Rd	331	35	100	93.25	0.05	6.7	87		13	
4	Monitored Natural Attenuation	I-40	National Old Trails Rd	327	35	100	93.65	0.05	6.3	87		13	
5	Freshwater Flushing	I-40	National Old Trails Rd	678	35	100	95.05	0.05	4.9	87		13	
6	Monitoring of Groundwater Remediation	I-40	National Old Trails Rd	327	35	100	93.65	0.05	6.3	87		13	
7	Continued Operations of IM-3	I-40	National Old Trails Rd	336	35	100	93.85	0.05	6.1	87		13	

Appendix Noise 4

Traffic Noise Prediction Model, (FHWA RD-77-108)

Predicted Noise Levels

EDAW | AECOM

Project Name : Topock Compressor Station
Project Number : 06110033.05
Modeling Condition : Operations and Maintenance
Metric (Leq, Ldn, CNEL) Ldn

		Segment		Noise Levels, dB Ldn				Distance to Traffic Noise Contours, Feet				
Segment	Alternative	From	To	Auto	MT	HT	Total	70 dB	65 dB	60 dB	55 dB	50 dB
1	Pump and Treat	I-40	National Old Trails Rd	43.1	20.0	46.2	47.9	3	7	16	34	72
2	Floodplain In Situ Barrier	I-40	National Old Trails Rd	43.0	20.0	46.5	48.1	3	7	16	35	75
3	Upland In Situ Treatment	I-40	National Old Trails Rd	43.0	20.0	46.5	48.1	3	7	16	35	75
4	Monitored Natural Attenuation	I-40	National Old Trails Rd	43.0	19.9	46.1	47.9	3	7	16	33	72
5	Freshwater Flushing	I-40	National Old Trails Rd	46.2	23.1	48.2	50.4	5	11	23	49	106
6	Monitoring of Groundwater Remediation	I-40	National Old Trails Rd	43.0	19.9	46.1	47.9	3	7	16	33	72
7	Continued Operations of IM-3	I-40	National Old Trails Rd	43.1	20.1	46.1	47.9	3	7	16	34	72

Appendix X2

Project-Generated Construction Source Vibration Prediction Model

Topock Compressor Station

Location	Distance to Nearest Receiver in feet	Predicted Vibration Level (PPV)		Predicted Vibration Level (VdB)		Equipment	Reference Distance	PPV at 25 feet (in/sec)[1]	Approximate Lv (VdB) at 25 feet[2]
		Drilling	Trucks	Drilling	Trucks				
CA Threshold (0.08 PPV)	**30**	**0.068**	**0.058**			Drilling	25	0.089	87
CA Threshold (80VdB)	**45**			**79**	**78**	Trucks	25	0.076	86
AZ Threshold (0.002 PPV)	**275**	**0.002**	**0.002**						
AZ Threshold (80VdB)	**45**			**79**	**78**				

Notes:

[1] Where PPV is the peak particle velocity

[2] Where Lv is the RMS velocity expressed in vibration decibels (VdB), assuming a crest factor of 4.

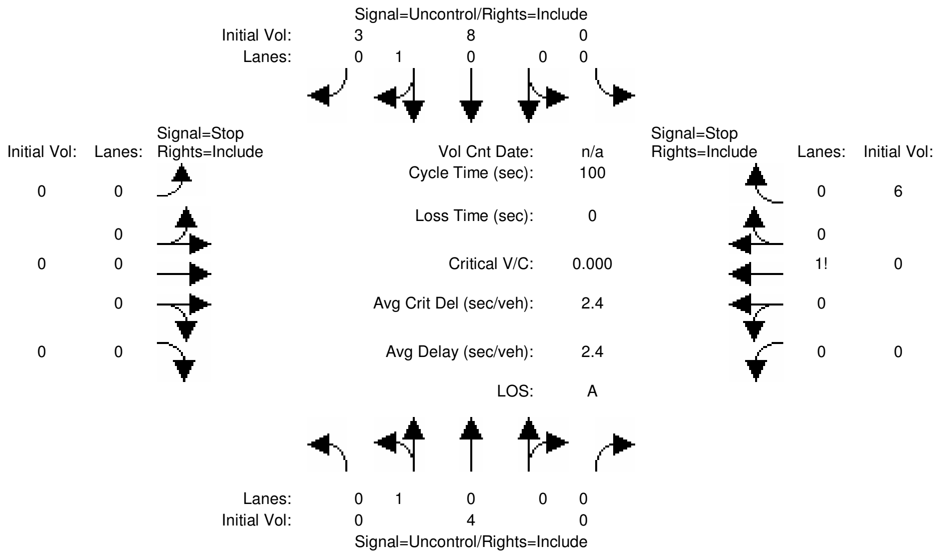
Source: Caltrans 2002, FTA 2006

APPENDIX TR

Transportation

Level Of Service Computation Report
2000 HCM Unsignalized (Future Volume Alternative)
Existing AM

Intersection #1: I-40 WB/Park Moabi



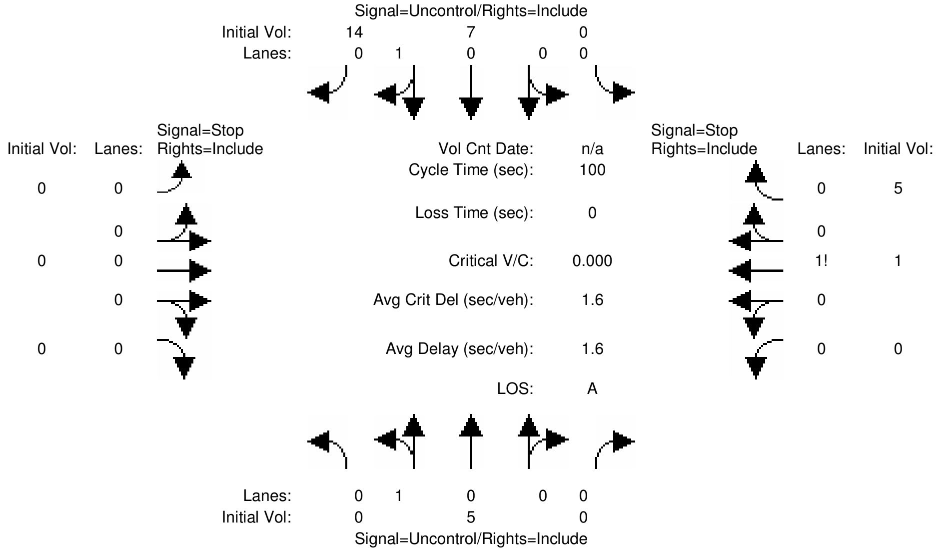
Vol Cnt Date: n/a
Cycle Time (sec): 100
Loss Time (sec): 0
Critical V/C: 0.000
Avg Crit Del (sec/veh): 2.4
Avg Delay (sec/veh): 2.4
LOS: A

```
Street Name:         Park Moabi Road                    I-40 WB Ramp
Approach:      North Bound      South Bound       East Bound        West Bound
Movement:     L  -  T  -  R    L  -  T  -  R    L  -  T  -  R    L  -  T  -  R
------------|---------------||---------------||---------------||---------------|
Volume Module:
Base Vol:       0    4     0     0    8     3     0    0     0     0    0     6
Growth Adj:  1.00 1.00  1.00  1.00 1.00  1.00  1.00 1.00  1.00  1.00 1.00  1.00
Initial Bse:    0    4     0     0    8     3     0    0     0     0    0     6
Added Vol:      0    0     0     0    0     0     0    0     0     0    0     0
PasserByVol:    0    0     0     0    0     0     0    0     0     0    0     0
Initial Fut:    0    4     0     0    8     3     0    0     0     0    0     6
User Adj:    1.00 1.00  1.00  1.00 1.00  1.00  1.00 1.00  1.00  1.00 1.00  1.00
PHF Adj:     0.58 0.58  0.58  0.58 0.58  0.58  0.58 0.58  0.58  0.58 0.58  0.58
PHF Volume:     0    7     0     0   14     5     0    0     0     0    0    10
Reduct Vol:     0    0     0     0    0     0     0    0     0     0    0     0
FinalVolume:    0    7     0     0   14     5     0    0     0     0    0    10
------------|---------------||---------------||---------------||---------------|
Critical Gap Module:
Critical Gp:xxxxx xxxx xxxxx xxxxx xxxx xxxxx xxxxx xxxx xxxxx xxxxx xxxx   6.2
FollowUpTim:xxxxx xxxx xxxxx xxxxx xxxx xxxxx xxxxx xxxx xxxxx xxxxx xxxx   3.3
------------|---------------||---------------||---------------||---------------|
Capacity Module:
Cnflict Vol: xxxx xxxx xxxxx  xxxx xxxx xxxxx  xxxx xxxx xxxxx  xxxx xxxx     7
Potent Cap.: xxxx xxxx xxxxx  xxxx xxxx xxxxx  xxxx xxxx xxxxx  xxxx xxxx  1081
Move Cap.:   xxxx xxxx xxxxx  xxxx xxxx xxxxx  xxxx xxxx xxxxx  xxxx xxxx  1081
Volume/Cap:  xxxx xxxx  xxxx  xxxx xxxx  xxxx  xxxx xxxx  xxxx  xxxx xxxx  0.01
------------|---------------||---------------||---------------||---------------|
Level Of Service Module:
2Way95thQ:   xxxx xxxx xxxxx  xxxx xxxx xxxxx  xxxx xxxx xxxxx  xxxx xxxx   0.0
Control Del:xxxxx xxxx xxxxx xxxxx xxxx xxxxx xxxxx xxxx xxxxx xxxxx xxxx   8.4
LOS by Move:    *    *     *     *    *     *     *    *     *     *    *     A
Movement:     LT - LTR - RT    LT - LTR - RT    LT - LTR - RT    LT - LTR - RT
Shared Cap.: xxxx xxxx xxxxx  xxxx xxxx xxxxx  xxxx xxxx xxxxx  xxxx xxxx xxxxx
SharedQueue:xxxxx xxxx xxxxx xxxxx xxxx xxxxx xxxxx xxxx xxxxx xxxxx xxxx xxxxx
Shrd ConDel:xxxxx xxxx xxxxx xxxxx xxxx xxxxx xxxxx xxxx xxxxx xxxxx xxxx xxxxx
Shared LOS:     *    *     *     *    *     *     *    *     *     *    *     *
ApproachDel:    xxxxxx           xxxxxx           xxxxxx              8.4
ApproachLOS:        *                *                *                A
Note: Queue reported is the number of cars per lane.
```

IE08-0015 Topock Remediation

Level Of Service Computation Report
2000 HCM Unsignalized (Future Volume Alternative)
Existing PM

Intersection #1: I-40 WB/Park Moabi

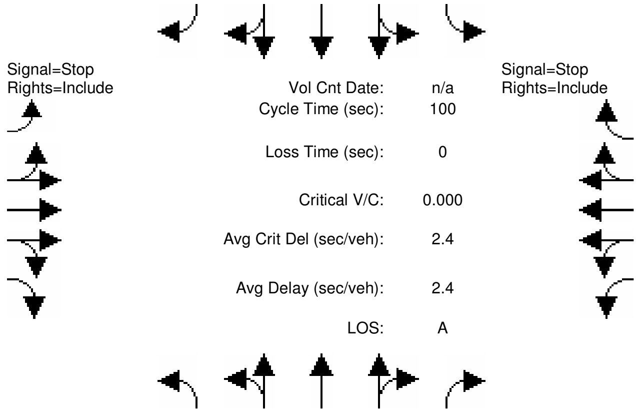


Vol Cnt Date: n/a
Cycle Time (sec): 100
Loss Time (sec): 0
Critical V/C: 0.000
Avg Crit Del (sec/veh): 1.6
Avg Delay (sec/veh): 1.6
LOS: A

```
Street Name:         Park Moabi Road                    I-40 WB Ramp
Approach:      North Bound      South Bound       East Bound       West Bound
Movement:     L  -  T  -  R    L  -  T  -  R    L  -  T  -  R    L  -  T  -  R
------------|---------------||---------------||---------------||---------------|
Volume Module:
Base Vol:       0    5     0     0    7    14     0    0     0     0    1     5
Growth Adj:  1.00 1.00  1.00  1.00 1.00  1.00  1.00 1.00  1.00  1.00 1.00  1.00
Initial Bse:    0    5     0     0    7    14     0    0     0     0    1     5
Added Vol:      0    0     0     0    0     0     0    0     0     0    0     0
PasserByVol:    0    0     0     0    0     0     0    0     0     0    0     0
Initial Fut:    0    5     0     0    7    14     0    0     0     0    1     5
User Adj:    1.00 1.00  1.00  1.00 1.00  1.00  1.00 1.00  1.00  1.00 1.00  1.00
PHF Adj:     0.80 0.80  0.80  0.80 0.80  0.80  0.80 0.80  0.80  0.80 0.80  0.80
PHF Volume:     0    6     0     0    9    18     0    0     0     0    1     6
Reduct Vol:     0    0     0     0    0     0     0    0     0     0    0     0
FinalVolume:    0    6     0     0    9    18     0    0     0     0    1     6
------------|---------------||---------------||---------------||---------------|
Critical Gap Module:
Critical Gp:xxxxx xxxx xxxxx xxxxx xxxx xxxxx xxxxx xxxx xxxxx xxxxx  6.5   6.2
FollowUpTim:xxxxx xxxx xxxxx xxxxx xxxx xxxxx xxxxx xxxx xxxxx xxxxx  4.0   3.3
------------|---------------||---------------||---------------||---------------|
Capacity Module:
Cnflict Vol: xxxx xxxx xxxxx  xxxx xxxx xxxxx  xxxx xxxx xxxxx  xxxx   33     6
Potent Cap.: xxxx xxxx xxxxx  xxxx xxxx xxxxx  xxxx xxxx xxxxx  xxxx  864  1082
Move Cap.:   xxxx xxxx xxxxx  xxxx xxxx xxxxx  xxxx xxxx xxxxx  xxxx  864  1082
Volume/Cap:  xxxx xxxx  xxxx  xxxx xxxx  xxxx  xxxx xxxx  xxxx  xxxx 0.00  0.01
------------|---------------||---------------||---------------||---------------|
Level Of Service Module:
2Way95thQ:   xxxx xxxx xxxxx  xxxx xxxx xxxxx  xxxx xxxx xxxxx  xxxx xxxx xxxxx
Control Del:xxxxx xxxx xxxxx xxxxx xxxx xxxxx xxxxx xxxx xxxxx xxxxx xxxx xxxxx
LOS by Move:    *    *     *     *    *     *     *    *     *     *    *     *
Movement:     LT - LTR - RT    LT - LTR - RT    LT - LTR - RT    LT - LTR - RT
Shared Cap.: xxxx xxxx xxxxx  xxxx xxxx xxxxx  xxxx xxxx xxxxx  xxxx xxxx  1039
SharedQueue:xxxxx xxxx xxxxx xxxxx xxxx xxxxx xxxxx xxxx xxxxx xxxxx xxxx   0.0
Shrd ConDel:xxxxx xxxx xxxxx xxxxx xxxx xxxxx xxxxx xxxx xxxxx xxxxx xxxx   8.5
Shared LOS:     *    *     *     *    *     *     *    *     *     *    *     A
ApproachDel:    xxxxxx           xxxxxx           xxxxxx              8.5
ApproachLOS:         *                *                *                A
Note: Queue reported is the number of cars per lane.
```

Level Of Service Computation Report
2000 HCM Unsignalized (Future Volume Alternative)
Cumulative AM

Intersection #1: I-40 WB/Park Moabi



```
                         Signal=Uncontrol/Rights=Include
            Initial Vol:     5          12          0
                  Lanes:     0    1      0      0   0

                 Signal=Stop                                   Signal=Stop
Initial Vol:  Lanes:  Rights=Include     Vol Cnt Date:    n/a   Rights=Include   Lanes:  Initial Vol:
                                      Cycle Time (sec):   100
     0          0                                                                   0        9
                                       Loss Time (sec):     0
                0                                                                   0
     0          0                          Critical V/C:  0.000                     1!       0
                0                   Avg Crit Del (sec/veh):  2.4                    0
     0          0                      Avg Delay (sec/veh):  2.4                    0        0
                                                    LOS:     A

                  Lanes:     0    1      0      0   0
            Initial Vol:     0           6          0
                         Signal=Uncontrol/Rights=Include
```

```
Street Name:         Park Moabi Road                     I-40 WB Ramp
Approach:      North Bound      South Bound       East Bound        West Bound
Movement:     L  -  T  -  R    L  -  T  -  R    L  -  T  -  R    L  -  T  -  R
------------|---------------||---------------||---------------||---------------|
Volume Module:
Base Vol:       0    4     0     0    8     3     0    0     0     0    0     6
Growth Adj:  1.55 1.55  1.55  1.55 1.55  1.55  1.55 1.55  1.55  1.55 1.55  1.55
Initial Bse:    0    6     0     0   12     5     0    0     0     0    0     9
Added Vol:      0    0     0     0    0     0     0    0     0     0    0     0
PasserByVol:    0    0     0     0    0     0     0    0     0     0    0     0
Initial Fut:    0    6     0     0   12     5     0    0     0     0    0     9
User Adj:    1.00 1.00  1.00  1.00 1.00  1.00  1.00 1.00  1.00  1.00 1.00  1.00
PHF Adj:     0.58 0.58  0.58  0.58 0.58  0.58  0.58 0.58  0.58  0.58 0.58  0.58
PHF Volume:     0   11     0     0   21     8     0    0     0     0    0    16
Reduct Vol:     0    0     0     0    0     0     0    0     0     0    0     0
FinalVolume:    0   11     0     0   21     8     0    0     0     0    0    16
------------|---------------||---------------||---------------||---------------|
Critical Gap Module:
Critical Gp:xxxxx xxxx xxxxx xxxxx xxxx xxxxx xxxxx xxxx xxxxx xxxxx xxxx   6.2
FollowUpTim:xxxxx xxxx xxxxx xxxxx xxxx xxxxx xxxxx xxxx xxxxx xxxxx xxxx   3.3
------------|---------------||---------------||---------------||---------------|
Capacity Module:
Cnflict Vol: xxxx xxxx xxxxx  xxxx xxxx xxxxx  xxxx xxxx xxxxx  xxxx xxxx    11
Potent Cap.: xxxx xxxx xxxxx  xxxx xxxx xxxxx  xxxx xxxx xxxxx  xxxx xxxx  1076
Move Cap.:   xxxx xxxx xxxxx  xxxx xxxx xxxxx  xxxx xxxx xxxxx  xxxx xxxx  1076
Volume/Cap:  xxxx xxxx  xxxx  xxxx xxxx  xxxx  xxxx xxxx  xxxx  xxxx xxxx  0.01
------------|---------------||---------------||---------------||---------------|
Level Of Service Module:
2Way95thQ:   xxxx xxxx xxxxx  xxxx xxxx xxxxx  xxxx xxxx xxxxx  xxxx xxxx   0.0
Control Del:xxxxx xxxx xxxxx xxxxx xxxx xxxxx xxxxx xxxx xxxxx xxxxx xxxx   8.4
LOS by Move:    *    *     *     *    *     *     *    *     *     *    *     A
Movement:     LT - LTR - RT    LT - LTR - RT    LT - LTR - RT    LT - LTR - RT
Shared Cap.: xxxx xxxx xxxxx  xxxx xxxx xxxxx  xxxx xxxx xxxxx  xxxx xxxx xxxxx
SharedQueue:xxxxx xxxx xxxxx xxxxx xxxx xxxxx xxxxx xxxx xxxxx xxxxx xxxx xxxxx
Shrd ConDel:xxxxx xxxx xxxxx xxxxx xxxx xxxxx xxxxx xxxx xxxxx xxxxx xxxx xxxxx
Shared LOS:     *    *     *     *    *     *     *    *     *     *    *     *
ApproachDel:    xxxxxx           xxxxxx           xxxxxx              8.4
ApproachLOS:         *                *                *                A
Note: Queue reported is the number of cars per lane.
                     Peak Hour Delay Signal Warrant Report
********************************************************************************
Intersection #1 I-40 WB/Park Moabi
********************************************************************************
Future Volume Alternative: Peak Hour Warrant NOT Met
```

```
------------|---------------||---------------||---------------||---------------|
Approach:      North Bound      South Bound       East Bound       West Bound
Movement:     L  -  T  -  R    L  -  T  -  R    L  -  T  -  R    L  -  T  -  R
------------|---------------||---------------||---------------||---------------|
Control:       Uncontrolled     Uncontrolled      Stop Sign        Stop Sign
Lanes:        0  0  1  0  0    0  0  0  1  0    0  0  0  0  0    0  0  0  0  1
Initial Vol:    0    6     0     0   12     5     0    0     0     0    0     9
ApproachDel:    xxxxxx           xxxxxx           xxxxxx              8.4
------------|---------------||---------------||---------------||---------------|
Approach[westbound][lanes=1][control=Stop Sign]
Signal Warrant Rule #1: [vehicle-hours=0.0]
   FAIL - Vehicle-hours less than 4 for one lane approach.
Signal Warrant Rule #2: [approach volume=9]
   FAIL - Approach volume less than 100 for one lane approach.
Signal Warrant Rule #3: [approach count=3][total volume=33]
   FAIL - Total volume less than 650 for intersection
          with less than four approaches.
--------------------------------------------------------------------------------
SIGNAL WARRANT DISCLAIMER
This peak hour signal warrant analysis should be considered solely as an
"indicator" of the likelihood of an unsignalized intersection warranting
a traffic signal in the future.  Intersections that exceed this warrant
are probably more likely to meet one or more of the other volume based
signal warrant (such as the 4-hour or 8-hour warrants).

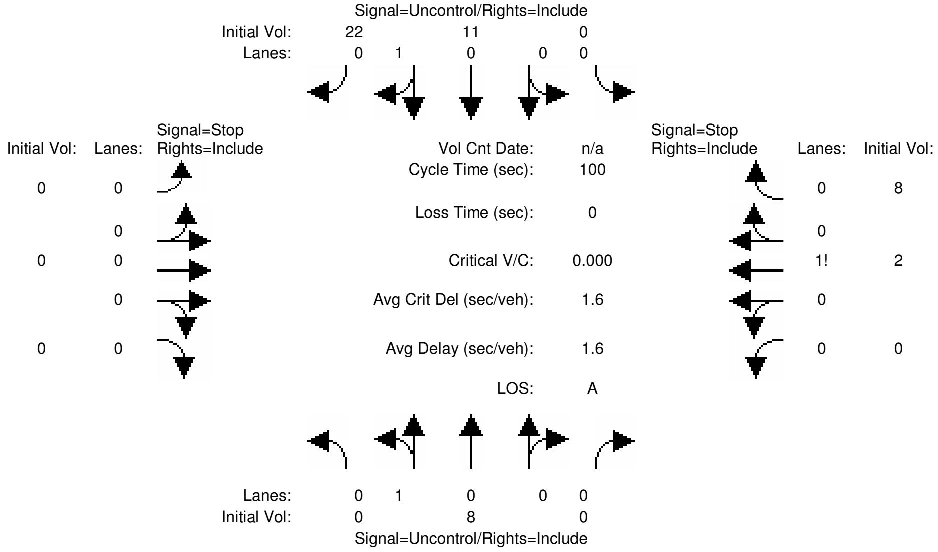
The peak hour warrant analysis in this report is not intended to replace
a rigorous and complete traffic signal warrant analysis by the responsible
jurisdiction.  Consideration of the other signal warrants, which is beyond
the scope of this software, may yield different results.
                Peak Hour Volume Signal Warrant Report [Urban]
********************************************************************************
Intersection #1 I-40 WB/Park Moabi
********************************************************************************
Future Volume Alternative: Peak Hour Warrant NOT Met
------------|---------------||---------------||---------------||---------------|
Approach:      North Bound      South Bound       East Bound       West Bound
Movement:     L  -  T  -  R    L  -  T  -  R    L  -  T  -  R    L  -  T  -  R
------------|---------------||---------------||---------------||---------------|
Control:       Uncontrolled     Uncontrolled      Stop Sign        Stop Sign
Lanes:        0  0  1  0  0    0  0  0  1  0    0  0  0  0  0    0  0  0  0  1
Initial Vol:    0    6     0     0   12     5     0    0     0     0    0     9
------------|---------------||---------------||---------------||---------------|
Major Street Volume:             23
Minor Approach Volume:           9
Minor Approach Volume Threshold: 1223
--------------------------------------------------------------------------------
SIGNAL WARRANT DISCLAIMER
This peak hour signal warrant analysis should be considered solely as an
"indicator" of the likelihood of an unsignalized intersection warranting
a traffic signal in the future.  Intersections that exceed this warrant
are probably more likely to meet one or more of the other volume based
signal warrant (such as the 4-hour or 8-hour warrants).

The peak hour warrant analysis in this report is not intended to replace
a rigorous and complete traffic signal warrant analysis by the responsible
jurisdiction.  Consideration of the other signal warrants, which is beyond
the scope of this software, may yield different results.
```

IE08-0015 Topock Remediation

Level Of Service Computation Report
2000 HCM Unsignalized (Future Volume Alternative)
Cumulative PM

Intersection #1: I-40 WB/Park Moabi



Vol Cnt Date: n/a
Cycle Time (sec): 100
Loss Time (sec): 0
Critical V/C: 0.000
Avg Crit Del (sec/veh): 1.6
Avg Delay (sec/veh): 1.6
LOS: A

```
Street Name:        Park Moabi Road                  I-40 WB Ramp
Approach:      North Bound      South Bound       East Bound       West Bound
Movement:     L  -  T  -  R    L  -  T  -  R    L  -  T  -  R    L  -  T  -  R
------------|---------------||---------------||---------------||---------------|
Volume Module:
Base Vol:       0    5     0     0    7    14     0    0     0     0    1     5
Growth Adj:  1.55 1.55  1.55  1.55 1.55  1.55  1.55 1.55  1.55  1.55 1.55  1.55
Initial Bse:    0    8     0     0   11    22     0    0     0     0    2     8
Added Vol:      0    0     0     0    0     0     0    0     0     0    0     0
PasserByVol:    0    0     0     0    0     0     0    0     0     0    0     0
Initial Fut:    0    8     0     0   11    22     0    0     0     0    2     8
User Adj:    1.00 1.00  1.00  1.00 1.00  1.00  1.00 1.00  1.00  1.00 1.00  1.00
PHF Adj:     0.80 0.80  0.80  0.80 0.80  0.80  0.80 0.80  0.80  0.80 0.80  0.80
PHF Volume:     0   10     0     0   14    27     0    0     0     0    2    10
Reduct Vol:     0    0     0     0    0     0     0    0     0     0    0     0
FinalVolume:    0   10     0     0   14    27     0    0     0     0    2    10
------------|---------------||---------------||---------------||---------------|
Critical Gap Module:
Critical Gp:xxxxx xxxx xxxxx xxxxx xxxx xxxxx xxxxx xxxx xxxxx xxxxx  6.5   6.2
FollowUpTim:xxxxx xxxx xxxxx xxxxx xxxx xxxxx xxxxx xxxx xxxxx xxxxx  4.0   3.3
------------|---------------||---------------||---------------||---------------|
Capacity Module:
Cnflict Vol: xxxx xxxx xxxxx  xxxx xxxx xxxxx  xxxx xxxx xxxxx  xxxx   50    10
Potent Cap.: xxxx xxxx xxxxx  xxxx xxxx xxxxx  xxxx xxxx xxxxx  xxxx  845  1078
Move Cap.:   xxxx xxxx xxxxx  xxxx xxxx xxxxx  xxxx xxxx xxxxx  xxxx  845  1078
Volume/Cap:  xxxx xxxx  xxxx  xxxx xxxx  xxxx  xxxx xxxx  xxxx  xxxx 0.00  0.01
------------|---------------||---------------||---------------||---------------|
Level Of Service Module:
2Way95thQ:   xxxx xxxx xxxxx  xxxx xxxx xxxxx  xxxx xxxx xxxxx  xxxx xxxx xxxxx
Control Del:xxxxx xxxx xxxxx xxxxx xxxx xxxxx xxxxx xxxx xxxxx xxxxx xxxx xxxxx
LOS by Move:    *    *     *     *    *     *     *    *     *     *    *     *
Movement:     LT - LTR - RT    LT - LTR - RT    LT - LTR - RT    LT - LTR - RT
Shared Cap.: xxxx xxxx xxxxx  xxxx xxxx xxxxx  xxxx xxxx xxxxx  xxxx xxxx  1030
SharedQueue:xxxxx xxxx xxxxx xxxxx xxxx xxxxx xxxxx xxxx xxxxx xxxxx xxxx   0.0
Shrd ConDel:xxxxx xxxx xxxxx xxxxx xxxx xxxxx xxxxx xxxx xxxxx xxxxx xxxx   8.5
Shared LOS:     *    *     *     *    *     *     *    *     *     *    *     A
ApproachDel:    xxxxxx           xxxxxx           xxxxxx              8.5
ApproachLOS:         *                *                *                A
Note: Queue reported is the number of cars per lane.
                     Peak Hour Delay Signal Warrant Report
*********************************************************************************
Intersection #1 I-40 WB/Park Moabi
*********************************************************************************
Future Volume Alternative: Peak Hour Warrant NOT Met
```

```
------------|---------------||---------------||---------------||---------------|
Approach:      North Bound      South Bound       East Bound       West Bound
Movement:     L  -  T  -  R    L  -  T  -  R    L  -  T  -  R    L  -  T  -  R
------------|---------------||---------------||---------------||---------------|
Control:       Uncontrolled     Uncontrolled      Stop Sign        Stop Sign
Lanes:        0  0  1  0  0    0  0  0  1  0    0  0  0  0  0    0  0  0  1  0
Initial Vol:    0    8     0     0   11    22     0    0     0     0    2     8
ApproachDel:    xxxxxx           xxxxxx           xxxxxx              8.5
------------|---------------||---------------||---------------||---------------|
Approach[westbound][lanes=1][control=Stop Sign]
Signal Warrant Rule #1: [vehicle-hours=0.0]
   FAIL - Vehicle-hours less than 4 for one lane approach.
Signal Warrant Rule #2: [approach volume=9]
   FAIL - Approach volume less than 100 for one lane approach.
Signal Warrant Rule #3: [approach count=3][total volume=50]
   FAIL - Total volume less than 650 for intersection
          with less than four approaches.
--------------------------------------------------------------------------------
SIGNAL WARRANT DISCLAIMER
This peak hour signal warrant analysis should be considered solely as an
"indicator" of the likelihood of an unsignalized intersection warranting
a traffic signal in the future.  Intersections that exceed this warrant
are probably more likely to meet one or more of the other volume based
signal warrant (such as the 4-hour or 8-hour warrants).

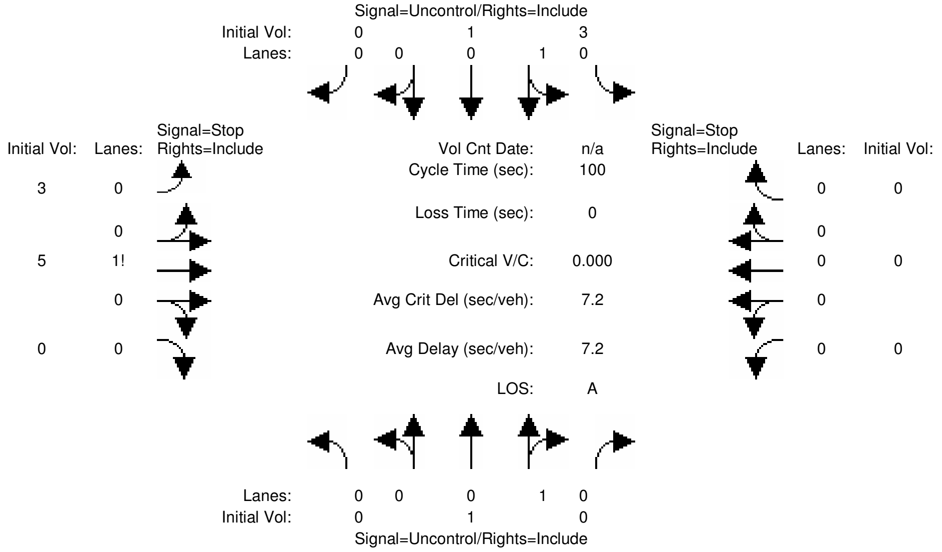
The peak hour warrant analysis in this report is not intended to replace
a rigorous and complete traffic signal warrant analysis by the responsible
jurisdiction.  Consideration of the other signal warrants, which is beyond
the scope of this software, may yield different results.
                Peak Hour Volume Signal Warrant Report [Urban]
********************************************************************************
Intersection #1 I-40 WB/Park Moabi
********************************************************************************
Future Volume Alternative: Peak Hour Warrant NOT Met
------------|---------------||---------------||---------------||---------------|
Approach:      North Bound      South Bound       East Bound       West Bound
Movement:     L  -  T  -  R    L  -  T  -  R    L  -  T  -  R    L  -  T  -  R
------------|---------------||---------------||---------------||---------------|
Control:       Uncontrolled     Uncontrolled      Stop Sign        Stop Sign
Lanes:        0  0  1  0  0    0  0  0  1  0    0  0  0  0  0    0  0  0  1  0
Initial Vol:    0    8     0     0   11    22     0    0     0     0    2     8
------------|---------------||---------------||---------------||---------------|
Major Street Volume:             40
Minor Approach Volume:           9
Minor Approach Volume Threshold: 1076
--------------------------------------------------------------------------------
SIGNAL WARRANT DISCLAIMER
This peak hour signal warrant analysis should be considered solely as an
"indicator" of the likelihood of an unsignalized intersection warranting
a traffic signal in the future.  Intersections that exceed this warrant
are probably more likely to meet one or more of the other volume based
signal warrant (such as the 4-hour or 8-hour warrants).

The peak hour warrant analysis in this report is not intended to replace
a rigorous and complete traffic signal warrant analysis by the responsible
jurisdiction.  Consideration of the other signal warrants, which is beyond
the scope of this software, may yield different results.
```

IE08-0015 Topock Remediation

Level Of Service Computation Report
2000 HCM Unsignalized (Future Volume Alternative)
Existing AM

Intersection #2: I-40 EB/Park Moabi

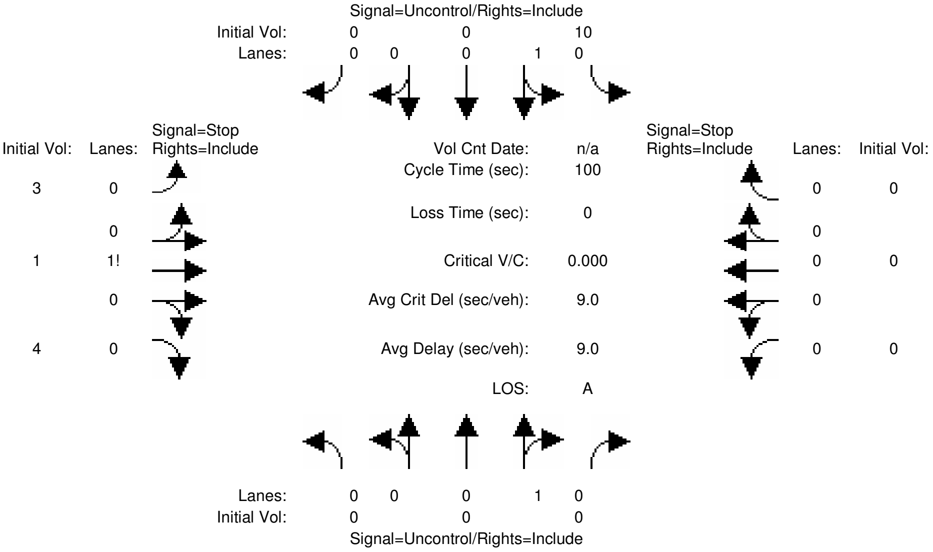


Vol Cnt Date: n/a
Cycle Time (sec): 100
Loss Time (sec): 0
Critical V/C: 0.000
Avg Crit Del (sec/veh): 7.2
Avg Delay (sec/veh): 7.2
LOS: A

```
Street Name:         Park Moabi Road                    I-40 EB Ramp
Approach:      North Bound      South Bound       East Bound        West Bound
Movement:    L  -  T  -  R    L  -  T  -  R    L  -  T  -  R    L  -  T  -  R
------------|---------------||---------------||---------------||---------------|
Volume Module:
Base Vol:       0    1     0     3    1     0     3    5     0     0    0     0
Growth Adj:  1.00 1.00  1.00  1.00 1.00  1.00  1.00 1.00  1.00  1.00 1.00  1.00
Initial Bse:    0    1     0     3    1     0     3    5     0     0    0     0
Added Vol:      0    0     0     0    0     0     0    0     0     0    0     0
PasserByVol:    0    0     0     0    0     0     0    0     0     0    0     0
Initial Fut:    0    1     0     3    1     0     3    5     0     0    0     0
User Adj:    1.00 1.00  1.00  1.00 1.00  1.00  1.00 1.00  1.00  1.00 1.00  1.00
PHF Adj:     0.54 0.54  0.54  0.54 0.54  0.54  0.54 0.54  0.54  0.54 0.54  0.54
PHF Volume:     0    2     0     6    2     0     6    9     0     0    0     0
Reduct Vol:     0    0     0     0    0     0     0    0     0     0    0     0
FinalVolume:    0    2     0     6    2     0     6    9     0     0    0     0
------------|---------------||---------------||---------------||---------------|
Critical Gap Module:
Critical Gp:xxxxx xxxx xxxxx   4.1 xxxx xxxxx   6.4  6.5 xxxxx xxxxx xxxx xxxxx
FollowUpTim:xxxxx xxxx xxxxx   2.2 xxxx xxxxx   3.5  4.0 xxxxx xxxxx xxxx xxxxx
------------|---------------||---------------||---------------||---------------|
Capacity Module:
Cnflict Vol: xxxx xxxx xxxxx     2 xxxx xxxxx    15   15 xxxxx  xxxx xxxx xxxxx
Potent Cap.: xxxx xxxx xxxxx  1634 xxxx xxxxx  1009  883 xxxxx  xxxx xxxx xxxxx
Move Cap.:   xxxx xxxx xxxxx  1634 xxxx xxxxx  1006  880 xxxxx  xxxx xxxx xxxxx
Volume/Cap:  xxxx xxxx  xxxx  0.00 xxxx  xxxx  0.01 0.01  xxxx  xxxx xxxx  xxxx
------------|---------------||---------------||---------------||---------------|
Level Of Service Module:
2Way95thQ:   xxxx xxxx xxxxx   0.0 xxxx xxxxx  xxxx xxxx xxxxx  xxxx xxxx xxxxx
Control Del:xxxxx xxxx xxxxx   7.2 xxxx xxxxx xxxxx xxxx xxxxx xxxxx xxxx xxxxx
LOS by Move:    *    *     *     A    *     *     *    *     *     *    *     *
Movement:     LT - LTR - RT    LT - LTR - RT    LT - LTR - RT    LT - LTR - RT
Shared Cap.: xxxx xxxx xxxxx  xxxx xxxx xxxxx   924 xxxx xxxxx  xxxx xxxx xxxxx
SharedQueue:xxxxx xxxx xxxxx   0.0 xxxx xxxxx   0.0 xxxx xxxxx xxxxx xxxx xxxxx
Shrd ConDel:xxxxx xxxx xxxxx   7.2 xxxx xxxxx   9.0 xxxx xxxxx xxxxx xxxx xxxxx
Shared LOS:     *    *     *     A    *     *     A    *     *     *    *     *
ApproachDel:    xxxxxx           xxxxxx              9.0            xxxxxx
ApproachLOS:         *                *                A                 *
Note: Queue reported is the number of cars per lane.
```

Level Of Service Computation Report
2000 HCM Unsignalized (Future Volume Alternative)
Existing PM

Intersection #2: I-40 EB/Park Moabi



Signal=Uncontrol/Rights=Include
Initial Vol: 0 0 10
Lanes: 0 0 0 1 0

Signal=Stop
Rights=Include
Initial Vol: 3, 1, 4
Lanes: 0, 0, 1!, 0, 0

Vol Cnt Date: n/a
Cycle Time (sec): 100
Loss Time (sec): 0
Critical V/C: 0.000
Avg Crit Del (sec/veh): 9.0
Avg Delay (sec/veh): 9.0
LOS: A

Signal=Stop
Rights=Include
Lanes: 0, 0, 0, 0, 0
Initial Vol: 0, 0, 0

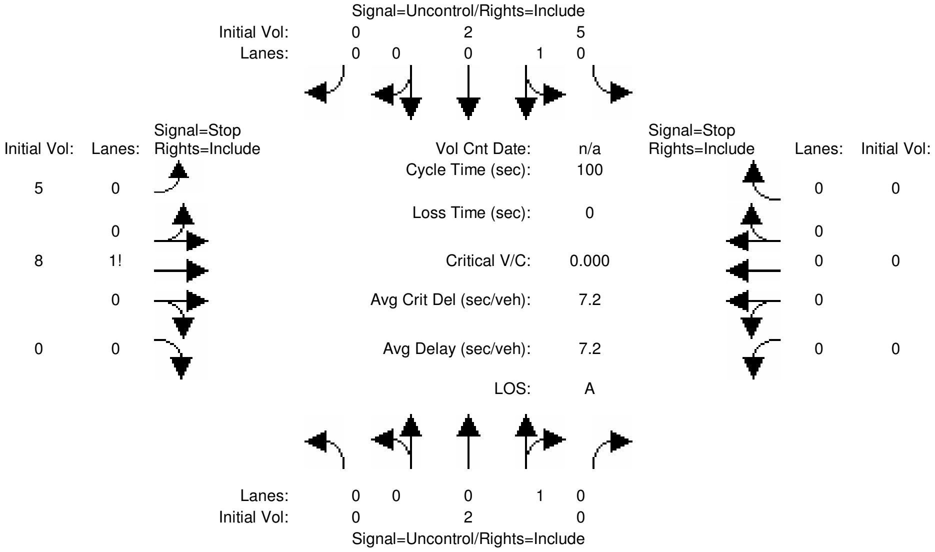
Lanes: 0 0 0 1 0
Initial Vol: 0 0 0
Signal=Uncontrol/Rights=Include

```
Street Name:          Park Moabi Road                    I-40 EB Ramp
Approach:      North Bound      South Bound       East Bound       West Bound
Movement:    L  -  T  -  R    L  -  T  -  R    L  -  T  -  R    L  -  T  -  R
------------|---------------||---------------||---------------||---------------|
Volume Module:
Base Vol:       0    0     0    10    0     0     3    1     4     0    0     0
Growth Adj:  1.00 1.00  1.00  1.00 1.00  1.00  1.00 1.00  1.00  1.00 1.00  1.00
Initial Bse:    0    0     0    10    0     0     3    1     4     0    0     0
Added Vol:      0    0     0     0    0     0     0    0     0     0    0     0
PasserByVol:    0    0     0     0    0     0     0    0     0     0    0     0
Initial Fut:    0    0     0    10    0     0     3    1     4     0    0     0
User Adj:    1.00 1.00  1.00  1.00 1.00  1.00  1.00 1.00  1.00  1.00 1.00  1.00
PHF Adj:     0.70 0.70  0.70  0.70 0.70  0.70  0.70 0.70  0.70  0.70 0.70  0.70
PHF Volume:     0    0     0    14    0     0     4    1     6     0    0     0
Reduct Vol:     0    0     0     0    0     0     0    0     0     0    0     0
FinalVolume:    0    0     0    14    0     0     4    1     6     0    0     0
------------|---------------||---------------||---------------||---------------|
Critical Gap Module:
Critical Gp:xxxxx xxxx xxxxx   4.1 xxxx xxxxx   6.4  6.5   6.2 xxxxx xxxx xxxxx
FollowUpTim:xxxxx xxxx xxxxx   2.2 xxxx xxxxx   3.5  4.0   3.3 xxxxx xxxx xxxxx
------------|---------------||---------------||---------------||---------------|
Capacity Module:
Cnflict Vol: xxxx xxxx xxxxx     0 xxxx xxxxx    29   29     0  xxxx xxxx xxxxx
Potent Cap.: xxxx xxxx xxxxx   900 xxxx xxxxx   991  868   900  xxxx xxxx xxxxx
Move Cap.:   xxxx xxxx xxxxx   900 xxxx xxxxx   979  855   900  xxxx xxxx xxxxx
Volume/Cap:  xxxx xxxx  xxxx  0.02 xxxx  xxxx  0.00 0.00  0.01  xxxx xxxx  xxxx
------------|---------------||---------------||---------------||---------------|
Level Of Service Module:
2Way95thQ:   xxxx xxxx xxxxx   0.0 xxxx xxxxx  xxxx xxxx xxxxx  xxxx xxxx xxxxx
Control Del:xxxxx xxxx xxxxx   9.1 xxxx xxxxx xxxxx xxxx xxxxx xxxxx xxxx xxxxx
LOS by Move:    *    *     *     A    *     *     *    *     *     *    *     *
Movement:     LT - LTR - RT    LT - LTR - RT    LT - LTR - RT    LT - LTR - RT
Shared Cap.: xxxx xxxx xxxxx  xxxx xxxx xxxxx  xxxx  922 xxxxx  xxxx xxxx xxxxx
SharedQueue:xxxxx xxxx xxxxx xxxxx xxxx xxxxx xxxxx  0.0 xxxxx xxxxx xxxx xxxxx
Shrd ConDel:xxxxx xxxx xxxxx xxxxx xxxx xxxxx xxxxx  9.0 xxxxx xxxxx xxxx xxxxx
Shared LOS:     *    *     *     *    *     *     *    A     *     *    *     *
ApproachDel:    xxxxxx           xxxxxx             9.0             xxxxxx
ApproachLOS:         *                *               A                  *
Note: Queue reported is the number of cars per lane.
```

IE08-0015 Topock Remediation

Level Of Service Computation Report
2000 HCM Unsignalized (Future Volume Alternative)
Cumulative AM

Intersection #2: I-40 EB/Park Moabi



Vol Cnt Date: n/a
Cycle Time (sec): 100
Loss Time (sec): 0
Critical V/C: 0.000
Avg Crit Del (sec/veh): 7.2
Avg Delay (sec/veh): 7.2
LOS: A

```
Street Name:          Park Moabi Road                    I-40 EB Ramp
Approach:       North Bound      South Bound       East Bound       West Bound
Movement:     L  -  T  -  R    L  -  T  -  R    L  -  T  -  R    L  -  T  -  R
------------|---------------||---------------||---------------||---------------|
Volume Module:
Base Vol:       0    1     0     3    1     0     3    5     0     0    0     0
Growth Adj:  1.55 1.55  1.55  1.55 1.55  1.55  1.55 1.55  1.55  1.55 1.55  1.55
Initial Bse:    0    2     0     5    2     0     5    8     0     0    0     0
Added Vol:      0    0     0     0    0     0     0    0     0     0    0     0
PasserByVol:    0    0     0     0    0     0     0    0     0     0    0     0
Initial Fut:    0    2     0     5    2     0     5    8     0     0    0     0
User Adj:    1.00 1.00  1.00  1.00 1.00  1.00  1.00 1.00  1.00  1.00 1.00  1.00
PHF Adj:     0.54 0.54  0.54  0.54 0.54  0.54  0.54 0.54  0.54  0.54 0.54  0.54
PHF Volume:     0    3     0     9    3     0     9   14     0     0    0     0
Reduct Vol:     0    0     0     0    0     0     0    0     0     0    0     0
FinalVolume:    0    3     0     9    3     0     9   14     0     0    0     0
------------|---------------||---------------||---------------||---------------|
Critical Gap Module:
Critical Gp:xxxxx xxxx xxxxx   4.1 xxxx xxxxx   6.4  6.5 xxxxx xxxxx xxxx xxxxx
FollowUpTim:xxxxx xxxx xxxxx   2.2 xxxx xxxxx   3.5  4.0 xxxxx xxxxx xxxx xxxxx
------------|---------------||---------------||---------------||---------------|
Capacity Module:
Cnflict Vol: xxxx xxxx xxxxx     3 xxxx xxxxx    23   23 xxxxx  xxxx xxxx xxxxx
Potent Cap.: xxxx xxxx xxxxx  1632 xxxx xxxxx   998  875 xxxxx  xxxx xxxx xxxxx
Move Cap.:   xxxx xxxx xxxxx  1632 xxxx xxxxx   994  870 xxxxx  xxxx xxxx xxxxx
Volume/Cap:  xxxx xxxx  xxxx  0.01 xxxx  xxxx  0.01 0.02  xxxx  xxxx xxxx  xxxx
------------|---------------||---------------||---------------||---------------|
Level Of Service Module:
2Way95thQ:   xxxx xxxx xxxxx   0.0 xxxx xxxxx  xxxx xxxx xxxxx  xxxx xxxx xxxxx
Control Del:xxxxx xxxx xxxxx   7.2 xxxx xxxxx xxxxx xxxx xxxxx xxxxx xxxx xxxxx
LOS by Move:    *    *     *     A    *     *     *    *     *     *    *     *
Movement:     LT - LTR - RT    LT - LTR - RT    LT - LTR - RT    LT - LTR - RT
Shared Cap.: xxxx xxxx xxxxx  xxxx xxxx xxxxx   913 xxxx xxxxx  xxxx xxxx xxxxx
SharedQueue:xxxxx xxxx xxxxx   0.0 xxxx xxxxx   0.1 xxxx xxxxx xxxxx xxxx xxxxx
Shrd ConDel:xxxxx xxxx xxxxx   7.2 xxxx xxxxx   9.0 xxxx xxxxx xxxxx xxxx xxxxx
Shared LOS:     *    *     *     A    *     *     A    *     *     *    *     *
ApproachDel:    xxxxxx           xxxxxx             9.0            xxxxxx
ApproachLOS:       *                *                A                *
Note: Queue reported is the number of cars per lane.
                      Peak Hour Delay Signal Warrant Report
**********************************************************************************
Intersection #2 I-40 EB/Park Moabi
**********************************************************************************
Future Volume Alternative: Peak Hour Warrant NOT Met
```

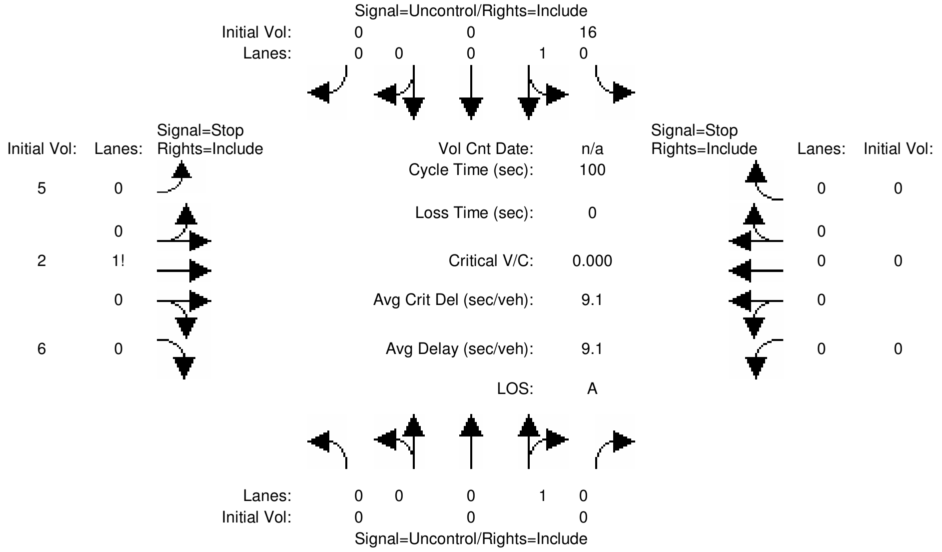
```
------------|---------------||---------------||---------------||---------------|
Approach:      North Bound      South Bound       East Bound       West Bound
Movement:     L  -  T  -  R    L  -  T  -  R    L  -  T  -  R    L  -  T  -  R
------------|---------------||---------------||---------------||---------------|
Control:       Uncontrolled     Uncontrolled      Stop Sign        Stop Sign
Lanes:        0  0  1  0  0    0  1  0  0  0    0  1  0  0  0    0  0  0  0  0
Initial Vol:    0    2     0     5    2     0     5    8     0     0    0     0
ApproachDel:    xxxxxx           xxxxxx              9.0           xxxxxx
------------|---------------||---------------||---------------||---------------|
Approach[eastbound][lanes=1][control=Stop Sign]
Signal Warrant Rule #1: [vehicle-hours=0.0]
   FAIL - Vehicle-hours less than 4 for one lane approach.
Signal Warrant Rule #2: [approach volume=12]
   FAIL - Approach volume less than 100 for one lane approach.
Signal Warrant Rule #3: [approach count=3][total volume=20]
   FAIL - Total volume less than 650 for intersection
          with less than four approaches.
--------------------------------------------------------------------------------
SIGNAL WARRANT DISCLAIMER
This peak hour signal warrant analysis should be considered solely as an
"indicator" of the likelihood of an unsignalized intersection warranting
a traffic signal in the future.  Intersections that exceed this warrant
are probably more likely to meet one or more of the other volume based
signal warrant (such as the 4-hour or 8-hour warrants).

The peak hour warrant analysis in this report is not intended to replace
a rigorous and complete traffic signal warrant analysis by the responsible
jurisdiction.  Consideration of the other signal warrants, which is beyond
the scope of this software, may yield different results.
                Peak Hour Volume Signal Warrant Report [Urban]
********************************************************************************
Intersection #2 I-40 EB/Park Moabi
********************************************************************************
Future Volume Alternative: Peak Hour Warrant NOT Met
------------|---------------||---------------||---------------||---------------|
Approach:      North Bound      South Bound       East Bound       West Bound
Movement:     L  -  T  -  R    L  -  T  -  R    L  -  T  -  R    L  -  T  -  R
------------|---------------||---------------||---------------||---------------|
Control:       Uncontrolled     Uncontrolled      Stop Sign        Stop Sign
Lanes:        0  0  1  0  0    0  1  0  0  0    0  1  0  0  0    0  0  0  0  0
Initial Vol:    0    2     0     5    2     0     5    8     0     0    0     0
------------|---------------||---------------||---------------||---------------|
Major Street Volume:             8
Minor Approach Volume:           12
Minor Approach Volume Threshold: 1516
--------------------------------------------------------------------------------
SIGNAL WARRANT DISCLAIMER
This peak hour signal warrant analysis should be considered solely as an
"indicator" of the likelihood of an unsignalized intersection warranting
a traffic signal in the future.  Intersections that exceed this warrant
are probably more likely to meet one or more of the other volume based
signal warrant (such as the 4-hour or 8-hour warrants).

The peak hour warrant analysis in this report is not intended to replace
a rigorous and complete traffic signal warrant analysis by the responsible
jurisdiction.  Consideration of the other signal warrants, which is beyond
the scope of this software, may yield different results.
```

Level Of Service Computation Report
2000 HCM Unsignalized (Future Volume Alternative)
Cumulative PM

Intersection #2: I-40 EB/Park Moabi



Vol Cnt Date: n/a
Cycle Time (sec): 100
Loss Time (sec): 0
Critical V/C: 0.000
Avg Crit Del (sec/veh): 9.1
Avg Delay (sec/veh): 9.1
LOS: A

```
Street Name:         Park Moabi Road                     I-40 EB Ramp
Approach:      North Bound      South Bound       East Bound        West Bound
Movement:     L  -  T  -  R    L  -  T  -  R    L  -  T  -  R    L  -  T  -  R
------------|---------------||---------------||---------------||---------------|
Volume Module:
Base Vol:        0    0     0    10    0     0     3    1     4     0    0     0
Growth Adj:   1.55 1.55  1.55  1.55 1.55  1.55  1.55 1.55  1.55  1.55 1.55  1.55
Initial Bse:     0    0     0    16    0     0     5    2     6     0    0     0
Added Vol:       0    0     0     0    0     0     0    0     0     0    0     0
PasserByVol:     0    0     0     0    0     0     0    0     0     0    0     0
Initial Fut:     0    0     0    16    0     0     5    2     6     0    0     0
User Adj:     1.00 1.00  1.00  1.00 1.00  1.00  1.00 1.00  1.00  1.00 1.00  1.00
PHF Adj:      0.70 0.70  0.70  0.70 0.70  0.70  0.70 0.70  0.70  0.70 0.70  0.70
PHF Volume:      0    0     0    22    0     0     7    2     9     0    0     0
Reduct Vol:      0    0     0     0    0     0     0    0     0     0    0     0
FinalVolume:     0    0     0    22    0     0     7    2     9     0    0     0
------------|---------------||---------------||---------------||---------------|
Critical Gap Module:
Critical Gp:xxxxx xxxx xxxxx   4.1 xxxx xxxxx   6.4  6.5   6.2 xxxxx xxxx xxxxx
FollowUpTim:xxxxx xxxx xxxxx   2.2 xxxx xxxxx   3.5  4.0   3.3 xxxxx xxxx xxxxx
------------|---------------||---------------||---------------||---------------|
Capacity Module:
Cnflict Vol: xxxx xxxx xxxxx     0 xxxx xxxxx    44   44     0  xxxx xxxx xxxxx
Potent Cap.: xxxx xxxx xxxxx   900 xxxx xxxxx   971  851   900  xxxx xxxx xxxxx
Move Cap.:   xxxx xxxx xxxxx   900 xxxx xxxxx   953  830   900  xxxx xxxx xxxxx
Volume/Cap:  xxxx xxxx  xxxx  0.02 xxxx  xxxx  0.01 0.00  0.01  xxxx xxxx  xxxx
------------|---------------||---------------||---------------||---------------|
Level Of Service Module:
2Way95thQ:   xxxx xxxx xxxxx   0.1 xxxx xxxxx  xxxx xxxx xxxxx  xxxx xxxx xxxxx
Control Del:xxxxx xxxx xxxxx   9.1 xxxx xxxxx xxxxx xxxx xxxxx xxxxx xxxx xxxxx
LOS by Move:    *    *     *     A    *     *     *    *     *     *    *     *
Movement:     LT - LTR - RT    LT - LTR - RT    LT - LTR - RT    LT - LTR - RT
Shared Cap.: xxxx xxxx xxxxx  xxxx xxxx xxxxx  xxxx  909 xxxxx  xxxx xxxx xxxxx
SharedQueue:xxxxx xxxx xxxxx xxxxx xxxx xxxxx xxxxx  0.1 xxxxx xxxxx xxxx xxxxx
Shrd ConDel:xxxxx xxxx xxxxx xxxxx xxxx xxxxx xxxxx  9.0 xxxxx xxxxx xxxx xxxxx
Shared LOS:     *    *     *     *    *     *     *    A     *     *    *     *
ApproachDel:    xxxxxx           xxxxxx              9.0             xxxxxx
ApproachLOS:         *                *                A                *
Note: Queue reported is the number of cars per lane.
                     Peak Hour Delay Signal Warrant Report
********************************************************************************
Intersection #2 I-40 EB/Park Moabi
********************************************************************************
Future Volume Alternative: Peak Hour Warrant NOT Met
```

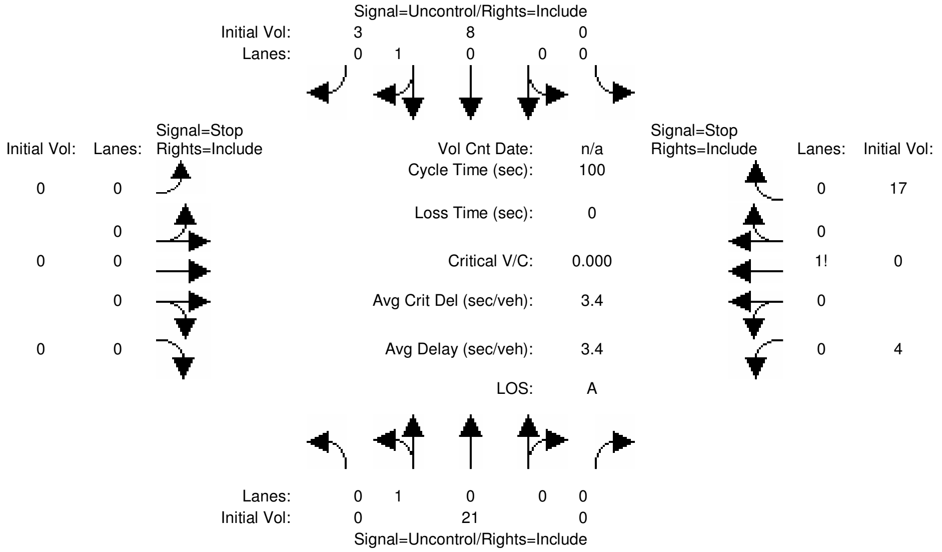
```
------------|---------------||---------------||---------------||---------------|
Approach:      North Bound      South Bound       East Bound       West Bound
Movement:     L  -  T  -  R    L  -  T  -  R    L  -  T  -  R    L  -  T  -  R
------------|---------------||---------------||---------------||---------------|
Control:       Uncontrolled     Uncontrolled      Stop Sign        Stop Sign
Lanes:        0  0  0  1  0    1  0  0  0  0    0  0  1! 0  0    0  0  0  0  0
Initial Vol:    0    0     0    16    0     0     5    2     6     0    0     0
ApproachDel:    xxxxxx           xxxxxx               9.0            xxxxxx
------------|---------------||---------------||---------------||---------------|
Approach[eastbound][lanes=1][control=Stop Sign]
Signal Warrant Rule #1: [vehicle-hours=0.0]
   FAIL - Vehicle-hours less than 4 for one lane approach.
Signal Warrant Rule #2: [approach volume=12]
   FAIL - Approach volume less than 100 for one lane approach.
Signal Warrant Rule #3: [approach count=2][total volume=28]
   FAIL - Total volume less than 650 for intersection
          with less than four approaches.
--------------------------------------------------------------------------------
SIGNAL WARRANT DISCLAIMER
This peak hour signal warrant analysis should be considered solely as an
"indicator" of the likelihood of an unsignalized intersection warranting
a traffic signal in the future.  Intersections that exceed this warrant
are probably more likely to meet one or more of the other volume based
signal warrant (such as the 4-hour or 8-hour warrants).

The peak hour warrant analysis in this report is not intended to replace
a rigorous and complete traffic signal warrant analysis by the responsible
jurisdiction.  Consideration of the other signal warrants, which is beyond
the scope of this software, may yield different results.
                Peak Hour Volume Signal Warrant Report [Urban]
********************************************************************************
Intersection #2 I-40 EB/Park Moabi
********************************************************************************
Future Volume Alternative: Peak Hour Warrant NOT Met
------------|---------------||---------------||---------------||---------------|
Approach:      North Bound      South Bound       East Bound       West Bound
Movement:     L  -  T  -  R    L  -  T  -  R    L  -  T  -  R    L  -  T  -  R
------------|---------------||---------------||---------------||---------------|
Control:       Uncontrolled     Uncontrolled      Stop Sign        Stop Sign
Lanes:        0  0  0  1  0    1  0  0  0  0    0  0  1! 0  0    0  0  0  0  0
Initial Vol:    0    0     0    16    0     0     5    2     6     0    0     0
------------|---------------||---------------||---------------||---------------|
Major Street Volume:             16
Minor Approach Volume:           12
Minor Approach Volume Threshold: 1331
--------------------------------------------------------------------------------
SIGNAL WARRANT DISCLAIMER
This peak hour signal warrant analysis should be considered solely as an
"indicator" of the likelihood of an unsignalized intersection warranting
a traffic signal in the future.  Intersections that exceed this warrant
are probably more likely to meet one or more of the other volume based
signal warrant (such as the 4-hour or 8-hour warrants).

The peak hour warrant analysis in this report is not intended to replace
a rigorous and complete traffic signal warrant analysis by the responsible
jurisdiction.  Consideration of the other signal warrants, which is beyond
the scope of this software, may yield different results.
```

Level Of Service Computation Report
2000 HCM Unsignalized (Future Volume Alternative)
Existing Plus Project AM Construction

Intersection #1: I-40 WB/Park Moabi



Signal=Uncontrol/Rights=Include
Initial Vol: 3 8 0
Lanes: 0 1 0 0 0

Signal=Stop
Rights=Include
Initial Vol: 0 0 0
Lanes: 0 0 0 0 0

Vol Cnt Date: n/a
Cycle Time (sec): 100
Loss Time (sec): 0
Critical V/C: 0.000
Avg Crit Del (sec/veh): 3.4
Avg Delay (sec/veh): 3.4
LOS: A

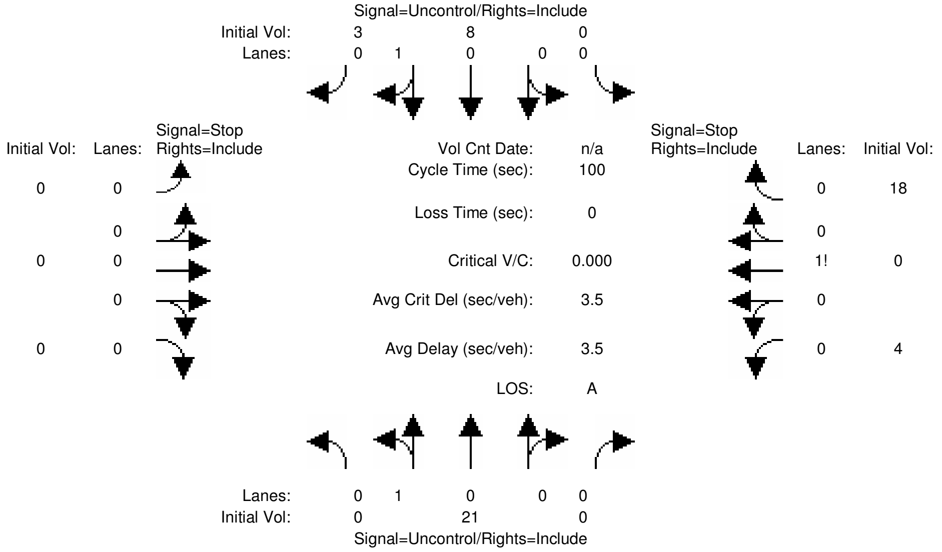
Signal=Stop
Rights=Include
Lanes: 0 0 1! 0 0
Initial Vol: 17 0 4

Lanes: 0 1 0 0 0
Initial Vol: 0 21 0
Signal=Uncontrol/Rights=Include

```
Street Name:         Park Moabi Road                     I-40 WB Ramp
Approach:      North Bound      South Bound       East Bound       West Bound
Movement:     L  -  T  -  R    L  -  T  -  R    L  -  T  -  R    L  -  T  -  R
------------|---------------||---------------||---------------||---------------|
Volume Module:
Base Vol:       0    4     0     0    8     3     0    0     0     0    0     6
Growth Adj:  1.00 1.00  1.00  1.00 1.00  1.00  1.00 1.00  1.00  1.00 1.00  1.00
Initial Bse:    0    4     0     0    8     3     0    0     0     0    0     6
Added Vol:      0    0     0     0    0     0     0    0     0     0    0     0
Project Tri:    0   17     0     0    0     0     0    0     0     4    0    11
Initial Fut:    0   21     0     0    8     3     0    0     0     4    0    17
User Adj:    1.00 1.00  1.00  1.00 1.00  1.00  1.00 1.00  1.00  1.00 1.00  1.00
PHF Adj:     0.58 0.58  0.58  0.58 0.58  0.58  0.58 0.58  0.58  0.58 0.58  0.58
PHF Volume:     0   36     0     0   14     5     0    0     0     7    0    29
Reduct Vol:     0    0     0     0    0     0     0    0     0     0    0     0
FinalVolume:    0   36     0     0   14     5     0    0     0     7    0    29
------------|---------------||---------------||---------------||---------------|
Critical Gap Module:
Critical Gp:xxxxx xxxx xxxxx xxxxx xxxx xxxxx xxxxx xxxx xxxxx   6.4  6.5   6.2
FollowUpTim:xxxxx xxxx xxxxx xxxxx xxxx xxxxx xxxxx xxxx xxxxx   3.5  4.0   3.3
------------|---------------||---------------||---------------||---------------|
Capacity Module:
Cnflict Vol: xxxx xxxx xxxxx  xxxx xxxx xxxxx  xxxx xxxx xxxxx    53   55    36
Potent Cap.: xxxx xxxx xxxxx  xxxx xxxx xxxxx  xxxx xxxx xxxxx   961  840  1042
Move Cap.:   xxxx xxxx xxxxx  xxxx xxxx xxxxx  xxxx xxxx xxxxx   961  840  1042
Volume/Cap:  xxxx xxxx  xxxx  xxxx xxxx  xxxx  xxxx xxxx  xxxx  0.01 0.00  0.03
------------|---------------||---------------||---------------||---------------|
Level Of Service Module:
2Way95thQ:   xxxx xxxx xxxxx  xxxx xxxx xxxxx  xxxx xxxx xxxxx  xxxx xxxx xxxxx
Control Del:xxxxx xxxx xxxxx xxxxx xxxx xxxxx xxxxx xxxx xxxxx xxxxx xxxx xxxxx
LOS by Move:    *    *     *     *    *     *     *    *     *     *    *     *
Movement:     LT - LTR - RT    LT - LTR - RT    LT - LTR - RT    LT - LTR - RT
Shared Cap.: xxxx xxxx xxxxx  xxxx xxxx xxxxx  xxxx xxxx xxxxx  xxxx 1026 xxxxx
SharedQueue:xxxxx xxxx xxxxx xxxxx xxxx xxxxx xxxxx xxxx xxxxx xxxxx  0.1 xxxxx
Shrd ConDel:xxxxx xxxx xxxxx xxxxx xxxx xxxxx xxxxx xxxx xxxxx xxxxx  8.6 xxxxx
Shared LOS:     *    *     *     *    *     *     *    *     *     *    A     *
ApproachDel:    xxxxxx           xxxxxx           xxxxxx               8.6
ApproachLOS:        *                 *                *                A
Note: Queue reported is the number of cars per lane.
```

Level Of Service Computation Report
2000 HCM Unsignalized (Future Volume Alternative)
Existing Plus Project AM O+M+C

Intersection #1: I-40 WB/Park Moabi



Signal=Uncontrol/Rights=Include
Initial Vol: 3 8 0
Lanes: 0 1 0 0 0

Initial Vol: Lanes: Signal=Stop Rights=Include
0 0
0
0 0
0
0 0

Vol Cnt Date: n/a
Cycle Time (sec): 100
Loss Time (sec): 0
Critical V/C: 0.000
Avg Crit Del (sec/veh): 3.5
Avg Delay (sec/veh): 3.5
LOS: A

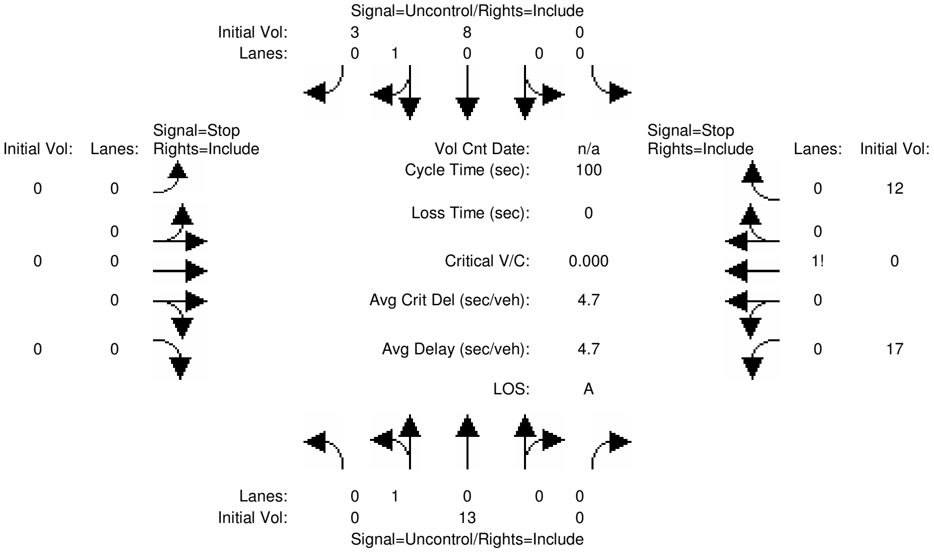
Signal=Stop Rights=Include Lanes: Initial Vol:
0 18
0
1! 0
0
0 4

Lanes: 0 1 0 0 0
Initial Vol: 0 21 0
Signal=Uncontrol/Rights=Include

```
Street Name:          Park Moabi Road                     I-40 WB Ramp
Approach:      North Bound      South Bound       East Bound        West Bound
Movement:     L  -  T  -  R    L  -  T  -  R    L  -  T  -  R    L  -  T  -  R
------------|---------------||---------------||---------------||---------------|
Volume Module:
Base Vol:        0    4    0     0    8    3     0    0    0     0    0    6
Growth Adj:   1.00 1.00 1.00  1.00 1.00 1.00  1.00 1.00 1.00  1.00 1.00 1.00
Initial Bse:     0    4    0     0    8    3     0    0    0     0    0    6
Added Vol:       0    0    0     0    0    0     0    0    0     0    0    0
Project Tri:     0   17    0     0    0    0     0    0    0     4    0   12
Initial Fut:     0   21    0     0    8    3     0    0    0     4    0   18
User Adj:     1.00 1.00 1.00  1.00 1.00 1.00  1.00 1.00 1.00  1.00 1.00 1.00
PHF Adj:      0.58 0.58 0.58  0.58 0.58 0.58  0.58 0.58 0.58  0.58 0.58 0.58
PHF Volume:      0   36    0     0   14    5     0    0    0     7    0   31
Reduct Vol:      0    0    0     0    0    0     0    0    0     0    0    0
FinalVolume:     0   36    0     0   14    5     0    0    0     7    0   31
------------|---------------||---------------||---------------||---------------|
Critical Gap Module:
Critical Gp:xxxxx xxxx xxxxx xxxxx xxxx xxxxx xxxxx xxxx xxxxx   6.4  6.5  6.2
FollowUpTim:xxxxx xxxx xxxxx xxxxx xxxx xxxxx xxxxx xxxx xxxxx   3.5  4.0  3.3
------------|---------------||---------------||---------------||---------------|
Capacity Module:
Cnflict Vol: xxxx xxxx xxxxx  xxxx xxxx xxxxx  xxxx xxxx xxxxx    53   55   36
Potent Cap.: xxxx xxxx xxxxx  xxxx xxxx xxxxx  xxxx xxxx xxxxx   961  840 1042
Move Cap.:   xxxx xxxx xxxxx  xxxx xxxx xxxxx  xxxx xxxx xxxxx   961  840 1042
Volume/Cap:  xxxx xxxx  xxxx  xxxx xxxx  xxxx  xxxx xxxx  xxxx  0.01 0.00 0.03
------------|---------------||---------------||---------------||---------------|
Level Of Service Module:
2Way95thQ:   xxxx xxxx xxxxx  xxxx xxxx xxxxx  xxxx xxxx xxxxx  xxxx xxxx xxxxx
Control Del:xxxxx xxxx xxxxx xxxxx xxxx xxxxx xxxxx xxxx xxxxx xxxxx xxxx xxxxx
LOS by Move:     *    *    *     *    *    *     *    *    *     *    *    *
Movement:      LT - LTR - RT    LT - LTR - RT    LT - LTR - RT    LT - LTR - RT
Shared Cap.: xxxx xxxx xxxxx  xxxx xxxx xxxxx  xxxx xxxx xxxxx  xxxx 1026 xxxxx
SharedQueue:xxxxx xxxx xxxxx xxxxx xxxx xxxxx xxxxx xxxx xxxxx xxxxx  0.1 xxxxx
Shrd ConDel:xxxxx xxxx xxxxx xxxxx xxxx xxxxx xxxxx xxxx xxxxx xxxxx  8.6 xxxxx
Shared LOS:      *    *    *     *    *    *     *    *    *     *    A    *
ApproachDel:     xxxxxx           xxxxxx           xxxxxx              8.6
ApproachLOS:        *                *                *                 A
Note: Queue reported is the number of cars per lane.
```

Level Of Service Computation Report
2000 HCM Unsignalized (Future Volume Alternative)
Existing Plus Project AM O+M+D

Intersection #1: I-40 WB/Park Moabi

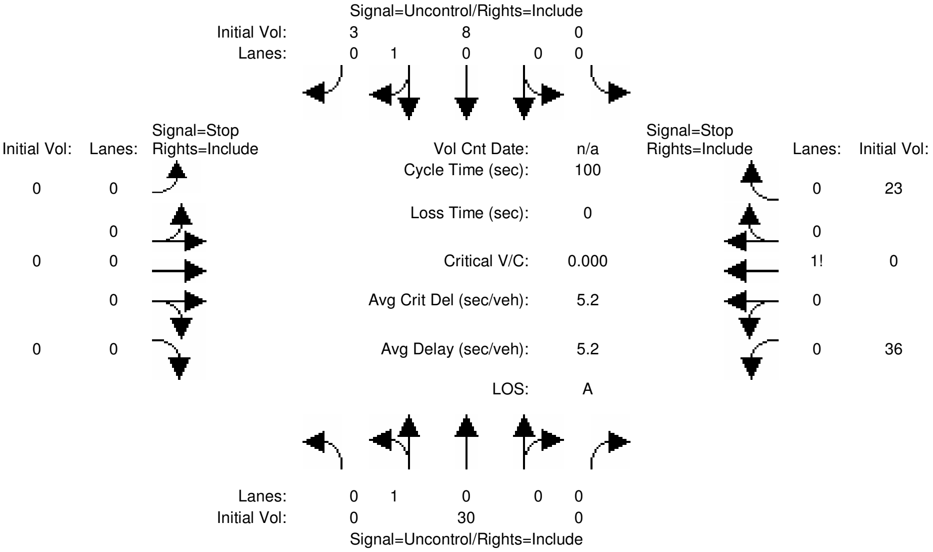


Vol Cnt Date: n/a
Cycle Time (sec): 100
Loss Time (sec): 0
Critical V/C: 0.000
Avg Crit Del (sec/veh): 4.7
Avg Delay (sec/veh): 4.7
LOS: A

```
Street Name:         Park Moabi Road                     I-40 WB Ramp
Approach:      North Bound      South Bound      East Bound       West Bound
Movement:     L  -  T  -  R    L  -  T  -  R    L  -  T  -  R    L  -  T  -  R
------------|---------------||---------------||---------------||---------------|
Volume Module:
Base Vol:       0    4     0     0    8     3     0    0     0     0    0     6
Growth Adj:  1.00 1.00  1.00  1.00 1.00  1.00  1.00 1.00  1.00  1.00 1.00  1.00
Initial Bse:    0    4     0     0    8     3     0    0     0     0    0     6
Added Vol:      0    0     0     0    0     0     0    0     0     0    0     0
Project Tri:    0    9     0     0    0     0     0    0     0    17    0     6
Initial Fut:    0   13     0     0    8     3     0    0     0    17    0    12
User Adj:    1.00 1.00  1.00  1.00 1.00  1.00  1.00 1.00  1.00  1.00 1.00  1.00
PHF Adj:     1.00 1.00  1.00  1.00 1.00  1.00  1.00 1.00  1.00  1.00 1.00  1.00
PHF Volume:     0   13     0     0    8     3     0    0     0    17    0    12
Reduct Vol:     0    0     0     0    0     0     0    0     0     0    0     0
FinalVolume:    0   13     0     0    8     3     0    0     0    17    0    12
------------|---------------||---------------||---------------||---------------|
Critical Gap Module:
Critical Gp:xxxxx xxxx xxxxx xxxxx xxxx xxxxx xxxxx xxxx xxxxx   6.4  6.5   6.2
FollowUpTim:xxxxx xxxx xxxxx xxxxx xxxx xxxxx xxxxx xxxx xxxxx   3.5  4.0   3.3
------------|---------------||---------------||---------------||---------------|
Capacity Module:
Cnflict Vol: xxxx xxxx xxxxx  xxxx xxxx xxxxx  xxxx xxxx xxxxx    23   24    13
Potent Cap.: xxxx xxxx xxxxx  xxxx xxxx xxxxx  xxxx xxxx xxxxx   999  873  1073
Move Cap.:   xxxx xxxx xxxxx  xxxx xxxx xxxxx  xxxx xxxx xxxxx   999  873  1073
Volume/Cap:  xxxx xxxx  xxxx  xxxx xxxx  xxxx  xxxx xxxx  xxxx  0.02 0.00  0.01
------------|---------------||---------------||---------------||---------------|
Level Of Service Module:
2Way95thQ:   xxxx xxxx xxxxx  xxxx xxxx xxxxx  xxxx xxxx xxxxx  xxxx xxxx xxxxx
Control Del:xxxxx xxxx xxxxx xxxxx xxxx xxxxx xxxxx xxxx xxxxx xxxxx xxxx xxxxx
LOS by Move:    *    *     *     *    *     *     *    *     *     *    *     *
Movement:     LT - LTR - RT    LT - LTR - RT    LT - LTR - RT    LT - LTR - RT
Shared Cap.: xxxx xxxx xxxxx  xxxx xxxx xxxxx  xxxx xxxx xxxxx  xxxx 1028 xxxxx
SharedQueue:xxxxx xxxx xxxxx xxxxx xxxx xxxxx xxxxx xxxx xxxxx xxxxx  0.1 xxxxx
Shrd ConDel:xxxxx xxxx xxxxx xxxxx xxxx xxxxx xxxxx xxxx xxxxx xxxxx  8.6 xxxxx
Shared LOS:     *    *     *     *    *     *     *    *     *     *    A     *
ApproachDel:    xxxxxx           xxxxxx           xxxxxx              8.6
ApproachLOS:         *                *                *                A
Note: Queue reported is the number of cars per lane.
```

Level Of Service Computation Report
2000 HCM Unsignalized (Future Volume Alternative)
Existing Plus Project AM Decommissioning

Intersection #1: I-40 WB/Park Moabi

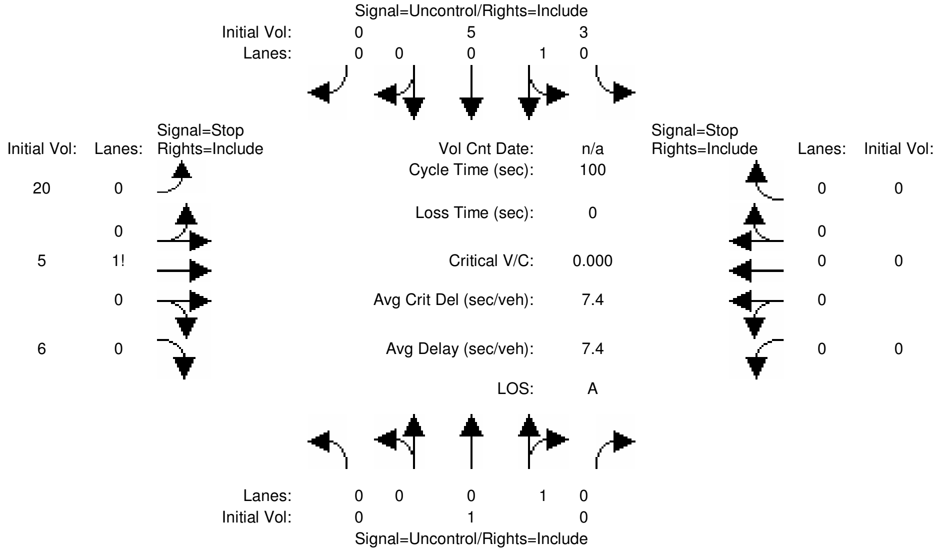


Vol Cnt Date: n/a
Cycle Time (sec): 100
Loss Time (sec): 0
Critical V/C: 0.000
Avg Crit Del (sec/veh): 5.2
Avg Delay (sec/veh): 5.2
LOS: A

```
Street Name:         Park Moabi Road                     I-40 WB Ramp
Approach:      North Bound      South Bound       East Bound        West Bound
Movement:     L  -  T  -  R    L  -  T  -  R    L  -  T  -  R    L  -  T  -  R
------------|---------------||---------------||---------------||---------------|
Volume Module:
Base Vol:        0    4    0     0    8    3     0    0    0     0    0    6
Growth Adj:   1.00 1.00 1.00  1.00 1.00 1.00  1.00 1.00 1.00  1.00 1.00 1.00
Initial Bse:     0    4    0     0    8    3     0    0    0     0    0    6
Added Vol:       0    0    0     0    0    0     0    0    0     0    0    0
Project Tri:     0   26    0     0    0    0     0    0    0    36    0   17
Initial Fut:     0   30    0     0    8    3     0    0    0    36    0   23
User Adj:     1.00 1.00 1.00  1.00 1.00 1.00  1.00 1.00 1.00  1.00 1.00 1.00
PHF Adj:      1.00 1.00 1.00  1.00 1.00 1.00  1.00 1.00 1.00  1.00 1.00 1.00
PHF Volume:      0   30    0     0    8    3     0    0    0    36    0   23
Reduct Vol:      0    0    0     0    0    0     0    0    0     0    0    0
FinalVolume:     0   30    0     0    8    3     0    0    0    36    0   23
------------|---------------||---------------||---------------||---------------|
Critical Gap Module:
Critical Gp:xxxxx xxxx xxxxx xxxxx xxxx xxxxx xxxxx xxxx xxxxx   6.4  6.5   6.2
FollowUpTim:xxxxx xxxx xxxxx xxxxx xxxx xxxxx xxxxx xxxx xxxxx   3.5  4.0   3.3
------------|---------------||---------------||---------------||---------------|
Capacity Module:
Cnflict Vol: xxxx xxxx xxxxx  xxxx xxxx xxxxx  xxxx xxxx xxxxx    40   41    30
Potent Cap.: xxxx xxxx xxxxx  xxxx xxxx xxxxx  xxxx xxxx xxxxx   977  855  1050
Move Cap.:   xxxx xxxx xxxxx  xxxx xxxx xxxxx  xxxx xxxx xxxxx   977  855  1050
Volume/Cap:  xxxx xxxx  xxxx  xxxx xxxx  xxxx  xxxx xxxx  xxxx  0.04 0.00  0.02
------------|---------------||---------------||---------------||---------------|
Level Of Service Module:
2Way95thQ:   xxxx xxxx xxxxx  xxxx xxxx xxxxx  xxxx xxxx xxxxx  xxxx xxxx xxxxx
Control Del:xxxxx xxxx xxxxx xxxxx xxxx xxxxx xxxxx xxxx xxxxx xxxxx xxxx xxxxx
LOS by Move:    *    *     *     *    *     *     *    *     *     *    *     *
Movement:     LT - LTR - RT    LT - LTR - RT    LT - LTR - RT    LT - LTR - RT
Shared Cap.: xxxx xxxx xxxxx  xxxx xxxx xxxxx  xxxx xxxx xxxxx  xxxx 1005 xxxxx
SharedQueue:xxxxx xxxx xxxxx xxxxx xxxx xxxxx xxxxx xxxx xxxxx xxxxx  0.2 xxxxx
Shrd ConDel:xxxxx xxxx xxxxx xxxxx xxxx xxxxx xxxxx xxxx xxxxx xxxxx  8.8 xxxxx
Shared LOS:     *    *     *     *    *     *     *    *     *     *    A     *
ApproachDel:    xxxxxx           xxxxxx           xxxxxx              8.8
ApproachLOS:         *                *                *                A
Note: Queue reported is the number of cars per lane.
```

Level Of Service Computation Report
2000 HCM Unsignalized (Future Volume Alternative)
Existing Plus Project AM Construction

Intersection #2: I-40 EB/Park Moabi

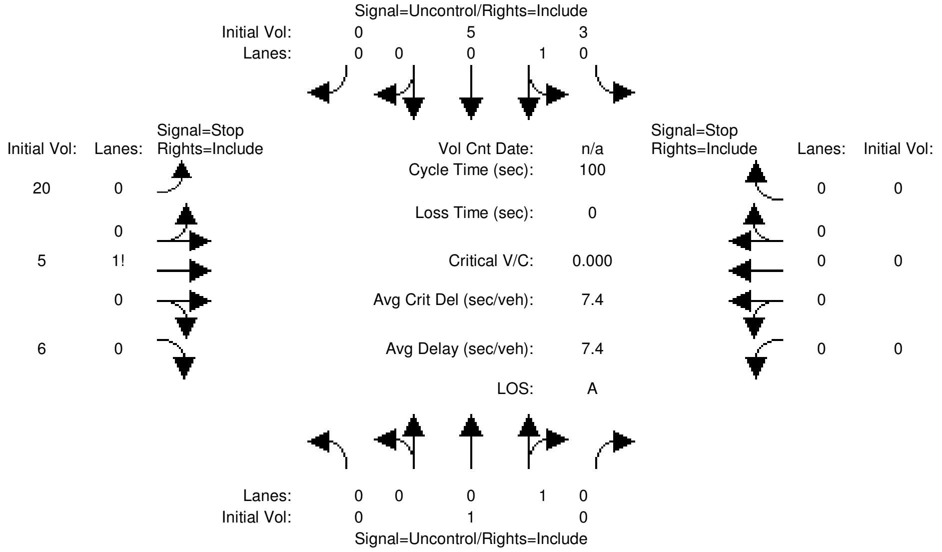


Vol Cnt Date: n/a
Cycle Time (sec): 100
Loss Time (sec): 0
Critical V/C: 0.000
Avg Crit Del (sec/veh): 7.4
Avg Delay (sec/veh): 7.4
LOS: A

```
Street Name:          Park Moabi Road                 I-40 EB Ramp
Approach:      North Bound      South Bound       East Bound       West Bound
Movement:     L  -  T  -  R   L  -  T  -  R   L  -  T  -  R   L  -  T  -  R
------------|---------------||---------------||---------------||---------------|
Volume Module:
Base Vol:       0    1     0     3    1     0     3    5     0     0    0     0
Growth Adj:  1.00 1.00  1.00  1.00 1.00  1.00  1.00 1.00  1.00  1.00 1.00  1.00
Initial Bse:    0    1     0     3    1     0     3    5     0     0    0     0
Added Vol:      0    0     0     0    0     0     0    0     0     0    0     0
Proj Trips:     0    0     0     0    4     0    17    0     6     0    0     0
Initial Fut:    0    1     0     3    5     0    20    5     6     0    0     0
User Adj:    1.00 1.00  1.00  1.00 1.00  1.00  1.00 1.00  1.00  1.00 1.00  1.00
PHF Adj:     0.54 0.54  0.54  0.54 0.54  0.54  0.54 0.54  0.54  0.54 0.54  0.54
PHF Volume:     0    2     0     6    9     0    37    9    11     0    0     0
Reduct Vol:     0    0     0     0    0     0     0    0     0     0    0     0
FinalVolume:    0    2     0     6    9     0    37    9    11     0    0     0
------------|---------------||---------------||---------------||---------------|
Critical Gap Module:
Critical Gp:xxxxx xxxx xxxxx   4.1 xxxx xxxxx   6.4  6.5   6.2 xxxxx xxxx xxxxx
FollowUpTim:xxxxx xxxx xxxxx   2.2 xxxx xxxxx   3.5  4.0   3.3 xxxxx xxxx xxxxx
------------|---------------||---------------||---------------||---------------|
Capacity Module:
Cnflict Vol: xxxx xxxx xxxxx     2 xxxx xxxxx    22   22     9  xxxx xxxx xxxxx
Potent Cap.: xxxx xxxx xxxxx  1634 xxxx xxxxx   999  875  1078  xxxx xxxx xxxxx
Move Cap.:   xxxx xxxx xxxxx  1634 xxxx xxxxx   997  872  1078  xxxx xxxx xxxxx
Volume/Cap:  xxxx xxxx  xxxx  0.00 xxxx  xxxx  0.04 0.01  0.01  xxxx xxxx  xxxx
------------|---------------||---------------||---------------||---------------|
Level Of Service Module:
2Way95thQ:   xxxx xxxx xxxxx   0.0 xxxx xxxxx  xxxx xxxx xxxxx  xxxx xxxx xxxxx
Control Del:xxxxx xxxx xxxxx   7.2 xxxx xxxxx xxxxx xxxx xxxxx xxxxx xxxx xxxxx
LOS by Move:    *    *     *     A    *     *     *    *     *     *    *     *
Movement:     LT - LTR - RT    LT - LTR - RT    LT - LTR - RT    LT - LTR - RT
Shared Cap.: xxxx xxxx xxxxx  xxxx xxxx xxxxx  xxxx  989 xxxxx  xxxx xxxx xxxxx
SharedQueue:xxxxx xxxx xxxxx   0.0 xxxx xxxxx xxxxx  0.2 xxxxx xxxxx xxxx xxxxx
Shrd ConDel:xxxxx xxxx xxxxx   7.2 xxxx xxxxx xxxxx  8.9 xxxxx xxxxx xxxx xxxxx
Shared LOS:     *    *     *     A    *     *     *    A     *     *    *     *
ApproachDel:    xxxxxx           xxxxxx             8.9            xxxxxx
ApproachLOS:         *                *               A                 *
Note: Queue reported is the number of cars per lane.
```

Level Of Service Computation Report
2000 HCM Unsignalized (Future Volume Alternative)
Existing Plus Project AM O+M+C

Intersection #2: I-40 EB/Park Moabi



```
                              Signal=Uncontrol/Rights=Include
                 Initial Vol:    0           5          3
                       Lanes:    0    0      0      1   0

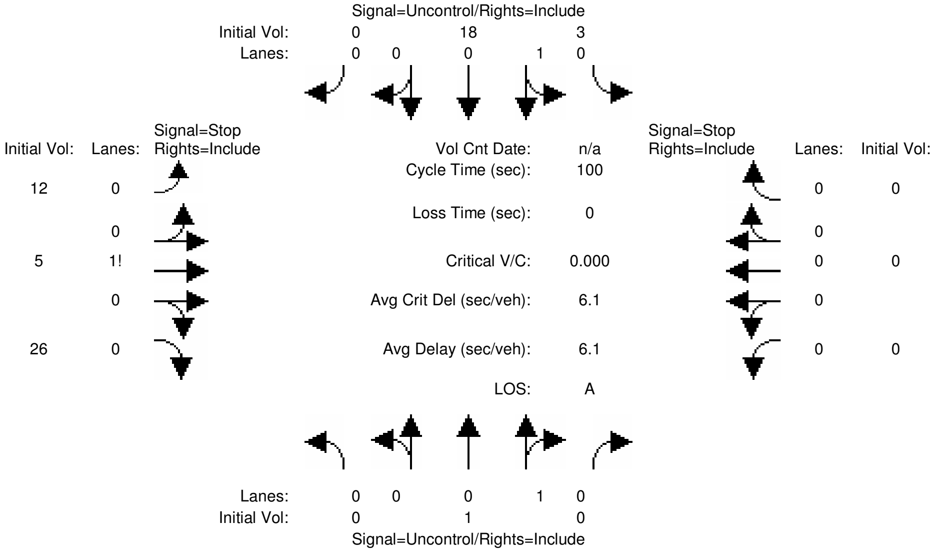
                  Signal=Stop                                            Signal=Stop
Initial Vol:  Lanes:  Rights=Include         Vol Cnt Date:     n/a       Rights=Include   Lanes:  Initial Vol:
                                             Cycle Time (sec): 100
   20          0                                                                          0        0
                                             Loss Time (sec):   0
               0                                                                          0
    5          1!                            Critical V/C:     0.000                      0        0
               0                             Avg Crit Del (sec/veh): 7.4                  0
    6          0                             Avg Delay (sec/veh):    7.4                  0        0
                                             LOS:               A

                       Lanes:    0    0      0      1   0
                 Initial Vol:    0           1          0
                              Signal=Uncontrol/Rights=Include
```

```
Street Name:          Park Moabi Road                     I-40 EB Ramp
Approach:      North Bound      South Bound       East Bound       West Bound
Movement:     L  -  T  -  R    L  -  T  -  R    L  -  T  -  R    L  -  T  -  R
------------|---------------||---------------||---------------||---------------|
Volume Module:
Base Vol:       0    1     0     3    1     0     3    5     0     0    0     0
Growth Adj:  1.00 1.00  1.00  1.00 1.00  1.00  1.00 1.00  1.00  1.00 1.00  1.00
Initial Bse:    0    1     0     3    1     0     3    5     0     0    0     0
Added Vol:      0    0     0     0    0     0     0    0     0     0    0     0
Project Tri:    0    0     0     0    4     0    17    0     6     0    0     0
Initial Fut:    0    1     0     3    5     0    20    5     6     0    0     0
User Adj:    1.00 1.00  1.00  1.00 1.00  1.00  1.00 1.00  1.00  1.00 1.00  1.00
PHF Adj:     0.54 0.54  0.54  0.54 0.54  0.54  0.54 0.54  0.54  0.54 0.54  0.54
PHF Volume:     0    2     0     6    9     0    37    9    11     0    0     0
Reduct Vol:     0    0     0     0    0     0     0    0     0     0    0     0
FinalVolume:    0    2     0     6    9     0    37    9    11     0    0     0
------------|---------------||---------------||---------------||---------------|
Critical Gap Module:
Critical Gp:xxxxx xxxx xxxxx   4.1 xxxx xxxxx   6.4  6.5   6.2 xxxxx xxxx xxxxx
FollowUpTim:xxxxx xxxx xxxxx   2.2 xxxx xxxxx   3.5  4.0   3.3 xxxxx xxxx xxxxx
------------|---------------||---------------||---------------||---------------|
Capacity Module:
Cnflict Vol: xxxx xxxx xxxxx     2 xxxx xxxxx    22   22     9  xxxx xxxx xxxxx
Potent Cap.: xxxx xxxx xxxxx  1634 xxxx xxxxx   999  875  1078  xxxx xxxx xxxxx
Move Cap.:   xxxx xxxx xxxxx  1634 xxxx xxxxx   997  872  1078  xxxx xxxx xxxxx
Volume/Cap:  xxxx xxxx  xxxx  0.00 xxxx  xxxx  0.04 0.01  0.01  xxxx xxxx  xxxx
------------|---------------||---------------||---------------||---------------|
Level Of Service Module:
2Way95thQ:   xxxx xxxx xxxxx   0.0 xxxx xxxxx  xxxx xxxx xxxxx  xxxx xxxx xxxxx
Control Del:xxxxx xxxx xxxxx   7.2 xxxx xxxxx xxxxx xxxx xxxxx xxxxx xxxx xxxxx
LOS by Move:    *    *     *     A    *     *     *    *     *     *    *     *
Movement:     LT - LTR - RT    LT - LTR - RT    LT - LTR - RT    LT - LTR - RT
Shared Cap.: xxxx xxxx xxxxx  xxxx xxxx xxxxx  xxxx  989 xxxxx  xxxx xxxx xxxxx
SharedQueue:xxxxx xxxx xxxxx   0.0 xxxx xxxxx xxxxx  0.2 xxxxx xxxxx xxxx xxxxx
Shrd ConDel:xxxxx xxxx xxxxx   7.2 xxxx xxxxx xxxxx  8.9 xxxxx xxxxx xxxx xxxxx
Shared LOS:     *    *     *     A    *     *     *    A     *     *    *     *
ApproachDel:    xxxxxx           xxxxxx              8.9            xxxxxx
ApproachLOS:         *                *                A                 *
Note: Queue reported is the number of cars per lane.
```

Level Of Service Computation Report
2000 HCM Unsignalized (Future Volume Alternative)
Existing Plus Project AM O+M+D

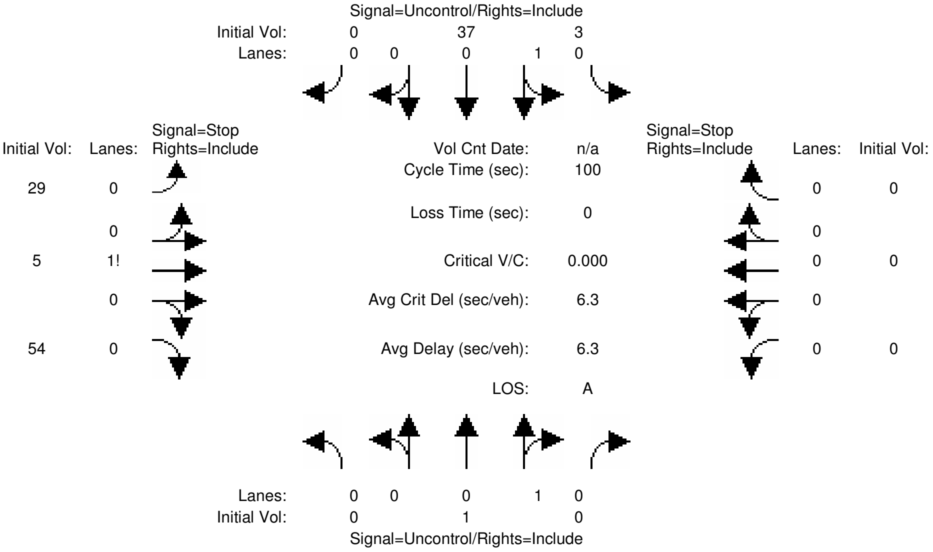
Intersection #2: I-40 EB/Park Moabi



```
Street Name:          Park Moabi Road                    I-40 EB Ramp
Approach:      North Bound      South Bound       East Bound       West Bound
Movement:     L  -  T  -  R    L  -  T  -  R    L  -  T  -  R    L  -  T  -  R
------------|---------------||---------------||---------------||---------------|
Volume Module:
Base Vol:       0    1     0     3    1     0     3    5     0     0    0     0
Growth Adj:  1.00 1.00  1.00  1.00 1.00  1.00  1.00 1.00  1.00  1.00 1.00  1.00
Initial Bse:    0    1     0     3    1     0     3    5     0     0    0     0
Added Vol:      0    0     0     0    0     0     0    0     0     0    0     0
Project Tri:    0    0     0     0   17     0     9    0    26     0    0     0
Initial Fut:    0    1     0     3   18     0    12    5    26     0    0     0
User Adj:    1.00 1.00  1.00  1.00 1.00  1.00  1.00 1.00  1.00  1.00 1.00  1.00
PHF Adj:     1.00 1.00  1.00  1.00 1.00  1.00  1.00 1.00  1.00  1.00 1.00  1.00
PHF Volume:     0    1     0     3   18     0    12    5    26     0    0     0
Reduct Vol:     0    0     0     0    0     0     0    0     0     0    0     0
FinalVolume:    0    1     0     3   18     0    12    5    26     0    0     0
------------|---------------||---------------||---------------||---------------|
Critical Gap Module:
Critical Gp:xxxxx xxxx xxxxx   4.1 xxxx xxxxx   6.4  6.5   6.2 xxxxx xxxx xxxxx
FollowUpTim:xxxxx xxxx xxxxx   2.2 xxxx xxxxx   3.5  4.0   3.3 xxxxx xxxx xxxxx
------------|---------------||---------------||---------------||---------------|
Capacity Module:
Cnflict Vol: xxxx xxxx xxxxx     1 xxxx xxxxx    25   25    18  xxxx xxxx xxxxx
Potent Cap.: xxxx xxxx xxxxx  1635 xxxx xxxxx   996  872  1066  xxxx xxxx xxxxx
Move Cap.:   xxxx xxxx xxxxx  1635 xxxx xxxxx   994  871  1066  xxxx xxxx xxxxx
Volume/Cap:  xxxx xxxx  xxxx  0.00 xxxx  xxxx  0.01 0.01  0.02  xxxx xxxx  xxxx
------------|---------------||---------------||---------------||---------------|
Level Of Service Module:
2Way95thQ:   xxxx xxxx xxxxx   0.0 xxxx xxxxx  xxxx xxxx xxxxx  xxxx xxxx xxxxx
Control Del:xxxxx xxxx xxxxx   7.2 xxxx xxxxx xxxxx xxxx xxxxx xxxxx xxxx xxxxx
LOS by Move:    *    *     *     A    *     *     *    *     *     *    *     *
Movement:     LT - LTR - RT    LT - LTR - RT    LT - LTR - RT    LT - LTR - RT
Shared Cap.: xxxx xxxx xxxxx  xxxx xxxx xxxxx  xxxx 1019 xxxxx  xxxx xxxx xxxxx
SharedQueue:xxxxx xxxx xxxxx   0.0 xxxx xxxxx xxxxx  0.1 xxxxx xxxxx xxxx xxxxx
Shrd ConDel:xxxxx xxxx xxxxx   7.2 xxxx xxxxx xxxxx  8.7 xxxxx xxxxx xxxx xxxxx
Shared LOS:     *    *     *     A    *     *     *    A     *     *    *     *
ApproachDel:   xxxxxx           xxxxxx                8.7           xxxxxx
ApproachLOS:        *                *                A                *
Note: Queue reported is the number of cars per lane.
```

Level Of Service Computation Report
2000 HCM Unsignalized (Future Volume Alternative)
Existing Plus Project AM Decommissioning

Intersection #2: I-40 EB/Park Moabi



```
                              Signal=Uncontrol/Rights=Include
                 Initial Vol:     0          37         3
                       Lanes:     0    0      0       1  0

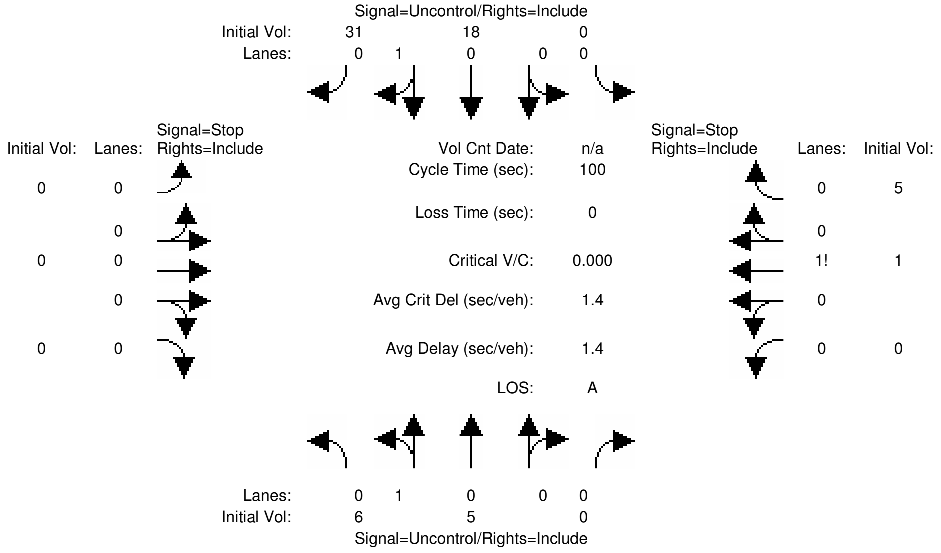
                    Signal=Stop                                    Signal=Stop
Initial Vol:  Lanes: Rights=Include     Vol Cnt Date:    n/a       Rights=Include   Lanes:  Initial Vol:
     29          0                   Cycle Time (sec):   100                          0         0
                 0                     Loss Time (sec):    0                          0
      5         1!                        Critical V/C: 0.000                         0         0
                 0               Avg Crit Del (sec/veh):   6.3                        0
     54          0                   Avg Delay (sec/veh):  6.3                        0         0
                                                   LOS:    A

                       Lanes:     0    0      0       1  0
                 Initial Vol:     0           1         0
                              Signal=Uncontrol/Rights=Include
```

```
Street Name:          Park Moabi Road                    I-40 EB Ramp
Approach:      North Bound      South Bound       East Bound       West Bound
Movement:    L  -  T  -  R    L  -  T  -  R    L  -  T  -  R    L  -  T  -  R
------------|---------------||---------------||---------------||---------------|
Volume Module:
Base Vol:       0    1     0     3    1     0     3    5     0     0    0     0
Growth Adj:  1.00 1.00  1.00  1.00 1.00  1.00  1.00 1.00  1.00  1.00 1.00  1.00
Initial Bse:    0    1     0     3    1     0     3    5     0     0    0     0
Added Vol:      0    0     0     0    0     0     0    0     0     0    0     0
Project Tri:    0    0     0     0   36     0    26    0    54     0    0     0
Initial Fut:    0    1     0     3   37     0    29    5    54     0    0     0
User Adj:    1.00 1.00  1.00  1.00 1.00  1.00  1.00 1.00  1.00  1.00 1.00  1.00
PHF Adj:     1.00 1.00  1.00  1.00 1.00  1.00  1.00 1.00  1.00  1.00 1.00  1.00
PHF Volume:     0    1     0     3   37     0    29    5    54     0    0     0
Reduct Vol:     0    0     0     0    0     0     0    0     0     0    0     0
FinalVolume:    0    1     0     3   37     0    29    5    54     0    0     0
------------|---------------||---------------||---------------||---------------|
Critical Gap Module:
Critical Gp:xxxxx xxxx xxxxx   4.1 xxxx xxxxx   6.4  6.5   6.2 xxxxx xxxx xxxxx
FollowUpTim:xxxxx xxxx xxxxx   2.2 xxxx xxxxx   3.5  4.0   3.3 xxxxx xxxx xxxxx
------------|---------------||---------------||---------------||---------------|
Capacity Module:
Cnflict Vol: xxxx xxxx xxxxx     1 xxxx xxxxx    44   44    37  xxxx xxxx xxxxx
Potent Cap.: xxxx xxxx xxxxx  1635 xxxx xxxxx   972  852  1041  xxxx xxxx xxxxx
Move Cap.:   xxxx xxxx xxxxx  1635 xxxx xxxxx   970  850  1041  xxxx xxxx xxxxx
Volume/Cap:  xxxx xxxx  xxxx  0.00 xxxx  xxxx  0.03 0.01  0.05  xxxx xxxx  xxxx
------------|---------------||---------------||---------------||---------------|
Level Of Service Module:
2Way95thQ:   xxxx xxxx xxxxx   0.0 xxxx xxxxx  xxxx xxxx xxxxx  xxxx xxxx xxxxx
Control Del:xxxxx xxxx xxxxx   7.2 xxxx xxxxx xxxxx xxxx xxxxx xxxxx xxxx xxxxx
LOS by Move:    *    *     *     A    *     *     *    *     *     *    *     *
Movement:     LT - LTR - RT    LT - LTR - RT    LT - LTR - RT    LT - LTR - RT
Shared Cap.: xxxx xxxx xxxxx  xxxx xxxx xxxxx  xxxx 1004 xxxxx  xxxx xxxx xxxxx
SharedQueue:xxxxx xxxx xxxxx   0.0 xxxx xxxxx xxxxx  0.3 xxxxx xxxxx xxxx xxxxx
Shrd ConDel:xxxxx xxxx xxxxx   7.2 xxxx xxxxx xxxxx  8.9 xxxxx xxxxx xxxx xxxxx
Shared LOS:     *    *     *     A    *     *     *    A     *     *    *     *
ApproachDel:    xxxxxx           xxxxxx              8.9            xxxxxx
ApproachLOS:       *                *                 A                *
Note: Queue reported is the number of cars per lane.
```

Level Of Service Computation Report
2000 HCM Unsignalized (Future Volume Alternative)
Existing Plus Project PM Construction

Intersection #1: I-40 WB/Park Moabi

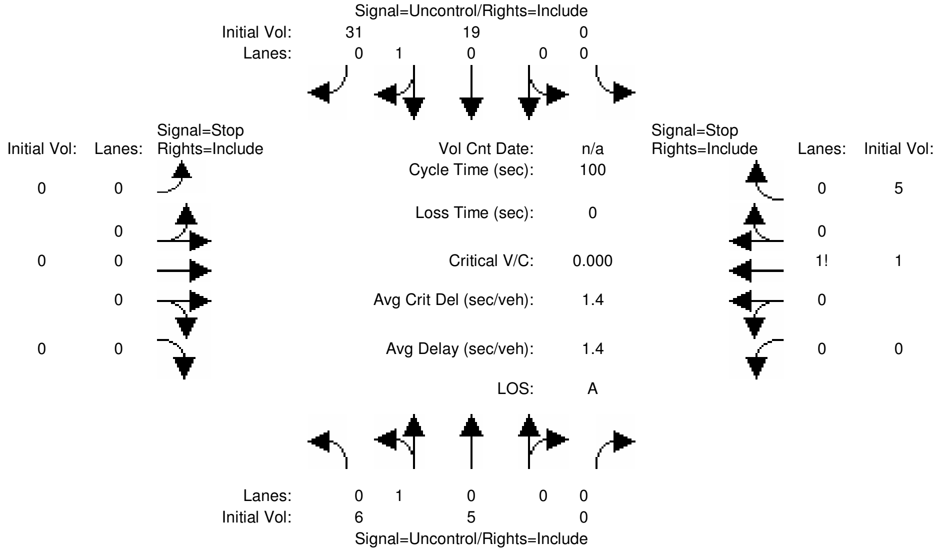


Vol Cnt Date: n/a
Cycle Time (sec): 100
Loss Time (sec): 0
Critical V/C: 0.000
Avg Crit Del (sec/veh): 1.4
Avg Delay (sec/veh): 1.4
LOS: A

```
Street Name:          Park Moabi Road                    I-40 WB Ramp
Approach:      North Bound      South Bound       East Bound        West Bound
Movement:     L  -  T  -  R    L  -  T  -  R    L  -  T  -  R    L  -  T  -  R
------------|---------------||---------------||---------------||---------------|
Volume Module:
Base Vol:        0    5     0     0    7    14     0    0     0     0    1     5
Growth Adj:   1.00 1.00  1.00  1.00 1.00  1.00  1.00 1.00  1.00  1.00 1.00  1.00
Initial Bse:     0    5     0     0    7    14     0    0     0     0    1     5
Added Vol:       0    0     0     0    0     0     0    0     0     0    0     0
PasserByVol:     6    0     0     0   11    17     0    0     0     0    0     0
Initial Fut:     6    5     0     0   18    31     0    0     0     0    1     5
User Adj:     1.00 1.00  1.00  1.00 1.00  1.00  1.00 1.00  1.00  1.00 1.00  1.00
PHF Adj:      0.80 0.80  0.80  0.80 0.80  0.80  0.80 0.80  0.80  0.80 0.80  0.80
PHF Volume:      8    6     0     0   23    39     0    0     0     0    1     6
Reduct Vol:      0    0     0     0    0     0     0    0     0     0    0     0
FinalVolume:     8    6     0     0   23    39     0    0     0     0    1     6
------------|---------------||---------------||---------------||---------------|
Critical Gap Module:
Critical Gp:  4.1 xxxx xxxxx xxxxx xxxx xxxxx xxxxx xxxx xxxxx xxxxx  6.5   6.2
FollowUpTim:  2.2 xxxx xxxxx xxxxx xxxx xxxxx xxxxx xxxx xxxxx xxxxx  4.0   3.3
------------|---------------||---------------||---------------||---------------|
Capacity Module:
Cnflict Vol:   61 xxxx xxxxx  xxxx xxxx xxxxx  xxxx xxxx xxxxx  xxxx   83     6
Potent Cap.: 1555 xxxx xxxxx  xxxx xxxx xxxxx  xxxx xxxx xxxxx  xxxx  812  1082
Move Cap.:   1555 xxxx xxxxx  xxxx xxxx xxxxx  xxxx xxxx xxxxx  xxxx  808  1082
Volume/Cap:  0.00 xxxx  xxxx  xxxx xxxx  xxxx  xxxx xxxx  xxxx  xxxx 0.00  0.01
------------|---------------||---------------||---------------||---------------|
Level Of Service Module:
2Way95thQ:    0.0 xxxx xxxxx  xxxx xxxx xxxxx  xxxx xxxx xxxxx  xxxx xxxx xxxxx
Control Del:  7.3 xxxx xxxxx xxxxx xxxx xxxxx xxxxx xxxx xxxxx xxxxx xxxx xxxxx
LOS by Move:    A    *     *     *    *     *     *    *     *     *    *     *
Movement:     LT - LTR - RT    LT - LTR - RT    LT - LTR - RT    LT - LTR - RT
Shared Cap.: xxxx xxxx xxxxx  xxxx xxxx xxxxx  xxxx xxxx xxxxx  xxxx xxxx  1024
SharedQueue:  0.0 xxxx xxxxx xxxxx xxxx xxxxx xxxxx xxxx xxxxx xxxxx xxxx   0.0
Shrd ConDel:  7.3 xxxx xxxxx xxxxx xxxx xxxxx xxxxx xxxx xxxxx xxxxx xxxx   8.5
Shared LOS:     A    *     *     *    *     *     *    *     *     *    *     A
ApproachDel:     xxxxxx           xxxxxx           xxxxxx             8.5
ApproachLOS:        *                *                *                A
Note: Queue reported is the number of cars per lane.
```

Level Of Service Computation Report
2000 HCM Unsignalized (Future Volume Alternative)
Existing Plus Project PM O+M+C

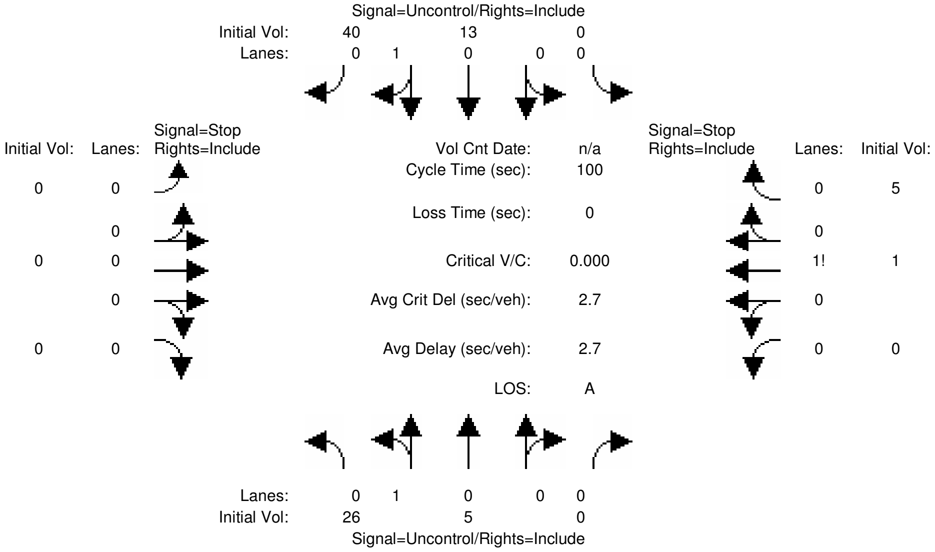
Intersection #1: I-40 WB/Park Moabi



```
Street Name:          Park Moabi Road                     I-40 WB Ramp
Approach:      North Bound      South Bound       East Bound       West Bound
Movement:     L  -  T  -  R   L  -  T  -  R    L  -  T  -  R    L  -  T  -  R
------------|---------------||---------------||---------------||---------------|
Volume Module:
Base Vol:       0    5     0     0    7    14     0    0     0     0    1     5
Growth Adj:  1.00 1.00  1.00  1.00 1.00  1.00  1.00 1.00  1.00  1.00 1.00  1.00
Initial Bse:    0    5     0     0    7    14     0    0     0     0    1     5
Added Vol:      0    0     0     0    0     0     0    0     0     0    0     0
Project Tri:    6    0     0     0   12    17     0    0     0     0    0     0
Initial Fut:    6    5     0     0   19    31     0    0     0     0    1     5
User Adj:    1.00 1.00  1.00  1.00 1.00  1.00  1.00 1.00  1.00  1.00 1.00  1.00
PHF Adj:     0.80 0.80  0.80  0.80 0.80  0.80  0.80 0.80  0.80  0.80 0.80  0.80
PHF Volume:     8    6     0     0   24    39     0    0     0     0    1     6
Reduct Vol:     0    0     0     0    0     0     0    0     0     0    0     0
FinalVolume:    8    6     0     0   24    39     0    0     0     0    1     6
------------|---------------||---------------||---------------||---------------|
Critical Gap Module:
Critical Gp:  4.1 xxxx xxxxx xxxxx xxxx xxxxx xxxxx xxxx xxxxx xxxxx  6.5   6.2
FollowUpTim:  2.2 xxxx xxxxx xxxxx xxxx xxxxx xxxxx xxxx xxxxx xxxxx  4.0   3.3
------------|---------------||---------------||---------------||---------------|
Capacity Module:
Cnflict Vol:   63 xxxx xxxxx  xxxx xxxx xxxxx  xxxx xxxx xxxxx  xxxx   84     6
Potent Cap.: 1553 xxxx xxxxx  xxxx xxxx xxxxx  xxxx xxxx xxxxx  xxxx  810  1082
Move Cap.:   1553 xxxx xxxxx  xxxx xxxx xxxxx  xxxx xxxx xxxxx  xxxx  806  1082
Volume/Cap:  0.00 xxxx  xxxx  xxxx xxxx  xxxx  xxxx xxxx  xxxx  xxxx 0.00  0.01
------------|---------------||---------------||---------------||---------------|
Level Of Service Module:
2Way95thQ:    0.0 xxxx xxxxx  xxxx xxxx xxxxx  xxxx xxxx xxxxx  xxxx xxxx xxxxx
Control Del:  7.3 xxxx xxxxx xxxxx xxxx xxxxx xxxxx xxxx xxxxx xxxxx xxxx xxxxx
LOS by Move:    A    *     *     *    *     *     *    *     *     *    *     *
Movement:      LT - LTR - RT    LT - LTR - RT    LT - LTR - RT    LT - LTR - RT
Shared Cap.: xxxx xxxx xxxxx  xxxx xxxx xxxxx  xxxx xxxx xxxxx  xxxx xxxx  1024
SharedQueue:  0.0 xxxx xxxxx xxxxx xxxx xxxxx xxxxx xxxx xxxxx xxxxx xxxx   0.0
Shrd ConDel:  7.3 xxxx xxxxx xxxxx xxxx xxxxx xxxxx xxxx xxxxx xxxxx xxxx   8.5
Shared LOS:     A    *     *     *    *     *     *    *     *     *    *     A
ApproachDel:    xxxxxx           xxxxxx           xxxxxx             8.5
ApproachLOS:         *                *                *               A
Note: Queue reported is the number of cars per lane.
```

Level Of Service Computation Report
2000 HCM Unsignalized (Future Volume Alternative)
Existing Plus Project PM O+M+D

Intersection #1: I-40 WB/Park Moabi



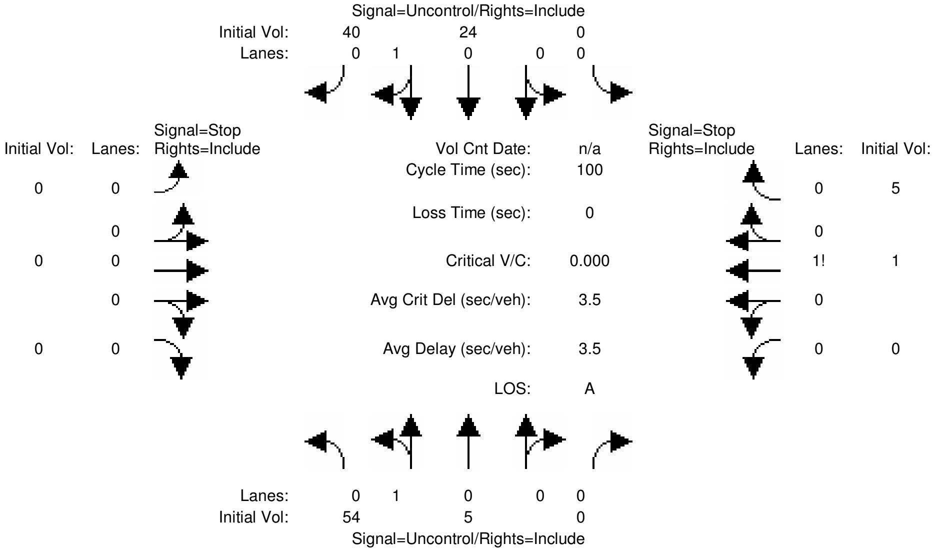
Vol Cnt Date: n/a
Cycle Time (sec): 100
Loss Time (sec): 0
Critical V/C: 0.000
Avg Crit Del (sec/veh): 2.7
Avg Delay (sec/veh): 2.7
LOS: A

```
Street Name:          Park Moabi Road                     I-40 WB Ramp
Approach:      North Bound      South Bound       East Bound       West Bound
Movement:     L  -  T  -  R    L  -  T  -  R    L  -  T  -  R    L  -  T  -  R
------------|---------------||---------------||---------------||---------------|
Volume Module:
Base Vol:        0    5     0     0    7    14     0    0     0     0    1     5
Growth Adj:   1.00 1.00  1.00  1.00 1.00  1.00  1.00 1.00  1.00  1.00 1.00  1.00
Initial Bse:     0    5     0     0    7    14     0    0     0     0    1     5
Added Vol:       0    0     0     0    0     0     0    0     0     0    0     0
Project Tri:    26    0     0     0    6    26     0    0     0     0    0     0
Initial Fut:    26    5     0     0   13    40     0    0     0     0    1     5
User Adj:     1.00 1.00  1.00  1.00 1.00  1.00  1.00 1.00  1.00  1.00 1.00  1.00
PHF Adj:      1.00 1.00  1.00  1.00 1.00  1.00  1.00 1.00  1.00  1.00 1.00  1.00
PHF Volume:     26    5     0     0   13    40     0    0     0     0    1     5
Reduct Vol:      0    0     0     0    0     0     0    0     0     0    0     0
FinalVolume:    26    5     0     0   13    40     0    0     0     0    1     5
------------|---------------||---------------||---------------||---------------|
Critical Gap Module:
Critical Gp:   4.1 xxxx xxxxx xxxxx xxxx xxxxx xxxxx xxxx xxxxx xxxxx  6.5   6.2
FollowUpTim:   2.2 xxxx xxxxx xxxxx xxxx xxxxx xxxxx xxxx xxxxx xxxxx  4.0   3.3
------------|---------------||---------------||---------------||---------------|
Capacity Module:
Cnflict Vol:    53 xxxx xxxxx  xxxx xxxx xxxxx  xxxx xxxx xxxxx  xxxx  110     5
Potent Cap.: 1566 xxxx xxxxx  xxxx xxxx xxxxx  xxxx xxxx xxxxx  xxxx  784  1084
Move Cap.:    1566 xxxx xxxxx  xxxx xxxx xxxxx  xxxx xxxx xxxxx  xxxx  771  1084
Volume/Cap:   0.02 xxxx  xxxx  xxxx xxxx  xxxx  xxxx xxxx  xxxx  xxxx 0.00  0.00
------------|---------------||---------------||---------------||---------------|
Level Of Service Module:
2WayQ95thQ:    0.1 xxxx xxxxx  xxxx xxxx xxxxx  xxxx xxxx xxxxx  xxxx xxxx xxxxx
Control Del:   7.3 xxxx xxxxx xxxxx xxxx xxxxx xxxxx xxxx xxxxx xxxxx xxxx xxxxx
LOS by Move:     A    *     *     *    *     *     *    *     *     *    *     *
Movement:      LT - LTR - RT    LT - LTR - RT    LT - LTR - RT    LT - LTR - RT
Shared Cap.: xxxx xxxx xxxxx  xxxx xxxx xxxxx  xxxx xxxx xxxxx  xxxx xxxx  1015
SharedQueue:   0.1 xxxx xxxxx xxxxx xxxx xxxxx xxxxx xxxx xxxxx xxxxx xxxx   0.0
Shrd ConDel:   7.3 xxxx xxxxx xxxxx xxxx xxxxx xxxxx xxxx xxxxx xxxxx xxxx   8.6
Shared LOS:      A    *     *     *    *     *     *    *     *     *    *     A
ApproachDel:     xxxxxx           xxxxxx           xxxxxx             8.6
ApproachLOS:          *                *                *               A
Note: Queue reported is the number of cars per lane.
```

IE08-0015 Topock Remediation

Level Of Service Computation Report
2000 HCM Unsignalized (Future Volume Alternative)
Existing Plus Project PM Decommissioning

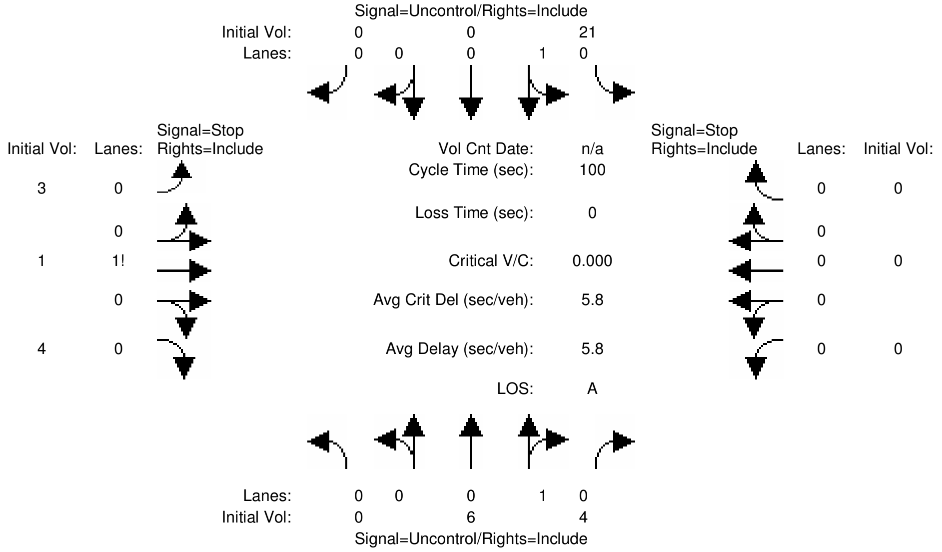
Intersection #1: I-40 WB/Park Moabi



```
Street Name:         Park Moabi Road                   I-40 WB Ramp
Approach:      North Bound      South Bound       East Bound       West Bound
Movement:     L  -  T  -  R    L  -  T  -  R    L  -  T  -  R    L  -  T  -  R
------------|---------------||---------------||---------------||---------------|
Volume Module:
Base Vol:       0    5     0     0    7    14     0    0     0     0    1     5
Growth Adj:  1.00 1.00  1.00  1.00 1.00  1.00  1.00 1.00  1.00  1.00 1.00  1.00
Initial Bse:    0    5     0     0    7    14     0    0     0     0    1     5
Added Vol:      0    0     0     0    0     0     0    0     0     0    0     0
Project Tri:   54    0     0     0   17    26     0    0     0     0    0     0
Initial Fut:   54    5     0     0   24    40     0    0     0     0    1     5
User Adj:    1.00 1.00  1.00  1.00 1.00  1.00  1.00 1.00  1.00  1.00 1.00  1.00
PHF Adj:     1.00 1.00  1.00  1.00 1.00  1.00  1.00 1.00  1.00  1.00 1.00  1.00
PHF Volume:    54    5     0     0   24    40     0    0     0     0    1     5
Reduct Vol:     0    0     0     0    0     0     0    0     0     0    0     0
FinalVolume:   54    5     0     0   24    40     0    0     0     0    1     5
------------|---------------||---------------||---------------||---------------|
Critical Gap Module:
Critical Gp:  4.1 xxxx xxxxx xxxxx xxxx xxxxx xxxxx xxxx xxxxx xxxxx  6.5   6.2
FollowUpTim:  2.2 xxxx xxxxx xxxxx xxxx xxxxx xxxxx xxxx xxxxx xxxxx  4.0   3.3
------------|---------------||---------------||---------------||---------------|
Capacity Module:
Cnflict Vol:   64 xxxx xxxxx  xxxx xxxx xxxxx  xxxx xxxx xxxxx  xxxx  177     5
Potent Cap.: 1551 xxxx xxxxx  xxxx xxxx xxxxx  xxxx xxxx xxxxx  xxxx  720  1084
Move Cap.:   1551 xxxx xxxxx  xxxx xxxx xxxxx  xxxx xxxx xxxxx  xxxx  694  1084
Volume/Cap:  0.03 xxxx  xxxx  xxxx xxxx  xxxx  xxxx xxxx  xxxx  xxxx 0.00  0.00
------------|---------------||---------------||---------------||---------------|
Level Of Service Module:
2Way95thQ:    0.1 xxxx xxxxx  xxxx xxxx xxxxx  xxxx xxxx xxxxx  xxxx xxxx xxxxx
Control Del:  7.4 xxxx xxxxx xxxxx xxxx xxxxx xxxxx xxxx xxxxx xxxxx xxxx xxxxx
LOS by Move:    A    *     *     *    *     *     *    *     *     *    *     *
Movement:     LT - LTR - RT    LT - LTR - RT    LT - LTR - RT    LT - LTR - RT
Shared Cap.: xxxx xxxx xxxxx  xxxx xxxx xxxxx  xxxx xxxx xxxxx  xxxx xxxx   991
SharedQueue:  0.1 xxxx xxxxx xxxxx xxxx xxxxx xxxxx xxxx xxxxx xxxxx xxxx   0.0
Shrd ConDel:  7.4 xxxx xxxxx xxxxx xxxx xxxxx xxxxx xxxx xxxxx xxxxx xxxx   8.7
Shared LOS:     A    *     *     *    *     *     *    *     *     *    *     A
ApproachDel:    xxxxxx           xxxxxx           xxxxxx              8.7
ApproachLOS:         *                *                *                A
Note: Queue reported is the number of cars per lane.
```

Level Of Service Computation Report
2000 HCM Unsignalized (Future Volume Alternative)
Existing Plus Project PM Construction

Intersection #2: I-40 EB/Park Moabi



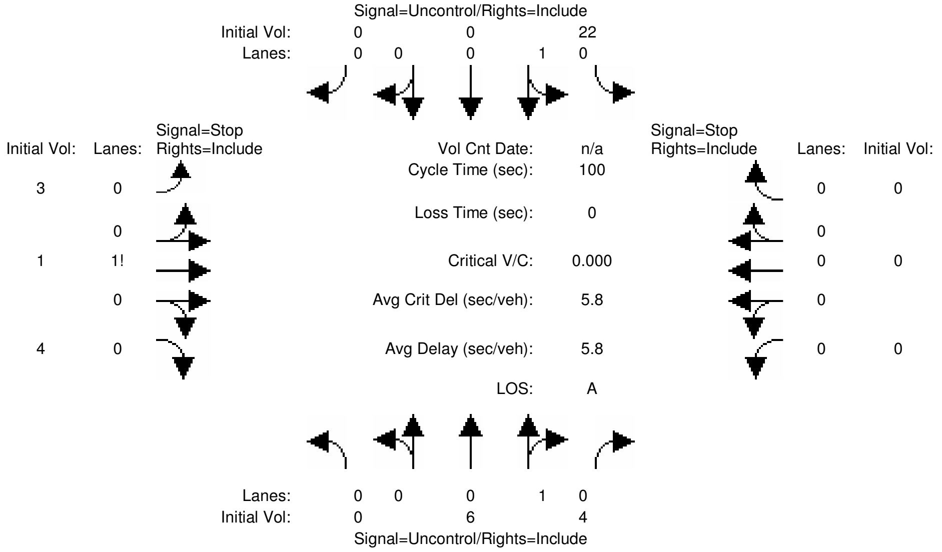
Vol Cnt Date: n/a
Cycle Time (sec): 100
Loss Time (sec): 0
Critical V/C: 0.000
Avg Crit Del (sec/veh): 5.8
Avg Delay (sec/veh): 5.8
LOS: A

```
Street Name:         Park Moabi Road                   I-40 EB Ramp
Approach:      North Bound      South Bound       East Bound       West Bound
Movement:     L  -  T  -  R    L  -  T  -  R    L  -  T  -  R    L  -  T  -  R
------------|---------------||---------------||---------------||---------------|
Volume Module:
Base Vol:       0    0     0    10    0     0     3    1     4     0    0     0
Growth Adj:  1.00 1.00  1.00  1.00 1.00  1.00  1.00 1.00  1.00  1.00 1.00  1.00
Initial Bse:    0    0     0    10    0     0     3    1     4     0    0     0
Added Vol:      0    0     0     0    0     0     0    0     0     0    0     0
Project Tri:    0    6     4    11    0     0     0    0     0     0    0     0
Initial Fut:    0    6     4    21    0     0     3    1     4     0    0     0
User Adj:    1.00 1.00  1.00  1.00 1.00  1.00  1.00 1.00  1.00  1.00 1.00  1.00
PHF Adj:     0.70 0.70  0.70  0.70 0.70  0.70  0.70 0.70  0.70  0.70 0.70  0.70
PHF Volume:     0    9     6    30    0     0     4    1     6     0    0     0
Reduct Vol:     0    0     0     0    0     0     0    0     0     0    0     0
FinalVolume:    0    9     6    30    0     0     4    1     6     0    0     0
------------|---------------||---------------||---------------||---------------|
Critical Gap Module:
Critical Gp:xxxxx xxxx xxxxx   4.1 xxxx xxxxx   6.4  6.5   6.2 xxxxx xxxx xxxxx
FollowUpTim:xxxxx xxxx xxxxx   2.2 xxxx xxxxx   3.5  4.0   3.3 xxxxx xxxx xxxxx
------------|---------------||---------------||---------------||---------------|
Capacity Module:
Cnflict Vol: xxxx xxxx xxxxx    14 xxxx xxxxx    71   74     0  xxxx xxxx xxxxx
Potent Cap.: xxxx xxxx xxxxx  1617 xxxx xxxxx   938  820   900  xxxx xxxx xxxxx
Move Cap.:   xxxx xxxx xxxxx  1617 xxxx xxxxx   924  805   900  xxxx xxxx xxxxx
Volume/Cap:  xxxx xxxx  xxxx  0.02 xxxx  xxxx  0.00 0.00  0.01  xxxx xxxx  xxxx
------------|---------------||---------------||---------------||---------------|
Level Of Service Module:
2Way95thQ:   xxxx xxxx xxxxx   0.1 xxxx xxxxx  xxxx xxxx xxxxx  xxxx xxxx xxxxx
Control Del:xxxxx xxxx xxxxx   7.3 xxxx xxxxx xxxxx xxxx xxxxx xxxxx xxxx xxxxx
LOS by Move:    *    *     *     A    *     *     *    *     *     *    *     *
Movement:     LT - LTR - RT    LT - LTR - RT    LT - LTR - RT    LT - LTR - RT
Shared Cap.: xxxx xxxx xxxxx  xxxx xxxx xxxxx  xxxx  896 xxxxx  xxxx xxxx xxxxx
SharedQueue:xxxxx xxxx xxxxx xxxxx xxxx xxxxx xxxxx  0.0 xxxxx xxxxx xxxx xxxxx
Shrd ConDel:xxxxx xxxx xxxxx xxxxx xxxx xxxxx xxxxx  9.1 xxxxx xxxxx xxxx xxxxx
Shared LOS:     *    *     *     *    *     *     *    A     *     *    *     *
ApproachDel:    xxxxxx            xxxxxx              9.1             xxxxxx
ApproachLOS:         *                 *                A                  *
Note: Queue reported is the number of cars per lane.
```

IE08-0015 Topock Remediation

Level Of Service Computation Report
2000 HCM Unsignalized (Future Volume Alternative)
Existing Plus Project PM O+M+C

Intersection #2: I-40 EB/Park Moabi

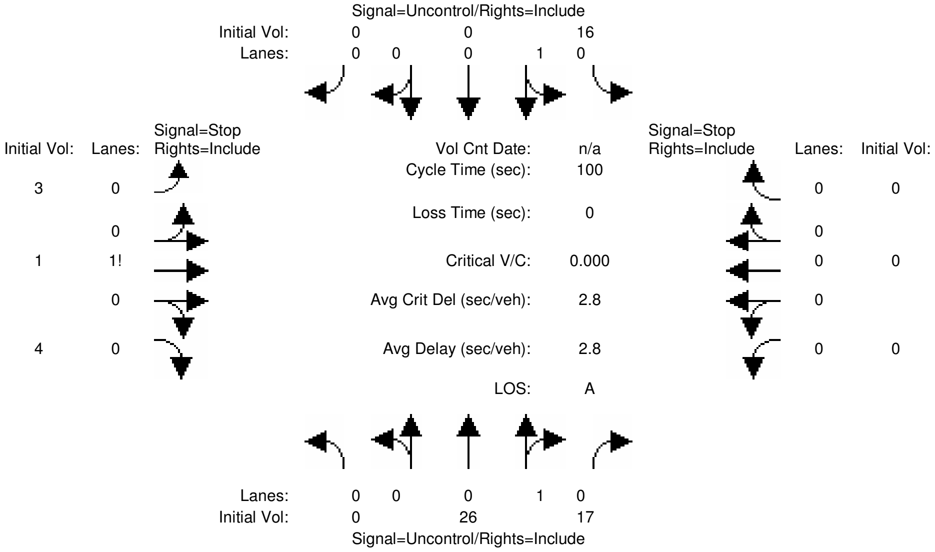


Vol Cnt Date: n/a
Cycle Time (sec): 100
Loss Time (sec): 0
Critical V/C: 0.000
Avg Crit Del (sec/veh): 5.8
Avg Delay (sec/veh): 5.8
LOS: A

```
Street Name:          Park Moabi Road                     I-40 EB Ramp
Approach:      North Bound      South Bound       East Bound       West Bound
Movement:    L  -  T  -  R    L  -  T  -  R    L  -  T  -  R    L  -  T  -  R
------------|---------------||---------------||---------------||---------------|
Volume Module:
Base Vol:       0    0     0    10    0     0     3    1     4     0    0     0
Growth Adj:  1.00 1.00  1.00  1.00 1.00  1.00  1.00 1.00  1.00  1.00 1.00  1.00
Initial Bse:    0    0     0    10    0     0     3    1     4     0    0     0
Added Vol:      0    0     0     0    0     0     0    0     0     0    0     0
Project Tri:    0    6     4    12    0     0     0    0     0     0    0     0
Initial Fut:    0    6     4    22    0     0     3    1     4     0    0     0
User Adj:    1.00 1.00  1.00  1.00 1.00  1.00  1.00 1.00  1.00  1.00 1.00  1.00
PHF Adj:     0.70 0.70  0.70  0.70 0.70  0.70  0.70 0.70  0.70  0.70 0.70  0.70
PHF Volume:     0    9     6    31    0     0     4    1     6     0    0     0
Reduct Vol:     0    0     0     0    0     0     0    0     0     0    0     0
FinalVolume:    0    9     6    31    0     0     4    1     6     0    0     0
------------|---------------||---------------||---------------||---------------|
Critical Gap Module:
Critical Gp:xxxxx xxxx xxxxx   4.1 xxxx xxxxx   6.4  6.5   6.2 xxxxx xxxx xxxxx
FollowUpTim:xxxxx xxxx xxxxx   2.2 xxxx xxxxx   3.5  4.0   3.3 xxxxx xxxx xxxxx
------------|---------------||---------------||---------------||---------------|
Capacity Module:
Cnflict Vol: xxxx xxxx xxxxx    14 xxxx xxxxx    74   77     0  xxxx xxxx xxxxx
Potent Cap.: xxxx xxxx xxxxx  1617 xxxx xxxxx   934  817   900  xxxx xxxx xxxxx
Move Cap.:   xxxx xxxx xxxxx  1617 xxxx xxxxx   920  801   900  xxxx xxxx xxxxx
Volume/Cap:  xxxx xxxx  xxxx  0.02 xxxx  xxxx  0.00 0.00  0.01  xxxx xxxx  xxxx
------------|---------------||---------------||---------------||---------------|
Level Of Service Module:
2Way95thQ:   xxxx xxxx xxxxx   0.1 xxxx xxxxx  xxxx xxxx xxxxx  xxxx xxxx xxxxx
Control Del:xxxxx xxxx xxxxx   7.3 xxxx xxxxx xxxxx xxxx xxxxx xxxxx xxxx xxxxx
LOS by Move:    *    *     *     A    *     *     *    *     *     *    *     *
Movement:     LT - LTR - RT    LT - LTR - RT    LT - LTR - RT    LT - LTR - RT
Shared Cap.: xxxx xxxx xxxxx  xxxx xxxx xxxxx  xxxx  894 xxxxx  xxxx xxxx xxxxx
SharedQueue:xxxxx xxxx xxxxx xxxxx xxxx xxxxx xxxxx  0.0 xxxxx xxxxx xxxx xxxxx
Shrd ConDel:xxxxx xxxx xxxxx xxxxx xxxx xxxxx xxxxx  9.1 xxxxx xxxxx xxxx xxxxx
Shared LOS:     *    *     *     *    *     *     *    A     *     *    *     *
ApproachDel:    xxxxxx           xxxxxx               9.1             xxxxxx
ApproachLOS:       *                *                  A                 *
Note: Queue reported is the number of cars per lane.
```

Level Of Service Computation Report
2000 HCM Unsignalized (Future Volume Alternative)
Existing Plus Project PM O+M+D

Intersection #2: I-40 EB/Park Moabi

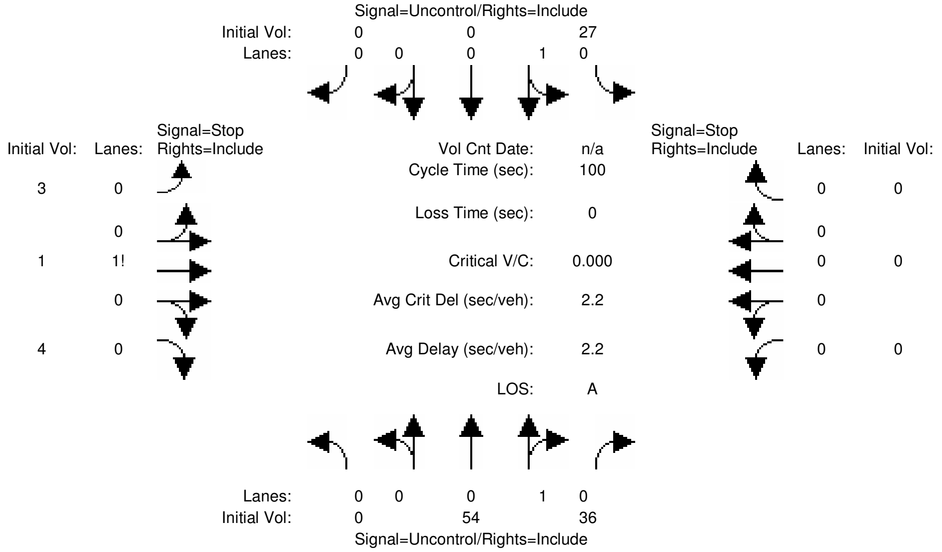


```
Street Name:          Park Moabi Road                    I-40 EB Ramp
Approach:      North Bound      South Bound       East Bound       West Bound
Movement:     L  -  T  -  R    L  -  T  -  R    L  -  T  -  R    L  -  T  -  R
------------|---------------||---------------||---------------||---------------|
Volume Module:
Base Vol:        0    0     0    10    0     0     3    1     4     0    0     0
Growth Adj:   1.00 1.00  1.00  1.00 1.00  1.00  1.00 1.00  1.00  1.00 1.00  1.00
Initial Bse:     0    0     0    10    0     0     3    1     4     0    0     0
Added Vol:       0    0     0     0    0     0     0    0     0     0    0     0
Project Tri:     0   26    17     6    0     0     0    0     0     0    0     0
Initial Fut:     0   26    17    16    0     0     3    1     4     0    0     0
User Adj:     1.00 1.00  1.00  1.00 1.00  1.00  1.00 1.00  1.00  1.00 1.00  1.00
PHF Adj:      1.00 1.00  1.00  1.00 1.00  1.00  1.00 1.00  1.00  1.00 1.00  1.00
PHF Volume:      0   26    17    16    0     0     3    1     4     0    0     0
Reduct Vol:      0    0     0     0    0     0     0    0     0     0    0     0
FinalVolume:     0   26    17    16    0     0     3    1     4     0    0     0
------------|---------------||---------------||---------------||---------------|
Critical Gap Module:
Critical Gp:xxxxx xxxx xxxxx   4.1 xxxx xxxxx   6.4  6.5   6.2 xxxxx xxxx xxxxx
FollowUpTim:xxxxx xxxx xxxxx   2.2 xxxx xxxxx   3.5  4.0   3.3 xxxxx xxxx xxxxx
------------|---------------||---------------||---------------||---------------|
Capacity Module:
Cnflict Vol: xxxx xxxx xxxxx    43 xxxx xxxxx    67   75     0  xxxx xxxx xxxxx
Potent Cap.: xxxx xxxx xxxxx  1579 xxxx xxxxx   944  819   900  xxxx xxxx xxxxx
Move Cap.:   xxxx xxxx xxxxx  1579 xxxx xxxxx   936  811   900  xxxx xxxx xxxxx
Volume/Cap:  xxxx xxxx  xxxx  0.01 xxxx  xxxx  0.00 0.00  0.00  xxxx xxxx  xxxx
------------|---------------||---------------||---------------||---------------|
Level Of Service Module:
2Way95thQ:   xxxx xxxx xxxxx   0.0 xxxx xxxxx  xxxx xxxx xxxxx  xxxx xxxx xxxxx
Control Del:xxxxx xxxx xxxxx   7.3 xxxx xxxxx xxxxx xxxx xxxxx xxxxx xxxx xxxxx
LOS by Move:    *    *     *     A    *     *     *    *     *     *    *     *
Movement:     LT - LTR - RT    LT - LTR - RT    LT - LTR - RT    LT - LTR - RT
Shared Cap.: xxxx xxxx xxxxx  xxxx xxxx xxxxx  xxxx  901 xxxxx  xxxx xxxx xxxxx
SharedQueue:xxxxx xxxx xxxxx xxxxx xxxx xxxxx xxxxx  0.0 xxxxx xxxxx xxxx xxxxx
Shrd ConDel:xxxxx xxxx xxxxx xxxxx xxxx xxxxx xxxxx  9.0 xxxxx xxxxx xxxx xxxxx
Shared LOS:     *    *     *     *    *     *     *    A     *     *    *     *
ApproachDel:    xxxxxx            xxxxxx              9.0             xxxxxx
ApproachLOS:         *                 *                A                  *
Note: Queue reported is the number of cars per lane.
```

IE08-0015 Topock Remediation

Level Of Service Computation Report
2000 HCM Unsignalized (Future Volume Alternative)
Existing Plus Project PM Decommissioning

Intersection #2: I-40 EB/Park Moabi



```
                         Signal=Uncontrol/Rights=Include
              Initial Vol:    0          0            27
                    Lanes:    0    0     0       1    0

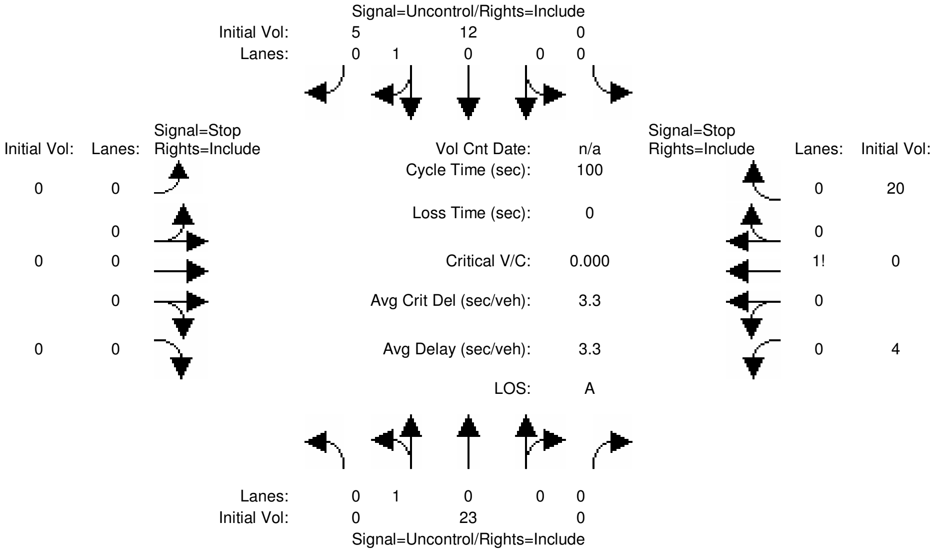
                 Signal=Stop                                          Signal=Stop
Initial Vol:  Lanes:  Rights=Include        Vol Cnt Date:    n/a      Rights=Include   Lanes:  Initial Vol:
                                          Cycle Time (sec):  100
     3          0                                                                        0         0
                                           Loss Time (sec):   0
                0                                                                        0
     1          1!                           Critical V/C:  0.000                        0         0
                0                      Avg Crit Del (sec/veh):  2.2                      0
     4          0                         Avg Delay (sec/veh):  2.2                      0         0
                                                     LOS:     A

                    Lanes:    0    0     0       1    0
              Initial Vol:    0         54            36
                         Signal=Uncontrol/Rights=Include
```

```
Street Name:          Park Moabi Road                     I-40 EB Ramp
Approach:       North Bound       South Bound       East Bound        West Bound
Movement:     L  -  T  -  R    L  -  T  -  R    L  -  T  -  R    L  -  T  -  R
------------|---------------||---------------||---------------||---------------|
Volume Module:
Base Vol:        0    0     0    10    0     0     3    1     4     0    0     0
Growth Adj:   1.00 1.00  1.00  1.00 1.00  1.00  1.00 1.00  1.00  1.00 1.00  1.00
Initial Bse:     0    0     0    10    0     0     3    1     4     0    0     0
Added Vol:       0    0     0     0    0     0     0    0     0     0    0     0
Project Tri:     0   54    36    17    0     0     0    0     0     0    0     0
Initial Fut:     0   54    36    27    0     0     3    1     4     0    0     0
User Adj:     1.00 1.00  1.00  1.00 1.00  1.00  1.00 1.00  1.00  1.00 1.00  1.00
PHF Adj:      1.00 1.00  1.00  1.00 1.00  1.00  1.00 1.00  1.00  1.00 1.00  1.00
PHF Volume:      0   54    36    27    0     0     3    1     4     0    0     0
Reduct Vol:      0    0     0     0    0     0     0    0     0     0    0     0
FinalVolume:     0   54    36    27    0     0     3    1     4     0    0     0
------------|---------------||---------------||---------------||---------------|
Critical Gap Module:
Critical Gp:xxxxx xxxx xxxxx   4.1 xxxx xxxxx   6.4  6.5   6.2 xxxxx xxxx xxxxx
FollowUpTim:xxxxx xxxx xxxxx   2.2 xxxx xxxxx   3.5  4.0   3.3 xxxxx xxxx xxxxx
------------|---------------||---------------||---------------||---------------|
Capacity Module:
Cnflict Vol: xxxx xxxx xxxxx    90 xxxx xxxxx   126  144     0  xxxx xxxx xxxxx
Potent Cap.: xxxx xxxx xxxxx  1518 xxxx xxxxx   874  751   900  xxxx xxxx xxxxx
Move Cap.:   xxxx xxxx xxxxx  1518 xxxx xxxxx   862  738   900  xxxx xxxx xxxxx
Volume/Cap:  xxxx xxxx  xxxx  0.02 xxxx  xxxx  0.00 0.00  0.00  xxxx xxxx  xxxx
------------|---------------||---------------||---------------||---------------|
Level Of Service Module:
2Way95thQ:   xxxx xxxx xxxxx   0.1 xxxx xxxxx  xxxx xxxx xxxxx  xxxx xxxx xxxxx
Control Del:xxxxx xxxx xxxxx   7.4 xxxx xxxxx xxxxx xxxx xxxxx xxxxx xxxx xxxxx
LOS by Move:    *    *     *     A    *     *     *    *     *     *    *     *
Movement:     LT - LTR - RT    LT - LTR - RT    LT - LTR - RT    LT - LTR - RT
Shared Cap.: xxxx xxxx xxxxx  xxxx xxxx xxxxx  xxxx  862 xxxxx  xxxx xxxx xxxxx
SharedQueue:xxxxx xxxx xxxxx xxxxx xxxx xxxxx xxxxx  0.0 xxxxx xxxxx xxxx xxxxx
Shrd ConDel:xxxxx xxxx xxxxx xxxxx xxxx xxxxx xxxxx  9.2 xxxxx xxxxx xxxx xxxxx
Shared LOS:     *    *     *     *    *     *     *    A     *     *    *     *
ApproachDel:    xxxxxx            xxxxxx              9.2            xxxxxx
ApproachLOS:         *                 *                A                 *
Note: Queue reported is the number of cars per lane.
```

Level Of Service Computation Report
2000 HCM Unsignalized (Future Volume Alternative)
Cumulative Plus Project AM Construction

Intersection #1: I-40 WB/Park Moabi



```
Street Name:          Park Moabi Road                    I-40 WB Ramp
Approach:       North Bound      South Bound       East Bound       West Bound
Movement:     L  -  T  -  R    L  -  T  -  R    L  -  T  -  R    L  -  T  -  R
------------|---------------||---------------||---------------||---------------|
Volume Module:
Base Vol:       0    4     0     0    8     3     0    0     0     0    0     6
Growth Adj:  1.55 1.55  1.55  1.55 1.55  1.55  1.55 1.55  1.55  1.55 1.55  1.55
Initial Bse:    0    6     0     0   12     5     0    0     0     0    0     9
Added Vol:      0    0     0     0    0     0     0    0     0     0    0     0
PasserByVol:    0   17     0     0    0     0     0    0     0     4    0    11
Initial Fut:    0   23     0     0   12     5     0    0     0     4    0    20
User Adj:    1.00 1.00  1.00  1.00 1.00  1.00  1.00 1.00  1.00  1.00 1.00  1.00
PHF Adj:     0.58 0.58  0.58  0.58 0.58  0.58  0.58 0.58  0.58  0.58 0.58  0.58
PHF Volume:     0   40     0     0   21     8     0    0     0     7    0    35
Reduct Vol:     0    0     0     0    0     0     0    0     0     0    0     0
FinalVolume:    0   40     0     0   21     8     0    0     0     7    0    35
------------|---------------||---------------||---------------||---------------|
Critical Gap Module:
Critical Gp:xxxxx xxxx xxxxx xxxxx xxxx xxxxx xxxxx xxxx xxxxx   6.4  6.5   6.2
FollowUpTim:xxxxx xxxx xxxxx xxxxx xxxx xxxxx xxxxx xxxx xxxxx   3.5  4.0   3.3
------------|---------------||---------------||---------------||---------------|
Capacity Module:
Cnflict Vol: xxxx xxxx xxxxx  xxxx xxxx xxxxx  xxxx xxxx xxxxx    65   69    40
Potent Cap.: xxxx xxxx xxxxx  xxxx xxxx xxxxx  xxxx xxxx xxxxx   945  825  1037
Move Cap.:   xxxx xxxx xxxxx  xxxx xxxx xxxxx  xxxx xxxx xxxxx   945  825  1037
Volume/Cap:  xxxx xxxx  xxxx  xxxx xxxx  xxxx  xxxx xxxx  xxxx  0.01 0.00  0.03
------------|---------------||---------------||---------------||---------------|
Level Of Service Module:
2Way95thQ:   xxxx xxxx xxxxx  xxxx xxxx xxxxx  xxxx xxxx xxxxx  xxxx xxxx xxxxx
Control Del:xxxxx xxxx xxxxx xxxxx xxxx xxxxx xxxxx xxxx xxxxx xxxxx xxxx xxxxx
LOS by Move:    *    *     *     *    *     *     *    *     *     *    *     *
Movement:     LT - LTR - RT    LT - LTR - RT    LT - LTR - RT    LT - LTR - RT
Shared Cap.: xxxx xxxx xxxxx  xxxx xxxx xxxxx  xxxx xxxx xxxxx  xxxx 1021 xxxxx
SharedQueue:xxxxx xxxx xxxxx xxxxx xxxx xxxxx xxxxx xxxx xxxxx xxxxx  0.1 xxxxx
Shrd ConDel:xxxxx xxxx xxxxx xxxxx xxxx xxxxx xxxxx xxxx xxxxx xxxxx  8.7 xxxxx
Shared LOS:     *    *     *     *    *     *     *    *     *     *    A     *
ApproachDel:    xxxxxx           xxxxxx           xxxxxx              8.7
ApproachLOS:         *                *                *                A
Note: Queue reported is the number of cars per lane.
                     Peak Hour Delay Signal Warrant Report
*******************************************************************************
Intersection #1 I-40 WB/Park Moabi
*******************************************************************************
Future Volume Alternative: Peak Hour Warrant NOT Met
```

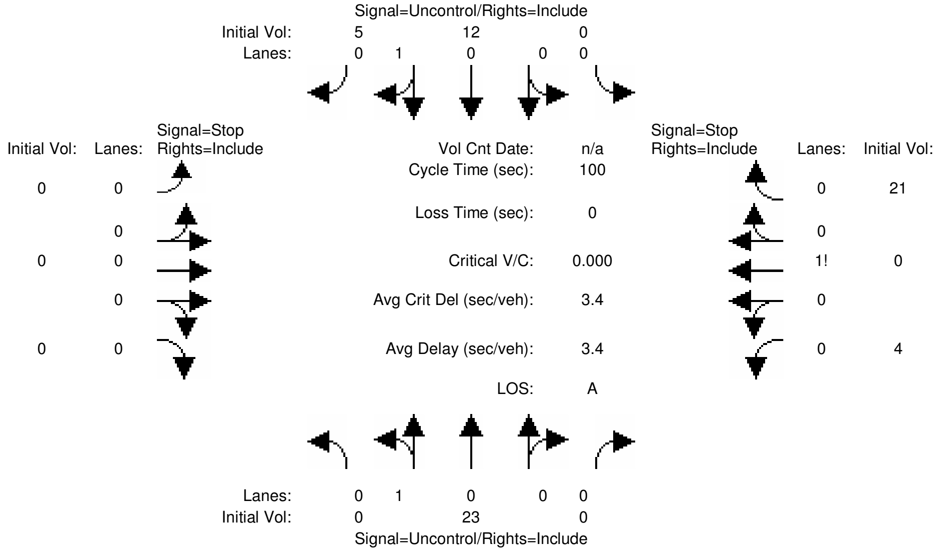
```
------------|---------------||---------------||---------------||---------------|
Approach:      North Bound      South Bound       East Bound       West Bound
Movement:     L  -  T  -  R    L  -  T  -  R    L  -  T  -  R    L  -  T  -  R
------------|---------------||---------------||---------------||---------------|
Control:       Uncontrolled     Uncontrolled      Stop Sign        Stop Sign
Lanes:        0  0  1  0  0    0  0  0  1  0    0  0  0  0  0    0  0  1! 0  0
Initial Vol:     0   23     0     0   12     5     0    0     0     4    0    20
ApproachDel:     xxxxxx           xxxxxx           xxxxxx              8.7
------------|---------------||---------------||---------------||---------------|
Approach[westbound][lanes=1][control=Stop Sign]
Signal Warrant Rule #1: [vehicle-hours=0.1]
   FAIL - Vehicle-hours less than 4 for one lane approach.
Signal Warrant Rule #2: [approach volume=24]
   FAIL - Approach volume less than 100 for one lane approach.
Signal Warrant Rule #3: [approach count=3][total volume=65]
   FAIL - Total volume less than 650 for intersection
          with less than four approaches.
--------------------------------------------------------------------------------
SIGNAL WARRANT DISCLAIMER
This peak hour signal warrant analysis should be considered solely as an
"indicator" of the likelihood of an unsignalized intersection warranting
a traffic signal in the future.  Intersections that exceed this warrant
are probably more likely to meet one or more of the other volume based
signal warrant (such as the 4-hour or 8-hour warrants).

The peak hour warrant analysis in this report is not intended to replace
a rigorous and complete traffic signal warrant analysis by the responsible
jurisdiction.  Consideration of the other signal warrants, which is beyond
the scope of this software, may yield different results.
                Peak Hour Volume Signal Warrant Report [Urban]
********************************************************************************
Intersection #1 I-40 WB/Park Moabi
********************************************************************************
Future Volume Alternative: Peak Hour Warrant NOT Met
------------|---------------||---------------||---------------||---------------|
Approach:      North Bound      South Bound       East Bound       West Bound
Movement:     L  -  T  -  R    L  -  T  -  R    L  -  T  -  R    L  -  T  -  R
------------|---------------||---------------||---------------||---------------|
Control:       Uncontrolled     Uncontrolled      Stop Sign        Stop Sign
Lanes:        0  0  1  0  0    0  0  0  1  0    0  0  0  0  0    0  0  1! 0  0
Initial Vol:     0   23     0     0   12     5     0    0     0     4    0    20
------------|---------------||---------------||---------------||---------------|
Major Street Volume:            40
Minor Approach Volume:          24
Minor Approach Volume Threshold: 1076
--------------------------------------------------------------------------------
SIGNAL WARRANT DISCLAIMER
This peak hour signal warrant analysis should be considered solely as an
"indicator" of the likelihood of an unsignalized intersection warranting
a traffic signal in the future.  Intersections that exceed this warrant
are probably more likely to meet one or more of the other volume based
signal warrant (such as the 4-hour or 8-hour warrants).

The peak hour warrant analysis in this report is not intended to replace
a rigorous and complete traffic signal warrant analysis by the responsible
jurisdiction.  Consideration of the other signal warrants, which is beyond
the scope of this software, may yield different results.
```

Level Of Service Computation Report
2000 HCM Unsignalized (Future Volume Alternative)
Cumulative Plus Project AM O+M+C

Intersection #1: I-40 WB/Park Moabi

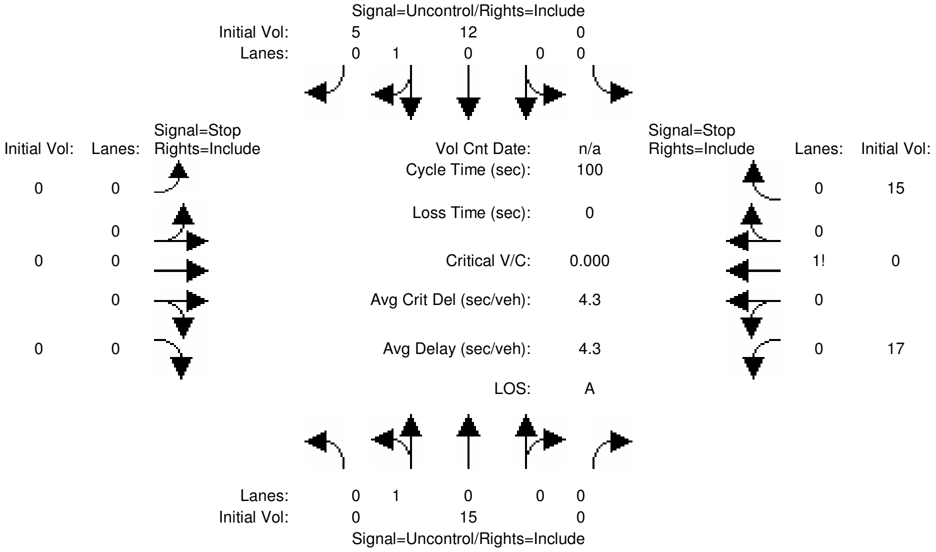


Vol Cnt Date: n/a
Cycle Time (sec): 100
Loss Time (sec): 0
Critical V/C: 0.000
Avg Crit Del (sec/veh): 3.4
Avg Delay (sec/veh): 3.4
LOS: A

```
Street Name:          Park Moabi Road                     I-40 WB Ramp
Approach:       North Bound       South Bound        East Bound        West Bound
Movement:     L  -  T  -  R     L  -  T  -  R     L  -  T  -  R     L  -  T  -  R
------------|---------------||---------------||---------------||---------------|
Volume Module:
Base Vol:        0    4     0     0    8     3     0    0     0     0    0     6
Growth Adj:   1.55 1.55  1.55  1.55 1.55  1.55  1.55 1.55  1.55  1.55 1.55  1.55
Initial Bse:     0    6     0     0   12     5     0    0     0     0    0     9
Added Vol:       0    0     0     0    0     0     0    0     0     0    0     0
Project Tri:     0   17     0     0    0     0     0    0     0     4    0    12
Initial Fut:     0   23     0     0   12     5     0    0     0     4    0    21
User Adj:     1.00 1.00  1.00  1.00 1.00  1.00  1.00 1.00  1.00  1.00 1.00  1.00
PHF Adj:      0.58 0.58  0.58  0.58 0.58  0.58  0.58 0.58  0.58  0.58 0.58  0.58
PHF Volume:      0   40     0     0   21     8     0    0     0     7    0    37
Reduct Vol:      0    0     0     0    0     0     0    0     0     0    0     0
FinalVolume:     0   40     0     0   21     8     0    0     0     7    0    37
------------|---------------||---------------||---------------||---------------|
Critical Gap Module:
Critical Gp:xxxxx xxxx xxxxx xxxxx xxxx xxxxx xxxxx xxxx xxxxx   6.4  6.5   6.2
FollowUpTim:xxxxx xxxx xxxxx xxxxx xxxx xxxxx xxxxx xxxx xxxxx   3.5  4.0   3.3
------------|---------------||---------------||---------------||---------------|
Capacity Module:
Cnflict Vol: xxxx xxxx xxxxx  xxxx xxxx xxxxx  xxxx xxxx xxxxx    65   69    40
Potent Cap.: xxxx xxxx xxxxx  xxxx xxxx xxxxx  xxxx xxxx xxxxx   945  825  1037
Move Cap.:   xxxx xxxx xxxxx  xxxx xxxx xxxxx  xxxx xxxx xxxxx   945  825  1037
Volume/Cap:  xxxx xxxx  xxxx  xxxx xxxx  xxxx  xxxx xxxx  xxxx  0.01 0.00  0.04
------------|---------------||---------------||---------------||---------------|
Level Of Service Module:
2Way95thQ:   xxxx xxxx xxxxx  xxxx xxxx xxxxx  xxxx xxxx xxxxx  xxxx xxxx xxxxx
Control Del:xxxxx xxxx xxxxx xxxxx xxxx xxxxx xxxxx xxxx xxxxx xxxxx xxxx xxxxx
LOS by Move:     *    *     *     *    *     *     *    *     *     *    *     *
Movement:     LT - LTR - RT    LT - LTR - RT    LT - LTR - RT    LT - LTR - RT
Shared Cap.: xxxx xxxx xxxxx  xxxx xxxx xxxxx  xxxx xxxx xxxxx  xxxx 1021 xxxxx
SharedQueue:xxxxx xxxx xxxxx xxxxx xxxx xxxxx xxxxx xxxx xxxxx xxxxx  0.1 xxxxx
Shrd ConDel:xxxxx xxxx xxxxx xxxxx xxxx xxxxx xxxxx xxxx xxxxx xxxxx  8.7 xxxxx
Shared LOS:      *    *     *     *    *     *     *    *     *     *    A     *
ApproachDel:    xxxxxx            xxxxxx            xxxxxx              8.7
ApproachLOS:         *                 *                 *                A
Note: Queue reported is the number of cars per lane.
```

Level Of Service Computation Report
2000 HCM Unsignalized (Future Volume Alternative)
Cumulative Plus Project AM O+M+D

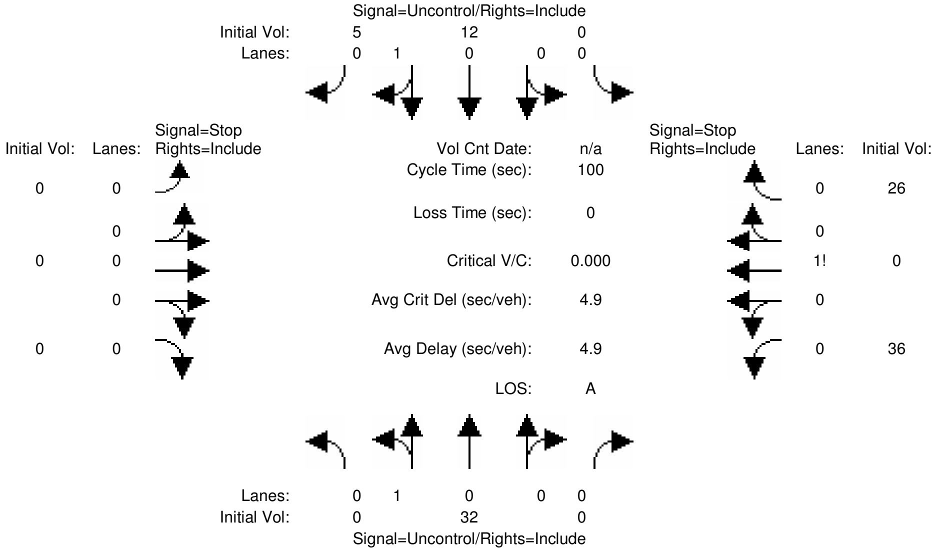
Intersection #1: I-40 WB/Park Moabi



```
Street Name:          Park Moabi Road                    I-40 WB Ramp
Approach:      North Bound      South Bound       East Bound       West Bound
Movement:     L  -  T  -  R    L  -  T  -  R    L  -  T  -  R    L  -  T  -  R
------------|---------------||---------------||---------------||---------------|
Volume Module:
Base Vol:       0    4     0     0    8     3     0    0     0     0    0     6
Growth Adj:  1.55 1.55  1.55  1.55 1.55  1.55  1.55 1.55  1.55  1.55 1.55  1.55
Initial Bse:    0    6     0     0   12     5     0    0     0     0    0     9
Added Vol:      0    0     0     0    0     0     0    0     0     0    0     0
Project Tri:    0    9     0     0    0     0     0    0     0    17    0     6
Initial Fut:    0   15     0     0   12     5     0    0     0    17    0    15
User Adj:    1.00 1.00  1.00  1.00 1.00  1.00  1.00 1.00  1.00  1.00 1.00  1.00
PHF Adj:     1.00 1.00  1.00  1.00 1.00  1.00  1.00 1.00  1.00  1.00 1.00  1.00
PHF Volume:     0   15     0     0   12     5     0    0     0    17    0    15
Reduct Vol:     0    0     0     0    0     0     0    0     0     0    0     0
FinalVolume:    0   15     0     0   12     5     0    0     0    17    0    15
------------|---------------||---------------||---------------||---------------|
Critical Gap Module:
Critical Gp:xxxxx xxxx xxxxx xxxxx xxxx xxxxx xxxxx xxxx xxxxx   6.4  6.5   6.2
FollowUpTim:xxxxx xxxx xxxxx xxxxx xxxx xxxxx xxxxx xxxx xxxxx   3.5  4.0   3.3
------------|---------------||---------------||---------------||---------------|
Capacity Module:
Cnflict Vol: xxxx xxxx xxxxx  xxxx xxxx xxxxx  xxxx xxxx xxxxx    30   32    15
Potent Cap.: xxxx xxxx xxxxx  xxxx xxxx xxxxx  xxxx xxxx xxxxx   990  864  1070
Move Cap.:   xxxx xxxx xxxxx  xxxx xxxx xxxxx  xxxx xxxx xxxxx   990  864  1070
Volume/Cap:  xxxx xxxx  xxxx  xxxx xxxx  xxxx  xxxx xxxx  xxxx  0.02 0.00  0.01
------------|---------------||---------------||---------------||---------------|
Level Of Service Module:
2Way95thQ:   xxxx xxxx xxxxx  xxxx xxxx xxxxx  xxxx xxxx xxxxx  xxxx xxxx xxxxx
Control Del:xxxxx xxxx xxxxx xxxxx xxxx xxxxx xxxxx xxxx xxxxx xxxxx xxxx xxxxx
LOS by Move:    *    *     *     *    *     *     *    *     *     *    *     *
Movement:     LT - LTR - RT    LT - LTR - RT    LT - LTR - RT    LT - LTR - RT
Shared Cap.: xxxx xxxx xxxxx  xxxx xxxx xxxxx  xxxx xxxx xxxxx  xxxx 1026 xxxxx
SharedQueue:xxxxx xxxx xxxxx xxxxx xxxx xxxxx xxxxx xxxx xxxxx xxxxx  0.1 xxxxx
Shrd ConDel:xxxxx xxxx xxxxx xxxxx xxxx xxxxx xxxxx xxxx xxxxx xxxxx  8.6 xxxxx
Shared LOS:     *    *     *     *    *     *     *    *     *     *    A     *
ApproachDel:    xxxxxx           xxxxxx           xxxxxx              8.6
ApproachLOS:         *                *                *               A
Note: Queue reported is the number of cars per lane.
```

Level Of Service Computation Report
2000 HCM Unsignalized (Future Volume Alternative)
Cumulative Plus Project AM Decommissioning

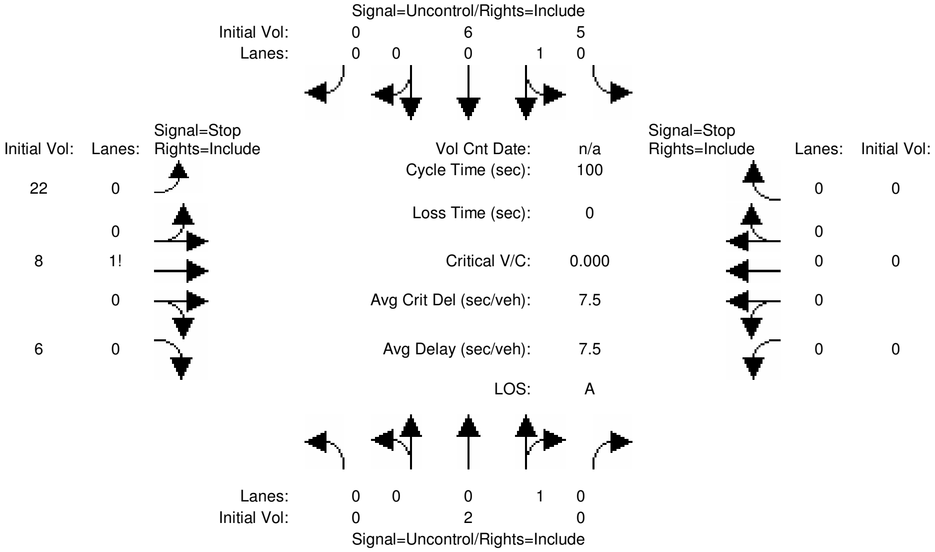
Intersection #1: I-40 WB/Park Moabi



```
Street Name:          Park Moabi Road                     I-40 WB Ramp
Approach:       North Bound       South Bound        East Bound        West Bound
Movement:     L  -  T  -  R    L  -  T  -  R    L  -  T  -  R    L  -  T  -  R
------------|---------------||---------------||---------------||---------------|
Volume Module:
Base Vol:        0    4     0     0    8     3     0    0     0     0    0     6
Growth Adj:  1.55 1.55  1.55  1.55 1.55  1.55  1.55 1.55  1.55  1.55 1.55  1.55
Initial Bse:     0    6     0     0   12     5     0    0     0     0    0     9
Added Vol:       0    0     0     0    0     0     0    0     0     0    0     0
Project Tri:     0   26     0     0    0     0     0    0     0    36    0    17
Initial Fut:     0   32     0     0   12     5     0    0     0    36    0    26
User Adj:     1.00 1.00  1.00  1.00 1.00  1.00  1.00 1.00  1.00  1.00 1.00  1.00
PHF Adj:      1.00 1.00  1.00  1.00 1.00  1.00  1.00 1.00  1.00  1.00 1.00  1.00
PHF Volume:      0   32     0     0   12     5     0    0     0    36    0    26
Reduct Vol:      0    0     0     0    0     0     0    0     0     0    0     0
FinalVolume:     0   32     0     0   12     5     0    0     0    36    0    26
------------|---------------||---------------||---------------||---------------|
Critical Gap Module:
Critical Gp:xxxxx xxxx xxxxx xxxxx xxxx xxxxx xxxxx xxxx xxxxx   6.4  6.5   6.2
FollowUpTim:xxxxx xxxx xxxxx xxxxx xxxx xxxxx xxxxx xxxx xxxxx   3.5  4.0   3.3
------------|---------------||---------------||---------------||---------------|
Capacity Module:
Cnflict Vol: xxxx xxxx xxxxx  xxxx xxxx xxxxx  xxxx xxxx xxxxx    47   49    32
Potent Cap.: xxxx xxxx xxxxx  xxxx xxxx xxxxx  xxxx xxxx xxxxx   968  846  1047
Move Cap.:   xxxx xxxx xxxxx  xxxx xxxx xxxxx  xxxx xxxx xxxxx   968  846  1047
Volume/Cap:  xxxx xxxx  xxxx  xxxx xxxx  xxxx  xxxx xxxx  xxxx  0.04 0.00  0.03
------------|---------------||---------------||---------------||---------------|
Level Of Service Module:
2Way95thQ:   xxxx xxxx xxxxx  xxxx xxxx xxxxx  xxxx xxxx xxxxx  xxxx xxxx xxxxx
Control Del:xxxxx xxxx xxxxx xxxxx xxxx xxxxx xxxxx xxxx xxxxx xxxxx xxxx xxxxx
LOS by Move:     *    *     *     *    *     *     *    *     *     *    *     *
Movement:      LT - LTR - RT    LT - LTR - RT    LT - LTR - RT    LT - LTR - RT
Shared Cap.: xxxx xxxx xxxxx  xxxx xxxx xxxxx  xxxx xxxx xxxxx  xxxx 1000 xxxxx
SharedQueue:xxxxx xxxx xxxxx xxxxx xxxx xxxxx xxxxx xxxx xxxxx xxxxx  0.2 xxxxx
Shrd ConDel:xxxxx xxxx xxxxx xxxxx xxxx xxxxx xxxxx xxxx xxxxx xxxxx  8.8 xxxxx
Shared LOS:      *    *     *     *    *     *     *    *     *     *    A     *
ApproachDel:    xxxxxx           xxxxxx           xxxxxx              8.8
ApproachLOS:         *                *                *                A
Note: Queue reported is the number of cars per lane.
```

Level Of Service Computation Report
2000 HCM Unsignalized (Future Volume Alternative)
Cumulative Plus Project AM Construction

Intersection #2: I-40 EB/Park Moabi



```
                     Signal=Uncontrol/Rights=Include
            Initial Vol:   0         6          5
                 Lanes:    0    0    0     1    0

                Signal=Stop                                  Signal=Stop
Initial Vol: Lanes: Rights=Include   Vol Cnt Date:     n/a    Rights=Include  Lanes: Initial Vol:
  22          0                      Cycle Time (sec): 100                      0       0
              0                      Loss Time (sec):  0                        0
   8          1!                     Critical V/C:     0.000                    0       0
              0                      Avg Crit Del (sec/veh): 7.5                0
   6          0                      Avg Delay (sec/veh):    7.5                0       0
                                     LOS:              A

                 Lanes:    0    0    0     1    0
            Initial Vol:   0         2          0
                     Signal=Uncontrol/Rights=Include
```

```
Street Name:          Park Moabi Road                    I-40 EB Ramp
Approach:        North Bound       South Bound       East Bound        West Bound
Movement:      L  -  T  -  R    L  -  T  -  R    L  -  T  -  R    L  -  T  -  R
------------|---------------||---------------||---------------||---------------|
Volume Module:
Base Vol:        0    1     0     3    1     0     3    5     0     0    0     0
Growth Adj:   1.55 1.55  1.55  1.55 1.55  1.55  1.55 1.55  1.55  1.55 1.55  1.55
Initial Bse:     0    2     0     5    2     0     5    8     0     0    0     0
Added Vol:       0    0     0     0    0     0     0    0     0     0    0     0
Proj Trips:      0    0     0     0    4     0    17    0     6     0    0     0
Initial Fut:     0    2     0     5    6     0    22    8     6     0    0     0
User Adj:     1.00 1.00  1.00  1.00 1.00  1.00  1.00 1.00  1.00  1.00 1.00  1.00
PHF Adj:      0.54 0.54  0.54  0.54 0.54  0.54  0.54 0.54  0.54  0.54 0.54  0.54
PHF Volume:      0    3     0     9   10     0    40   14    11     0    0     0
Reduct Vol:      0    0     0     0    0     0     0    0     0     0    0     0
FinalVolume:     0    3     0     9   10     0    40   14    11     0    0     0
------------|---------------||---------------||---------------||---------------|
Critical Gap Module:
Critical Gp:xxxxx xxxx xxxxx   4.1 xxxx xxxxx   6.4  6.5   6.2 xxxxx xxxx xxxxx
FollowUpTim:xxxxx xxxx xxxxx   2.2 xxxx xxxxx   3.5  4.0   3.3 xxxxx xxxx xxxxx
------------|---------------||---------------||---------------||---------------|
Capacity Module:
Cnflict Vol: xxxx xxxx xxxxx     3 xxxx xxxxx    30   30    10  xxxx xxxx xxxxx
Potent Cap.: xxxx xxxx xxxxx  1632 xxxx xxxxx   989  866  1077  xxxx xxxx xxxxx
Move Cap.:   xxxx xxxx xxxxx  1632 xxxx xxxxx   985  862  1077  xxxx xxxx xxxxx
Volume/Cap:  xxxx xxxx  xxxx  0.01 xxxx  xxxx  0.04 0.02  0.01  xxxx xxxx  xxxx
------------|---------------||---------------||---------------||---------------|
Level Of Service Module:
2Way95thQ:   xxxx xxxx xxxxx   0.0 xxxx xxxxx  xxxx xxxx xxxxx  xxxx xxxx xxxxx
Control Del:xxxxx xxxx xxxxx   7.2 xxxx xxxxx xxxxx xxxx xxxxx xxxxx xxxx xxxxx
LOS by Move:    *    *     *     A    *     *     *    *     *     *    *     *
Movement:     LT - LTR - RT    LT - LTR - RT    LT - LTR - RT    LT - LTR - RT
Shared Cap.: xxxx xxxx xxxxx  xxxx xxxx xxxxx  xxxx  969 xxxxx  xxxx xxxx xxxxx
SharedQueue:xxxxx xxxx xxxxx   0.0 xxxx xxxxx xxxxx  0.2 xxxxx xxxxx xxxx xxxxx
Shrd ConDel:xxxxx xxxx xxxxx   7.2 xxxx xxxxx xxxxx  9.0 xxxxx xxxxx xxxx xxxxx
Shared LOS:     *    *     *     A    *     *     *    A     *     *    *     *
ApproachDel:    xxxxxx            xxxxxx               9.0            xxxxxx
ApproachLOS:         *                 *                 A                 *
Note: Queue reported is the number of cars per lane.
                    Peak Hour Delay Signal Warrant Report
*******************************************************************************
Intersection #2 I-40 EB/Park Moabi
*******************************************************************************
Future Volume Alternative: Peak Hour Warrant NOT Met
```

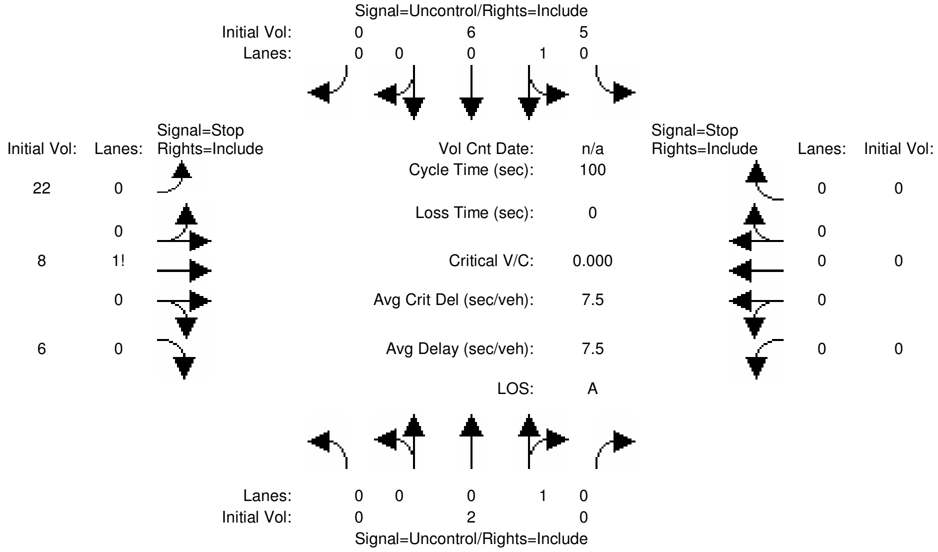
```
------------|---------------||---------------||---------------||---------------|
Approach:      North Bound      South Bound       East Bound       West Bound
Movement:     L  -  T  -  R    L  -  T  -  R    L  -  T  -  R    L  -  T  -  R
------------|---------------||---------------||---------------||---------------|
Control:       Uncontrolled     Uncontrolled      Stop Sign        Stop Sign
Lanes:        0  0  1  0  0    0  1  0  0  0    0  0  1! 0  0    0  0  0  0  0
Initial Vol:    0    2     0     5    6     0    22    8     6     0    0     0
ApproachDel:    xxxxxx           xxxxxx              9.0           xxxxxx
------------|---------------||---------------||---------------||---------------|
Approach[eastbound][lanes=1][control=Stop Sign]
Signal Warrant Rule #1: [vehicle-hours=0.1]
   FAIL - Vehicle-hours less than 4 for one lane approach.
Signal Warrant Rule #2: [approach volume=35]
   FAIL - Approach volume less than 100 for one lane approach.
Signal Warrant Rule #3: [approach count=3][total volume=47]
   FAIL - Total volume less than 650 for intersection
          with less than four approaches.
--------------------------------------------------------------------------------
SIGNAL WARRANT DISCLAIMER
This peak hour signal warrant analysis should be considered solely as an
"indicator" of the likelihood of an unsignalized intersection warranting
a traffic signal in the future.  Intersections that exceed this warrant
are probably more likely to meet one or more of the other volume based
signal warrant (such as the 4-hour or 8-hour warrants).

The peak hour warrant analysis in this report is not intended to replace
a rigorous and complete traffic signal warrant analysis by the responsible
jurisdiction.  Consideration of the other signal warrants, which is beyond
the scope of this software, may yield different results.
                Peak Hour Volume Signal Warrant Report [Urban]
********************************************************************************
Intersection #2 I-40 EB/Park Moabi
********************************************************************************
Future Volume Alternative: Peak Hour Warrant NOT Met
------------|---------------||---------------||---------------||---------------|
Approach:      North Bound      South Bound       East Bound       West Bound
Movement:     L  -  T  -  R    L  -  T  -  R    L  -  T  -  R    L  -  T  -  R
------------|---------------||---------------||---------------||---------------|
Control:       Uncontrolled     Uncontrolled      Stop Sign        Stop Sign
Lanes:        0  0  1  0  0    0  1  0  0  0    0  0  1! 0  0    0  0  0  0  0
Initial Vol:    0    2     0     5    6     0    22    8     6     0    0     0
------------|---------------||---------------||---------------||---------------|
Major Street Volume:             12
Minor Approach Volume:           35
Minor Approach Volume Threshold: 1405
--------------------------------------------------------------------------------
SIGNAL WARRANT DISCLAIMER
This peak hour signal warrant analysis should be considered solely as an
"indicator" of the likelihood of an unsignalized intersection warranting
a traffic signal in the future.  Intersections that exceed this warrant
are probably more likely to meet one or more of the other volume based
signal warrant (such as the 4-hour or 8-hour warrants).

The peak hour warrant analysis in this report is not intended to replace
a rigorous and complete traffic signal warrant analysis by the responsible
jurisdiction.  Consideration of the other signal warrants, which is beyond
the scope of this software, may yield different results.
```

Level Of Service Computation Report
2000 HCM Unsignalized (Future Volume Alternative)
Cumulative Plus Project AM O+M+C

Intersection #2: I-40 EB/Park Moabi

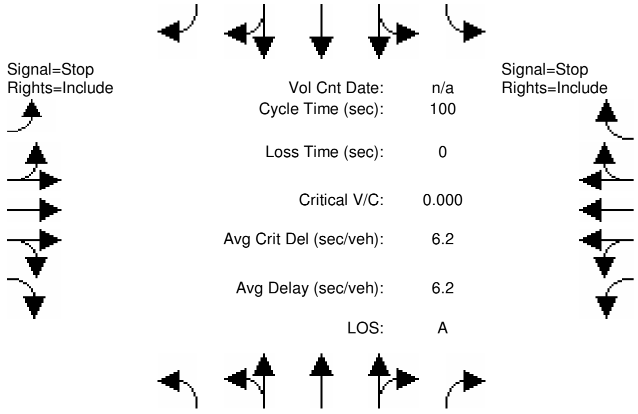


```
Street Name:         Park Moabi Road                     I-40 EB Ramp
Approach:      North Bound      South Bound       East Bound       West Bound
Movement:     L  -  T  -  R    L  -  T  -  R    L  -  T  -  R    L  -  T  -  R
------------|---------------||---------------||---------------||---------------|
Volume Module:
Base Vol:       0    1     0     3    1     0     3    5     0     0    0     0
Growth Adj:  1.55 1.55  1.55  1.55 1.55  1.55  1.55 1.55  1.55  1.55 1.55  1.55
Initial Bse:    0    2     0     5    2     0     5    8     0     0    0     0
Added Vol:      0    0     0     0    0     0     0    0     0     0    0     0
Project Tri:    0    0     0     0    4     0    17    0     6     0    0     0
Initial Fut:    0    2     0     5    6     0    22    8     6     0    0     0
User Adj:    1.00 1.00  1.00  1.00 1.00  1.00  1.00 1.00  1.00  1.00 1.00  1.00
PHF Adj:     0.54 0.54  0.54  0.54 0.54  0.54  0.54 0.54  0.54  0.54 0.54  0.54
PHF Volume:     0    3     0     9   10     0    40   14    11     0    0     0
Reduct Vol:     0    0     0     0    0     0     0    0     0     0    0     0
FinalVolume:    0    3     0     9   10     0    40   14    11     0    0     0
------------|---------------||---------------||---------------||---------------|
Critical Gap Module:
Critical Gp:xxxxx xxxx xxxxx   4.1 xxxx xxxxx   6.4  6.5   6.2 xxxxx xxxx xxxxx
FollowUpTim:xxxxx xxxx xxxxx   2.2 xxxx xxxxx   3.5  4.0   3.3 xxxxx xxxx xxxxx
------------|---------------||---------------||---------------||---------------|
Capacity Module:
Cnflict Vol: xxxx xxxx xxxxx     3 xxxx xxxxx    30   30    10  xxxx xxxx xxxxx
Potent Cap.: xxxx xxxx xxxxx  1632 xxxx xxxxx   989  866  1077  xxxx xxxx xxxxx
Move Cap.:   xxxx xxxx xxxxx  1632 xxxx xxxxx   985  862  1077  xxxx xxxx xxxxx
Volume/Cap:  xxxx xxxx  xxxx  0.01 xxxx  xxxx  0.04 0.02  0.01  xxxx xxxx  xxxx
------------|---------------||---------------||---------------||---------------|
Level Of Service Module:
2Way95thQ:   xxxx xxxx xxxxx   0.0 xxxx xxxxx  xxxx xxxx xxxxx  xxxx xxxx xxxxx
Control Del:xxxxx xxxx xxxxx   7.2 xxxx xxxxx xxxxx xxxx xxxxx xxxxx xxxx xxxxx
LOS by Move:    *    *     *     A    *     *     *    *     *     *    *     *
Movement:     LT - LTR - RT    LT - LTR - RT    LT - LTR - RT    LT - LTR - RT
Shared Cap.: xxxx xxxx xxxxx  xxxx xxxx xxxxx  xxxx  969 xxxxx  xxxx xxxx xxxxx
SharedQueue:xxxxx xxxx xxxxx   0.0 xxxx xxxxx xxxxx  0.2 xxxxx xxxxx xxxx xxxxx
Shrd ConDel:xxxxx xxxx xxxxx   7.2 xxxx xxxxx xxxxx  9.0 xxxxx xxxxx xxxx xxxxx
Shared LOS:     *    *     *     A    *     *     *    A     *     *    *     *
ApproachDel:   xxxxxx           xxxxxx                9.0           xxxxxx
ApproachLOS:        *                *                  A                *
Note: Queue reported is the number of cars per lane.
```

Level Of Service Computation Report
2000 HCM Unsignalized (Future Volume Alternative)
Cumulative Plus Project AM O+M+D

Intersection #2: I-40 EB/Park Moabi

Signal=Uncontrol/Rights=Include
Initial Vol: 0 19 5
Lanes: 0 0 0 1 0



Signal=Stop
Rights=Include

Initial Vol:	Lanes:
14	0
	0
8	1!
	0
26	0

Vol Cnt Date: n/a
Cycle Time (sec): 100
Loss Time (sec): 0
Critical V/C: 0.000
Avg Crit Del (sec/veh): 6.2
Avg Delay (sec/veh): 6.2
LOS: A

Signal=Stop
Rights=Include

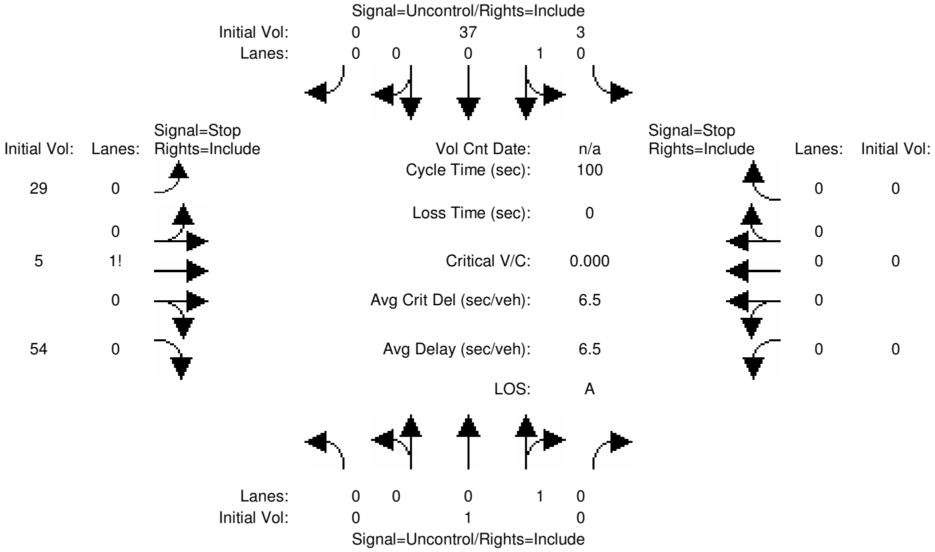
Lanes:	Initial Vol:
0	0
0	
0	0
0	
0	0

Lanes: 0 0 0 1 0
Initial Vol: 0 2 0
Signal=Uncontrol/Rights=Include

```
Street Name:          Park Moabi Road                     I-40 EB Ramp
Approach:       North Bound      South Bound       East Bound       West Bound
Movement:     L  -  T  -  R    L  -  T  -  R    L  -  T  -  R    L  -  T  -  R
------------|---------------||---------------||---------------||---------------|
Volume Module:
Base Vol:       0    1     0     3    1     0     3    5     0     0    0     0
Growth Adj:  1.55 1.55  1.55  1.55 1.55  1.55  1.55 1.55  1.55  1.55 1.55  1.55
Initial Bse:    0    2     0     5    2     0     5    8     0     0    0     0
Added Vol:      0    0     0     0    0     0     0    0     0     0    0     0
Project Tri:    0    0     0     0   17     0     9    0    26     0    0     0
Initial Fut:    0    2     0     5   19     0    14    8    26     0    0     0
User Adj:    1.00 1.00  1.00  1.00 1.00  1.00  1.00 1.00  1.00  1.00 1.00  1.00
PHF Adj:     1.00 1.00  1.00  1.00 1.00  1.00  1.00 1.00  1.00  1.00 1.00  1.00
PHF Volume:     0    2     0     5   19     0    14    8    26     0    0     0
Reduct Vol:     0    0     0     0    0     0     0    0     0     0    0     0
FinalVolume:    0    2     0     5   19     0    14    8    26     0    0     0
------------|---------------||---------------||---------------||---------------|
Critical Gap Module:
Critical Gp:xxxxx xxxx xxxxx   4.1 xxxx xxxxx   6.4  6.5   6.2 xxxxx xxxx xxxxx
FollowUpTim:xxxxx xxxx xxxxx   2.2 xxxx xxxxx   3.5  4.0   3.3 xxxxx xxxx xxxxx
------------|---------------||---------------||---------------||---------------|
Capacity Module:
Cnflict Vol: xxxx xxxx xxxxx     2 xxxx xxxxx    29   29    19  xxxx xxxx xxxxx
Potent Cap.: xxxx xxxx xxxxx  1634 xxxx xxxxx   990  867  1066  xxxx xxxx xxxxx
Move Cap.:   xxxx xxxx xxxxx  1634 xxxx xxxxx   988  865  1066  xxxx xxxx xxxxx
Volume/Cap:  xxxx xxxx  xxxx  0.00 xxxx  xxxx  0.01 0.01  0.02  xxxx xxxx  xxxx
------------|---------------||---------------||---------------||---------------|
Level Of Service Module:
2Way95thQ:   xxxx xxxx xxxxx   0.0 xxxx xxxxx  xxxx xxxx xxxxx  xxxx xxxx xxxxx
Control Del:xxxxx xxxx xxxxx   7.2 xxxx xxxxx xxxxx xxxx xxxxx xxxxx xxxx xxxxx
LOS by Move:    *    *     *     A    *     *     *    *     *     *    *     *
Movement:     LT - LTR - RT    LT - LTR - RT    LT - LTR - RT    LT - LTR - RT
Shared Cap.: xxxx xxxx xxxxx  xxxx xxxx xxxxx  xxxx 1005 xxxxx  xxxx xxxx xxxxx
SharedQueue:xxxxx xxxx xxxxx   0.0 xxxx xxxxx xxxxx  0.1 xxxxx xxxxx xxxx xxxxx
Shrd ConDel:xxxxx xxxx xxxxx   7.2 xxxx xxxxx xxxxx  8.8 xxxxx xxxxx xxxx xxxxx
Shared LOS:     *    *     *     A    *     *     *    A     *     *    *     *
ApproachDel:    xxxxxx           xxxxxx              8.8           xxxxxx
ApproachLOS:       *                *                 A                *
Note: Queue reported is the number of cars per lane.
```

Level Of Service Computation Report
2000 HCM Unsignalized (Future Volume Alternative)
Cumulative Plus Project AM Decommissioning

Intersection #2: I-40 EB/Park Moabi



```
                              Signal=Uncontrol/Rights=Include
                 Initial Vol:    0          37           3
                       Lanes:    0    0      0       1   0

                 Signal=Stop                                           Signal=Stop
Initial Vol:  Lanes:  Rights=Include       Vol Cnt Date:     n/a      Rights=Include    Lanes:  Initial Vol:
                                       Cycle Time (sec):     100
    29           0                                                                        0         0

                 0                         Loss Time (sec):    0                          0

     5          1!                            Critical V/C:  0.000                        0         0

                 0                    Avg Crit Del (sec/veh):  6.5                        0

    54           0                       Avg Delay (sec/veh):  6.5                        0         0

                                                      LOS:     A

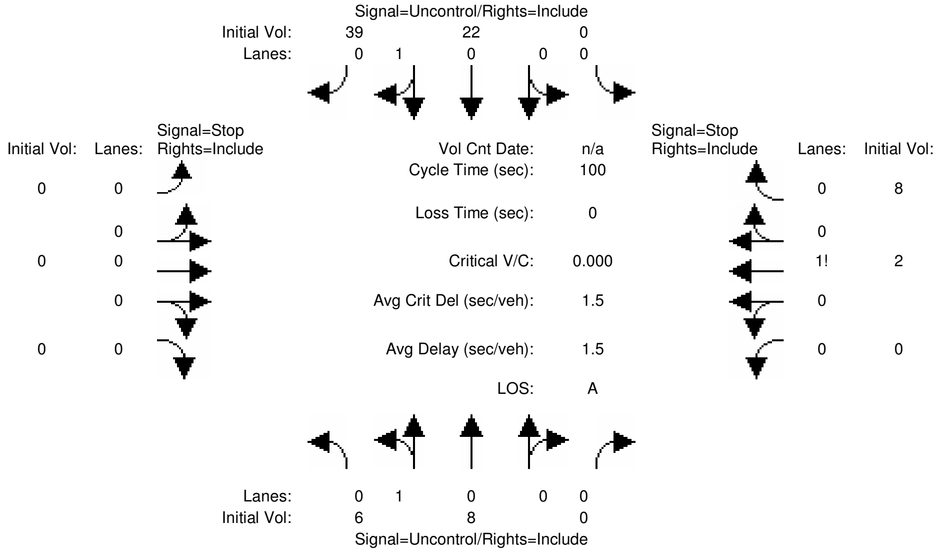
                       Lanes:    0    0      0       1   0
                 Initial Vol:    0           1           0
                              Signal=Uncontrol/Rights=Include
```

```
Street Name:         Park Moabi Road                      I-40 EB Ramp
Approach:      North Bound      South Bound       East Bound       West Bound
Movement:     L  -  T  -  R    L  -  T  -  R    L  -  T  -  R    L  -  T  -  R
------------|---------------||---------------||---------------||---------------|
Volume Module:
Base Vol:       0    1     0     3    1     0     3    5     0     0    0     0
Growth Adj:  1.00 1.00  1.00  1.00 1.00  1.00  1.00 1.00  1.00  1.00 1.00  1.00
Initial Bse:    0    1     0     3    1     0     3    5     0     0    0     0
Added Vol:      0    0     0     0    0     0     0    0     0     0    0     0
Project Tri:    0    0     0     0   36     0    26    0    54     0    0     0
Initial Fut:    0    1     0     3   37     0    29    5    54     0    0     0
User Adj:    1.55 1.55  1.55  1.55 1.55  1.55  1.55 1.55  1.55  1.55 1.55  1.55
PHF Adj:     1.00 1.00  1.00  1.00 1.00  1.00  1.00 1.00  1.00  1.00 1.00  1.00
PHF Volume:     0    2     0     5   57     0    45    8    84     0    0     0
Reduct Vol:     0    0     0     0    0     0     0    0     0     0    0     0
FinalVolume:    0    2     0     5   57     0    45    8    84     0    0     0
------------|---------------||---------------||---------------||---------------|
Critical Gap Module:
Critical Gp:xxxxx xxxx xxxxx   4.1 xxxx xxxxx   6.4  6.5   6.2 xxxxx xxxx xxxxx
FollowUpTim:xxxxx xxxx xxxxx   2.2 xxxx xxxxx   3.5  4.0   3.3 xxxxx xxxx xxxxx
------------|---------------||---------------||---------------||---------------|
Capacity Module:
Cnflict Vol: xxxx xxxx xxxxx     2 xxxx xxxxx    68   68    57  xxxx xxxx xxxxx
Potent Cap.: xxxx xxxx xxxxx  1634 xxxx xxxxx   942  826  1015  xxxx xxxx xxxxx
Move Cap.:   xxxx xxxx xxxxx  1634 xxxx xxxxx   940  824  1015  xxxx xxxx xxxxx
Volume/Cap:  xxxx xxxx  xxxx  0.00 xxxx  xxxx  0.05 0.01  0.08  xxxx xxxx  xxxx
------------|---------------||---------------||---------------||---------------|
Level Of Service Module:
2Way95thQ:   xxxx xxxx xxxxx   0.0 xxxx xxxxx  xxxx xxxx xxxxx  xxxx xxxx xxxxx
Control Del:xxxxx xxxx xxxxx   7.2 xxxx xxxxx xxxxx xxxx xxxxx xxxxx xxxx xxxxx
LOS by Move:    *    *     *     A    *     *     *    *     *     *    *     *
Movement:     LT - LTR - RT    LT - LTR - RT    LT - LTR - RT    LT - LTR - RT
Shared Cap.: xxxx xxxx xxxxx  xxxx xxxx xxxxx  xxxx  976 xxxxx  xxxx xxxx xxxxx
SharedQueue:xxxxx xxxx xxxxx   0.0 xxxx xxxxx xxxxx  0.5 xxxxx xxxxx xxxx xxxxx
Shrd ConDel:xxxxx xxxx xxxxx   7.2 xxxx xxxxx xxxxx  9.3 xxxxx xxxxx xxxx xxxxx
Shared LOS:     *    *     *     A    *     *     *    A     *     *    *     *
ApproachDel:    xxxxxx           xxxxxx                9.3             xxxxxx
ApproachLOS:         *                *                A                *
Note: Queue reported is the number of cars per lane.
```

IE08-0015 Topock Remediation

Level Of Service Computation Report
2000 HCM Unsignalized (Future Volume Alternative)
Cumulative Plus Project PM Construction

Intersection #1: I-40 WB/Park Moabi



```
Street Name:         Park Moabi Road                    I-40 WB Ramp
Approach:      North Bound      South Bound       East Bound       West Bound
Movement:     L  -  T  -  R    L  -  T  -  R    L  -  T  -  R    L  -  T  -  R
------------|---------------||---------------||---------------||---------------|
Volume Module:
Base Vol:       0    5     0     0    7    14     0    0     0     0    1     5
Growth Adj:  1.55 1.55  1.55  1.55 1.55  1.55  1.55 1.55  1.55  1.55 1.55  1.55
Initial Bse:    0    8     0     0   11    22     0    0     0     0    2     8
Added Vol:      0    0     0     0    0     0     0    0     0     0    0     0
PasserByVol:    6    0     0     0   11    17     0    0     0     0    0     0
Initial Fut:    6    8     0     0   22    39     0    0     0     0    2     8
User Adj:    1.00 1.00  1.00  1.00 1.00  1.00  1.00 1.00  1.00  1.00 1.00  1.00
PHF Adj:     0.80 0.80  0.80  0.80 0.80  0.80  0.80 0.80  0.80  0.80 0.80  0.80
PHF Volume:     8   10     0     0   27    48     0    0     0     0    2    10
Reduct Vol:     0    0     0     0    0     0     0    0     0     0    0     0
FinalVolume:    8   10     0     0   27    48     0    0     0     0    2    10
------------|---------------||---------------||---------------||---------------|
Critical Gap Module:
Critical Gp:  4.1 xxxx xxxxx xxxxx xxxx xxxxx xxxxx xxxx xxxxx xxxxx  6.5   6.2
FollowUpTim:  2.2 xxxx xxxxx xxxxx xxxx xxxxx xxxxx xxxx xxxxx xxxxx  4.0   3.3
------------|---------------||---------------||---------------||---------------|
Capacity Module:
Cnflict Vol:   76 xxxx xxxxx  xxxx xxxx xxxxx  xxxx xxxx xxxxx  xxxx  100    10
Potent Cap.: 1536 xxxx xxxxx  xxxx xxxx xxxxx  xxxx xxxx xxxxx  xxxx  793  1078
Move Cap.:   1536 xxxx xxxxx  xxxx xxxx xxxxx  xxxx xxxx xxxxx  xxxx  790  1078
Volume/Cap:  0.00 xxxx  xxxx  xxxx xxxx  xxxx  xxxx xxxx  xxxx  xxxx 0.00  0.01
------------|---------------||---------------||---------------||---------------|
Level Of Service Module:
2Way95thQ:    0.0 xxxx xxxxx  xxxx xxxx xxxxx  xxxx xxxx xxxxx  xxxx xxxx xxxxx
Control Del:  7.4 xxxx xxxxx xxxxx xxxx xxxxx xxxxx xxxx xxxxx xxxxx xxxx xxxxx
LOS by Move:    A    *     *     *    *     *     *    *     *     *    *     *
Movement:     LT - LTR - RT    LT - LTR - RT    LT - LTR - RT    LT - LTR - RT
Shared Cap.: xxxx xxxx xxxxx  xxxx xxxx xxxxx  xxxx xxxx xxxxx  xxxx xxxx  1016
SharedQueue:  0.0 xxxx xxxxx xxxxx xxxx xxxxx xxxxx xxxx xxxxx xxxxx xxxx   0.0
Shrd ConDel:  7.4 xxxx xxxxx xxxxx xxxx xxxxx xxxxx xxxx xxxxx xxxxx xxxx   8.6
Shared LOS:     A    *     *     *    *     *     *    *     *     *    *     A
ApproachDel:     xxxxxx           xxxxxx           xxxxxx             8.6
ApproachLOS:        *                *                *                A
Note: Queue reported is the number of cars per lane.
                    Peak Hour Delay Signal Warrant Report
********************************************************************************
Intersection #1 I-40 WB/Park Moabi
********************************************************************************
Future Volume Alternative: Peak Hour Warrant NOT Met
```

```
------------|---------------||---------------||---------------||---------------|
Approach:      North Bound      South Bound       East Bound       West Bound
Movement:     L  -  T  -  R    L  -  T  -  R    L  -  T  -  R    L  -  T  -  R
------------|---------------||---------------||---------------||---------------|
Control:       Uncontrolled     Uncontrolled      Stop Sign        Stop Sign
Lanes:        0  1  0  0  0    0  0  0  1  0    0  0  0  0  0    0  0  0  1  0
Initial Vol:    6    8     0     0   22    39     0    0     0     0    2     8
ApproachDel:    xxxxxx           xxxxxx           xxxxxx              8.6
------------|---------------||---------------||---------------||---------------|
Approach[westbound][lanes=1][control=Stop Sign]
Signal Warrant Rule #1: [vehicle-hours=0.0]
   FAIL - Vehicle-hours less than 4 for one lane approach.
Signal Warrant Rule #2: [approach volume=9]
   FAIL - Approach volume less than 100 for one lane approach.
Signal Warrant Rule #3: [approach count=3][total volume=84]
   FAIL - Total volume less than 650 for intersection
          with less than four approaches.
--------------------------------------------------------------------------------
SIGNAL WARRANT DISCLAIMER
This peak hour signal warrant analysis should be considered solely as an
"indicator" of the likelihood of an unsignalized intersection warranting
a traffic signal in the future.  Intersections that exceed this warrant
are probably more likely to meet one or more of the other volume based
signal warrant (such as the 4-hour or 8-hour warrants).

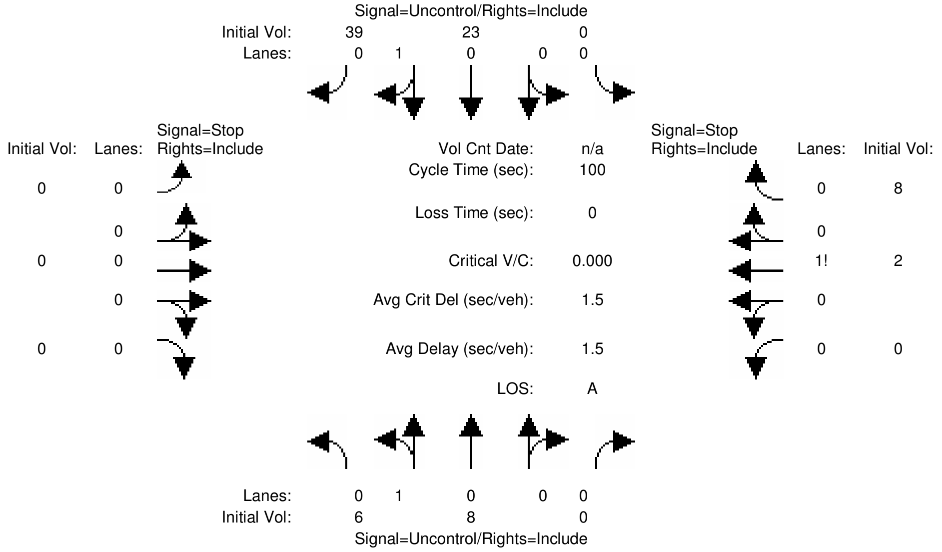
The peak hour warrant analysis in this report is not intended to replace
a rigorous and complete traffic signal warrant analysis by the responsible
jurisdiction.  Consideration of the other signal warrants, which is beyond
the scope of this software, may yield different results.
                Peak Hour Volume Signal Warrant Report [Urban]
********************************************************************************
Intersection #1 I-40 WB/Park Moabi
********************************************************************************
Future Volume Alternative: Peak Hour Warrant NOT Met
------------|---------------||---------------||---------------||---------------|
Approach:      North Bound      South Bound       East Bound       West Bound
Movement:     L  -  T  -  R    L  -  T  -  R    L  -  T  -  R    L  -  T  -  R
------------|---------------||---------------||---------------||---------------|
Control:       Uncontrolled     Uncontrolled      Stop Sign        Stop Sign
Lanes:        0  1  0  0  0    0  0  0  1  0    0  0  0  0  0    0  0  0  1  0
Initial Vol:    6    8     0     0   22    39     0    0     0     0    2     8
------------|---------------||---------------||---------------||---------------|
Major Street Volume:             74
Minor Approach Volume:           9
Minor Approach Volume Threshold: 913
--------------------------------------------------------------------------------
SIGNAL WARRANT DISCLAIMER
This peak hour signal warrant analysis should be considered solely as an
"indicator" of the likelihood of an unsignalized intersection warranting
a traffic signal in the future.  Intersections that exceed this warrant
are probably more likely to meet one or more of the other volume based
signal warrant (such as the 4-hour or 8-hour warrants).

The peak hour warrant analysis in this report is not intended to replace
a rigorous and complete traffic signal warrant analysis by the responsible
jurisdiction.  Consideration of the other signal warrants, which is beyond
the scope of this software, may yield different results.
```

IE08-0015 Topock Remediation

Level Of Service Computation Report
2000 HCM Unsignalized (Future Volume Alternative)
Cumulative Plus Project PM O+M+C

Intersection #1: I-40 WB/Park Moabi



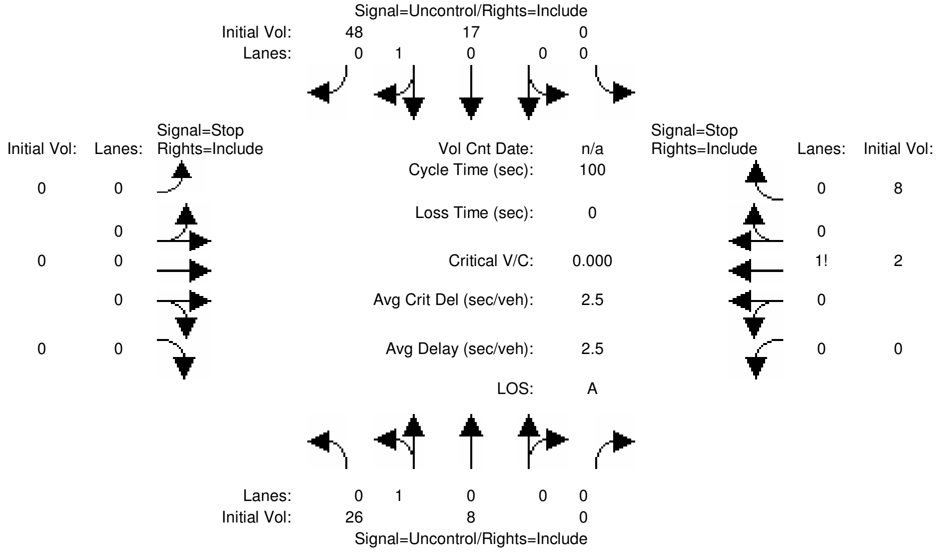
Vol Cnt Date: n/a
Cycle Time (sec): 100
Loss Time (sec): 0
Critical V/C: 0.000
Avg Crit Del (sec/veh): 1.5
Avg Delay (sec/veh): 1.5
LOS: A

```
Street Name:         Park Moabi Road                    I-40 WB Ramp
Approach:      North Bound      South Bound       East Bound        West Bound
Movement:     L  -  T  -  R    L  -  T  -  R    L  -  T  -  R    L  -  T  -  R
------------|---------------||---------------||---------------||---------------|
Volume Module:
Base Vol:       0    5     0     0    7    14     0    0     0     0    1     5
Growth Adj:  1.55 1.55  1.55  1.55 1.55  1.55  1.55 1.55  1.55  1.55 1.55  1.55
Initial Bse:    0    8     0     0   11    22     0    0     0     0    2     8
Added Vol:      0    0     0     0    0     0     0    0     0     0    0     0
Project Tri:    6    0     0     0   12    17     0    0     0     0    0     0
Initial Fut:    6    8     0     0   23    39     0    0     0     0    2     8
User Adj:    1.00 1.00  1.00  1.00 1.00  1.00  1.00 1.00  1.00  1.00 1.00  1.00
PHF Adj:     0.58 0.58  0.58  0.58 0.58  0.58  0.58 0.58  0.58  0.58 0.58  0.58
PHF Volume:    10   13     0     0   39    67     0    0     0     0    3    13
Reduct Vol:     0    0     0     0    0     0     0    0     0     0    0     0
FinalVolume:   10   13     0     0   39    67     0    0     0     0    3    13
------------|---------------||---------------||---------------||---------------|
Critical Gap Module:
Critical Gp:  4.1 xxxx xxxxx xxxxx xxxx xxxxx xxxxx xxxx xxxxx xxxxx  6.5   6.2
FollowUpTim:  2.2 xxxx xxxxx xxxxx xxxx xxxxx xxxxx xxxx xxxxx xxxxx  4.0   3.3
------------|---------------||---------------||---------------||---------------|
Capacity Module:
Cnflict Vol:  106 xxxx xxxxx  xxxx xxxx xxxxx  xxxx xxxx xxxxx  xxxx  140    13
Potent Cap.: 1498 xxxx xxxxx  xxxx xxxx xxxxx  xxxx xxxx xxxxx  xxxx  755  1073
Move Cap.:   1498 xxxx xxxxx  xxxx xxxx xxxxx  xxxx xxxx xxxxx  xxxx  749  1073
Volume/Cap:  0.01 xxxx  xxxx  xxxx xxxx  xxxx  xxxx xxxx  xxxx  xxxx 0.00  0.01
------------|---------------||---------------||---------------||---------------|
Level Of Service Module:
2Way95thQ:    0.0 xxxx xxxxx  xxxx xxxx xxxxx  xxxx xxxx xxxxx  xxxx xxxx xxxxx
Control Del:  7.4 xxxx xxxxx xxxxx xxxx xxxxx xxxxx xxxx xxxxx xxxxx xxxx xxxxx
LOS by Move:    A    *     *     *    *     *     *    *     *     *    *     *
Movement:     LT - LTR - RT    LT - LTR - RT    LT - LTR - RT    LT - LTR - RT
Shared Cap.: xxxx xxxx xxxxx  xxxx xxxx xxxxx  xxxx xxxx xxxxx  xxxx xxxx  1001
SharedQueue:  0.0 xxxx xxxxx xxxxx xxxx xxxxx xxxxx xxxx xxxxx xxxxx xxxx   0.0
Shrd ConDel:  7.4 xxxx xxxxx xxxxx xxxx xxxxx xxxxx xxxx xxxxx xxxxx xxxx   8.7
Shared LOS:     A    *     *     *    *     *     *    *     *     *    *     A
ApproachDel:    xxxxxx           xxxxxx           xxxxxx             8.7
ApproachLOS:         *                *                *               A
Note: Queue reported is the number of cars per lane.
```

IE08-0015 Topock Remediation

Level Of Service Computation Report
2000 HCM Unsignalized (Future Volume Alternative)
Cumulative Plus Project PM O+M+D

Intersection #1: I-40 WB/Park Moabi

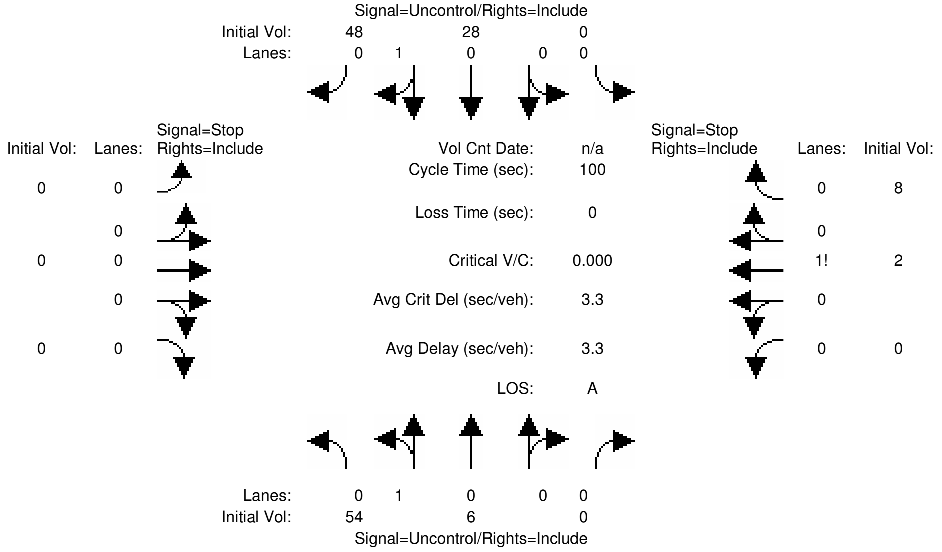


```
Street Name:          Park Moabi Road                  I-40 WB Ramp
Approach:      North Bound      South Bound      East Bound       West Bound
Movement:    L  -  T  -  R    L  -  T  -  R    L  -  T  -  R    L  -  T  -  R
------------|---------------||---------------||---------------||---------------|
Volume Module:
Base Vol:        0    5     0     0    7    14     0    0     0     0    1     5
Growth Adj:  1.55 1.55  1.55  1.55 1.55  1.55  1.55 1.55  1.55  1.55 1.55  1.55
Initial Bse:     0    8     0     0   11    22     0    0     0     0    2     8
Added Vol:       0    0     0     0    0     0     0    0     0     0    0     0
Project Tri:    26    0     0     0    6    26     0    0     0     0    0     0
Initial Fut:    26    8     0     0   17    48     0    0     0     0    2     8
User Adj:    1.00 1.00  1.00  1.00 1.00  1.00  1.00 1.00  1.00  1.00 1.00  1.00
PHF Adj:     1.00 1.00  1.00  1.00 1.00  1.00  1.00 1.00  1.00  1.00 1.00  1.00
PHF Volume:     26    8     0     0   17    48     0    0     0     0    2     8
Reduct Vol:      0    0     0     0    0     0     0    0     0     0    0     0
FinalVolume:    26    8     0     0   17    48     0    0     0     0    2     8
------------|---------------||---------------||---------------||---------------|
Critical Gap Module:
Critical Gp:   4.1 xxxx xxxxx xxxxx xxxx xxxxx xxxxx xxxx xxxxx xxxxx  6.5   6.2
FollowUpTim:   2.2 xxxx xxxxx xxxxx xxxx xxxxx xxxxx xxxx xxxxx xxxxx  4.0   3.3
------------|---------------||---------------||---------------||---------------|
Capacity Module:
Cnflict Vol:    65 xxxx xxxxx  xxxx xxxx xxxxx  xxxx xxxx xxxxx  xxxx  124     8
Potent Cap.: 1551 xxxx xxxxx  xxxx xxxx xxxxx  xxxx xxxx xxxxx  xxxx  770  1080
Move Cap.:   1551 xxxx xxxxx  xxxx xxxx xxxxx  xxxx xxxx xxxxx  xxxx  757  1080
Volume/Cap:  0.02 xxxx  xxxx  xxxx xxxx  xxxx  xxxx xxxx  xxxx  xxxx 0.00  0.01
------------|---------------||---------------||---------------||---------------|
Level Of Service Module:
2Way95thQ:     0.1 xxxx xxxxx  xxxx xxxx xxxxx  xxxx xxxx xxxxx  xxxx xxxx xxxxx
Control Del:   7.4 xxxx xxxxx xxxxx xxxx xxxxx xxxxx xxxx xxxxx xxxxx xxxx xxxxx
LOS by Move:     A    *     *     *    *     *     *    *     *     *    *     *
Movement:     LT - LTR - RT    LT - LTR - RT    LT - LTR - RT    LT - LTR - RT
Shared Cap.: xxxx xxxx xxxxx  xxxx xxxx xxxxx  xxxx xxxx xxxxx  xxxx xxxx  1008
SharedQueue:   0.1 xxxx xxxxx xxxxx xxxx xxxxx xxxxx xxxx xxxxx xxxxx xxxx   0.0
Shrd ConDel:   7.4 xxxx xxxxx xxxxx xxxx xxxxx xxxxx xxxx xxxxx xxxxx xxxx   8.6
Shared LOS:      A    *     *     *    *     *     *    *     *     *    *     A
ApproachDel:     xxxxxx           xxxxxx           xxxxxx             8.6
ApproachLOS:          *                *                *               A
Note: Queue reported is the number of cars per lane.
```

IE08-0015 Topock Remediation

Level Of Service Computation Report
2000 HCM Unsignalized (Future Volume Alternative)
Cumulative Plus Project PM Decommissioning

Intersection #1: I-40 WB/Park Moabi

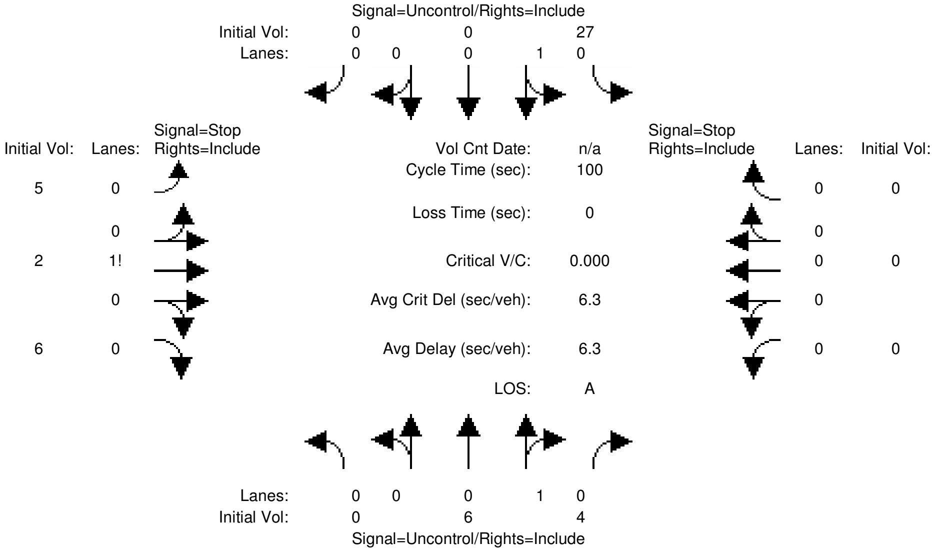


```
Street Name:          Park Moabi Road                    I-40 WB Ramp
Approach:      North Bound      South Bound      East Bound       West Bound
Movement:    L  -  T  -  R   L  -  T  -  R   L  -  T  -  R   L  -  T  -  R
------------|---------------||---------------||---------------||---------------|
Volume Module:
Base Vol:       0    4     0     0    7    14     0    0     0     0    1     5
Growth Adj:  1.55 1.55  1.55  1.55 1.55  1.55  1.55 1.55  1.55  1.55 1.55  1.55
Initial Bse:    0    6     0     0   11    22     0    0     0     0    2     8
Added Vol:      0    0     0     0    0     0     0    0     0     0    0     0
Project Tri:   54    0     0     0   17    26     0    0     0     0    0     0
Initial Fut:   54    6     0     0   28    48     0    0     0     0    2     8
User Adj:    1.00 1.00  1.00  1.00 1.00  1.00  1.00 1.00  1.00  1.00 1.00  1.00
PHF Adj:     1.00 1.00  1.00  1.00 1.00  1.00  1.00 1.00  1.00  1.00 1.00  1.00
PHF Volume:    54    6     0     0   28    48     0    0     0     0    2     8
Reduct Vol:     0    0     0     0    0     0     0    0     0     0    0     0
FinalVolume:   54    6     0     0   28    48     0    0     0     0    2     8
------------|---------------||---------------||---------------||---------------|
Critical Gap Module:
Critical Gp:  4.1 xxxx xxxxx xxxxx xxxx xxxxx xxxxx xxxx xxxxx xxxxx  6.5   6.2
FollowUpTim:  2.2 xxxx xxxxx xxxxx xxxx xxxxx xxxxx xxxx xxxxx xxxxx  4.0   3.3
------------|---------------||---------------||---------------||---------------|
Capacity Module:
Cnflict Vol:   76 xxxx xxxxx  xxxx xxxx xxxxx  xxxx xxxx xxxxx  xxxx  190     6
Potent Cap.: 1536 xxxx xxxxx  xxxx xxxx xxxxx  xxxx xxxx xxxxx  xxxx  709  1082
Move Cap.:   1536 xxxx xxxxx  xxxx xxxx xxxxx  xxxx xxxx xxxxx  xxxx  683  1082
Volume/Cap:  0.04 xxxx  xxxx  xxxx xxxx  xxxx  xxxx xxxx  xxxx  xxxx 0.00  0.01
------------|---------------||---------------||---------------||---------------|
Level Of Service Module:
2Way95thQ:    0.1 xxxx xxxxx  xxxx xxxx xxxxx  xxxx xxxx xxxxx  xxxx xxxx xxxxx
Control Del:  7.4 xxxx xxxxx xxxxx xxxx xxxxx xxxxx xxxx xxxxx xxxxx xxxx xxxxx
LOS by Move:    A    *     *     *    *     *     *    *     *     *    *     *
Movement:     LT - LTR - RT    LT - LTR - RT    LT - LTR - RT    LT - LTR - RT
Shared Cap.: xxxx xxxx xxxxx  xxxx xxxx xxxxx  xxxx xxxx xxxxx  xxxx xxxx   986
SharedQueue:  0.1 xxxx xxxxx xxxxx xxxx xxxxx xxxxx xxxx xxxxx xxxxx xxxx   0.0
Shrd ConDel:  7.4 xxxx xxxxx xxxxx xxxx xxxxx xxxxx xxxx xxxxx xxxxx xxxx   8.7
Shared LOS:     A    *     *     *    *     *     *    *     *     *    *     A
ApproachDel:    xxxxxx           xxxxxx           xxxxxx             8.7
ApproachLOS:         *                *                *               A
Note: Queue reported is the number of cars per lane.
```

IE08-0015 Topock Remediation

Level Of Service Computation Report
2000 HCM Unsignalized (Future Volume Alternative)
Cumulative Plus Project PM Construction

Intersection #2: I-40 EB/Park Moabi



Vol Cnt Date: n/a
Cycle Time (sec): 100
Loss Time (sec): 0
Critical V/C: 0.000
Avg Crit Del (sec/veh): 6.3
Avg Delay (sec/veh): 6.3
LOS: A

```
Street Name:         Park Moabi Road                     I-40 EB Ramp
Approach:      North Bound       South Bound       East Bound        West Bound
Movement:     L  -  T  -  R    L  -  T  -  R    L  -  T  -  R    L  -  T  -  R
------------|---------------||---------------||---------------||---------------|
Volume Module:
Base Vol:       0    0     0    10    0     0     3    1     4     0    0     0
Growth Adj:  1.55 1.55  1.55  1.55 1.55  1.55  1.55 1.55  1.55  1.55 1.55  1.55
Initial Bse:    0    0     0    16    0     0     5    2     6     0    0     0
Added Vol:      0    0     0     0    0     0     0    0     0     0    0     0
Project Tri:    0    6     4    11    0     0     0    0     0     0    0     0
Initial Fut:    0    6     4    27    0     0     5    2     6     0    0     0
User Adj:    1.00 1.00  1.00  1.00 1.00  1.00  1.00 1.00  1.00  1.00 1.00  1.00
PHF Adj:     0.70 0.70  0.70  0.70 0.70  0.70  0.70 0.70  0.70  0.70 0.70  0.70
PHF Volume:     0    9     6    38    0     0     7    2     9     0    0     0
Reduct Vol:     0    0     0     0    0     0     0    0     0     0    0     0
FinalVolume:    0    9     6    38    0     0     7    2     9     0    0     0
------------|---------------||---------------||---------------||---------------|
Critical Gap Module:
Critical Gp:xxxxx xxxx xxxxx   4.1 xxxx xxxxx   6.4  6.5   6.2 xxxxx xxxx xxxxx
FollowUpTim:xxxxx xxxx xxxxx   2.2 xxxx xxxxx   3.5  4.0   3.3 xxxxx xxxx xxxxx
------------|---------------||---------------||---------------||---------------|
Capacity Module:
Cnflict Vol: xxxx xxxx xxxxx    14 xxxx xxxxx    87   90     0  xxxx xxxx xxxxx
Potent Cap.: xxxx xxxx xxxxx  1617 xxxx xxxxx   919  804   900  xxxx xxxx xxxxx
Move Cap.:   xxxx xxxx xxxxx  1617 xxxx xxxxx   902  785   900  xxxx xxxx xxxxx
Volume/Cap:  xxxx xxxx  xxxx  0.02 xxxx  xxxx  0.01 0.00  0.01  xxxx xxxx  xxxx
------------|---------------||---------------||---------------||---------------|
Level Of Service Module:
2Way95thQ:   xxxx xxxx xxxxx   0.1 xxxx xxxxx  xxxx xxxx xxxxx  xxxx xxxx xxxxx
Control Del:xxxxx xxxx xxxxx   7.3 xxxx xxxxx xxxxx xxxx xxxxx xxxxx xxxx xxxxx
LOS by Move:    *    *     *     A    *     *     *    *     *     *    *     *
Movement:     LT - LTR - RT    LT - LTR - RT    LT - LTR - RT    LT - LTR - RT
Shared Cap.: xxxx xxxx xxxxx  xxxx xxxx xxxxx  xxxx  885 xxxxx  xxxx xxxx xxxxx
SharedQueue:xxxxx xxxx xxxxx xxxxx xxxx xxxxx xxxxx  0.1 xxxxx xxxxx xxxx xxxxx
Shrd ConDel:xxxxx xxxx xxxxx xxxxx xxxx xxxxx xxxxx  9.2 xxxxx xxxxx xxxx xxxxx
Shared LOS:     *    *     *     *    *     *     *    A     *     *    *     *
ApproachDel:    xxxxxx           xxxxxx              9.2           xxxxxx
ApproachLOS:         *                *                A                *
Note: Queue reported is the number of cars per lane.
                     Peak Hour Delay Signal Warrant Report
********************************************************************************
Intersection #2 I-40 EB/Park Moabi
********************************************************************************
Future Volume Alternative: Peak Hour Warrant NOT Met
```

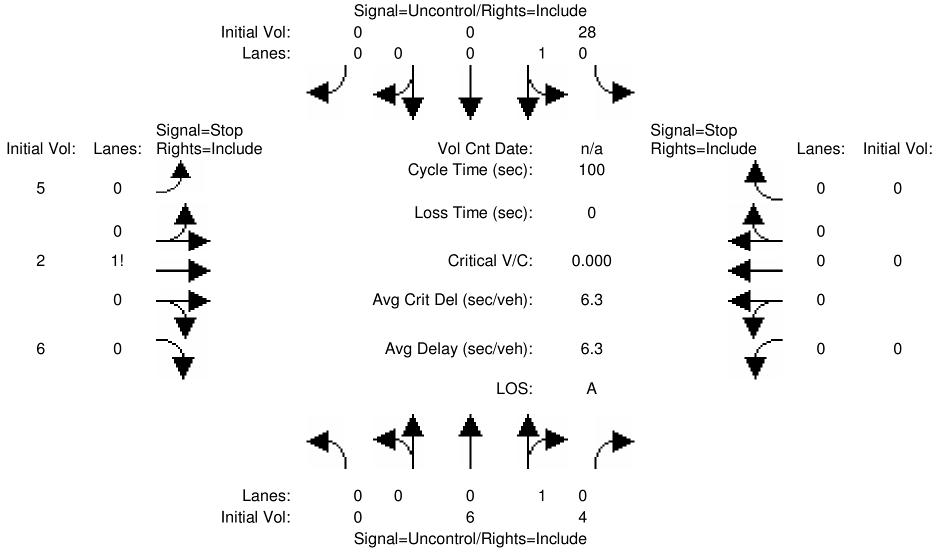
```
------------|---------------||---------------||---------------||---------------|
Approach:      North Bound      South Bound       East Bound       West Bound
Movement:     L  -  T  -  R    L  -  T  -  R    L  -  T  -  R    L  -  T  -  R
------------|---------------||---------------||---------------||---------------|
Control:       Uncontrolled     Uncontrolled      Stop Sign        Stop Sign
Lanes:        0  0  0  1  0    1  0  0  0  0    0  0  1! 0  0    0  0  0  0  0
Initial Vol:    0    6     4    27    0     0     5    2     6     0    0     0
ApproachDel:    xxxxxx           xxxxxx              9.2             xxxxxx
------------|---------------||---------------||---------------||---------------|
Approach[eastbound][lanes=1][control=Stop Sign]
Signal Warrant Rule #1: [vehicle-hours=0.0]
   FAIL - Vehicle-hours less than 4 for one lane approach.
Signal Warrant Rule #2: [approach volume=12]
   FAIL - Approach volume less than 100 for one lane approach.
Signal Warrant Rule #3: [approach count=3][total volume=49]
   FAIL - Total volume less than 650 for intersection
          with less than four approaches.
--------------------------------------------------------------------------------
SIGNAL WARRANT DISCLAIMER
This peak hour signal warrant analysis should be considered solely as an
"indicator" of the likelihood of an unsignalized intersection warranting
a traffic signal in the future.  Intersections that exceed this warrant
are probably more likely to meet one or more of the other volume based
signal warrant (such as the 4-hour or 8-hour warrants).

The peak hour warrant analysis in this report is not intended to replace
a rigorous and complete traffic signal warrant analysis by the responsible
jurisdiction.  Consideration of the other signal warrants, which is beyond
the scope of this software, may yield different results.
                Peak Hour Volume Signal Warrant Report [Urban]
********************************************************************************
Intersection #2 I-40 EB/Park Moabi
********************************************************************************
Future Volume Alternative: Peak Hour Warrant NOT Met
------------|---------------||---------------||---------------||---------------|
Approach:      North Bound      South Bound       East Bound       West Bound
Movement:     L  -  T  -  R    L  -  T  -  R    L  -  T  -  R    L  -  T  -  R
------------|---------------||---------------||---------------||---------------|
Control:       Uncontrolled     Uncontrolled      Stop Sign        Stop Sign
Lanes:        0  0  0  1  0    1  0  0  0  0    0  0  1! 0  0    0  0  0  0  0
Initial Vol:    0    6     4    27    0     0     5    2     6     0    0     0
------------|---------------||---------------||---------------||---------------|
Major Street Volume:             37
Minor Approach Volume:           12
Minor Approach Volume Threshold: 1102
--------------------------------------------------------------------------------
SIGNAL WARRANT DISCLAIMER
This peak hour signal warrant analysis should be considered solely as an
"indicator" of the likelihood of an unsignalized intersection warranting
a traffic signal in the future.  Intersections that exceed this warrant
are probably more likely to meet one or more of the other volume based
signal warrant (such as the 4-hour or 8-hour warrants).

The peak hour warrant analysis in this report is not intended to replace
a rigorous and complete traffic signal warrant analysis by the responsible
jurisdiction.  Consideration of the other signal warrants, which is beyond
the scope of this software, may yield different results.
```

Level Of Service Computation Report
2000 HCM Unsignalized (Future Volume Alternative)
Cumulative Plus Project PM O+M+C

Intersection #2: I-40 EB/Park Moabi



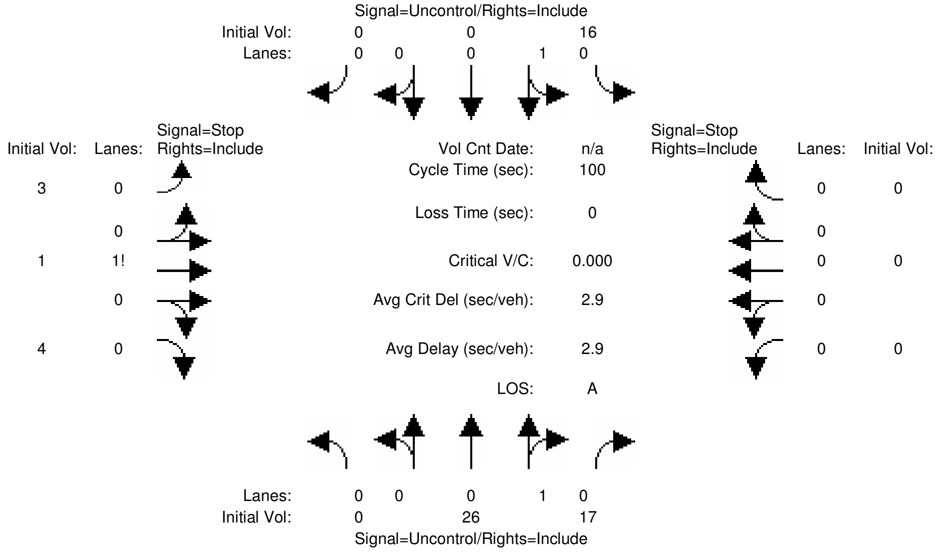
Vol Cnt Date: n/a
Cycle Time (sec): 100
Loss Time (sec): 0
Critical V/C: 0.000
Avg Crit Del (sec/veh): 6.3
Avg Delay (sec/veh): 6.3
LOS: A

```
Street Name:         Park Moabi Road                    I-40 EB Ramp
Approach:      North Bound      South Bound       East Bound       West Bound
Movement:    L  -  T  -  R    L  -  T  -  R    L  -  T  -  R    L  -  T  -  R
------------|---------------||---------------||---------------||---------------|
Volume Module:
Base Vol:       0    0     0    10    0     0     3    1     4     0    0     0
Growth Adj:  1.55 1.55  1.55  1.55 1.55  1.55  1.55 1.55  1.55  1.55 1.55  1.55
Initial Bse:    0    0     0    16    0     0     5    2     6     0    0     0
Added Vol:      0    0     0     0    0     0     0    0     0     0    0     0
Project Tri:    0    6     4    12    0     0     0    0     0     0    0     0
Initial Fut:    0    6     4    28    0     0     5    2     6     0    0     0
User Adj:    1.00 1.00  1.00  1.00 1.00  1.00  1.00 1.00  1.00  1.00 1.00  1.00
PHF Adj:     0.54 0.54  0.54  0.54 0.54  0.54  0.54 0.54  0.54  0.54 0.54  0.54
PHF Volume:     0   11     7    51    0     0     9    3    11     0    0     0
Reduct Vol:     0    0     0     0    0     0     0    0     0     0    0     0
FinalVolume:    0   11     7    51    0     0     9    3    11     0    0     0
------------|---------------||---------------||---------------||---------------|
Critical Gap Module:
Critical Gp:xxxxx xxxx xxxxx   4.1 xxxx xxxxx   6.4  6.5   6.2 xxxxx xxxx xxxxx
FollowUpTim:xxxxx xxxx xxxxx   2.2 xxxx xxxxx   3.5  4.0   3.3 xxxxx xxxx xxxxx
------------|---------------||---------------||---------------||---------------|
Capacity Module:
Cnflict Vol: xxxx xxxx xxxxx    19 xxxx xxxxx   117  120     0  xxxx xxxx xxxxx
Potent Cap.: xxxx xxxx xxxxx  1611 xxxx xxxxx   884  774   900  xxxx xxxx xxxxx
Move Cap.:   xxxx xxxx xxxxx  1611 xxxx xxxxx   863  749   900  xxxx xxxx xxxxx
Volume/Cap:  xxxx xxxx  xxxx  0.03 xxxx  xxxx  0.01 0.00  0.01  xxxx xxxx  xxxx
------------|---------------||---------------||---------------||---------------|
Level Of Service Module:
2Way95thQ:   xxxx xxxx xxxxx   0.1 xxxx xxxxx  xxxx xxxx xxxxx  xxxx xxxx xxxxx
Control Del:xxxxx xxxx xxxxx   7.3 xxxx xxxxx xxxxx xxxx xxxxx xxxxx xxxx xxxxx
LOS by Move:    *    *     *     A    *     *     *    *     *     *    *     *
Movement:     LT - LTR - RT    LT - LTR - RT    LT - LTR - RT    LT - LTR - RT
Shared Cap.: xxxx xxxx xxxxx  xxxx xxxx xxxxx  xxxx  864 xxxxx  xxxx xxxx xxxxx
SharedQueue:xxxxx xxxx xxxxx xxxxx xxxx xxxxx xxxxx  0.1 xxxxx xxxxx xxxx xxxxx
Shrd ConDel:xxxxx xxxx xxxxx xxxxx xxxx xxxxx xxxxx  9.3 xxxxx xxxxx xxxx xxxxx
Shared LOS:     *    *     *     *    *     *     *    A     *     *    *     *
ApproachDel:    xxxxxx           xxxxxx              9.3            xxxxxx
ApproachLOS:         *                *                A                 *
Note: Queue reported is the number of cars per lane.
```

IE08-0015 Topock Remediation

Level Of Service Computation Report
2000 HCM Unsignalized (Future Volume Alternative)
Cumulative Plus Project PM O+M+D

Intersection #2: I-40 EB/Park Moabi



```
                         Signal=Uncontrol/Rights=Include
           Initial Vol:  0            0           16
                 Lanes:  0    0       0      1    0

                 Signal=Stop                                   Signal=Stop
Initial Vol:  Lanes:  Rights=Include   Vol Cnt Date:      n/a  Rights=Include   Lanes:  Initial Vol:
                                       Cycle Time (sec):  100
     3          0                                                                  0        0
                                       Loss Time (sec):     0
                0                                                                  0
     1          1!                     Critical V/C:    0.000                      0        0
                0                      Avg Crit Del (sec/veh): 2.9                 0
     4          0                      Avg Delay (sec/veh):    2.9                 0        0
                                       LOS:                A

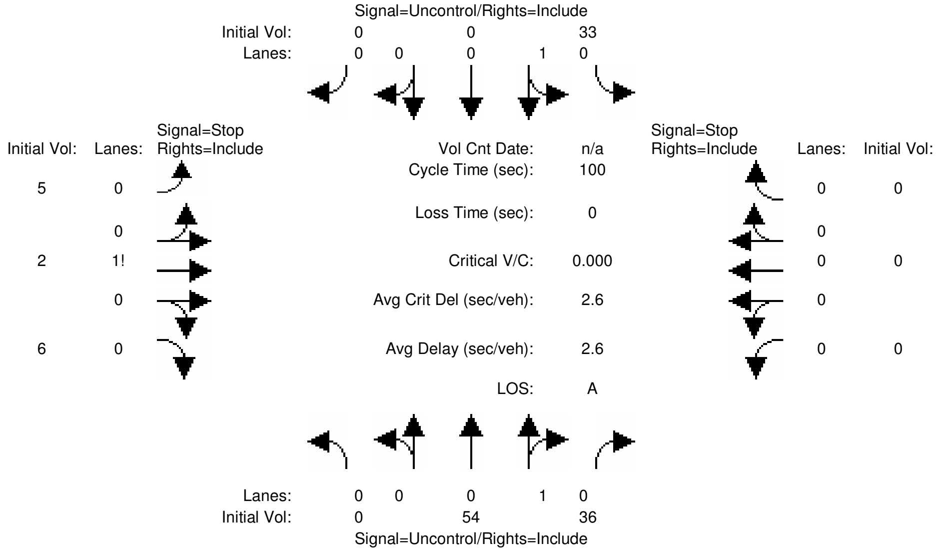
                 Lanes:  0    0       0      1    0
           Initial Vol:  0           26           17
                         Signal=Uncontrol/Rights=Include
```

```
Street Name:          Park Moabi Road                    I-40 EB Ramp
Approach:      North Bound      South Bound       East Bound       West Bound
Movement:     L  -  T  -  R    L  -  T  -  R    L  -  T  -  R    L  -  T  -  R
------------|---------------||---------------||---------------||---------------|
Volume Module:
Base Vol:       0    0     0    10    0     0     3    1     4     0    0     0
Growth Adj:  1.00 1.00  1.00  1.00 1.00  1.00  1.00 1.00  1.00  1.00 1.00  1.00
Initial Bse:    0    0     0    10    0     0     3    1     4     0    0     0
Added Vol:      0    0     0     0    0     0     0    0     0     0    0     0
Project Tri:    0   26    17     6    0     0     0    0     0     0    0     0
Initial Fut:    0   26    17    16    0     0     3    1     4     0    0     0
User Adj:    1.55 1.55  1.55  1.55 1.55  1.55  1.55 1.55  1.55  1.55 1.55  1.55
PHF Adj:     1.00 1.00  1.00  1.00 1.00  1.00  1.00 1.00  1.00  1.00 1.00  1.00
PHF Volume:     0   40    26    25    0     0     5    2     6     0    0     0
Reduct Vol:     0    0     0     0    0     0     0    0     0     0    0     0
FinalVolume:    0   40    26    25    0     0     5    2     6     0    0     0
------------|---------------||---------------||---------------||---------------|
Critical Gap Module:
Critical Gp:xxxxx xxxx xxxxx   4.1 xxxx xxxxx   6.4  6.5   6.2 xxxxx xxxx xxxxx
FollowUpTim:xxxxx xxxx xxxxx   2.2 xxxx xxxxx   3.5  4.0   3.3 xxxxx xxxx xxxxx
------------|---------------||---------------||---------------||---------------|
Capacity Module:
Cnflict Vol: xxxx xxxx xxxxx    67 xxxx xxxxx   103  116     0  xxxx xxxx xxxxx
Potent Cap.: xxxx xxxx xxxxx  1548 xxxx xxxxx   900  778   900  xxxx xxxx xxxxx
Move Cap.:   xxxx xxxx xxxxx  1548 xxxx xxxxx   889  765   900  xxxx xxxx xxxxx
Volume/Cap:  xxxx xxxx  xxxx  0.02 xxxx  xxxx  0.01 0.00  0.01  xxxx xxxx  xxxx
------------|---------------||---------------||---------------||---------------|
Level Of Service Module:
2Way95thQ:   xxxx xxxx xxxxx   0.0 xxxx xxxxx  xxxx xxxx xxxxx  xxxx xxxx xxxxx
Control Del:xxxxx xxxx xxxxx   7.4 xxxx xxxxx xxxxx xxxx xxxxx xxxxx xxxx xxxxx
LOS by Move:    *    *     *     A    *     *     *    *     *     *    *     *
Movement:     LT - LTR - RT    LT - LTR - RT    LT - LTR - RT    LT - LTR - RT
Shared Cap.: xxxx xxxx xxxxx  xxxx xxxx xxxxx  xxxx  877 xxxxx  xxxx xxxx xxxxx
SharedQueue:xxxxx xxxx xxxxx xxxxx xxxx xxxxx xxxxx  0.0 xxxxx xxxxx xxxx xxxxx
Shrd ConDel:xxxxx xxxx xxxxx xxxxx xxxx xxxxx xxxxx  9.2 xxxxx xxxxx xxxx xxxxx
Shared LOS:     *    *     *     *    *     *     *    A     *     *    *     *
ApproachDel:    xxxxxx           xxxxxx                9.2           xxxxxx
ApproachLOS:       *                *                  A                *
Note: Queue reported is the number of cars per lane.
```

IE08-0015 Topock Remediation

Level Of Service Computation Report
2000 HCM Unsignalized (Future Volume Alternative)
Cumulative Plus Project PM Decommissioning

Intersection #2: I-40 EB/Park Moabi



```
                         Signal=Uncontrol/Rights=Include
                Initial Vol:   0          0          33
                     Lanes:    0    0     0     1    0

           Signal=Stop                                   Signal=Stop
Initial Vol: Lanes: Rights=Include  Vol Cnt Date:     n/a  Rights=Include  Lanes:  Initial Vol:
     5        0                 Cycle Time (sec):     100                    0        0
              0                  Loss Time (sec):       0                    0
     2       1!                      Critical V/C:  0.000                    0        0
              0             Avg Crit Del (sec/veh):   2.6                    0
     6        0                 Avg Delay (sec/veh):  2.6                    0        0
                                              LOS:    A

                     Lanes:    0    0     0     1    0
                Initial Vol:   0          54         36
                         Signal=Uncontrol/Rights=Include
```

```
Street Name:          Park Moabi Road                      I-40 EB Ramp
Approach:      North Bound      South Bound       East Bound       West Bound
Movement:    L  -  T  -  R   L  -  T  -  R   L  -  T  -  R   L  -  T  -  R
------------|---------------||---------------||---------------||---------------|
Volume Module:
Base Vol:       0    0     0    10    0     0     3    1     4     0    0     0
Growth Adj:  1.55 1.55  1.55  1.55 1.55  1.55  1.55 1.55  1.55  1.55 1.55  1.55
Initial Bse:    0    0     0    16    0     0     5    2     6     0    0     0
Added Vol:      0    0     0     0    0     0     0    0     0     0    0     0
Project Tri:    0   54    36    17    0     0     0    0     0     0    0     0
Initial Fut:    0   54    36    33    0     0     5    2     6     0    0     0
User Adj:    1.00 1.00  1.00  1.00 1.00  1.00  1.00 1.00  1.00  1.00 1.00  1.00
PHF Adj:     1.00 1.00  1.00  1.00 1.00  1.00  1.00 1.00  1.00  1.00 1.00  1.00
PHF Volume:     0   54    36    33    0     0     5    2     6     0    0     0
Reduct Vol:     0    0     0     0    0     0     0    0     0     0    0     0
FinalVolume:    0   54    36    33    0     0     5    2     6     0    0     0
------------|---------------||---------------||---------------||---------------|
Critical Gap Module:
Critical Gp:xxxxx xxxx xxxxx   4.1 xxxx xxxxx   6.4  6.5   6.2 xxxxx xxxx xxxxx
FollowUpTim:xxxxx xxxx xxxxx   2.2 xxxx xxxxx   3.5  4.0   3.3 xxxxx xxxx xxxxx
------------|---------------||---------------||---------------||---------------|
Capacity Module:
Cnflict Vol: xxxx xxxx xxxxx    90 xxxx xxxxx   137  155     0  xxxx xxxx xxxxx
Potent Cap.: xxxx xxxx xxxxx  1518 xxxx xxxxx   861  741   900  xxxx xxxx xxxxx
Move Cap.:   xxxx xxxx xxxxx  1518 xxxx xxxxx   847  725   900  xxxx xxxx xxxxx
Volume/Cap:  xxxx xxxx  xxxx  0.02 xxxx  xxxx  0.01 0.00  0.01  xxxx xxxx  xxxx
------------|---------------||---------------||---------------||---------------|
Level Of Service Module:
2Way95thQ:   xxxx xxxx xxxxx   0.1 xxxx xxxxx  xxxx xxxx xxxxx  xxxx xxxx xxxxx
Control Del:xxxxx xxxx xxxxx   7.4 xxxx xxxxx xxxxx xxxx xxxxx xxxxx xxxx xxxxx
LOS by Move:    *    *     *     A    *     *     *    *     *     *    *     *
Movement:     LT - LTR - RT    LT - LTR - RT    LT - LTR - RT    LT - LTR - RT
Shared Cap.: xxxx xxxx xxxxx  xxxx xxxx xxxxx  xxxx  854 xxxxx  xxxx xxxx xxxxx
SharedQueue:xxxxx xxxx xxxxx xxxxx xxxx xxxxx xxxxx  0.0 xxxxx xxxxx xxxx xxxxx
Shrd ConDel:xxxxx xxxx xxxxx xxxxx xxxx xxxxx xxxxx  9.3 xxxxx xxxxx xxxx xxxxx
Shared LOS:     *    *     *     *    *     *     *    A     *     *    *     *
ApproachDel:    xxxxxx           xxxxxx              9.3           xxxxxx
ApproachLOS:       *                *                 A               *
Note: Queue reported is the number of cars per lane.
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APPENDIX SA

Settlement Agreement

Steven P. McDonald, State Bar No. 077368
LUCE, FORWARD, HAMILTON & SCRIPPS LLP
600 West Broadway, Suite 2600
San Diego, California 92101-3372
Telephone No.: 619.699.2576
Fax No.: 619.645-5315

Courtney Ann Coyle, State Bar No. 174934
Law Office of Courtney Ann Coyle
1609 Soledad Avenue
La Jolla, California 92037-3817
Telephone No.: 858.454.8687
Fax No.: 858.454.8493

Attorneys for Petitioner and Plaintiff Fort Mojave Indian Tribe

ENDORSED
[illegible]
By C. Lewis, Deputy

SUPERIOR COURT OF THE STATE OF CALIFORNIA

FOR THE COUNTY OF SACRAMENTO

FORT MOJAVE INDIAN TRIBE, a federally recognized Indian Tribe,

Petitioner and Plaintiff,

v.

DEPARTMENT OF TOXICS SUBSTANCES CONTROL, a state agency; METROPOLITAN WATER DISTRICT of SOUTHERN CALIFORNIA, a public corporation; and DOES 1 through 10, inclusive,

Respondents and Defendants,

PACIFIC GAS & ELECTRIC COMPANY, a corporation,

Real Party in Interest.

Case No. 05CS00437

STIPULATION AND ~~[PROPOSED]~~ ORDER TO RETAIN JURISDICTION TO ENFORCE SETTLEMENT BETWEEN TRIBE AND DTSC PURSUANT TO CODE OF CIVIL PROCEDURE § 664.6 AND TO DISMISS ACTION

Dept.: 11
Judge: The Honorable Gail D. Ohanesian
Action Filed: April 04, 2005

COPY

Petitioner Fort Mojave Indian Tribe ("Tribe") and Respondent and Defendant Department of Toxic Substances Control ("DTSC") (collectively, "Parties") have reached a settlement agreement ("Tribe/DTSC Agreement") (attached hereto as Exhibit A) that resolves the issues as to DTSC raised by this matter.

The Tribe also has reached separate settlements with Respondent and Defendant Metropolitan Water District of Southern California ("MWD") and Real Party in Interest Pacific Gas and Electric ("PG&E") filed concurrently herewith that will be entered as judgments of the Court as to the Tribe, MWD and PG&E. Pursuant to Section V.C of the Tribe/DTSC Agreement:

> Except as expressly provided [in the Tribe/DTSC Agreement], nothing in this Agreement shall be construed to limit DTSC's authority to take or to require corrective actions or response actions relating to the Topock Site, or to enforce laws, regulations and requirements, including, but not limited to, the [Hazardous Waste Control Law] and the Corrective Action Consent Agreement, with respect to PG&E or any other party. This Agreement does not settle or otherwise affect any claim which may be made or any action which may be taken against PG&E or MWD by DTSC or any other state agency, department or entity.
>
> Neither the provisions of the Tribe's separate agreements with MWD or PG&E, nor any future actions by the Tribe to enforce the provisions of those agreements, shall be binding on DTSC. DTSC retains all authority and reserves all rights to take or to require PG&E to perform any and all response actions or corrective actions authorized by law.

Pursuant to Code of Civil Procedure § 664.6, the Parties, through their respective attorneys, hereby stipulate and request that the Court retain jurisdiction of the Court to enforce the Tribe/DTSC Agreement, including without limitation any determination of any right to attorneys' fees and costs related to this action, until full performance of the terms thereof, and dismiss this action following entry of judgments regarding the Tribe, MWD and PG&E.

IT IS SO STIPULATED.

DATED: Nov. 7, 2006 LUCE, FORWARD, HAMILTON & SCRIPPS LLP

By: ______________________
Steven P. McDonald
Attorneys for the Fort Mojave Indian Tribe

DATED: Nov. 2, 2006

DEPARTMENT OF TOXIC SUBSTANCES CONTROL

BILL LOCKYER
Attorney General of the State of the California

By: ______________________________
Sarah Morrison
Attorneys for the State of California,
Department of Toxic Substances Control

THEREFORE, IT IS ORDERED THAT:

1. The Court will retain jurisdiction to enforce the attached Tribe/DTSC Agreement, including any determination of any right to attorneys' fees and costs related to this action, until performance in full of the terms therein; and

2. The action is dismissed with prejudice following entry of judgments as to the Tribe, MWD and PG&E.

DATED: DEC 18 2006

GAIL D. OHANESIAN
____
Hon. Gail D. Ohanesian
Judge of the Superior Court

3758388.1

EXHIBIT A

SUPERIOR COURT OF THE STATE OF CALIFORNIA

FOR THE COUNTY OF SACRAMENTO

FORT MOJAVE INDIAN TRIBE, a federally recognized Indian Tribe, Petitioner and Plaintiff, v. DEPARTMENT OF TOXIC SUBSTANCES CONTROL, a state agency; METROPOLITAN WATER DISTRICT OF SOUTHERN CALIFORNIA, a public corporation; and DOES 1 through 10, inclusive, Respondents and Defendants. PACIFIC GAS & ELECTRIC COMPANY, a corporation, Real Party in Interest.	Case No.: 05CS00437 **SETTLEMENT AGREEMENT BETWEEN FORT MOJAVE INDIAN TRIBE AND DTSC**

EXHIBIT A

IT IS HEREBY STIPULATED AND AGREED by and between Petitioner/Plaintiff, the Fort Mojave Indian Tribe ("Tribe") and Respondent/Defendant, the State of California Department of Toxic Substances Control ("DTSC"), (collectively, the "Parties") as follows:

I. RECITALS

A. The Tribe filed a petition for writ of mandate and a complaint in *Fort Mojave Indian Tribe v. Department of Toxic Substances Control, et. al.*, Sacramento Superior Court Case No. 05CS00437 (the "Action"), to challenge, among other things, the legal basis for (1) DTSC's approval of an interim measure authorizing the construction by Pacific Gas & Electric Company ("PG&E") of a treatment plant, related wells and other facilities ("IM-3") on private and public lands (hereinafter referred to as the "IM-3 Site"); and (2) the sale by the Metropolitan Water District of Southern California ("MWD") to PG&E of certain land (the "Former MWD Property") on which portions of IM-3 are located.

B. DTSC denies the material allegations of the Action.

C. DTSC alleges, but the Tribe does not admit, that IM-3 was necessary to address hazardous waste contamination, including hexavalent chromium, detected in the soil and groundwater in the vicinity of PG&E's Topock Gas Compressor Station near Needles, California ("Topock Site"), and to prevent the Topock Site contamination from reaching the Colorado River.

/ / /

/ / /

II. SETTLEMENT

A. Scope of Settlement

1. This Settlement Agreement between the Parties ("Agreement") is entered to resolve all issues between the Parties arising in the Action. The Parties enter into this Agreement pursuant to a compromise and settlement of disputed claims negotiated by the Parties in good faith to avoid complicated litigation and to further the public interest. This Agreement resolves the Tribe's claims against DTSC alleged in the Action, and constitutes a full and final settlement and satisfaction of the Tribe's claims against DTSC alleged in the Action.

2. Nothing in this Agreement is intended or shall be construed as an admission by DTSC of any allegation or violation alleged in the Action.

3. The Tribe expects to reach separate agreements with MWD and PG&E settling disputes among themselves related to the Action.

B. Consent to Jurisdiction.

For purposes of this Agreement only, the Parties stipulate that this Court has jurisdiction over the Action and personal jurisdiction over the Parties as to the acts alleged in the Action, that venue is proper in the County of Sacramento, and that this Court has jurisdiction to enter this Agreement and to enforce the provisions thereof.

/ / /

/ / /

/ / /

/ / /

III. DTSC OBLIGATIONS

A. Removal of IM-3

If PG&E submits a proposal or proposals for an alternative locations for the IM-3 treatment plant, related wells, and/or other IM-3 equipment or installations, DTSC shall promptly evaluate PG&E's proposal(s) in accordance with applicable laws, regulations, and requirements, including, but not limited to, the Hazardous Waste Control Law ("HWCL"), Health and Safety Code section 25100 et seq., and the California Environmental Quality Act ("CEQA"). If DTSC determines, in its discretion, that PG&E's proposal(s) for an alternative location for the IM-3 treatment plant, the related wells, and/or other IM-3 equipment or installations, (a) is in compliance with applicable laws and regulations, including, but not limited to, the HWCL and CEQA, and (b) is consistent with effectively remediating the contamination from the Topock Site, DTSC will, within the confines of the law and consistent with protection of public health and safety and the environment, authorize PG&E to move the IM-3 treatment plant, related wells, and/or other IM-3 facilities from the IM-3 Site, subject to any conditions imposed by DTSC, as expeditiously as practicable.

B. Schedule for Final Remedy

DTSC will utilize its best efforts to provide an expedited time frame for a decision on a final remedy for the Topock Site to the maximum extent possible under the HWCL and CEQA. To the extent that it may be necessary for PG&E to obtain certain local, state or federal government approvals or permits to implement the final remedy for the Topock Site, it is the responsibility of PG&E, not DTSC, to request and obtain such approvals or permits.

C. Initiation of Environmental Review

DTSC will immediately initiate CEQA studies on the proposed final remedy for the Topock Site according to a process that will recognize the Tribe's interests. In the event that the proposed final remedy for the Topock Site includes locating or retaining any equipment or installation on the IM-3 Site, DTSC will, in exercising its discretion regarding any such equipment or installation, and in compliance with applicable laws and regulations, including but not limited to CEQA, evaluate the significant environmental effects on cultural and biological resources on the IM-3 Site based upon the environmental setting as of January 2004, to the maximum extent permitted by CEQA.

D. Communication Process

1. Topock Site.

To the extent allowable by law, including but not limited to the HWCL, DTSC will promptly commence efforts to develop and adopt a specific and effective communication process, including the consideration of consultation, between DTSC and the Tribe, relating to remediation and restoration of the Topock Site. DTSC will also arrange meetings between representatives of the Tribe and DTSC, including DTSC's Director and the Tribe's Chairperson, to engage in dialogues regarding cultural resources information and the phases of the remediation process. The communication process shall include provisions for direct working level communication and the opportunity for discussion with the Tribe on all significant project activities, as determined by

DTSC. The communication process shall include a process for timely determining whether an activity may have the potential for a significant impact to the spiritual or cultural interests of the Tribe.

2. General Policy.

To the extent it is within DTSC's authority and allowable by law, DTSC will develop and adopt a general policy for timely and meaningful communication, including the consideration of consultation, regarding heritage resources, including sacred places, between DTSC and Indian tribes with cultural ties to such heritage resources that are located in California. The definition of "heritage resources," "sacred places" and "Indian tribes with cultural ties" will be the result of good faith dialogues between DTSC and tribes as part of the development of this policy. This commitment may be fulfilled by the adoption of such a State policy, regulation or law that is applicable to DTSC.

E. Statement.

DTSC understands that members of the Fort Mojave Tribe view the development of the IM-3 Site as a desecration of the cultural and spiritual nature of the larger area. DTSC regrets the spiritual consequences to the Tribe that have occurred in association with regulatory actions to avoid contamination of the Colorado River. Although DTSC relied in good faith on the counsel and expertise of other government agencies with specific responsibilities and authorities for protecting the Tribe's sacred sites, DTSC now recognizes that it should have taken a more active role in these matters regarding the cultural and spiritual beliefs of the Tribe. DTSC commits to communicate and plan its future actions in a manner that will respect those beliefs as it continues to work with the Tribe to protect the Colorado River and its spiritual resources.

F. Tribe's Access to Sacred Places.

To the extent it is within DTSC's authority and allowable by law, DTSC will make good faith efforts to improve the Tribe's access to the cultural resources and sacred places identified by the Tribe within the expanded Area of Potential Effects ("APE") depicted on the map attached hereto as Exhibit "A" and as expanded from time to time by agreement of the parties. DTSC will also support efforts that seek to heighten protections within the expanded APE to protect cultural resources and sacred places, to the extent that it is within DTSC's authority and allowable by law, and to the extent such efforts do not unreasonably conflict with the remediation of the Topock Site. The Tribe does not consider the foregoing locations as defining the full extent of areas of cultural sensitivity to the Tribe.

G. Training of DTSC Employees and Agents

To the extent allowable by law and collective bargaining agreements, DTSC will require the training of DTSC's management, employees, workers, contractors, and consultants involved with the remediation and/or restoration of the Topock Site about the importance of the Tribe's cultural resources and sacred places. DTSC will provide the Tribe with the opportunity to review, comment upon, and discuss DTSC's proposed training plan pursuant to this paragraph. DTSC shall provide the Tribe with an opportunity to provide a portion of such training.

/ / /

H. Facilitation of Other Efforts

To the extent it is within DTSC's authority and allowable by law, DTSC will facilitate the implementation of the following items by PG&E and/or PG&E's employees, consultants, contractors, or agents in order to better inform decisions on impacts to cultural resources and mitigation:

1. Title Search. A detailed title search conducted for the parcels identified as Site No. CA-SBr-219A, B, and C, that contain some or all of the original physical Topock Maze, plus a radius of one mile beyond the physical perimeter of Site No. CA-SBr-219A, B, and C.

2. Cultural Report and Archives. A cultural report and archives provided for Tribal use. As part of National Historic Preservation Act Section 106 consultation, DTSC understands that PG&E and the Tribe will be preparing an ethnographic study. This study and other related materials, such as, but not limited to, interview tapes and photos, will be archived with the Tribe or other tribes participating in the ethnographic study.

3. GPS/GIS Mapping. A detailed Geographic Positioning System/Geographic Information System (GPS/GIS) mapping conducted of the cultural resources within the parcels identified as Site No. CA-SBr-219A, B, and C, that contain some or all of the original physical Topock Maze, plus a radius of one mile beyond the physical perimeter of Site No. CA-SBr-219A, B, and C.

The Tribe does not consider the foregoing locations as defining the full extent of areas of cultural sensitivity to the Tribe.

/ / /

/ / /

I. Management Control or Ownership

Within its authority, DTSC will support the Tribe's efforts to obtain control, ownership and/or heightened protections of the properties containing and surrounding the Topock Maze, to the extent that such efforts do not unreasonably conflict with remediation of the Topock Site.

J. Memorandum of Agreement

DTSC will evaluate and consider becoming a party to a Memorandum of Agreement with the State Historic Preservation Office on activities arising from the Topock Site cleanup, and will meet with the Tribe to review the effectiveness of the cultural resource management plan.

K. Transfer of Former MWD Property

1. DTSC will not interfere with, or object to, the transfer to ownership of the Tribe of the Former MWD Property.

2. In the event the Tribe obtains ownership of the Former MWD Property, the Tribe agrees, subject to the Communications Process established under paragraph III.D above, that:

a. Access.

The Tribe will not object to DTSC and its authorized representatives otherwise exercising its authority to enter and move safely about the Former MWD Property at all reasonable times for purposes of ensuring compliance with laws, regulations and requirements, including but not limited to, the Corrective Action Consent Agreement and the HWCL. DTSC’s authority under this paragraph shall include, but not be limited to: inspecting records, operating logs, sampling and analytic data, and contracts relating to the Topock Site; reviewing the progress of the PG&E in carrying out the terms of the Corrective Action Consent Agreement; and verifying the data submitted to DTSC by PG&E. Nothing in this Agreement is intended or shall be construed to limit in any way the right of entry or inspection that DTSC or any other agency may otherwise have by operation of any law.

b. Use of Former MWD Property.

Until PG&E's receipt of a written determination by DTSC that remediation-related facilities will no longer be required on the IM-3 Site or unless otherwise agreed by DTSC, the Tribe shall not operate facilities on the Former MWD Property at which hazardous substances are located.

c. Tribe's Liability Arising Solely from the Ownership of the Former MWD Property.

DTSC covenants not to sue or take any civil, judicial or administrative action, to pursue any claim, enter any order or make any demand against the Tribe under any applicable laws, regulations or civil, judicial or administrative authorities, including, but not limited to, Section 107 of CERCLA, 42 U.S.C. § 9607; section 7003 of the Resource Conservation and Recovery Act; 42 U.S.C. § 6973; or division 20 of the Health and Safety Code, solely (i) with respect to the Existing Contamination at the Topock Site, as defined in the Corrective Action Consent Agreement, or any portion thereof, and (ii) arising from the Tribe's acquisition of fee title ownership of the Former MWD Property, or any portion thereof. Existing Contamination for purposes of this paragraph shall mean any contamination arising out of any hazardous substances, pollutants or contaminants, present or existing at, on, or under (including the groundwater beneath) the Topock Site as of the date upon which the Tribe takes ownership of the Former MWD Property. This covenant shall inure to the benefit of, and pass with each and every portion of the Former MWD Property and shall benefit the Tribe and any successors and assignees thereof.

d. Transfer into Trust.

Until PG&E's receipt of a written determination by DTSC that remediation-related facilities will no longer be required on the IM-3 Site or unless otherwise agreed by DTSC, the Tribe shall not transfer the Former MWD Property into trust by the federal government pursuant to 25 U.S.C. section 465.

IV. TRIBE'S RELEASE AND COVENANT NOT TO SUE

The Tribe releases and covenants not to sue DTSC, its employees, representatives and agents, as to any and all claims relating to (i) the allegations in the Action, (ii) IM-3, or (iii) the IM-3 Site, as of the time of the execution by the Tribe of this Agreement, that were or could have been asserted by the Tribe in the Action or in federal court, under the Comprehensive Environmental Response, Compensation and Liability Act, 42 U.S.C. section 9601 et seq., the Resource Conservation and Recovery Act, 42 U.S.C. section 6901 et seq., and the National Historic Preservation Act, 16 U.S.C. section 470 et seq., excluding, however, any federal action in which DTSC may be an indispensable party to achieve relief against a federal agency.

V. GENERAL PROVISIONS

A. Costs.

Nothing in this Agreement shall be interpreted as a release or waiver of any right of the Tribe to seek attorneys' fees and costs incurred in connection with the Action. Nothing in this Agreement shall be interpreted as a release or waiver of any right of DTSC to oppose any action of the Tribe to seek attorneys' fees and costs.

B. Compliance with Applicable Law.

All activities undertaken pursuant to this Agreement shall be undertaken in compliance with the requirements of all applicable federal, state and local laws, regulations, and requirements, including the HWCL, CEQA, and the Corrective Action Consent Agreement related to the Topock Site executed by PG&E on February 15, 1996 ("Corrective Action Consent Agreement"). This Agreement shall in no way relieve PG&E of its obligations to comply with such laws, regulations, and requirements applicable to the remediation of the Topock Site. This Agreement is not intended to be, nor shall it be construed as a permit issued pursuant to any federal or state statute or regulation.

C. DTSC Authority

Except as expressly provided herein, nothing in this Agreement shall be construed to limit DTSC's authority to take or to require corrective actions or response actions relating to the Topock Site, or to enforce laws, regulations and requirements, including, but not limited to, the HWCL and the Corrective Action Consent Agreement, with respect to PG&E or any other party. This Agreement does not settle or otherwise affect any claim which may be made or any action which may be taken against PG&E or MWD by DTSC or any other state agency, department or entity.

Neither the provisions of the Tribe's separate agreements with MWD or PG&E, nor any future actions by the Tribe to enforce the provisions of those agreements, shall be binding on DTSC. DTSC retains all authority and reserves all rights to take or to require PG&E to perform any and all response actions or corrective actions authorized by law.

D. Tribe's Reservation of Rights

Except as expressly set forth herein, the Tribe retains all authority and reserves all rights, including without limitation the rights of a sovereign nation, to challenge actions, determinations or decisions of DTSC or other agencies regarding the Topock Site.

E. Governmental Liability

DTSC shall not be liable for any injury or damage to persons or property resulting from acts or omissions by PG&E, MWD, the Tribe, or their respective employees, agents, or representatives in carrying out the obligations pursuant to the Agreement. Nor shall DTSC be held as a party to or guarantor of any contract entered into by PG&E, the Tribe, or their employees, agents, or representatives in carrying out the obligations required pursuant to this Agreement.

Nothing in this Agreement or the implementation thereof shall be construed to create any right of damages against the Tribe.

F. No Opposition by Parties

Each Party hereby agrees not to oppose the Court's determination that this Agreement was entered into as a good faith settlement of all Claims by the Parties, and not to challenge any provision of this Agreement.

G. Notices

Whenever, under the terms of this Agreement, written notice is required to be given or a report or other document is required to be sent by one Party to another, it shall be directed to the individuals at the addresses specified below, unless those individuals or their successors give notice of a change to the other Party in writing. All notices and submissions shall be considered effective upon receipt, unless otherwise provided. Written notice as specified herein shall constitute complete satisfaction of any written notice requirement of the Agreement with respect to the Parties.

As to the Tribe:
Chairwoman Nora McDowell
Fort Mojave Indian Tribe
500 Merriman Avenue
Needles, CA 92363

cc to: Courtney Ann Coyle, Esq.
1609 Soledad Avenue
La Jolla, CA 92037

As to DTSC:
Leonard Robinson
Acting Director
Department of Toxic Substances Control - Sacramento HQ
P.O. Box 806
Sacramento, CA 95812-0806

cc to: Nancy Long, Esq.
Senior Staff Counsel
Office of Legal Counsel
Department of Toxic Substances Control -
Sacramento HQ
P.O. Box 806
Sacramento, CA 95812-0806

H. Amendments and Modifications

This Agreement may not be amended or modified except in writing, consented to and signed by duly authorized representatives of the Parties hereto, that states the intent of the Parties to amend or modify this Agreement.

I. Severability

If any term, condition or provision of this Agreement, or the application thereof to any person or circumstance, shall to any extent be held by a court of competent jurisdiction or rendered by the adoption of a statute or regulation by the United States or the State of California invalid, void or unenforceable, the remainder of the terms, covenants, conditions or provisions of this Agreement, or the application thereof to any person or circumstance, shall remain in full force and effect and shall in no way be affected, impaired or invalidated thereby.

J. Construction

This Agreement was negotiated by the Parties with advice of counsel and any ambiguities determined to exist in this Agreement are not to be construed against any Party. The caption headings for the sections of this Agreement are for convenience only and shall not be considered to limit, amplify or define the terms or provisions hereof.

K. Dispute Resolution

In the event that a dispute arises between the Parties with respect to the subject matter of this Agreement, the Parties shall attempt in good faith to resolve any such dispute informally, for a period of time not to exceed thirty (30) days, unless such time period is extended by written agreement of the involved Parties. In the event that a mutually acceptable resolution has not been reached through these discussions, the Parties may pursue any remedy available to them on fifteen (15) days' notice, including seeking redress in the Sacramento County Superior Court. The invocation of the dispute resolution procedures under this Section shall not extend, postpone or affect in any way any obligation of the Parties under this Agreement. Notwithstanding the foregoing, either of the Parties may take actions necessary to address an imminent and/or substantial endangerment, an emergency, or irreparable injury without regard to this paragraph.

L. Compromise and Settlement; Arms-Length Negotiations

This Agreement represents a compromise and settlement of a pending dispute between the Parties and is the product of arms-length negotiation. The Parties have read this Agreement carefully and completely, have had the advice and assistance of legal counsel, and have not been influenced to any extent whatsoever by any representations or statements of fact or opinion made by any Party or its agents other than those contained in this Agreement. The Parties further agree that this Agreement has been negotiated and executed in good faith and without improper influence by any person.

M. Entire Agreement

This Agreement constitutes the entire agreement of the Parties. No promises, inducements, or considerations have been offered and accepted or given except as herein set forth. This Agreement supersedes all prior oral or written agreements, negotiations, discussions, understandings and representations between the Parties hereto and/or their respective counsel with respect to the Tribe's claims in this Action.

N. Authority

Each person signing this Agreement in a representative capacity hereby expressly warrants that he or she has express authority to legally bind his or her principal and signs this Agreement in such representative capacity on behalf of his or her principal.

O. Retention Of Jurisdiction

The Parties will jointly request that the Court shall retain jurisdiction over this matter for the duration of the performance of the terms and provisions of this Agreement to interpret, modify and enforce the terms and conditions of this Agreement, including any determination of any right to attorneys' fees and costs related to the Action.

P. Dismissal

The Tribe will file a request for dismissal with prejudice of the Action as to DTSC, within fifteen (15) days of notice of entry of the Court's order retaining jurisdiction to enforce the terms of this Agreement.

Q. Waiver of Appeal Right; Reservation of Right to Appeal Collateral Order

The parties agree to waive their right to appeal from this Agreement. Nothing in this Agreement shall be construed as a waiver of any party's right to appeal from an order that arises from an action to enforce the terms of this Agreement.

R. Counterparts

This Agreement may be executed in counterparts, with each copy deemed an original, and all such counterparts taken together shall constitute on and the same agreement.

S. Effective Date

The effective date of this Agreement shall be the date that it is executed by both Parties.

T. No Third Party Beneficiaries

This Agreement is made for the sole benefit of the Parties, and no other person or entity shall have any rights or remedies under or by reason of this Agreement, unless otherwise expressly provided for herein.

U. Survival

All representations and warranties expressly set forth in this Agreement shall survive the execution of this Agreement and the transactions contemplated hereunder, and are material and have been or will be relied upon by the parties hereto.

SO STIPULATED AND AGREED:

FORT MOJAVE INDIAN TRIBE

Dated: 12/28/05

By: Nora McDowell
NORA MCDOWELL, CHAIRPERSON
FORT MOJAVE INDIAN TRIBE

DEPARTMENT OF TOXIC SUBSTANCES CONTROL

Dated: 12/28/05

By:
LEONARD ROBINSON, ACTING DIRECTOR
DEPARTMENT OF TOXIC SUBSTANCES CONTROL

APPROVED AS TO FORM:

LUCE, FORWARD, HAMILTON & SCRIPPS, LLP

Dated: 1/10/06

By: S P McDonald
STEVEN P. McDONALD
Attorneys for Fort Mojave Indian Tribe

DEPARTMENT OF TOXIC SUBSTANCES CONTROL

BILL LOCKYER
Attorney General of the State of California

Dated: 1/30/06

By: Sarah E. Morrison
SARAH E. MORRISON
Attorneys for State of California,
Department of Toxic Substances Control