Pacific Gas and Electric Company

Yvonne J. Meeks
Topock Project Manager
Chromium Remediation Project Office
Gas Transmission & Distribution

6588 Ontario Road
San Luis Obispo, CA 93405

Mailing Address
4325 South Higuera Street
San Luis Obispo, CA 93401

805.546.5243
Internal: 664.5243
Fax:: 805.546.5232
E-Mail: YJM1@pge.com

June 29, 2007

Mr. Aaron Yue
Project Manager
California Department of Toxic Substances Control
5796 Corporate Avenue
Cypress, CA 90630

Subject: Corrective Measures/Feasibility Study Work Plan
PG&E Topock Compressor Station, Needles, California

Dear Mr. Yue:

This letter transmits the revised Corrective Measures/Feasibility Study Work Plan for the PG&E Topock Compressor Station. This work plan supersedes the Corrective Measures Study Work Plan submitted to DTSC in December 2002, and has been updated to include current site information as directed in DTSC's letter dated May 15, 2007.

Please call me at (805) 234-2257 if you have questions regarding the enclosed work plan.

Sincerely,

Yvonne Meeks

Enclosure

Cc: Karen Baker/DTSC
Chris Guerre/DTSC
Kris Doebbler/DOI

Draft Report

Corrective Measures/Feasibility Study Work Plan

Topock Compressor Station Needles, California

Prepared for

Department of Toxic Substances Control

On behalf of

Pacific Gas and Electric Company

June 2007

CH2MHILL

Corrective Measures/Feasibility Study Work Plan

PG&E Topock Compressor Station
Needles, California

Prepared for
Department of Toxic Substances Control

on behalf of
Pacific Gas and Electric Company

June 2007

This work plan was prepared under supervision of a California Professional Engineer:

Julie Eakins, PE
C 47243

REGISTERED PROFESSIONAL ENGINEER
JULIE LYNN EAKINS
No. C 047243
EXP. 12/31/07
CIVIL
STATE OF CALIFORNIA

Contents

Tables

Figures (located at the end of the report)

Exhibits

Acronyms and Glossary

AOC	Area of Concern
ARAR	applicable or relevant and appropriate requirement
CACA	Corrective Action Consent Agreement
CERCLA	Comprehensive Environmental Response, Compensation, and Liability Act
CMS/FS	corrective measures study/feasibility study
COPC	chemicals of potential concern
Cr(T)	total chromium
Cr(III)	trivalent chromium
Cr(VI)	hexavalent chromium
DOI	United States Department of Interior
DTSC	Department of Toxic Substances Control
ft/d	feet per day
ft/ft	feet per foot
IM	Interim Measure
mg/L	milligrams per Liter
PG&E	Pacific Gas and Electric Company
PRB	permeable reactive barrier
RCRA	Resource Conservation and Recovery Act
RFI/RI	RCRA facility investigation/remedial investigation
SWMU	Solid Waste Management Unit
DOE	United States Department of Energy
USEPA	United States Environmental Protection Agency

1.0 Introduction

This work plan describes the planned activities and the schedule to complete the corrective measures study/feasibility study (CMS/FS) at the Pacific Gas and Electric Company (PG&E) Topock Compressor Station located in eastern San Bernardino County, California. The purpose of the CMS/FS is to identify and evaluate potential remedies for past waste releases. A general vicinity map is shown in Figure 1-1.

The California Environmental Protection Agency, Department of Toxic Substances Control (DTSC) is the state lead regulatory agency overseeing remedial activities at the Topock Site under the Resource Conservation and Recovery Act (RCRA) and the California Health and Safety Code. In February 1996, PG&E and DTSC entered into a Corrective Action Consent Agreement (CACA) pursuant to Section 25187 of the California Health and Safety Code (DTSC, 1996). The CACA requires the preparation of a CMS if contaminant concentrations exceed current health-based action levels and/or if the DTSC determines that the contaminant releases pose a potential threat to human health and/or the environment.

The United States Department of the Interior (DOI) is the lead federal agency on land under its jurisdiction, custody, or control and is responsible for oversight of response actions being conducted by PG&E pursuant to the Comprehensive Environmental Response, Compensation and Liability Act of 1980 (CERCLA). Portions of the site where hazardous substances from the Topock Compressor Station have come to be located are on or under land managed by the Bureau of Land Management, United States Fish and Wildlife Service, and Bureau of Reclamation (collectively the "federal agencies"). In July 2005, PG&E and the federal agencies entered into an Administrative Consent Agreement to implement response actions at the site as set forth in the National Oil and Hazardous Substances Pollution Contingency Plan.

A RCRA Corrective Measures Study Work Plan was originally submitted to DTSC in 2002 (CH2M HILL, 2002). In its letter dated May 15, 2007, the DTSC provided consolidated comments from DTSC and DOI and directed that the work plan be revised and resubmitted to incorporate updated information about the site, schedule, and regulatory framework for the cleanup (DTSC, 2007a). This work plan addresses the comments contained in DTSC's May 15, 2007 letter, and incorporates the requirements of the CACA and the National Contingency Plan.

1.1 CMS/FS Process

Both the RCRA CMS and the CERCLA feasibility study identify actions that could be taken at hazardous waste sites to protect human health and the environment. Both build on the findings of the RCRA facility investigation/remedial investigation (RFI/RI) and follow very similar processes. Exhibit 1-1 shows the steps in the site investigation, the remedial action evaluation and implementation process, and how the RCRA terminology and steps align with the CERCLA terminology and steps.

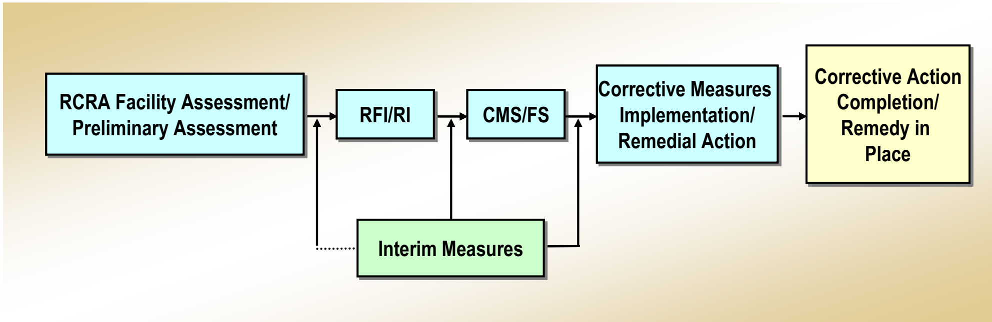


EXHIBIT 1-1
RCRA/CERCLA Process

To date, major portions of the site investigations have been completed for the Topock site, Interim Measures (IMs) have been implemented, and treatability studies have been initiated. The status and findings of these activities may be reviewed at the DTSC Topock web site: http://www.dtsc-topock.com. Following the completion of the RFI/RI, the CMS/FS will be prepared.

1.2 Site History and RFI/RI Status

Volume 1 of the RFI/RI provides the background and history of the PG&E Topock Compressor Station (CH2M HILL, 2006a). The RFI/RI Volume 1 identifies the solid waste management units (SWMUs), areas of concern (AOCs), and other undesignated areas to be carried forward in the RFI/RI. Based on the conclusions of the RFI/RI Volume 1 (as modified by DTSC's review (DTSC, 2007b)), there are two SWMUs, 17 AOCs, and one other undesignated area at the Topock Compressor Station to be addressed further in the RFI/RI. The locations of the SWMUs, AOCs, and other undesignated area to be addressed in the RFI/RI are shown in Figure 1-2.

Since 1996, there have been six phases of investigation at the Topock site to:

- Investigate past facility operations and sources of releases.
- Document significant features (biological, cultural, archaeological, historical, hydrogeological).
- Sample and analyze environmental media potentially affected by releases (soil, sediment, surface water, groundwater, air) to determine the nature and extent of contamination from the release.

Much of the focus of investigation in recent years has been on defining the extent of hexavalent chromium [Cr(VI)] in groundwater at the site. Additional investigation is planned to further delineate the distribution of Cr(VI) in groundwater and to complete the characterization of soil contamination within the fenceline of the compressor station and at locations outside the compressor station fenceline.

Following completion of additional investigations, the final RFI/RI will be prepared. Volume 2 of the RFI/RI will contain groundwater, surface water, pore water, and river sediment data; Volume 3 will contain soil data. The separation of the Final RFI/RI into three volumes is intended to efficiently manage the large amount of information associated with the RFI/RI and to accelerate site remediation by allowing remedial planning of those portions of the RFI/RI completed earlier.

In alliance with completion of the RFI/RI, risk assessments will be prepared, and applicable or relevant and appropriate requirements (ARARs) will be identified. Prior to the start of the CMS/FS, a determination will be made as to which of the two SWMUs, 17 AOCs, and one other undesignated area at the Topock Compressor Station will be carried forward from the RFI/RI to the CMS/FS.

1.3 Work Plan Organization

The organization of this work plan follows the steps in the CMS/FS process, as illustrated in Exhibit 1-2. This exhibit is repeated in each section with the relevant portion of the flowchart highlighted.

The contents of this work plan are as follows:

- Section 2.0 discusses the existing conceptual model and the proposed refinement of this model that will be incorporated into the CMS/FS.
- Section 3.0 presents the expected remedial action objectives and the inputs to be used to determine the media cleanup goals and standards in the CMS/FS.
- Section 4.0 identifies likely technologies to be screened and evaluated in the CMS/FS for the identified chemicals of potential concern (COPCs).
- Section 5.0 discusses how the remedial technologies will be formulated into remedial alternatives while considering key site features. This section also discusses how those remedial alternatives will be evaluated in the CMS/FS.
- Sections 6.0 and 7.0 provide the proposed outline and schedule for the CMS/FS report, respectively.
- Section 8.0 provides a list of references used in the preparation of this document.

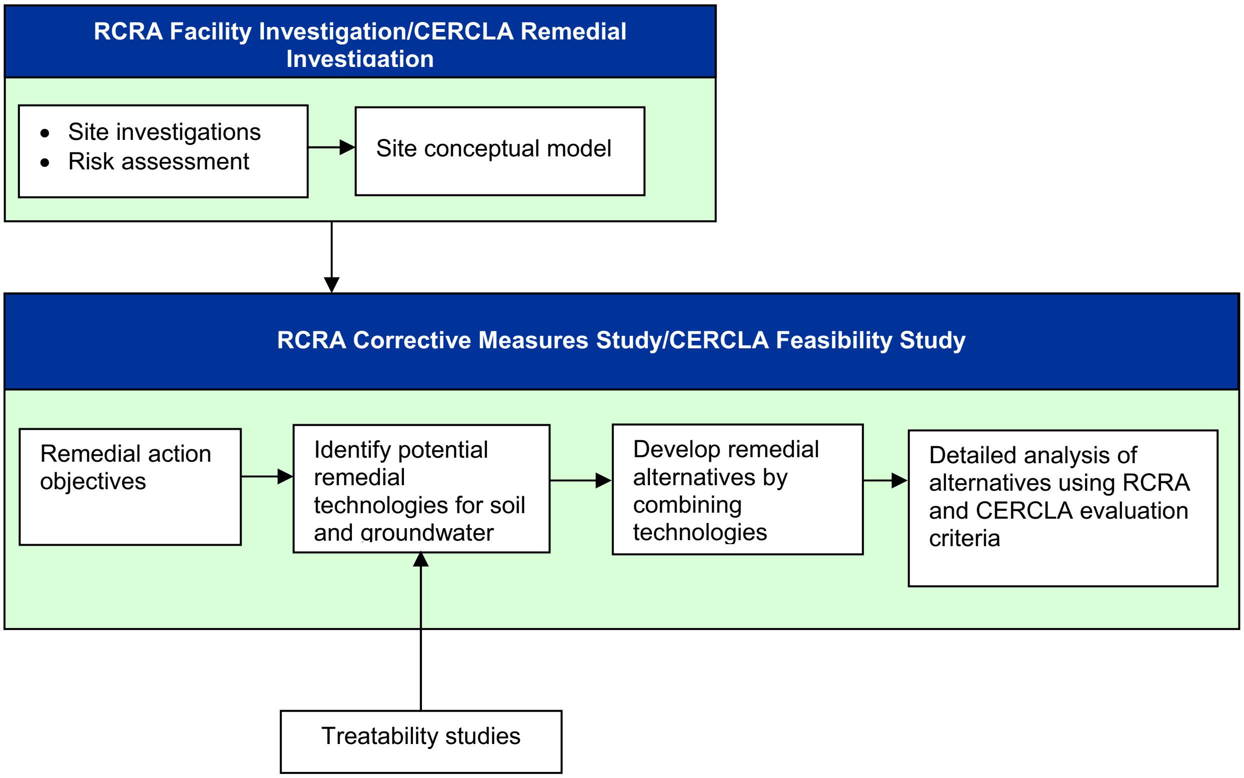


EXHIBIT 1-2
CMS/FS Process Overview

2.0 Site Conceptual Model

A conceptual model is a graphical and narrative summary of site conditions, based on currently available data, that describes the probable sources of contamination and potential pathways by which human or environmental exposures might occur. The current Topock site conceptual models for groundwater and soil are discussed below. The current site conceptual model will be modified as additional investigations of soil and groundwater are completed. Exhibit 2-1 shows how the conceptual model fits in with the CMS/FS process.

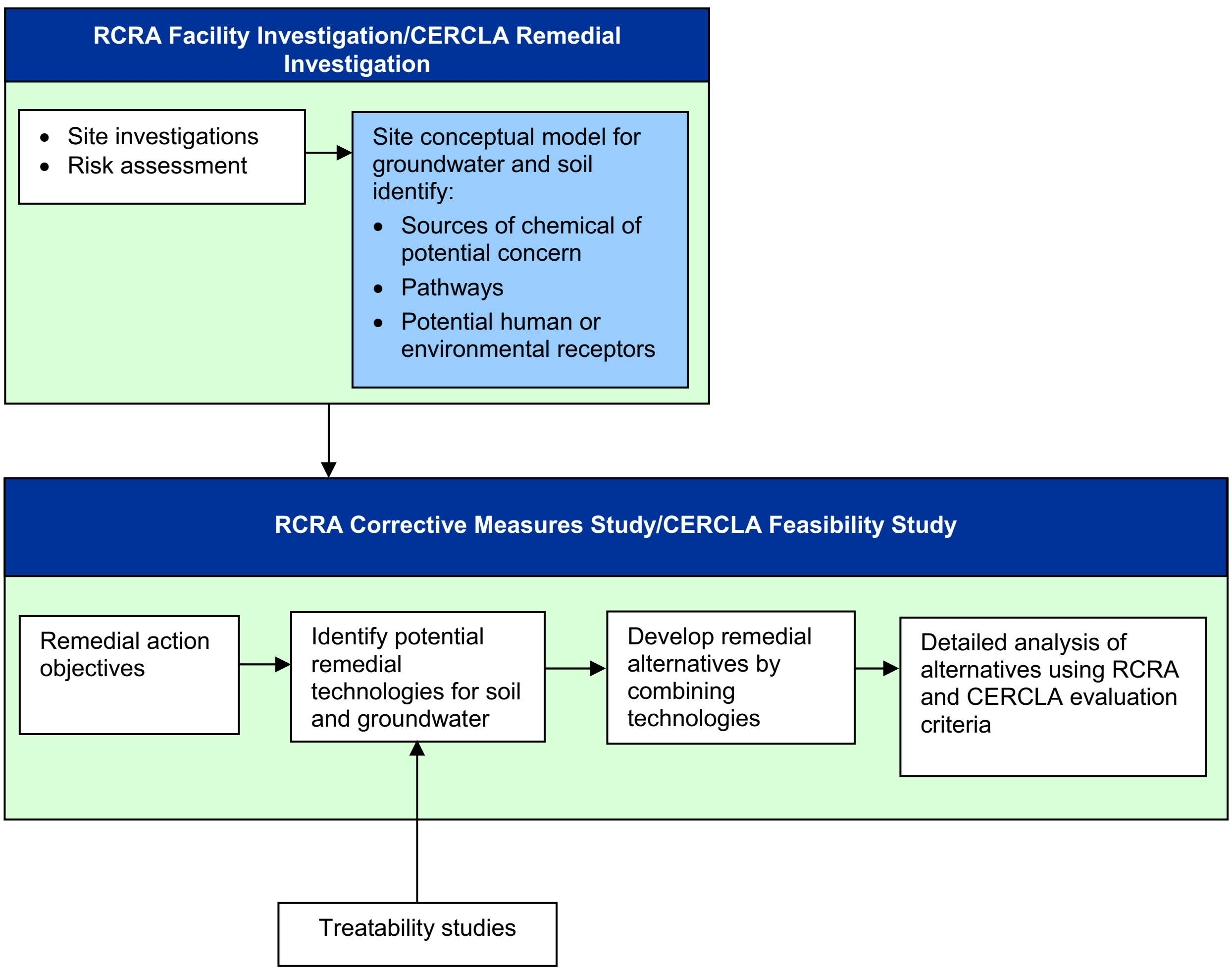


EXHIBIT 2-1
CMS/FS Process—Site Conceptual Model

2.1 Conceptual Model for Groundwater

2.1.1 Source of Groundwater Contaminants

The principal contaminant in groundwater at the site is hexavalent chromium. Cr(VI) was contained in water treatment products added to the cooling water from 1951 to 1985 to inhibit corrosion, minimize scale, and control biological growth. From 1951 to 1964, untreated cooling tower blowdown water containing Cr(VI) was discharged to Bat Cave Wash near the compressor station. From 1964 to 1969, PG&E began treating the wastewater by converting the Cr(VI) to trivalent chromium [Cr(III)]. In 1969, the process was expanded to two steps that converted Cr(VI) to Cr(III) (Step 1) and then removed Cr(III) via precipitation (Step 2). Beginning in May 1970, discharges to Bat Cave Wash ceased, and treated wastewater was discharged alternately to an injection well (PGE-08) located on PG&E property and lined ponds. In 1973, PG&E discontinued use of injection well PGE-08, and wastewater has since been discharged to lined ponds. PG&E replaced the Cr(VI)-based cooling water treatment products with non-hazardous phosphate-based products in 1985.

Nearly all of the Cr(VI) present in groundwater at the site is believed to have been released during the 13-year period when untreated wastewater was discharged to Bat Cave Wash. From the discharge locations in Bat Cave Wash, the cooling tower blowdown water infiltrated into the coarse sand and gravel of the wash bed and percolated approximately 75 downward feet through the unsaturated zone to reach groundwater Based on history of the wastewater discharge, the COPCs in groundwater are total chromium [Cr(T)], Cr(VI), copper, nickel, lead, zinc, pH, electrical conductivity and total petroleum hydrocarbons (CH2M HILL, 2006a). Other COPCs and sources to groundwater may be identified as ongoing investigations are completed.

2.1.2 Contaminant Distribution in Groundwater

For the RFI/RI, the chromium plume has been defined as chromium-bearing groundwater exceeding the State of California maximum contaminant level for Cr(T) of 0.05 milligrams per liter (mg/L). The conceptual model of groundwater plume and key site features are depicted in Figure 2-1. The chromium plume is essentially confined to the more permeable alluvial/fluvial deposits that comprise the Alluvial Aquifer. The plume exceeding the maximum contaminant level underlies an area of approximately 90 acres. The chromium plume in groundwater extends approximately 2,800 feet downgradient from the former cooling water disposal area in Bat Cave Wash to the Colorado River floodplain. Figure 2-2 shows the distribution of Cr(VI) in groundwater in the floodplain reported in May 2007. As new data are collected from existing wells and new wells are installed, the plume will be more precisely defined. Additional tools may be employed to assist in the delineation, such as stable isotopes of oxygen, hydrogen, and chromium, which may provide a chemical fingerprint of plume water.

Copper, nickel, and zinc were identified as site COPCs in the CACA and have been analyzed in groundwater during the RFI/RI and subsequent site monitoring. Over 5 years of sampling data indicate that these trace metals are either infrequently detected (copper, nickel) and/or are detected consistently at low concentrations below the drinking water maximum contaminant level (zinc). In August 2004, DTSC approved the deletion of these metals from the routine groundwater monitoring suite. The chemicals of concern to be addressed in the CMS/FS will be limited to those that are found to be elevated in groundwater during the site investigation and risk characterization.

2.1.3 Routes of Contaminant Migration in Groundwater

The primary route of chromium migration at the site is through groundwater transport. Groundwater gradients at the site are slight, on the order of 0.0005 foot per feet (ft/ft), and hydraulic conductivity of the aquifer along the axis of the plume is moderate, averaging about 30 feet per day (ft/d). Groundwater would therefore be expected to move relatively slowly. The general direction of groundwater flow from the source area in Bat Cave Wash is toward the north or northeast. Figure 2-3 is a regional hydrogeologic cross section.

Strongly-reducing geochemical conditions are observed in groundwater in the fluvial deposits along the Colorado River floodplain. Reducing conditions were also observed in the sediments beneath the river during the pore water study (CH2M HILL, 2006b) and the recent slant drilling under the river (CH2M HILL, 2007a). The pore water study included 64 sampling locations, each to a depth of 6 feet, located along a 3-mile reach of river both upstream and downstream from the Topock site. Slant drilling characterized the full thickness of the fluvial material from the river bottom to bedrock from the California shoreline towards the center of the river at two locations near the I-40 bridge. Cr(VI) is not stable in reducing conditions and reverts to Cr(III), which is strongly sorbed to aquifer materials or forms insoluble precipitates. 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.

2.1.4 Potential Groundwater Receptors

Receptors potentially could be affected if contaminated groundwater were to reach drinking water wells or the Colorado River. Drinking water wells would be primarily associated with human receptors. The Colorado River would be associated with both human and ecological receptors. There is currently no evidence of a complete pathway for Cr(VI) in groundwater to reach a receptor. The final remedy will be designed to protect potential receptors in the future.

2.2 Conceptual Model for Soil

The RFI/RI Volume 1 identified one SWMUs, 17 AOCs, and one other undesignated area to be addressed in the RFI/RI for soil.[1] Locations of the SWMUs, AOCs, and other undesignated area to be addressed in the RFI/RI are shown on Figure 1-2. Additional soil investigations are planned as part of the RFI/RI. Prior to the preparation of the CMS/FS, PG&E will collect additional soil samples at these SWMUs, AOCs, and the other undesignated area to supplement the existing dataset. The complete site conceptual model for soils will be provided in the CMS/FS. It will address the same general topics as described in the preceding sections for the groundwater conceptual model.

[1] RFI/RI Volume 1 (CH2M HILL, 2006a) as modified by DTSC comments (DTSC, 2007b). One SWMU (SWMU 2) will be addressed in RFI/RI Volume 2 for groundwater but not in RFI/RI Volume 3 for soil.

2.2.1 Source of Contaminants in Soils

Contaminants may have been released to soils through spills and leaks of cooling water and other fluids at the compressor station. Most of the AOCs and SWMUs are in or near the compressor station where spills or leaks may have occurred. AOCs outside the compressor station fence are generally associated with runoff or past disposal of debris and solid wastes.

Based on review of historical operations at the compressor station, COPCs identified for soil at the site include metals, pH, asbestos, polynuclear aromatic hydrocarbons, volatile organic compounds, semivolatile organic compounds, and total petroleum hydrocarbons (CH2M HILL, 2006a). The chemicals of concern to be addressed in the CMS/FS will be limited to those that are found to be elevated in soil during the site investigation and risk characterization.

2.2.2 Distribution of Contaminants in Soils

As indicated above, the characterization of soils is not yet complete for all SWMUs and AOCs. Existing data show that most of the chromium detected in soil is in the trivalent state. Sampling results to date indicate that, of a total of 281 analyses from locations outside of the compressor station fence, Cr(VI) was detected in 23 percent of the samples (64 detections), with a maximum concentration of 114 milligrams per kilogram. Sampling results to date on the 98 analyses inside the compressor station indicate Cr(VI) in 40 percent of the samples (39 detects), with a maximum concentration of 53 milligrams per kilogram. Copper and zinc have also been found above background levels in several areas.

2.2.3 Routes of Contaminant Migration in Soils

The primary routes of soil contaminant migration that will be considered in the CMS/FS are: (1) transport to groundwater through infiltration and (2) transport as suspended material in flowing surface water. Cleanup levels will be established and final remedies will be evaluated with these potential transport pathways in mind.

2.2.4 Potential Soil Receptors

Receptors for contaminants in soil include humans, animals, and plants. The remedy selection process in the CMS/FS will consider both direct exposure to contaminants in soils and indirect exposure to those contaminants that may leach from the soil to groundwater or be transported in flowing surface water. Different cleanup standards may be evaluated for different AOCs and SWMUs depending on location and intended future use.

2.3 Conceptual Model Development

The conceptual model, as discussed in this section, is based upon existing information collected through six rounds of RFI/RI data collection activities at the Topock site since 1996. Additional data are planned to be collected to complete the RFI/RI, and the conceptual site model will be refined in the final RFI/RI and risk assessments. Additional data planned prior to completion of the RFI/RI include:

- Further delineation of the distribution of chromium in groundwater in the area east and southeast of the existing floodplain wells. This will be accomplished using ongoing monitoring data of both existing and new wells, along with specialized tools such as analysis of stable isotopes of oxygen, hydrogen, and chromium.
- Delineation of chromium and other constituents in soil. Collection of additional soil data is planned at 19 SWMUs, AOCs, and other undesignated areas within and surrounding the compressor station through soil borings, trenching, and geophysical techniques. Samples will be analyzed for a wide range of potential contaminants.

Following completion of the site investigation, risk assessments will estimate potential exposure levels, evaluate potential adverse effects of exposures, and estimate potential adverse health or environmental effects based on carcinogenic, noncarcinogenic, and environmental risks. This analysis not only determines which constituents are of interest but also whether there are locations where COPCs are present in concentrations that pose unacceptable risk. This forms a basis for determining "points of compliance," or the geographic locations where risks need to be controlled or eliminated.

The schedule for completion of the additional data collection, site investigations, and risk assessments is presented in Section 7.0.

The CMS/FS will include the conceptual site model, as refined based on the additional site investigation and risk assessments, as well as any new information developed after the final RFI/RI report is prepared that could significantly affect the evaluation and selection of remedial alternatives.

3.0 Remedial Action Objectives

The results of the completed RFI/RI investigations, risk assessment, and conceptual site model development at the Topock site will provide the basis for identifying remedial action objectives for the site. Remedial action objectives specify medium-specific goals for removing or controlling risks to human health and the environment. COPCs, exposure route(s), receptor(s) and acceptable COPC levels are defined for each exposure route. These factors may be based on state and federal standards and regulations, risk assessment, and land use considerations, including existing restrictions on land uses and/or agreements made by authorities regarding limitations on land use. Exhibit 3-1 illustrates the process.

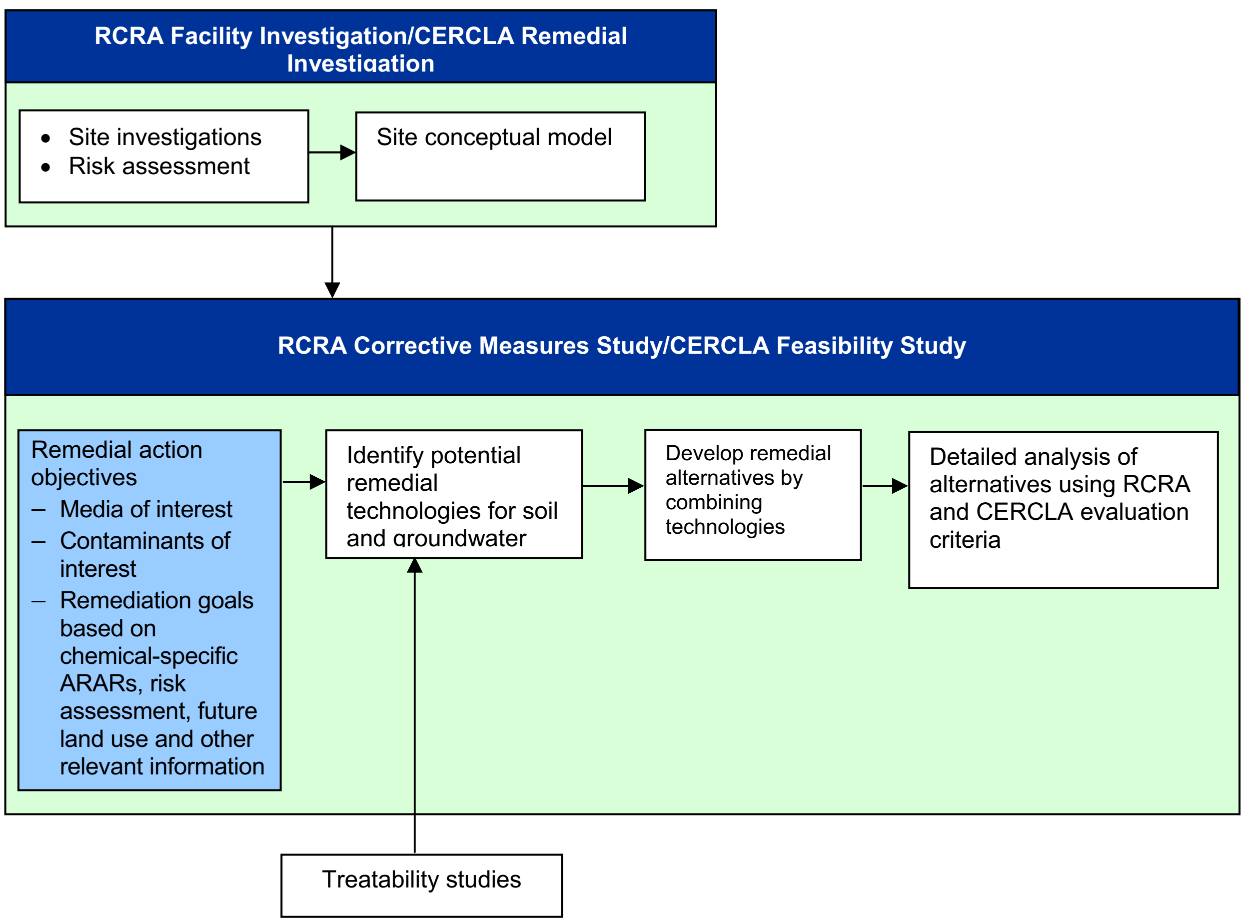


EXHIBIT 3-1
CMS/FS Process—Developing Remedial Action Objectives

3.1 Topock Site Objectives

Based on investigation findings to date, the expected remedial action objectives for the Topock site are identified below.

3.1.1 Groundwater

Remedial action objectives for groundwater include:

- Preventing elevated concentrations of Cr(VI) in groundwater at the Topock site from discharging to the Colorado River.
- Remediating groundwater to reduce Cr(VI) concentrations.
- Implementing 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 tribes in the area.
- Implementing remedial actions in a manner that limits the disturbance to wildlife and their habitats.

3.1.2 Soil

Remedial action objectives for soil include:

- Preventing unacceptable risks from direct exposure, inhalation, or ingestion of chemicals of concern in soil by humans or wildlife.
- Preventing unacceptable risks resulting from chemicals of concern in soils migrating to groundwater or surface water.
- Implementing 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 tribes in the area.
- Implementing remedial actions in a manner that limits the disturbance to wildlife and their habitats.

3.2 Media Cleanup Goals and Standards

The CMS/FS will define cleanup levels for groundwater and soil that will be protective of human health and the environment and will attain ARARs. Points of compliance and cleanup levels for soil and groundwater will be developed based on the results of site-specific risk assessments and/or ARARs, with consideration of natural background concentrations, as appropriate. Individual SWMUs, AOCs, and other undesignated areas may have different cleanup goals and standards based on specific contaminant distribution and exposure assumptions.

3.2.1 Site-specific Risk-based Media Cleanup Goals

Currently, there are no site-specific risk-based criteria for the Topock site. The human health risk assessment and screening ecological risk assessment have not yet been completed. Risk assessments for both groundwater and soil will be prepared following the completion of the RFI/RI report.

3.2.2 Applicable or Relevant and Appropriate Requirements

The DOI is leading a solicitation and evaluation of ARARs for the Topock site. ARARs are being developed during the RFI/RI to allow early opportunity for review and comment. Chemical-specific and location-specific ARARs for soil and groundwater will guide the development of the proposed medial cleanup goals and standards and will be included in the final RFI/RI report. Some anticipated chemical-specific ARARs for Cr(VI), Cr(III), and Cr(T) in groundwater and surface water are shown in Table 3-1. In addition to Cr(VI), Cr(III), and Cr(T) the ARARs evaluation will include other COPCs as appropriate, pending the results of the risk assessments.

TABLE 3-1
Anticipated Chemical-specific ARARs for Cr(VI), Cr(III), and Cr(T) in Groundwater and Surface Water
Corrective Measures Study Work Plan, Topock Compressor Station

	Unit	Cr (VI)	Cr(III)	Cr(T)
Groundwater				
California MCL (22 CCR δ64431)	mg/L	N/A	N/A	0.05
RCRA Concentration Limits (40 CFR δ264.94)	mg/L	N/A	N/A	0.05
Surface Water				
Numeric criteria for priority toxic pollutants for the State of California (40 CFR δ131.38)	mg/L	0.011	0.237[a]	N/A

Notes:
[a] Freshwater aquatic life, chronic, assuming $CaCO_3$ = 142 parts per million.
CCR = California Code of Regulations.
CFR = Code of Federal Regulations.
MCL = maximum contaminant level.
N/A = not applicable.

3.2.3 Ambient (Background) Conditions and Concentrations

Natural background concentrations of metals in soil and groundwater near the Topock site are being assessed through site-specific studies. A groundwater background study implemented between 2005 and 2006 calculated the background concentrations of Cr(VI), Cr(T), and other metals in groundwater near the Topock site (CH2M HILL, 2007b). A similar study is being implemented for soil. The results of the background studies will be considered as appropriate during development of media cleanup standards in the CMS/FS.

4.0 Corrective Measure/Remedial Action Technologies

Corrective measure/remedial action technologies are the building blocks from which complete sitewide cleanup alternatives are developed. For each medium of interest, technologies are identified that are judged to be capable of being implemented and of being potentially effective in meeting the remedial action objectives for the site based on the volume or area requiring remediation and the COPCs present.

Technologies may be identified based on data from application at other sites, bench-scale testing, or site-specific pilot testing. During the CMS/FS, remedial sitewide alternatives are developed using various combinations of technologies applied to different areas of the site or volumes of media (e.g., soil, groundwater) described in Section 5.0. Exhibit 4-1 illustrates this portion of the CMS/FS process.

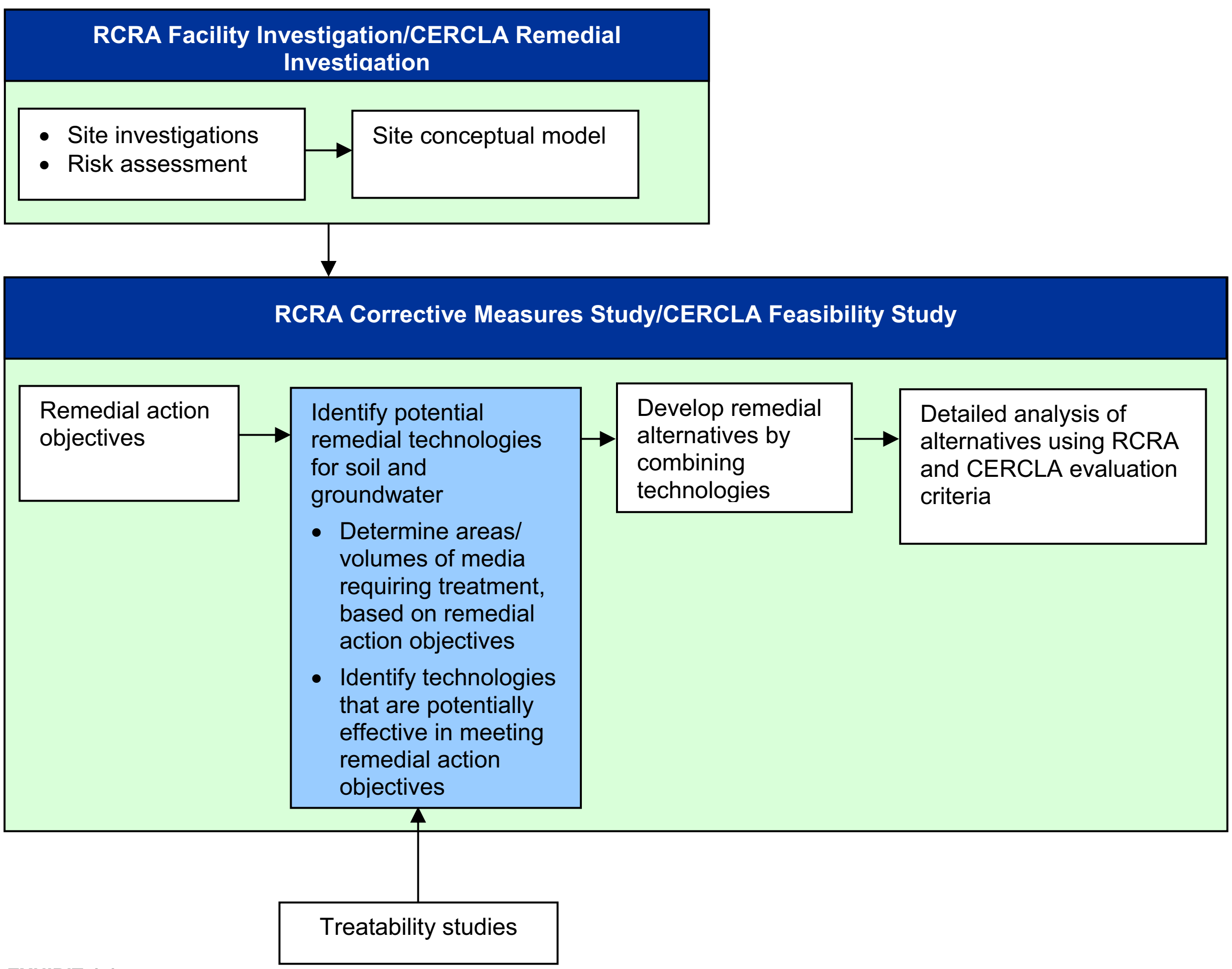


EXHIBIT 4-1
CMS/FS Process—Identifying Remedial Technologies

Potential treatment technologies for various COPCs in soil and groundwater are presented in Table 4-1. As the site investigations and risk characterization are completed, the list of COPCs will be refined prior to the CMS/FS.

TABLE 4-1
Potential Remedial Technologies
Corrective Measures Study Work Plan, Topock Compressor Station

Constituents of Potential Concerns	Potential Remedial Technologies	
	Groundwater	**Soil**
Total petroleum hydrocarbons	MNA, *in-situ* remediation, impermeable barriers	Excavation, stabilization, *in-situ* remediation, capping in place
Volatile organic compounds	MNA, *in-situ* remediation, pump and *ex-situ* treatment, permeable and impermeable barriers	Excavation, soil washing, *in-situ* remediation, soil-vapor extraction,
Semivolatile organic compounds	MNA, *in-situ* remediation, pump and *ex-situ* treatment, impermeable barriers	Excavation, soil washing, *in-situ* remediation, capping in place
Polynuclear aromatic hydrocarbons	Pump and *ex-situ* treatment, MNA, impermeable barriers	Excavation, stabilization, capping in place
Cr(VI)	MNA, pump and *ex-situ* treatment, permeable and impermeable barriers, reactive treatment zones	Excavation, soil washing, soil flushing, stabilization, *in-situ* chemical reduction, phytoremediation, capping in place
Metals (other than Cr(VI))	Pump and *ex-situ* treatment, *in-situ* remediation, impermeable barriers	Excavation, soil washing, stabilization, *in-situ* remediation, capping in place
Asbestos	N/A	Stabilization, excavation, capping in place

MNA = monitored natural attenuation.

Based on available site information, a preliminary list of potentially effective remedial technologies for groundwater and soil are presented in Sections 4.1 and 4.2. As the nature and extent of COPCs becomes better defined, these technologies can be refined, modified, or supplemented to accommodate any further site understanding.

Technologies to be used in developing remedial alternatives are typically screened based on expected effectiveness in meeting remedial action objectives, ability to be implemented, and cost-effectiveness. If appropriate, bench- or pilot-scale treatability tests may be performed to better evaluate specific technologies. Bench-scale and pilot testing to evaluate remedial alternatives at the Topock site are discussed in Section 4.3. Some of the proposed remedial alternatives may have significant impacts on cultural resources, and it is expected that alternatives will be subjected to screening based on the nature and type of potential impacts on cultural resources.

4.1 Groundwater Remediation Technologies

As indicated in Table 4-1, there is a wide range of technologies that may be applicable for different COPCs. Because the groundwater COPCs to be addressed in the CMS/FS have not yet been determined, this work plan focuses on technologies to address Cr(VI), which is the primary COPC at the site. The CMS/FS may include additional technologies if additional COPCs are identified during completion of the site investigations and risk characterization.

The five technologies that appear to have the potential to address Cr(VI) contamination in groundwater at the Topock site either alone or in combination are:

- **Monitored Natural Attenuation**: involves monitoring the effectiveness of naturally-occurring conditions to reduce concentrations of Cr(VI) and prevent it from discharging to the Colorado River.
- **Pump and Treat:** is an *ex-situ* technology similar to that employed for the Topock IM that involves pumping contaminated groundwater to the surface for treatment in an aboveground treatment plant to remove Cr(VI). Treated water could be reinjected to the subsurface, used for irrigation or industrial purposes, discharged to surface water, or managed by some other means. Pump-and-treat remediation is often implemented to provide hydraulic containment and prevent further expansion of a contaminant plume.
- **Impermeable Barrier:** involves constructing a barrier to groundwater flow (cutoff wall) from the ground surface to bedrock and pumping groundwater from the landward side of the barrier to prevent Cr(VI)-containing groundwater from reaching the Colorado River.
- **Permeable Reactive Barrier (PRB)**: involves a constructing a subsurface flow-through barrier between the contaminant plume and the Colorado River that would convert Cr(VI) into insoluble Cr(III), while allowing natural groundwater flow to continue.
- **Reactive Treatment Zones:** are areas where reductants are injected into the groundwater to create *in-situ* geochemical conditions that will remove Cr(VI) as the groundwater passes through the zone. *In-situ* reactive zones differ from reactive barriers in that they do not involve constructing a barrier below ground but, rather, use combinations of extraction and injection wells and/or natural groundwater movement to create a zone within the aquifer where Cr(VI) is converted into Cr(III).

The following sections provide additional general descriptions of these technologies without discussion of specific application to the Topock site. Specific application of selected technologies will be described in the CMS/FS after full consideration of site conditions and constraints.

4.1.1 Monitored Natural Attenuation

Monitored natural attenuation is any combination of "physical, chemical, or biological processes that, under favorable conditions, act without human intervention to reduce the mass, toxicity, mobility, volume, or concentration of contaminants in soil or groundwater" (USEPA, 1999). Groundwater monitoring data are collected to evaluate the effectiveness of natural conditions to reduce Cr(VI) concentrations. Specifically, monitoring evaluates the movement and reduction of Cr(VI) with respect to the point(s) of compliance and/or sensitive receptors.

Monitored natural attenuation is often combined with other active remedial technologies to provide a complete remedial alternative.

4.1.2 Groundwater Pump and Treat

Pump-and-treat remediation methods involve the installation of one or more groundwater extraction wells within the contaminant source zone and/or downgradient plume. Pumps are used to pull groundwater into the wells and bring it to the surface, where it is treated using one or more aboveground treatment processes. The number and spacing of wells, extraction rates, and treatment methods are dependent on the physical site characteristics and the contaminant type.

Pump and treat can provide an effective means for implementing hydraulic containment and is often used to prevent a plume of contaminated groundwater from spreading while simultaneously providing for contaminant removal. When used as the sole remedial technology, pump-and-treat groundwater systems typically require long timeframes to achieve cleanup objectives. Therefore, pump and treat is often combined with other remedial technologies to achieve cleanup goals more quickly.

As shown in Exhibit 4-2, pump-and-treat systems typically require:

- A groundwater extraction system to pump the contaminated groundwater from the aquifer.
- A groundwater treatment system to remove constituents from the extracted water.
- Conveyance piping to transport water to and from the treatment plant.
- Some means of disposal or reuse of the treated water.

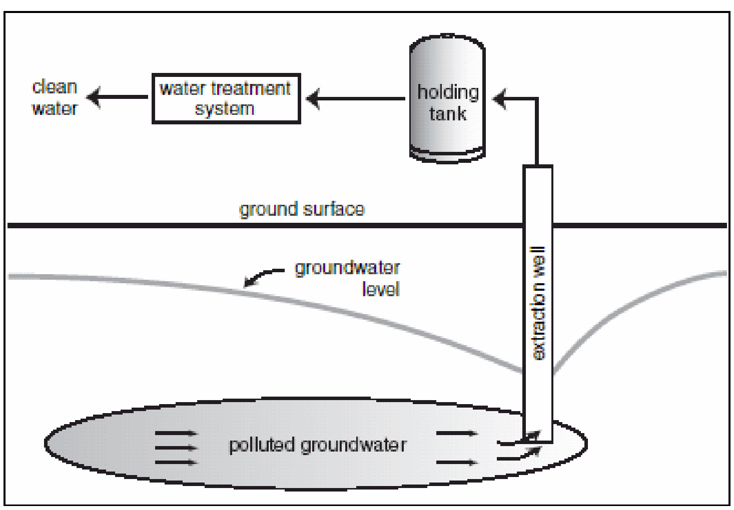


EXHIBIT 4-2
Groundwater Pump and Treat
Source: USEPA, 2001a.

Other considerations may include well placement constraints due to pipeline access considerations and maximum flow rate constraints due to the capacity of the water disposal/reuse facilities. A number of potential disposal/reuse options may exist for the Topock site including discharge to the Colorado River, reuse at the compressor station, irrigation, and injection into the aquifer.

An interim pump-and-treat system is now in place at the Topock site. PG&E and the Fort Mojave Indian Tribe have agreed that, to the extent that a pump-and-treat system is required as part of the final remedy, the treatment plant would be relocated to current location of the compressor station. It is expected that the CMS/FS will identify and evaluate potential locations for a treatment plant, should one be required as part of the final remedy.

4.1.3 Impermeable Barrier Wall

An impermeable barrier wall is a subsurface barrier installed across the flow path of groundwater to prevent movement of groundwater past the wall. Impermeable barriers are used to contain contaminated groundwater, divert uncontaminated groundwater flow, and/or provide barriers for groundwater treatment systems. These vertical barriers must extend down to an impermeable natural horizontal barrier, such as a clay or bedrock zone, to effectively impede groundwater flow. Exhibit 4-3 shows a typical impermeable barrier wall.

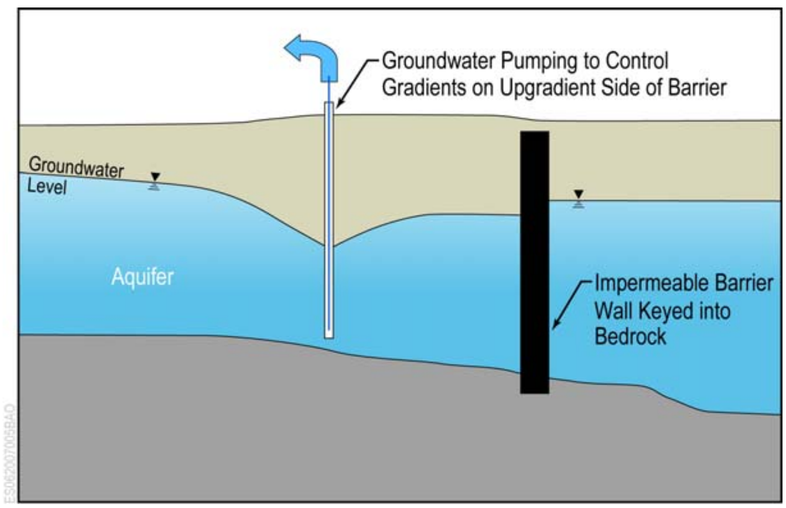


EXHIBIT 4-3
Impermeable Barrier Wall

Vertical barriers typically used to control groundwater flow include soil-bentonite, soil-cement-bentonite, cement-bentonite, sheet pile (steel or high-density polyethylene), and clay barriers. The most widely-used technique for containment is the soil-bentonite slurry wall.

A groundwater extraction system is typically installed upgradient of the impermeable barrier to prevent buildup of groundwater pressure that could cause groundwater to flow around the ends of the barrier or emerge at the land surface.

Impermeable barriers are typically placed at depths up to 100 feet and are 8 inches to 4 feet thick. Depending on the type of impermeable barrier and subsurface conditions, installation to greater depths is possible, but the difficulty of installation increases as depths increase below 100 feet. The most effective application of the impermeable barrier for site remediation is to base (or key) the slurry wall 2 to 3 feet into a low-permeability layer such as clay or bedrock. This “keying-in” provides for an effective foundation with minimum leakage potential.

4.1.4 Permeable Reactive Barrier

As shown in Exhibit 4-4, a PRB is a subsurface wall constructed of reactive materials that allow groundwater to pass through while prohibiting the movement of constituents. For Cr(VI), the reactive materials typically consist of zero-valent iron or sodium dithionite, which chemically reduce Cr(VI) to relatively insoluble Cr(III). The converted Cr(III) is then removed from groundwater within the PRB material, with groundwater containing acceptable chromium concentrations flowing out the downgradient side of the PRB.

Permeable reactive barriers work best at sites with loose sandy soil where contamination is no deeper than 50 to 100 feet and the barrier can be constructed down to an impermeable layer such as bedrock to prevent contaminated groundwater from passing beneath the barrier. As heavy equipment is needed for construction, vehicle access is a requirement. The installation of PRB walls is limited to depths of less than 150 feet below ground surface using continuous wall construction methods.

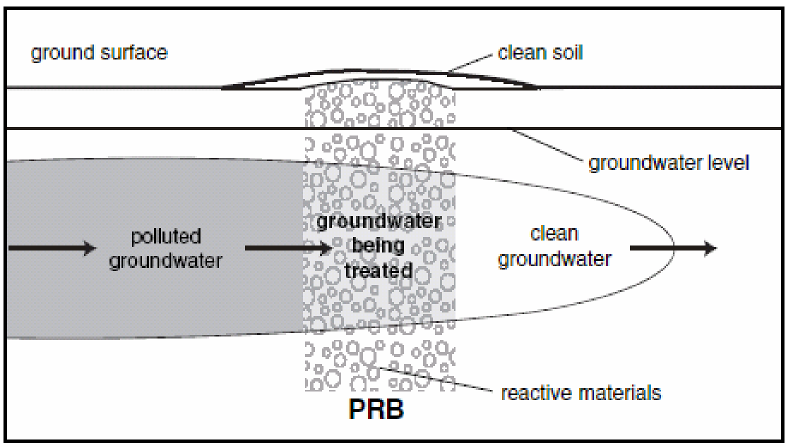


EXHIBIT 4-4
Permeable Reactive Barrier (PRB)
Source: USEPA, 2001b.

4.1.5 Reactive *In-situ* Treatment Zones

Chemical injection methods can be used to reduce Cr(VI) in groundwater to the relatively immobile Cr(III) without the use of the PRB structures, described in Section 4.1.4. The reduced chromium precipitates or becomes adsorbed onto aquifer solids. *In-situ* chemical reduction can be implemented by:

- Extracting contaminated groundwater and treating it aboveground followed by reinjection of the treated groundwater into the aquifer. The reinjected groundwater is dosed with a reductant to reduce any residual Cr(VI) remaining in the interstitial water.
- Injecting the reductant into the aquifer using a strategically designed well network to form an *in-situ* treatment zone.

A variety of reactive materials may be applicable at the Topock site, including both chemical reductants and organic carbon substrates. Chemical reductants—including sodium hydrosulfite (dithionite), ferrous sulfate, calcium polysulfide, and hydrogen releasing compounds—work directly to reduce Cr(VI). Organic carbon substrates such as lactate, ethanol, acetic acid (vinegar), molasses, or emulsified vegetable oil can be injected into the groundwater to stimulate microorganisms to create the necessary reducing conditions to convert Cr(VI) to Cr(III). At Topock, this technology is currently being pilot tested to evaluate performance at the field level and to determine design parameters such as substrate quantities and the number of injection wells required.

4.2 Soil Remediation Technologies

Additional studies are planned to determine the nature and extent of soil contamination at the Topock site. The need and type of soil remediation will be determined based on the findings of these studies. Because the soil COPCs to be addressed in the CMS/FS have not yet been determined, this work plan focuses on technologies to address Cr(VI), which is the primary COPC in groundwater and likely in soil. The CMS/FS may include additional technologies if additional COPCs are identified during completion of the site investigations and risk characterization.

- **Excavation and Offsite Disposal:** involves excavation, transportation, and disposal of contaminated material from the Topock site to a permitted offsite disposal facility. Pretreatment may be required to meet disposal requirements of the offsite facility.
- **Excavation and Onsite Treatment:** is an *ex-situ* method that involves excavation of contaminated soil and treatment onsite by either soil washing or chemical reduction.
- **Soil Flushing:** is an *in-situ* method that involves application of water or additive-containing water to soil to enhance contaminant solubility. Soil flushing is used in combination with groundwater remedial method. Contaminants are leached from soil into the groundwater, which is then remediated.
- **Solidification/Stabilization:** can be either *ex-situ* or *in-situ* and involves use of various chemical additives to physically bind or enclose contaminants within a stabilized mass (solidification) or to chemically reduce the contaminants' mobility by inducing chemical reaction between the stabilizing agent and the contaminants (stabilization).
- ***In Situ* Chemical Reduction:** involves addition of reagents to react with targeted constituents in soil to chemically convert hazardous contaminants to non-hazardous or less toxic compounds that are more stable, less mobile, and/or inert. Reductants could be applied to soil by infiltrating a liquid reductant from the surface, injecting a liquid reductant through wells, or injecting a gaseous reductant through wells.
- **Phytoremediation**: involves planting vegetation on contaminated soils. Contaminants are removed from soil through geochemical reactions in the root zone or through uptake by the roots and incorporation into the plant tissue. If contaminants become incorporated into the plants, the plant material may be periodically harvested and removed to a hazardous waste disposal facility. Phytoremediation is generally effective only for contaminants that are soluble in water and located at shallow depths that can be reached by the plant roots, or in combination with other measures, where it is used to reduce the amount of surface water infiltration to a deeper contaminated zone or to lower local groundwater levels to prevent contact with contaminated soils.

- **Capping in Place:** involves construction of a capping system on top of the contaminated area to contain and minimize exposure of the contaminants to the environment.

The following sections provide additional general descriptions of these technologies without discussion of specific application to the Topock site. Specific application of selected technologies will be described in the CMS/FS after full consideration of site conditions and constraints.

4.2.1 Excavation and Offsite Disposal

Excavation and offsite disposal is a well-proven technology. Prior to 1984, excavation and offsite disposal was the most common method for cleaning up contaminated sites. Excavation is the initial component in all *ex-situ* treatments. According to CERCLA's statutory preference for treatment of contaminants, excavation, and offsite disposal is now less acceptable than in the past.

As shown in Exhibit 4-5, the process of excavation and offsite disposal involves excavation of the contaminated area using backhoes, front loaders, continuous excavators, scrapers, and other equipment. The excavated material is typically staged for loading (treated if required) and loaded into transport vehicles for shipment to a permitted offsite disposal facility. Loading may be conducted directly from the excavators into the transport vehicles but is typically performed with front-end loaders after stockpiling, soil characterization, and/or pretreatment.

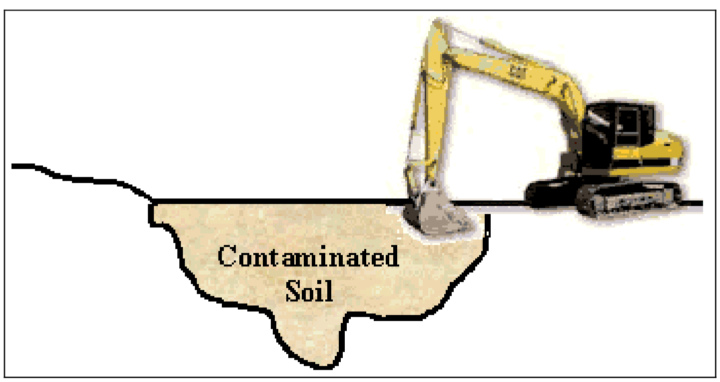


EXHIBIT 4-5
Typical Excavation

Landfill disposal typically requires that no free liquid be present in the material or that the material meet toxic characteristic leaching procedure leaching criteria or both. Where applicable, pretreatment (e.g., stabilization, fixation, etc.) of material may be required to bind free water and prevent leachate development from the excavated wastes once disposed of offsite.

Other considerations may include generation of fugitive emission during operations, distance from the site to the nearest disposal facility, and community acceptability towards excavation and transportation of the contaminated material.

4.2.2 Excavation and Onsite Treatment

This technology involves excavation of contaminated soil and treatment of the excavated soil onsite. Different treatment methods may be considered depending on the type of contaminants present. This work plan highlights two of the most common treatment methods: soil washing and chemical reduction/oxidation.

4.2.2.1 Soil Washing

Soil washing is an *ex-situ* soil separation technique that is often considered to be environmentally preferred and that is being widely used in Northern Europe and North America. It is a water-based soil scrubbing process to sort contaminated solids by sizes after the material is excavated. The process removes contaminants from soils either by:

- Dissolving or suspending the contaminants in the wash solution.
- Concentrating the contaminants into a smaller volume of soil through particle size separation and gravity separation.

The concept of reducing soil contamination through the use of particle size separation is based on the finding that most organic and inorganic contaminants tend to bind, either chemically or physically, to clay, silt, and organic soil particles. Washing processes that separate the fine clay and silt particles from the coarser sand and gravel soil particles can be used to effectively separate and concentrate the contaminants into smaller volumes of soil. Further treatment or disposal can be performed subsequent to the washing processes.

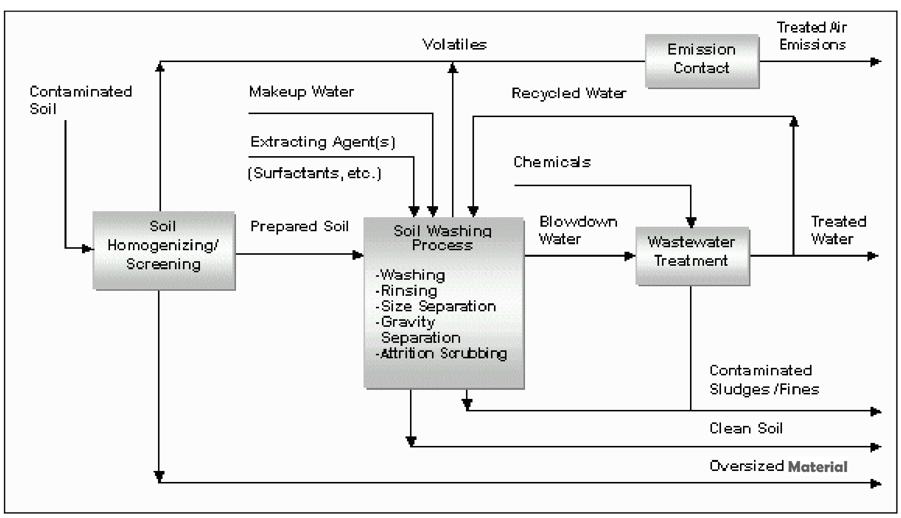


EXHIBIT 4-6
Typical Soil Washing Process
Source: Federal Remediation Technology Roundtable. 2002.

As shown in Exhibit 4-6, the soil washing process typically comprises the following components:

- Contaminated soil is excavated, screened, and homogenized prior to being fed into the washing apparatus. Oversized material is removed.

- Extraction agents and makeup water are added to the soil.
- After sufficient mixing, treated soils are separated from the wash water.
- Contaminants are concentrated into a smaller volume of soil through the separation of fine clay and silt particles from the coarser sand and gravel particles using various screening and controlled rate-settling processes. The cleaned soil can often be replaced onsite.

Soil washing is generally considered to be a media transfer technology. The wash water is treated in a wastewater treatment plant and, whenever possible, treated water is recycled back into the washing apparatus. Other considerations may include additional treatment that may be required on oversized materials, as well as management of wastewater, contaminated fines, and solids.

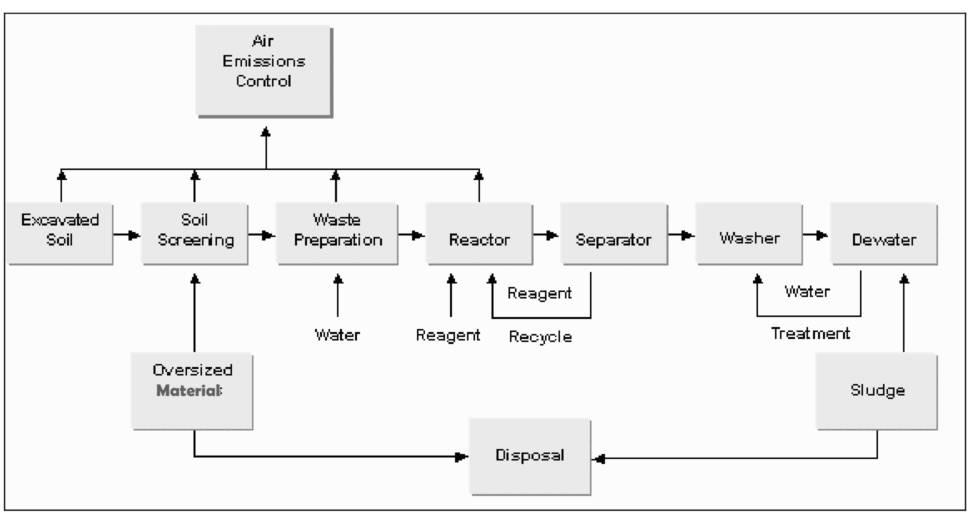
4.2.2.2 Chemical Reduction

Chemical reduction/oxidation is a full-scale, well-established technology for treatment of chromium-containing materials that involves chemical reactions of electron transfer (and usually other chemical groups) from one reactant (oxidized compound) to another compound (reduced compound).

As shown in Exhibit 4-7, the chemical reduction process typically comprises the following components:

- Contaminated soil is excavated, and screened. Oversized material is removed.
- Water is added to the screened soil, and the slurry is transferred to a reactor, where reagents are added to react with targeted constituents.
- The reagent/soil mixture is transferred to a separator, where excess reagent is removed and recycled back into the reactor. The treated soil is washed and dewatered.
- Water from the dewatering process is recycled back to the soils washer. The dewatered sludge is combined with the oversized material for disposal

EXHIBIT 4-7
Typical Chemical Reduction Process
Source: United States Army Corps of Engineers. 2003.



If the process is not optimized, formation of intermediate byproducts may occur. Other considerations may include additional treatment that may be required of effluent water from dewatering, sludge and oversized material.

4.2.3 Soil Flushing

Soil flushing is an *in-situ* treatment technology that is used in combination with a groundwater remedial technology. It is a developing technology that has had limited use in the United States. Laboratory and field treatability studies must be performed under site-specific conditions prior to its full-scale implementation.

As shown in Exhibit 4-8, the soil flushing process involves infiltrating water, with or without additives (such as surfactants), through contaminated soils to flush (*in-situ* wash) contaminants from the soil into the underlying groundwater for collection by downgradient groundwater extraction wells and treatment. Additives are typically surfactant compounds that enhance the solubility of the contaminants and improve the efficiency of the flushing process.

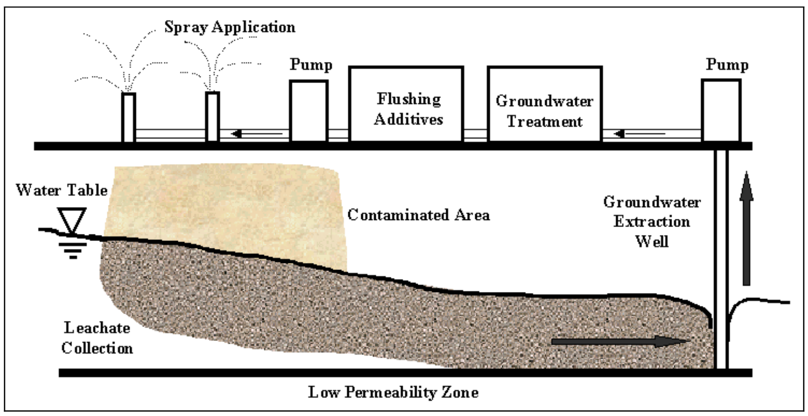


EXHIBIT 4-8
Soil Flushing
Source: Federal Remediation Technology Roundtable. 2002.

Soil flushing is typically coupled with groundwater treatment to allow contaminants flushed from soil to be removed from the groundwater. Recovered groundwater and flushing additives with the desorbed contaminants typically need treatment to meet appropriate discharge standards. Ideally, some or all of the treated groundwater can be reused in the flushing process.

The primary requirement for soil flushing is that groundwater can be captured, extracted, and treated or that the groundwater can be treated *in-situ* to prevent further spread of contamination. Other considerations may include the potential of washing of the contaminants beyond the capture zone and the introduction of surfactants to the subsurface.

4.2.4 Solidification/Stabilization

Solidification/stabilization reduces mobility of contaminants in the environment through both physical and chemical means. Solidification generally refers to a physical process where a semi-solid material is treated to render it more solid. Stabilization typically refers to a chemical process that actually binds the matrix of the contaminant such that its constituents are immobilized. Both processes tend to trap or immobilize contaminants within their “host” medium. Leachability testing is typically performed to measure the immobilization of contaminants.

As shown in Exhibit 4-9, solidification and stabilization can be performed *in-situ* or *ex-situ*. Typical binding/stabilizing agents include Portland cement, pozzolanic binders, and various kiln dusts. Most of these materials are highly alkaline and form a solidified matrix when mixed with the contaminated material.

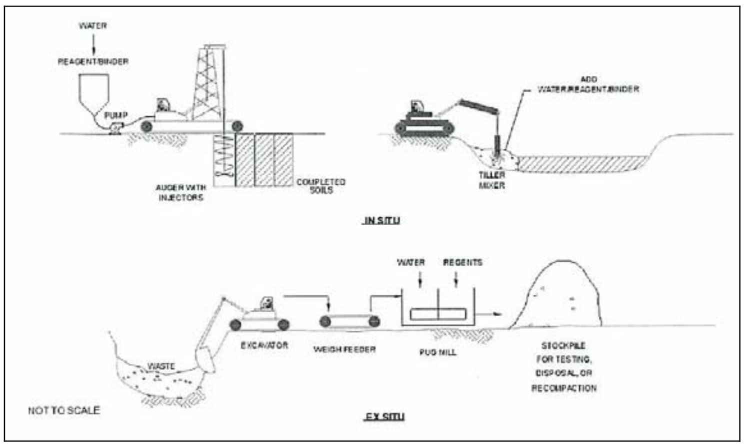


EXHIBIT 4-9
Solidification/Stabilization
Source: United States Army Corps of Engineers. 2003.

The *ex-situ* method involves excavation and staging of the soil, screening to remove larger-diameter material, blending the binding agents and water with solids, and stockpiling treated solids for testing prior to offsite disposal or placement back in the excavation. The *in-situ* method involves injection or mixing of stabilizing agents into subsurface soils, addition of water if necessary, and then repeated in-place mixing with the bucket of a backhoe or track hoe to thoroughly mix and stabilize the soils in place.

The *ex-situ* method generally requires greater material handling than for *in-situ* methods, but the degree of mixing and blending control is significantly higher than for *in-situ* processing. This generally yields higher confidence that the contaminants have been effectively immobilized and may require less reagent-per-unit-volume of solids treated. However, a significant consideration in applying the *ex-situ* technology is the swell factor in the solid volume created by the binding agent. This factor can approach up to 50 percent in some cases; in which case, not all of the treated material can be backfilled into the original excavation.

The solidification/stabilization process has been successfully demonstrated and used for inorganic contaminants such as metals. Laboratory and field treatability studies must be performed under site-specific conditions prior to its full-scale implementation.

4.2.5 *In-situ* Reduction

In-situ reduction in soil is a technology involves introducing reductants to the contaminated soil zone to chemically reduce contaminants. This method could be used to reduce Cr(VI) to Cr(III) in place without the need for excavation. Reductants can be introduced in either liquid or gaseous form. When using liquid reductants, this process would be similar to soil flushing described above except that only a fraction of the Cr(VI) would be flushed to the groundwater. Much of the Cr(VI) would be reduced by contact with the reductant within the unsaturated zone. Chemical reductants such as polysulfide or thiosulfate would be favored over biological amendments such as lactate or ethanol because of the difficulty of maintaining anaerobic conditions in the unsaturated zone necessary for biological reduction.

I*n-situ* reduction using gaseous injection would also be considered. This technology involves injecting a gaseous reductant such as sulfur dioxide or methane into a network of wells. Exhibit 4-10 shows the application of a gaseous injection system at the White Sands Missile Range in New Mexico. Although gaseous reduction technology has been demonstrated at a few sites, it has not seen widespread use.

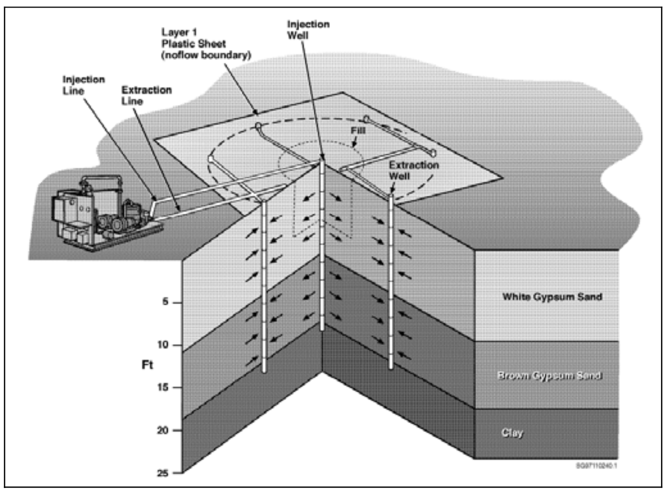


EXHIBIT 4-10
In-situ Reduction
Source: United States Department of Energy. 2000.

4.2.6 Capping in Place

Capping in place is the most common form of soil remediation. A capping system may consist of liners and covers. Liners are installed on the bottom and sides with natural and synthetic barriers to prevent liquids and waste from escaping into underlying soils. The engineered covers are installed on top to keep water from infiltrating into the materials, while maintaining a protective cover to secure the materials in place.

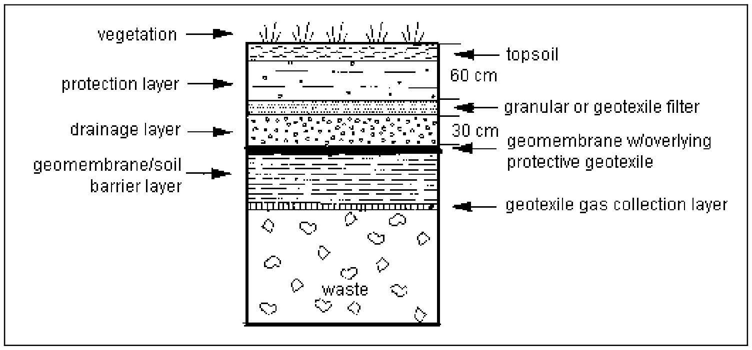


EXHIBIT 4-11
Capping in Place
Source: Federal Remediation Technology Roundtable. 2002.

As shown in Exhibit 4-11, typical cover installation includes the following procedures:

- Prior to installing an engineered cover, the surface of the area to be capped is contoured to enhance positive runoff drainage.
- The low-permeability liner is installed on top of the contaminated area.
- A layer of coarse sand or a engineered drainage layer is then placed over the liner to collect and transport the water off the surface of the cover.
- A protective soil layer is added to protect the underlying cover components and support vegetative growth.

Construction of a cap does not reduce toxicity, mobility, or volume of contaminated soil, but the cap does mitigate migration and direct exposure to surface receptors. The effective life of the capping system can be extended by long-term inspection and maintenance. In addition, precautions must be taken to ensure integrity of the cap is not compromised by further land use activities.

4.3 Treatability Studies and Other Relevant Studies

Treatability studies to collect data on technologies identified during the alternative development process are conducted, as appropriate, to provide additional information for evaluating technologies. CERCLA guidance (USEPA, 1988) focuses on investigations of treatment technologies; however, this subsection describes other relevant studies for the design and evaluation of remedial technologies.

At the PG&E Topock site, several studies have been performed or are planned to assist in the identification, screening, and evaluation of remedial technologies for soil and groundwater. These activities include:

- Extensive data collection regarding groundwater extraction, *ex-situ* groundwater treatment, and groundwater injection through implementation of interim measures.

- Groundwater, pore water, and surface water monitoring to define the extent of the elevated concentrations of chemical constituents in groundwater, geochemical characteristics of the groundwater, and variations of these parameters over time.
- Groundwater level measurements, hydraulic testing, and groundwater modeling to determine the direction and rate of groundwater movement to determine optimal locations for facilities and to estimate time required to achieve cleanup.
- Anaerobic core testing of shallow floodplain (fluvial) sediments to evaluate the capacity of anaerobic zone materials to chemically and biochemically reduce Cr(VI) to 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 survey to determine presence and depth to an impermeable base layer.
- Soil borings and soil sample analysis to characterize the aquifer permeability and flow rates.
- Soil borings and soil sample analysis to measure geotechnical properties needed to evaluate excavation techniques and to evaluate suitability of in-place materials for use in low-permeability backfill material.
- 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.

The schedule for completion of the studies is presented in Section 7.0.

5.0 Corrective/Remedial Measures Alternatives Development and Evaluation

More than one technology typically is needed to fully remediate a site due to site-specific goals and the presence of different media and COPCs. CERCLA and RCRA require that technologies be combined to develop a range of treatment and containment alternatives. Alternatives are screened against RCRA- and CERCLA-specified criteria to aid in remedy selection.

Sitewide corrective/remedial measures alternatives are developed by combining and configuring remedial technologies, with the goal of identifying a range of alternatives that will achieve the remedial action objectives through reduction of toxicity, mobility, or volume of contaminants. In addition to being effective in addressing contaminants in soil and groundwater, alternatives also must consider other site-specific constraints and regulatory requirements.

As shown in Exhibit 5-1, after a list of potentially effective remedial alternatives has been developed, the various alternatives are screened to identify those that cannot be technically implemented at the site. Alternatives that pass the initial screening are carried forward for more detailed analysis against the evaluation criteria, as described in Section 5.2.

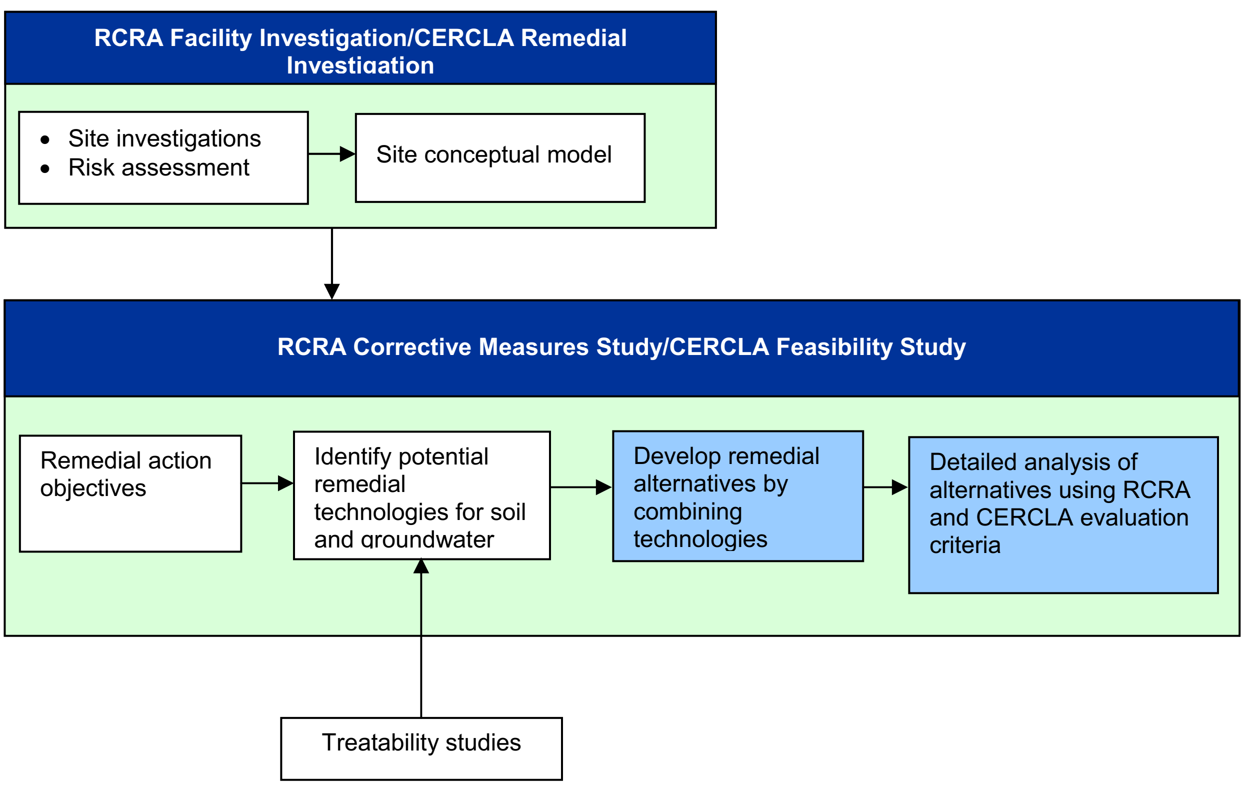


EXHIBIT 5-1
CMS/FS Process—Developing and Analyzing Remedial Alternatives

5.1 Development of Remedial Alternatives

The process by which remedial technologies are combined into site-specific remedial alternatives is described in detail in United States Environmental Protection Agency (USEPA) guidance (USEPA, 1988). Each site has unique hydrogeologic conditions and constraints that must be considered during the development of site-specific remedial alternatives.

At sites where multiple media are contaminated, combinations of remedial technologies are typically used to provide a complete remedy. Consideration must be given to the compatibility of these technologies so that the alternatives developed will be able to meet remedial action objectives for all media and contaminants of concern. For example, if soil flushing were selected as a remedy for deep soil contamination, it would be necessary to ensure that the groundwater remedy in the vicinity of the soil flushing operations was robust enough to handle the additional contaminants that would be flushed from the soil into the groundwater. Similarly, if a soil excavation remedy were selected in an area with a high density of groundwater remediation and monitoring wells, it would be necessary to ensure that the wells would be protected and continue to operate in the midst of the excavation work.

Even within a single medium, it is often necessary to combine one or more technologies to meet remedial action objectives. For example, an impermeable barrier wall functions like a subsurface dam, causing groundwater levels to build up on the upgradient side of the wall. It is typically necessary to combine a barrier wall with a groundwater pumping system to control the groundwater levels behind the wall. Groundwater pumping may also be combined with *in-situ* treatment zones or PRBs. The slow velocity of natural groundwater flow at the Topock site may not provide for flushing of contaminated groundwater through an *in-situ* treatment zone at a rate that would achieve cleanup in an acceptable amount of time. Combining an *in-situ* technology with groundwater pumping and injection could increase groundwater flow velocities through the *in-situ* treatment zone, resulting in shorter cleanup times.

5.1.1 Key Site Characteristics

There are several key characteristics of the Topock site that are expected to influence the effectiveness and implementability of corrective/remedial action alternatives:

- **Chemical Constituents:** Cr(VI) is the primary chemical of concern in groundwater. It is present above the regulatory standard for total chromium of 50 micrograms per liter in an area extending about 3,200 feet north of the Topock Compressor Station and 2,500 feet west of the Colorado River. There are, however, several other COPCs that have been identified in soil and groundwater at the site. The remedial alternatives developed in the CMS/FS will address all of the COPCs identified in the RFI/RI and risk assessment.

- **Groundwater Characteristics:** Natural groundwater moves very slowly at the Topock site; therefore, remediation technologies that rely solely on natural groundwater flow could require long time frames to achieve remedial action objectives. Groundwater flow rate can be increased or redirected by extraction or injection of water. The depth to groundwater across much of the site is relatively large, limiting the applicability of some types of groundwater remedies and drilling/construction methods.

- **Geochemical Conditions in the Colorado River Floodplain:** The aquifer materials in the vicinity of the Colorado River and floodplain exhibit natural "reducing" conditions characterized by the lack of dissolved oxygen and oxidized compounds. These reducing conditions naturally convert Cr(VI) into the relatively innocuous Cr(III), which is insoluble and is removed from groundwater by chemical precipitation.
- **Groundwater and Surface Water Uses:** The groundwater in the deeper portions of the aquifer in the vicinity of the Topock site has high levels of dissolved salts, which render it generally unusable for drinking water. Groundwater at the Topock site naturally flows north and east, toward the Colorado River, which is used for drinking water, recreation, fishing, and ecological habitat. Therefore, even though groundwater is not used for drinking at the Topock site, the remedial alternatives will need to be developed to ensure protection of the beneficial uses of the Colorado River.
- **Cultural Resources**: The study area encompasses archaeological and historic resources, including areas of important cultural and spiritual significance to a number of sovereign nations. It is anticipated that cultural resource identification will proceed in parallel with the development of the CMS/FS to ensure that cultural resources considerations are considered as part of the analysis of remedial alternatives.
- **Sensitive Habitats:** The site encompasses a portion of the Havasu National Wildlife Refuge, the proposed Beale Slough Area of Critical Environmental Concern, and the Colorado River floodplain, which contain sensitive wildlife habitat. Any actions taken must be in accord with the governing management plans and/or laws encompassing such areas.
- **Endangered Species:** Endangered species that may be present in the vicinity include the Southwest Willow Flycatcher, the Yuma Clapper Rail, and the Desert Tortoise. Construction and operation of remediation systems must avoid adverse impact to endangered species.
- **Existing Structures:** Design and construction of remedial alternatives will need to account for the existing transportation corridor including Interstate 40, the Burlington Northern Santa Fe Railroad, and natural gas transmission pipelines, as well as ongoing operations at the Topock Compressor Station.

5.1.2 Remedial Alternative Definition

Considering the key site characteristics described above, as well as the site-specific remedial objectives and remedial technologies appropriate for the site conditions, remedial alternatives will be developed for the Topock CMS/FS. Alternatives that are not compatible with site constraints or would clearly not meet remedial action objectives may be screened out early in the process.

Depending on the number of feasible alternatives and variations between alternatives, an appropriate number of alternatives will be defined for evaluation in the CMS/FS. The intent is to define a wide range of alternatives, including the "No Action" alternative. It is expected that between three and eight remedial alternatives for each media will be defined and carried forward in the alternatives evaluation. Each alternative will be defined to a sufficient level of detail to develop remedial cost estimate, in accordance with USEPA guidance (USEPA, 2000), including construction and operational and maintenance elements of each alternative.

It is expected that remedial alternatives for soil will be developed separately from remedial alternatives for groundwater, as the technologies will be different, and the location of the groundwater plume is geographically separate from the SWMUs and AOCs within and surrounding the compressor station. It is also expected that SWMUs and AOCs with similar remedial action objectives, similar COPCs, and similar site characteristics may be combined together for purposes of remedial alternative development and evaluation.

It is further expected that land use controls or other forms of institutional controls will be incorporated into the remedial alternative development. Likely, controls may include restrictions on residential or other sensitive uses, restrictions on the use of groundwater and development of water supplies, and access restrictions such as road closures or vehicular barriers.

5.2 Evaluation Criteria for Remedial Alternative

Criteria for evaluating alternatives are described in RCRA and CERCLA regulations and guidance and are summarized in Table 5-1. In the CMS/FS, the defined remedial alternatives will first be evaluated individually against the evaluation criteria then in comparison with each other.

A number of approaches to integrate and balance stakeholders values and preferences have been developed for the remediation industry in recent years. Such approaches use various techniques for comparing the benefits and costs associated with alternative remedial actions that affect the environment. The goal of the analysis is to rank these alternatives in terms of the total environmental benefits realized from their implementation (Efroymson, et al., 2004).

Available techniques will be evaluated and, if an appropriate tool is identified, it may be used to help address varied stakeholder interests at Topock by specifying metrics that capture stakeholder values to compare the effects of different remedial alternatives. For example, a metric that assesses land disturbance and visual aesthetics could be constructed. Similarly, metrics of habitat quality for sensitive habitats and endangered species could be constructed as well. Such an approach could be used to assess the trade-offs realized by each remedial alternative in terms of say, the change in levels of risk to drinking water versus the disturbance of sensitive habitats. Measuring how those metrics change over time from the implementation of each remedial alterative allows for the direct comparison of impacts across the different remedial alternatives.

TABLE 5-1
Selection Criteria under RCRA and CERCLA
Corrective Measures Study Work Plan, Topock Compressor Station

RCRA[a]	CERCLA[b]
Protect human health and the environment	Overall protection of human health and the environment
Attain media cleanup standards set by implementing agency	Compliance with ARARs
Control sources of releases	
Comply with applicable standards for management of wastes	
Long-term effectiveness and permanence	Long-term effectiveness and permanence
Reduction of toxicity, mobility, or volume through treatment	Reduction of toxicity, mobility, or volume through treatment
Short-term effectiveness	Short-term effectiveness
Implementability	Implementability
Cost	Cost
	Regulatory agency acceptance
	Community acceptance

Notes:

[a] USEPA, 1994.

[b] USEPA, 1988.

6.0 CMS/FS Report Outline

The Corrective Measures/Feasibility Study Report will present and evaluate potential remedial alternatives to address sitewide chromium management. The CMS/FS report will be prepared in accordance with the guidelines provided in the CACA for a corrective measures study (DTSC, 1996) and USEPA guidance for a feasibility study (USEPA, 1988).

The CMS/FS report will include the following elements:

- Introduction
  - Objectives of the CMS/FS
- Description of Current Conditions
  - Background information (summary of RFI/RI report, risk assessment, ARARs)
  - New information developed since the final RFI/RI report was prepared that could significantly affect the evaluation and selection of remedial alternatives
- Corrective Action/Remedial Action Objectives
  - Corrective action/remedial action objectives
  - Proposed media cleanup standards and points of compliance
- Identification and Screening of Technologies
  - Identification
  - Screening
- Development and Analysis of Corrective Measure/Remedial Action Alternatives
  - Alternatives development
  - Detailed analysis of corrective measure/remedial action alternatives
  - Comparative analysis of corrective measure/remedial action
- Recommended Corrective Measure/Remedial Action Alternative

7.0 Project Schedule

This section presents a preliminary schedule for the various tasks proposed as part of the CMS/FS. A schedule for the various tasks outlined below is provided in Figure 7-1.

Implementation of the CMS/FS tasks will follow completion of the various studies and evaluations for completion of the RFI/RI, ARARs identification, risk assessments, and treatability/pilot studies. As shown in the schedule, preparation of the groundwater CMS/FS is expected to precede preparation of the soil CMS/FS, as the current expected schedule for data collection for soil CMS/FS lag behind the current expected schedule for data collection for groundwater CMS/FS by approximately one year. As discussed previously, the remedial alternatives to be evaluated for groundwater are anticipated to be different from the alternatives to be evaluated for soil. This schedule is subject to change based on regulatory review and approvals, input from the various governmental agencies, and completion of the final RFI/RI reports.

8.0 References

California Department of Toxic Substance Control (DTSC). 1996. *Corrective Action Consent Agreement (Revised), Pacific Gas and Electric Company's Topock Compressor Station, Needles, California (EPA Identification No. CAT080011729)*. February 2.

________________. 2007a. Comments on the *RCRA Corrective Measures Study Work Plan, Pacific Gas and Electric Company, Topock Compressor Station, Needles, California*. May 15.

________________. 2007b. Comments on the *RCRA Facility Investigation Remedial Investigation – Volume 1 Site Background and History Report, Pacific Gas and Electric Company, Topock Compressor Station, Needles, California*. May 9.

CH2M HILL. 2002. *Corrective Measures Study Work Plan, Topock Compressor Station, Needles, California*. December.

________________. 2006a. *RCRA Facility Investigation/Remedial Investigation Report, PG&E Topock Compressor Station, Needles, California. Volume 1 – Site Background and History*. September.

________________. 2006b. *Pore Water and Seepage Study Report, PG&E Topock Compressor Station, Needles, California*. March.

________________. 2007a. *Well Installation Report for Slant Wells MW-52 and MW-53, PG&E Topock Compressor Station, Needles, California*. June 29.

________________. 2007b. *Groundwater Background Study, Steps 3 and 4 Results. Pacific Gas and Electric Company, Topock Compressor Station, Needles California*. January 26.

Efroymson, R.A., Nicolette, J.P., and Suter, G.W. 2004. *A Framework for Net Environmental Benefit Analysis for Remediation or Restoration of Contaminated Sites. Environmental Management*. Vol. 34, No. 3, pp. 315-331.

Federal Remediation Technology Roundtable. 2002. Remediation Technologies Screening Matrix and Reference Guide, 4th Edition. January.

United States Army Corps of Engineers. 2003. Safety and Health Aspects of Hazardous, Toxic, and Radioactive Waste (HTRW) Remediation Technologies. August.

United States Department of Energy. 2000. In Situ Gaseous Reduction System. Innovative Technology Summary Report. U.S. DOE, Office of Science and Technology. DOE/EM-0521. April.

United States Environmental Protection Agency (USEPA). 1988. *Guidance for Conducting Remedial Investigations and Feasibility Studies Under CERCLA*. Interim Final. March.

________________. 1994. *RCRA Corrective Action Plan*. Office of Waste Programs Enforcement, Office of Solid Waste. OSWER Directive 9902.3-2A. May.

________________. 1999. *Use of Monitored Natural Attenuation at Superfund, RCRA, Corrective Action, and Underground Storage Tank Sites*. April.

________________. 2000. *A Guide to Developing and Documenting Cost Estimates During the Feasibility Study*. EPA 540-R-00-002, OSWE 9355.0-075. July.

________________. 2001a. *A Citizen's Guide to Pump and Treat*. December.

________________. 2001b. *A Citizen's Guide to Permeable Reactive Barriers*. April.

Figures

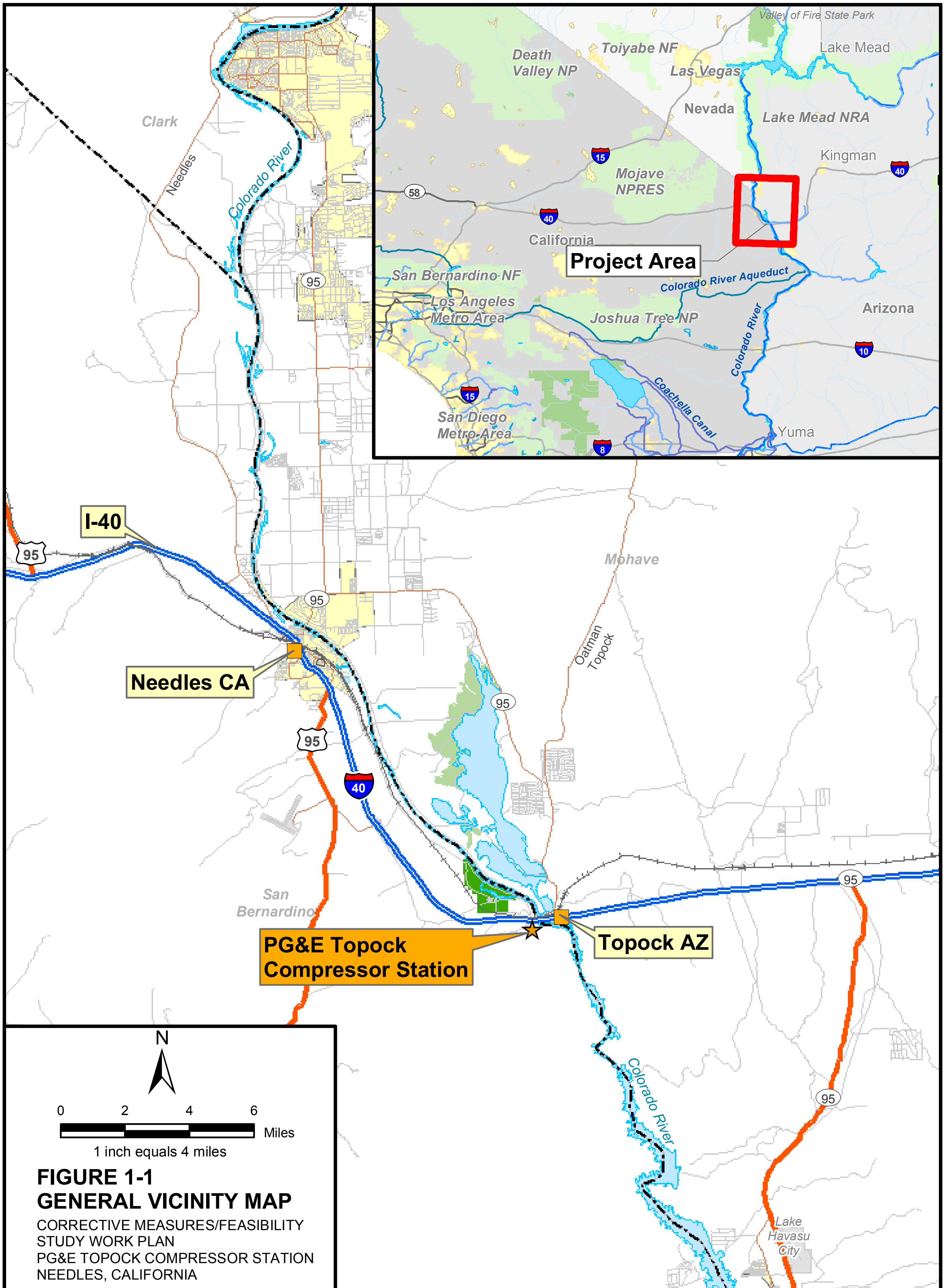


FIGURE 1-1
GENERAL VICINITY MAP

CORRECTIVE MEASURES/FEASIBILITY STUDY WORK PLAN
PG&E TOPOCK COMPRESSOR STATION
NEEDLES, CALIFORNIA

CH2MHILL

BAO \\ZINFANDEL\PROJ\PACIFICGASELECTRICCO\TOPOCKPROGRAM\GIS\MAPFILES\2007\CMFS_LOCATION_MAP_PORTRAIT.MXD
CMFS_LOCATION_MAP_PORTRAIT.PDF 6/5/2007 15:18:27

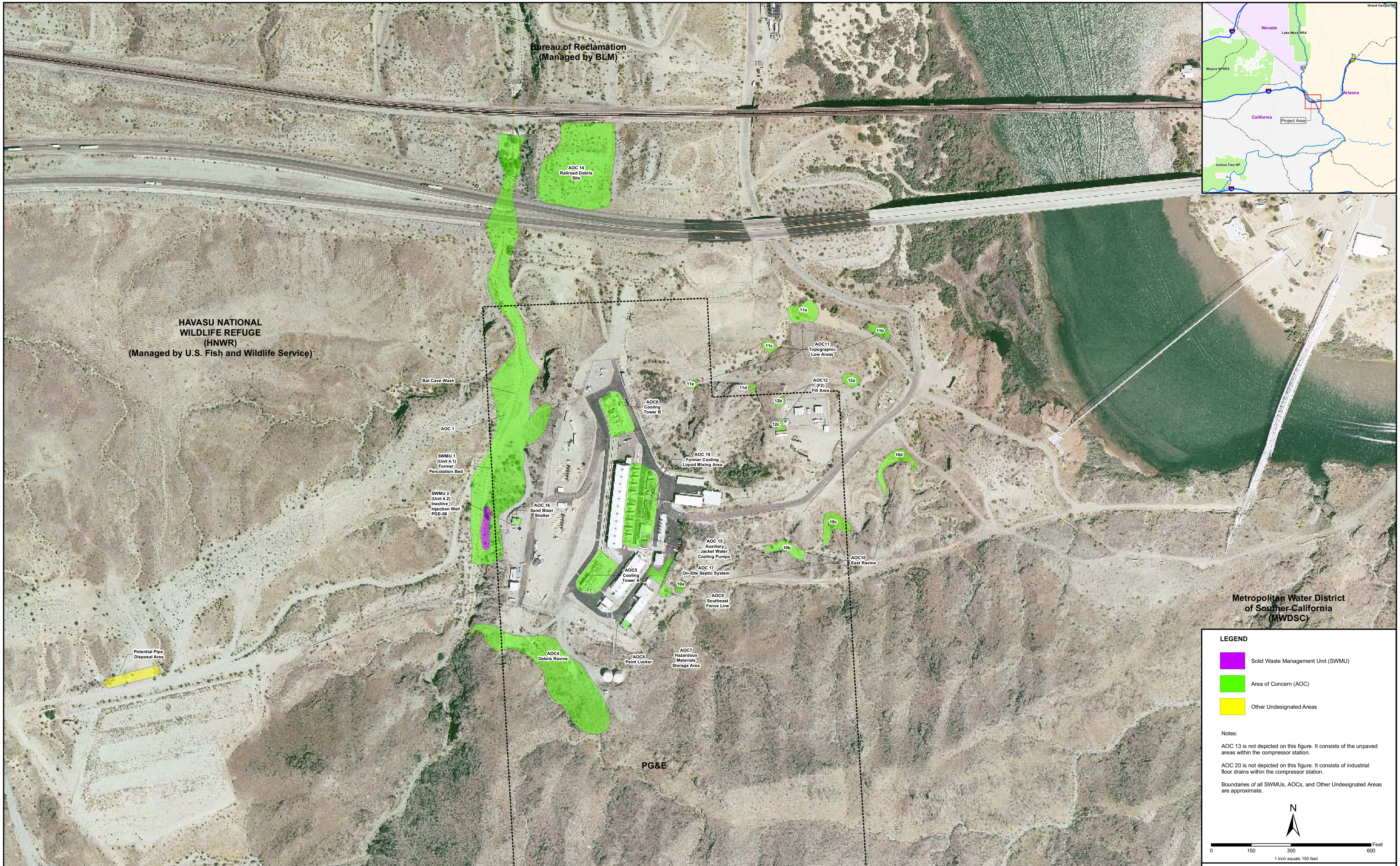
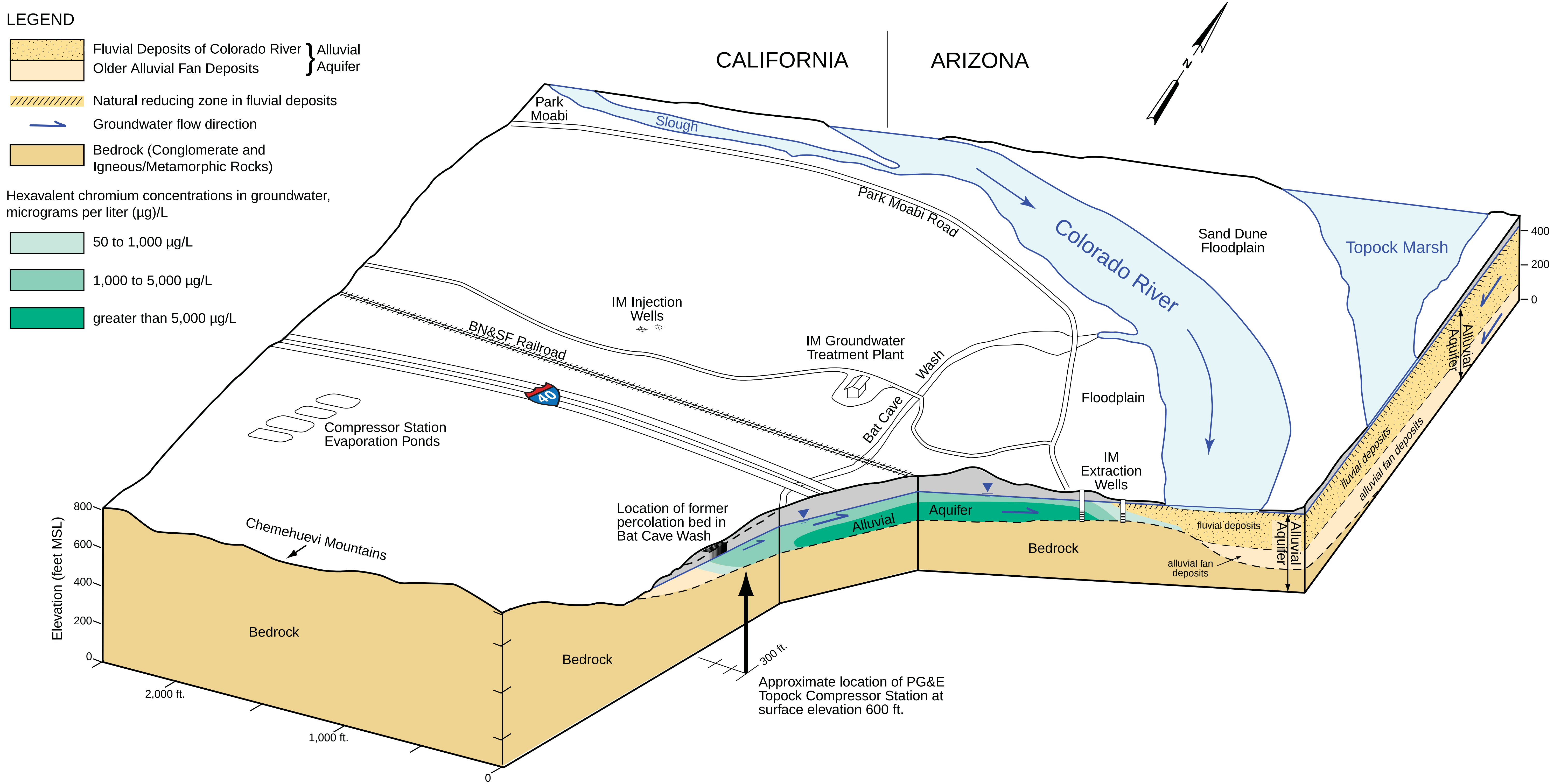


FIGURE 1-2
SOLID WASTE MANAGEMENT UNITS (SWMUS), AREAS OF CONCERN (AOCS), AND OTHER UNDESIGNATED AREAS TO BE ADDRESSED IN RFI/RI

CORRECTIVE MEASURES STUDY/
FEASIBILITY STUDY WORK PLAN
PG&E TOPOCK COMPRESSOR STATION
NEEDLES, CALIFORNIA

CH2MHILL

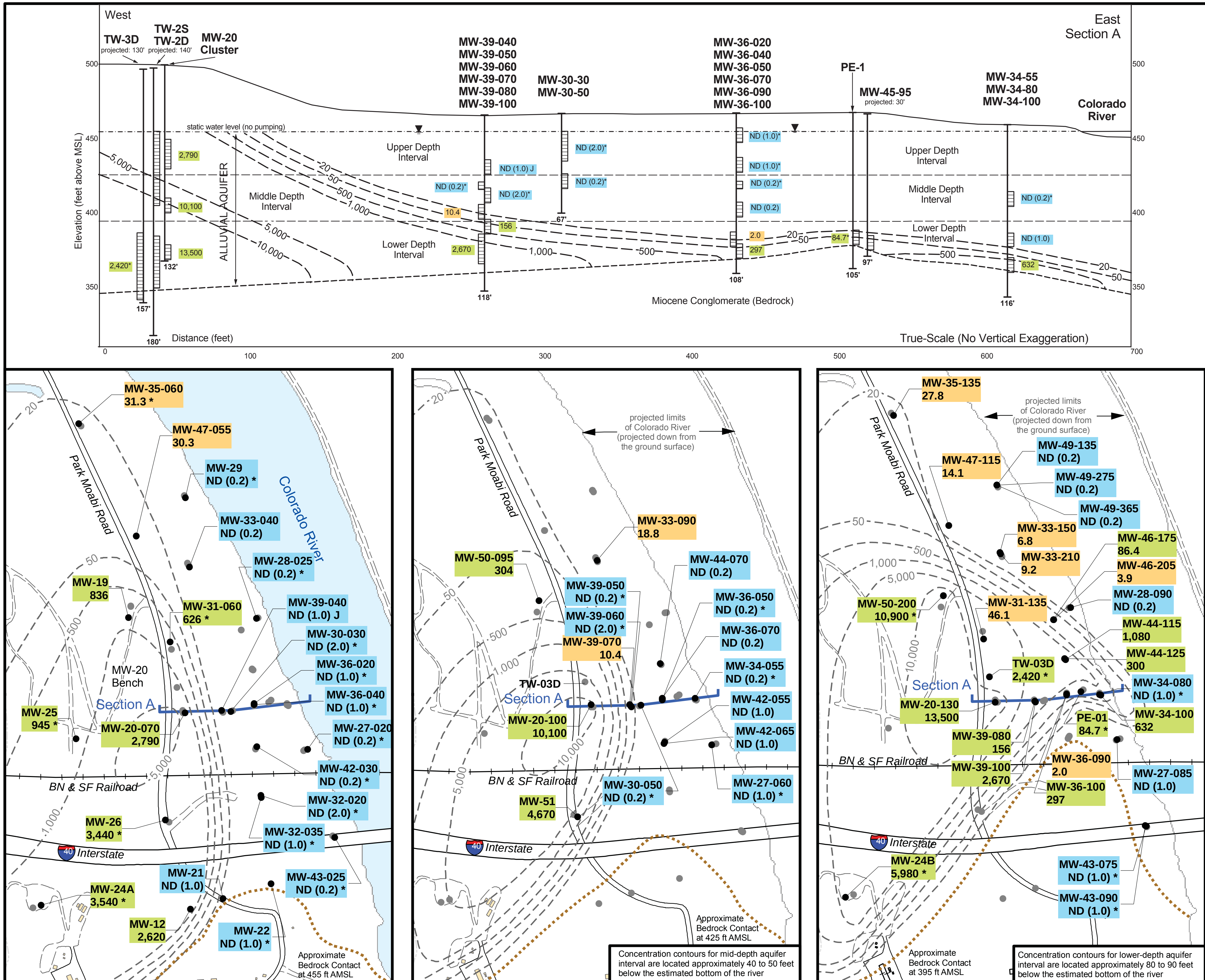
BAO \\ZINFANDEL\PROJ\PACIFICGASELECTRICCO\TOPOCKPROGRAM\GIS\MAPFILES\2007\CMSFS_SWMU_D.MXD CMSFS_SWMU_D.PDF 6/25/2007 16:48:11



SCHEMATIC DIAGRAM

FIGURE 2-1
TOPOCK SITE HYDROGEOLOGIC FEATURES
CORRECTIVE MEASURES/FEASIBILITY STUDY WORK PLAN
PG&E TOPOCK COMPRESSOR STATION
NEEDLES, CALIFORNIA

CH2MHILL



Shallow Wells (Upper Depth Interval) | Intermediate Wells (Middle Depth Interval) | Deep Wells (Lower Depth Interval)

LEGEND

Maximum Hexavalent Chromium [Cr(VI)] Concentrations in Groundwater, May 2007 Monitoring

Concentrations in micrograms per liter (µg/L) equivalent to parts per billion (ppb)

ND = Not detected at listed reporting limit
J = Concentration estimated by laboratory or data validation

Well MW-39-70 Cr(VI) results for May 2007 were rejected due to exceedence of laboratory holding time. As a result, the Cr(T) result from this event is posted. This well was resampled on June 12, 2007.

* Indicates samples from March and April 2007 or October 2006 sampling.
All other results are from the May 2007 quarterly sampling event.

Results posted are maximum concentrations from primary and duplicate samples.
See Tables B-1 and B-2 for sampling data and other results.

N 0 275 550 Feet

ND (1) Not detected at listed reporting limit (ppb)

41 Less than 50 ppb

3,810 Greater than 50 ppb

— — 50 — — Inferred Cr(VI) concentration contour within aquifer depth interval

Contours incorporate the maximum concentration from wells within each depth interval

Hydrogeologic Section A (true-scale) showing aquifer depth intervals, well screens, and Cr(VI) sampling results.

NOTES ON CONTOUR MAPS

1. The Cr(VI) contour maps for 2006-2007 performance monitoring incorporate data from new wells and water quality data trends for the floodplain area. The contour maps provide additional interpretation of plume limits and do not reflect plume migration during performance monitoring

2. The locations of the Cr(VI) contours shown for depths 80-90 feet below the Colorado River (east and southeast of well clusters MW-34) are estimated based on hydrogeologic and geochemical conditions documented in site investigations 2004-2006. The actual locations of contours beyond well control points in these areas are not certain, but are inferred using available site investigation and monitoring data (bedrock structure, hydraulic gradients, observed distribution of geochemically reducing conditions and Cr(VI) concentration gradients). There are no data confirming the existence of Cr(VI) under the Colorado River.

FIGURE 2-2
MAXIMUM CR(VI) CONCENTRATIONS IN ALLUVIAL AQUIFER, MAY 2007

CORRECTIVE MEASURES/FEASIBILITY STUDY WORK PLAN
PG&E TOPOCK COMPRESSOR STATION
NEEDLES, CALIFORNIA

CH2MHILL

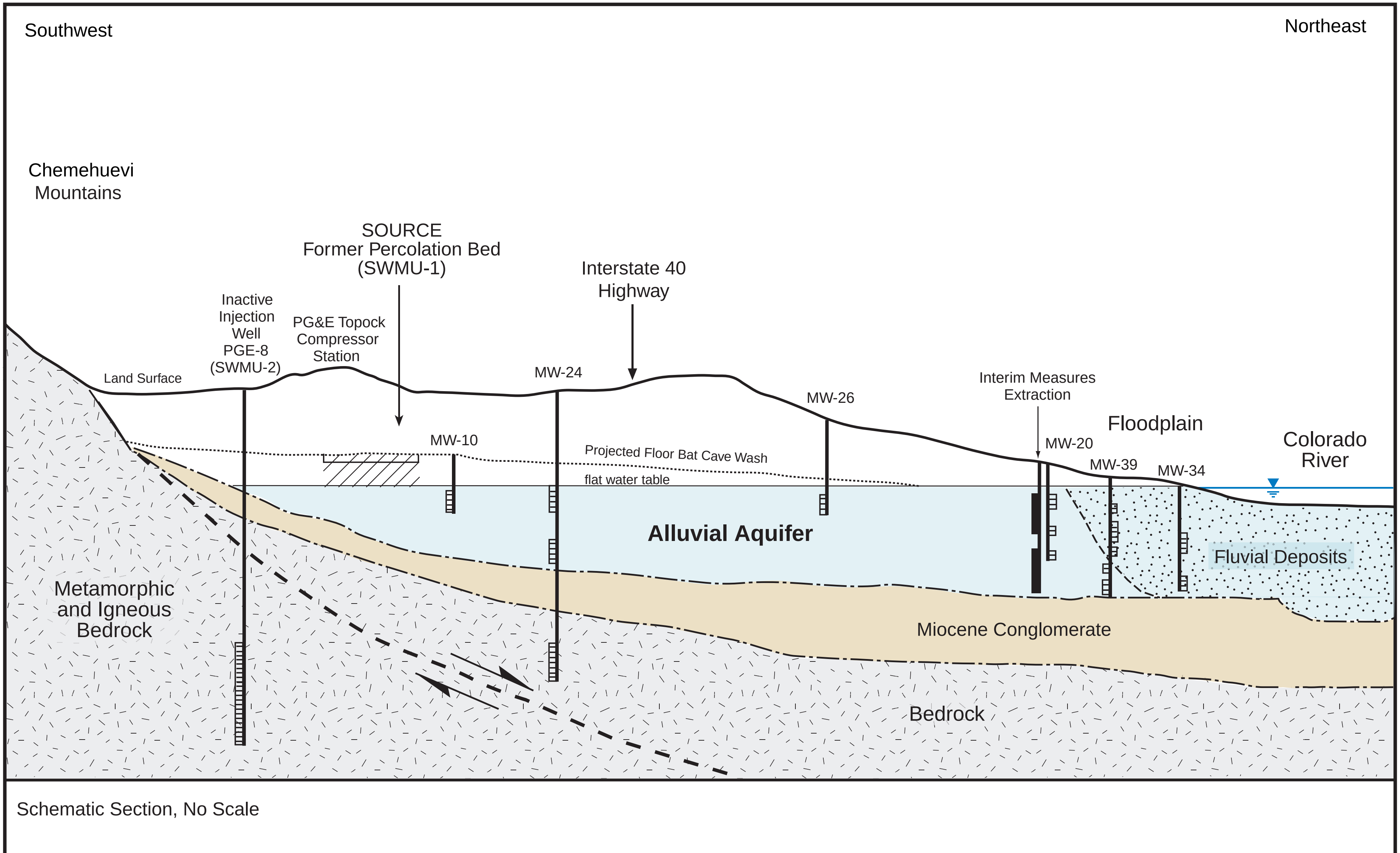


FIGURE 2-3
REGIONAL HYDROGEOLOGIC CROSS SECTION
CORRECTIVE MEASURES/FEASIBILITY STUDY WORKPLAN
PG&E TOPOCK COMPRESSOR STATION
NEEDLES, CALIFORNIA

CH2MHILL

ES092006010BAO_Fig2-3_RegionalHydro.ai 06-27-07 dash

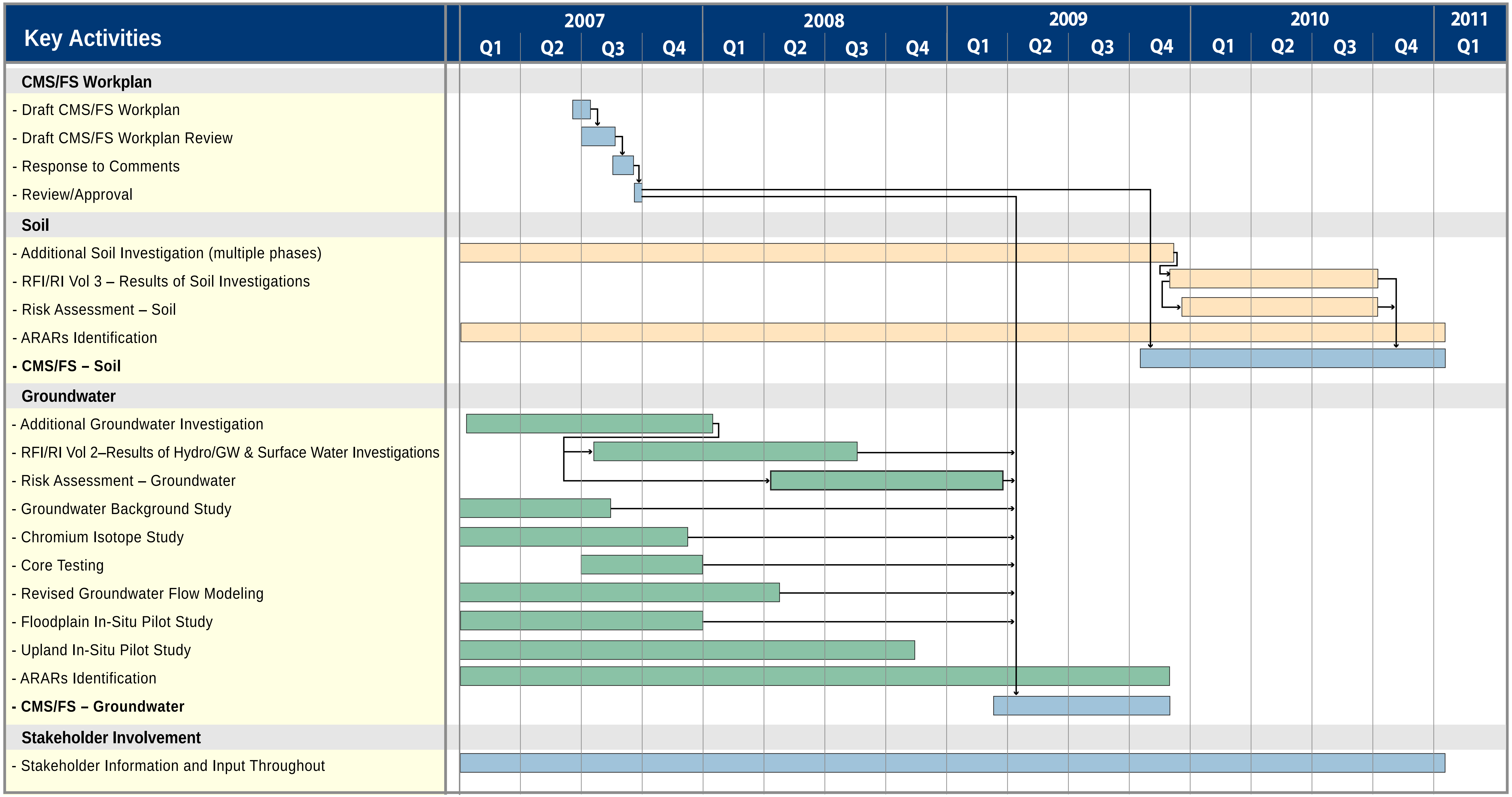


FIGURE 7-1
TOPOCK CORRECTIVE MEASURES/ FEASIBILITY STUDY SCHEDULE
PG&E TOPOCK COMPRESSOR STATION
NEEDLES, CALIFORNIA

CH2MHILL

ES092006010BAO_Fig7-1_Topock_StudySchedule_v2.ai_062207_llui