Pacific Gas and Electric Company

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November 18, 2016

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

Ms. Pamela Innis
U.S. Department of the Interior, Office of Environmental Policy and Compliance
One North Central Avenue, Suite 800
Phoenix, Arizona 85004

Subject: Supplemental and Errata Information for the Final (100%) Design for the Final Groundwater Remedy, PG&E Topock Compressor Station, Needles, California

Dear Mr. Yue and Ms. Innis:

On November 18, 2015, Pacific Gas and Electric Company (PG&E) submitted the Basis of Design Report/Final (100%) Design Submittal (100% BOD) and the companion Construction/Remedial Action Work Plan (C/RAWP) for the Final Groundwater Remedy. Collectively, these documents (including the Operation and Maintenance [O&M] Manual for the Final Groundwater Remedy that is Appendix L of the 100% BOD) are referred to as the Final Design.

Since the Final Design submittal, PG&E has conducted a number of activities related to the groundwater remedy design and continued to implement relevant mitigation measures for the groundwater remedy in the certified Environmental Impact Report (EIR). The purpose of this document is to summarize the supplemental information and errata for the November 2015 Final Design resulting from those activities.

In addition, as directed, PG&E is working on additional refinement to the updated groundwater model and will submit an addendum to the modeling report by January 9, 2017.

PG&E looks forward to the Agencies' approval of the Final Design submittal, along with this document and the forthcoming addendum to the modeling report, as it is an important milestone towards completion of site cleanup and protection of the Colorado River.

Please contact me at (805) 234-2257 if you have any questions or comments regarding this submittal.

Sincerely,

Yvonne Meeks

Yvonne Meeks
Topock Project Manager

cc: Kevin Sullivan/PG&E, Karen Baker/DTSC

Pacific Gas and Electric Company®

PG&E Topock Compressor Station
Needles, California

Supplemental and Errata Information for the Final (100%) Design for the Final Groundwater Remedy

November 2016

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ES102411163118BAO

Topock Project Executive Abstract

Document Title: *Supplemental and Errata Information for the Final (100%) Design for the Final Groundwater Remedy, PG&E Topock Compressor Station, Needles, California* Submitting Agency: DTSC, DOI Final Document? ☒ Yes ☐ No	Date of Document: 11/18/16 Who Created this Document?: (i.e. PG&E, DTSC, DOI, Other) PG&E
Priority Status: ☐ HIGH ☐ MED ☒ LOW Is this time critical? ☐ Yes ☒ No	Action Required: ☒ Information Only ☐ Review & Comment Return to: N/A By Date: N/A ☐ Other / Explain:
Type of Document: ☐ Draft ☒ Report ☐ Letter ☐ Memo ☐ 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 (RA) ☐ 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? This submittal is required for compliance with the 1996 Corrective Action Consent Agreement (CACA), the CERCLA Remedial Design/Remedial Action Consent Decree (CD), and the Corrective Measure Implementation/Remedial Design (CMI/RD) Work Plan.	Other Justification/s: ☐ Permit ☐ Other / Explain:

Brief Summary of attached document:

On November 18, 2015, PG&E submitted the Basis of Design Report/Final (100%) Design Submittal (100% BOD) and the companion Construction/Remedial Action Work Plan (C/RAWP) for the Final Groundwater Remedy to the oversight agencies – the California Department of Toxic Substances Control (DTSC) and the U.S. Department of the Interior (DOI). Collectively, these documents (including the Operation and Maintenance [O&M] Manual for the Final Groundwater Remedy that is Appendix L of the 100% BOD) are referred to herein as the Final Design.

Since the Final Design submittal, PG&E has conducted a number of activities related to the groundwater remedy design and continued to implement relevant mitigation measures for the groundwater remedy in the certified EIR (DTSC 2011). Key activities include the following:

- Updated the groundwater flow and solute transport models in accordance with DOI and DTSC's Final Design directives dated October 19, 2015. Currently conducting additional refinement to the updated groundwater model per DOI and DTSC's direction letter dated October 4, 2016.
- Continuing to obtain access agreements and permits necessary for the groundwater remedy, including but not limited to coordinating with Caltrans on the encroachment permit exception for the installation of the proposed monitoring well MW-U in the median of Interstate 40.
- Continuing to implement the mitigation measures for the groundwater remedy in the certified EIR (DTSC 2011) including conducting preliminary discussions with the operator of Moabi Regional Park on the provisions for the operator to communicate to visitors the parts of the project area that are off limits to off-road vehicle usage because of health and safety concerns, public lands management plans, or landowner requests. In addition, PG&E plans to design, develop, and

fund the installation of an informational kiosk within Moabi Regional Park that informs visitors of the work being done at the project site. Specifically, this kiosk would be located near or on an Informational Outreach Trailer proposed by PG&E to supplement outreach and project communications activities.

- Conducted additional resources surveys in support of the SEIR including a survey for biological and archaeological/historical resources in areas considered for addition to the EIR project area, as well as bat surveys. In addition; PG&E also proposed protective measures for roosting bats to avoid or minimize potential impacts from groundwater remedy activities, and conservation measures to be applied for project actions that will occur in or near potential northern Mexican gartersnake habitat near the southern end of Topock Marsh.
- Provided clarifications on the details presented in the Final Design to DTSC in support of DTSC's preparation of the Subsequent Environmental Impact Report (SEIR) for the Final Design.

The purpose of this document is to summarize the supplemental information and errata for the November 2015 Final Design resulting from the above activities.

Written by: Pacific Gas and Electric Company

Recommendations:

This document is provided for information only.

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

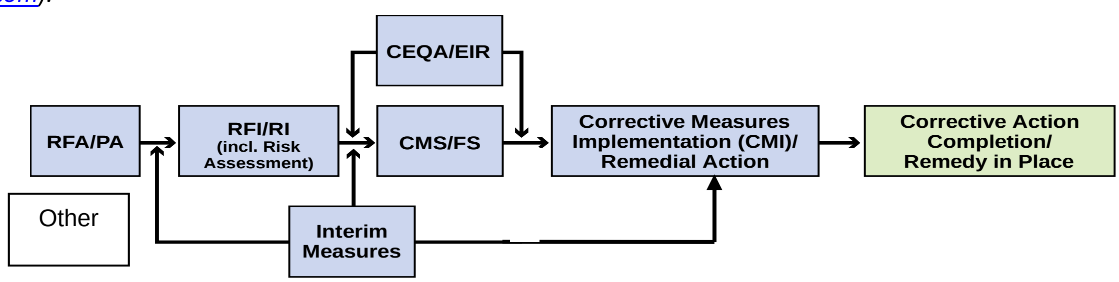
This submittal presents supplemental and errata information for the November 2015 Final (100%) Design of the selected groundwater remedy.

Other requirements of this information?

None.

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

Version 9

Report

Supplemental and Errata Information for the Final (100%) Design for the Final Groundwater Remedy

PG&E Topock Compressor Station Needles, California

Prepared for

Pacific Gas & Electric Company

November 2016

ch2m

155 Grand Avenue
Suite 800
Oakland, CA 94612

Contents

New Supplemental and Errata 100% Document Tables

Updated Text *(Located at the end of this document)*

- Updated text from the 100% Basis of Desgin (BOD)
- Updated text from the O&M Manual (Appendix L of the100% BOD)

Updated 100% BOD Table *(Located at the end of this document)*

Updated Figures *(Located at the end of this document)*

Updated 100% BOD Figures

Updated 100% BOD Appendix L, Operation and Maintenance Manual, Volume 1 Figures

Updated Construction/Remedial Action Work Plan (C/RAWP) Figures

Updated Exhibits *(Located at the end of this document)*

Updated C/RAWP Exhibit

Appendices

New and Updated 100% BOD Appendices

Acronyms and Abbreviations

AE	Applied Earthworks, Inc.
BLM	U.S. Bureau of Land Management
BOD	Basis of Design
Caltrans	California Department of Transportation
C/RAWP	Construction/Remedial Action Work Plan
CDFW	California Department of Fish and Wildlife
CHQ	Construction Headquarters
DOI	United States Department of the Interior
DTSC	California Department of Toxic Substances Control
EIR	Environmental Impact Report
I-40	Interstate 40
kWh	kilowatt-hour
O&M	operation and maintenance
PG&E	Pacific Gas and Electric Company
RTC	response to comments
SEIR	Subsequent Environmental Impact Report
TCS	Topock Compressor Station

SECTION 1

Summary of Information in This Document

Pacific Gas and Electric Company (PG&E) is implementing the selected groundwater remedy for chromium in groundwater at the PG&E Topock Compressor Station (TCS, or the Compressor Station) in San Bernardino County, California. On November 18, 2015, PG&E submitted the Basis of Design Report/Final (100%) Design Submittal (100% BOD [CH2M HILL 2015a]) and the companion Construction/Remedial Action Work Plan (C/RAWP [CH2M HILL 2015b]) for the Final Groundwater Remedy to the oversight agencies – the California Department of Toxic Substances Control (DTSC) and the U.S. Department of the Interior (DOI). Collectively, these documents (including the Operation and Maintenance [O&M] Manual for the Final Groundwater Remedy that is Appendix L of the 100% BOD) are referred to herein as the Final Design.

Since the Final Design submittal, PG&E has conducted a number of activities related to the groundwater remedy design and has continued to implement relevant mitigation measures for the groundwater remedy as listed in the certified Environmental Impact Report (EIR) (DTSC 2011). Key activities include the following:

- Updated the groundwater flow and solute transport models in accordance with DOI and DTSC's final design directives dated October 19, 2015. Currently conducting additional refinement to the updated groundwater model per DOI and DTSC's direction letter dated October 4, 2016.
- Continuing to obtain access agreements and permits necessary for the groundwater remedy, including but not limited to coordinating with the California Department of Transportation (Caltrans) on the encroachment permit exception for the installation of the proposed monitoring well MW-U in the median of Interstate 40 (I-40).
- Continuing to implement the mitigation measures for the groundwater remedy in the certified EIR (DTSC 2011), including conducting preliminary discussions with the operator of Moabi Regional Park on the provisions for the operator to communicate to visitors the parts of the project area that are off limits to off-road vehicle usage because of health and safety concerns, public lands management plans, or landowner requests. In addition, PG&E plans to design, develop, and fund the installation of an informational kiosk within Moabi Regional Park that informs visitors of the work being done at the project site. Specifically, this kiosk would be located near or on an Informational Outreach Trailer proposed by PG&E to supplement outreach and project communications activities.
- Conducted additional resources surveys including a survey for biological and archaeological/historical resources in areas considered for addition to the EIR project area, as well as bat surveys. In addition, PG&E also proposed protective measures for roosting bats to avoid or minimize potential impacts from groundwater remedy activities, and conservation measures to be applied for project actions that will occur in or near potential northern Mexican gartersnake habitat near the southern end of Topock Marsh.
- Provided clarifications on the details presented in the Final Design to DTSC in support of DTSC's preparation of the Subsequent Environmental Impact Report (SEIR) for the Final Design.

The purpose of this document is to summarize the supplemental or errata information for the Final Design resulting from the above activities for the administrative record (see Table 1-1). Where applicable, updates of relevant text, tables, figures, and exhibits from the 100% BOD, O&M Manual, and C/RAWP are summarized in Table 1-2 and also provided at the end of this document.

TABLE 1-1
Summary of Supplemental/Errata Information Included in this Document
Supplemental and Errata Submittal for the Final (100%) Basis of Design and Construction/Remedial Action Work Plan for the Final Groundwater Remedy
PG&E Topock Compressor Station, Needles, California

Activities Conducted Since Final Design	Summary of Relevant Information Provided in the Final Design (November 2015)	Summary of Supplemental/Errata Information Provided in this Document (Submitted November 18, 2016)
1. Updating groundwater flow and solute transport models	• Appendix B of the 100% BOD included documentation of the groundwater flow, solute transport, and geochemical models (collectively referred to as the groundwater model) constructed to support the Final Design. On October 19, 2015, DOI and DTSC (collectively referred to as "the Agencies") directed PG&E to make certain revisions to the groundwater model and the calibration, and to document/present the updates and recalibration to the Agencies.	• On February 29, 2016 and in compliance with the Agencies' October 19, 2015 directives, PG&E submitted to the Agencies a report titled *Development of Groundwater Flow and Solute Transport Models* (ARCADIS 2016) that documents the required model updates and calibration. A summary of the model update was presented at the March 16, 2016 Technical Working Group (TWG) meeting. The report has been added to **BOD Appendix B** at the end of this document. • After they evaluated the February 29, 2016 groundwater model revisions and considered the inputs received from interested stakeholders and Tribal groups, the Agencies issued a joint direction letter dated October 4, 2016 that requires PG&E to complete further refinement to the model prior to Final Design approval. In response to the October 4, 2016 direction letter, PG&E plans to submit an addendum to the February 2016 groundwater model update report on January 9, 2017.
2. Coordinating with Caltrans on the installation of proposed MW-U in the median of I-40	• Well MW-U is proposed to be installed in I-40 median.	• During its ongoing evaluation of PG&E's permit exception application for MW-U, Caltrans provided initial feedback that the proposed well would need to be relocated about 330 feet to the east to avoid impacts from a potential future Caltrans project in the I-40 median. Therefore, well MW-U's location was corrected to reflect this input in pertinent BOD and C/RAWP figures (see Table 1-2 below and revised **BOD Figure ES-4A and 3.6-1; O&M Manual Volume 1 Figure 2.1-1; and C/RAWP Figures 3.1-1, 3.2-1, and 4.1-2** at the end of this document for additional details). • At Caltrans' request, PG&E also conducted a desktop assessment of archaeological/historical resources for MW-U. On August 16, 2016, PG&E submitted a report entitled *Topock Compressor Station Groundwater Remediation Project - Archaeological and Historical Resources Assessment of Proposed Monitoring Well MW-U* (AE 2016a) to Caltrans. The report is included at the end of **BOD Appendix A15** at the end of this document.
3. Coordinating with Moabi Regional Park operator on the location and logistics of a temporary Information Outreach Trailer	• Not applicable.	• In accordance with Environmental Impact Report (DTSC 2011) measure CUL-1a-3c, PG&E has conducted preliminary discussions with the operator of Moabi Regional Park on the provisions for the operator to communicate to visitors the parts of the project area that are off limits to off-road vehicle usage because of health and safety concerns, public lands management plans, or landowner requests. In addition, PG&E plans to design, develop, and fund the installation of an informational kiosk within Moabi Regional Park that informs visitors of the work being done at the project site. Specifically, this kiosk would be located near or on an Informational Outreach Trailer proposed by PG&E to supplement outreach and project communications activities. This trailer will be located in the RV parking area just north and west of the intersection of Park Moabi Road and National Trails Highway (see **C/RAWP Figures 3.1-2, 4.2-1, and 4.2-3** at the end of this document). This trailer, comprising offices, bathroom, kitchenette, and conference room, will serve as meeting space for interested stakeholders and/or visitors to gather information about project activities and to meet with project personnel. It is anticipated that the trailer will be staffed for regular drop-in office hours and by

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Activities Conducted Since Final Design	Summary of Relevant Information Provided in the Final Design (November 2015)	Summary of Supplemental/Errata Information Provided in this Document (Submitted November 18, 2016)
		appointment, as project needs dictate. This meeting space may also supplement project needs such as project meetings, staff orientation, and trainings. The trailer location is currently an improved gravel parking lot and has ready access to utility hook-ups so that minimal site preparation activities will be needed to facilitate placement of the trailer. Nearby parking and Americans with Disabilities Act compliant access to the trailer are anticipated. While the trailer is anticipated to support increased stakeholder and/or visitor interest at the onset of construction activities, it is not anticipated to serve as a permanent facility.
4. Conducted additional resources surveys and evaluation	• Not applicable.	• On August 26, 2016, PG&E submitted a technical memorandum entitled *Assessment of Biological Resources for Additional Potential Environmental Impact Areas: Final Groundwater Remedy, Topock Compressor Station, California* (CH2M HILL 2016) that summarizes results from the May 24-25 and July 7-8, 2016 biological resources surveys (non-protocol floristic, mature plans, ethnobotanical plants, jurisdictional waters, and non-protocol desert tortoise) of the additional areas considered for the EIR Project Area. This memorandum is included as **BOD Appendix A13** at the end of this document. • **BOD Appendix A14** includes four documents related to survey of bat species and proposed protective measures for special-status bat species and bat maternity roosts: – A report entitled *Bat Surveys of the Topock Compressor Station Soil Investigation and Groundwater Remediation Project Areas, San Bernardino County, California* (P.E. Brown and W.E. Rainey 2015) assessed the potential for special-status bat species roosting and foraging in the project area. – A report entitled *Topock Compressor Station Summer Roosting Bat Surveys and Potential Project Impacts, Final Report* (H. T. Harvey and Associates 2015) summarized survey results and identified bat roost locations during a period from July 20 through 28, 2015 and on the night of September 25, 2015. The report also supports future appropriate mitigation measures to avoid or minimize potential impacts that would be associated with groundwater remedy activities. – A report entitled *Topock Compressor Station Spring 2016 Roosting Bat Surveys Report* (H. T. Harvey and Associates 2016) summarized survey results for the spring 2016 bat roost surveys and includes the locations of roosts found through previous surveys to provide a comprehensive coverage of the roost survey results through the spring of 2016. – A letter from Dr. Dave Johnston of H.T. Harvey and Associates to Ms. Marjorie Eisert of CH2M HILL dated June 27, 2016, that outlines recommended protective measures to avoid and minimize the potential impacts of groundwater remediation activities on special-status bat species and bat maternity roosts.

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		– In addition, **BOD Appendices A13 and A14** include a memorandum (to the file) dated November 17, 2016 that documents minor updates to the additional biological survey for additional potential environmental impact areas technical memorandum and the four bat documents, respectively. • **BOD Appendix A15** contains a chronology of surveys/assessment and reporting of archaeological and historical resources since the Final Design. • **BOD Appendix A16** consists of PG&E's assessment of proposed project activities' effects on the northern Mexican gartersnake (*Thamnophis eques megalops*) along with information on the regulatory status, natural history, distribution, abundance and habitat of the species, as well as proposed conservation measures.
5. Provided clarifications on the Final Design in support of DTSC's preparation of the Subsequent Environmental Impact Report	• After the discovery of a maternity colony of bats in the BNSF Railway overcrossing at National Trails Highway, PG&E evaluated the proximity of the colony to the Soil Processing Area as depicted in Drawing C-15-05 (100% BOD, Appendix D2). During the evaluation, it was realized that this drawing had not been updated to reflect the design that was presented during the 90% Design Response to Comment (RTC) process. • It was also realized that the V-ditch located along the east-southeast fenceline of the Construction Headquarter (CHQ), as depicted in Drawing C-15-08 (100% BOD, Appendix D2), had encroached into the nearby slope. It was determined that the V-ditch can be moved to flat ground to avoid cutting into the slope. • Other items that were identified as needing corrections include: – Drawing C-07-02 (100% BOD, Appendix D2) was found to be missing Pipeline P (pipeline from conditioned water tank to TCS wastewater discharge tank) and to have an incorrect T1 call-out. – Table D1-24 (aboveground non-emergency equipment sound level info) (100% BOD, Appendix D1) incorrectly referenced the Capstone microturbine and omitted some equipment/ footnotes. The missing equipment were pumps and an air compressor associated with the	• **Drawing C-15-05** (Drawings were presented in the 100% BOD, Appendix D2) and the associated **BOD Figure ES-4B, C/RAWP Figures 3.1-2 and 4.2-1**, and photo simulation in **C/RAWP Figure 4.2-2B** were corrected to reflect the design presented during the 90% RTC process. The driveway into the Soil Processing Area was also straightened for simplicity and to make the vehicle pathway further from the bat roosting location in the BNSF Railway overcrossing at National Trails Highway. See Table 1-2 and revised drawing/figures (at the end of the document) for additional details. • **Drawings C-15-01 through 05, C-15-08, E-15-03, and F-15-01** (and the associated **BOD Figure ES-14 and C/RAWP Figure 4.2-2**) were corrected to move the V-ditch (and fenceline) away from the slope. See Table 1-2 and revised drawing/figure (at the end of the document) for additional details. • **Drawing C-07-02** was corrected to add Pipeline P and show the correct T1 call-out. See revised drawing (at the end of the document). • **Table D1-24** (100% BOD, Appendix D1) was corrected to remove the reference to the Capstone microturbine and add the Cummins GGMC reciprocating internal combustion engine (RICE). Also added missing equipment/footnotes. See revised table and attachment (at the end of the document). • Caltrans provided initial feedback that the proposed well MW-U would need to be relocated about 330 feet to the east to avoid impacts from a potential future Caltrans project in the I-40 median. Therefore, well MW-U location was corrected to reflect Caltrans' input in select BOD and C/RAWP figures. See Table 1-2 and revised figures (at the end of the document) for additional details. • Well MW-FF location was also corrected in select BOD and C/RAWP figures. See Table 1-2 and revised figures (at the end of the document) for additional details. • Certain details in the access route figures in the **BOD (Figures 3.5-9A and B)**, **O&M Manual (Figures 7.4-1A and B)**, and **C/RAWP (Figure 4.2-3)** were corrected for consistency with the figure legend by changing the color of the access route. Also an access route was added to the temporary Informational Outreach trailer. In addition, temporary access for use during construction only was added for certain

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	Remedy-produced Water Conditioning System (included in Table D1-19 but not Table D1-24). – Well MW-U was proposed to be installed in I-40 median. MW-U needs to be moved per Caltrans' initial feedback. – MW-FF was incorrectly mapped in relevant figures of the BOD and C/RAWP. – Certain details in the access route figures in the BOD and C/RAWP are not consistent with the figure legend. – BOD Figure 2.4-5A was inadvertently mapped with California Department of Fish and Wildlife (CDFW) jurisdictional area shown in Arizona. – BOD Table ES-1 and C/RAWP Exhibit 3.1-1 showed incorrect quantities of piping/conduits and missed the quantity of underground trenches that contain the piping/conduits. – BOD Section 3.5.1 and O&M Plan (Volume 1 of O&M Manual) Section 2.4 showed the annual electricity consumption that is inconsistent with Drawing E-00-34. – It was realized that construction of the electrical node 02 (transformer and electrical panels) located between IRZ-32 and IRZ-33 along National Trails Highway would require the disruption and replacement of existing stormwater control features. In addition, the proposed location is also in close proximity to a Transwestern gas pipeline.	monitoring wells in the floodplain. See Table 1-2 and revised figures (at the end of the document) for additional details. • **BOD Figure 2.4-5A** was corrected to remove the CDFW jurisdictional area shown in Arizona. See revised figure (at the end of the document). • **BOD Table ES-1** was revised to show correct quantities of piping/conduits and added the quantity of underground trenches (that contain the piping/conduits). See revised table (at the end of the document). • **BOD Section 3.5.1 and O&M Plan (Volume 1 of O&M Manual) Section 2.4** were updated to show the correct annual electricity consumption. See revised text (at the end of the document). • To avoid disruption of existing stormwater control features and to make it safer for construction, the electrical node was moved approximately 100 feet east along an existing access dirt road (see **BOD Figure ES-4A**). At this location, the electrical node will also be less visible from National Trails Highway.

TABLE 1-2
Summary of Updated Tables, Figures, Exhibits, and Plans in this Document
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PG&E Topock Compressor Station, Needles, California

Final Design Document	Item Number	New or Updated?	Description of New or Updated Items
Tables			
BOD	ES-1	Updated	This table was revised to correct the quantity of fluid piping and conduits, and add the quantity of below-ground trenches that would contain the piping/conduits.
Figures			
BOD	ES-4A	Updated	This figure was updated to correct the locations of well MW-U (per Caltrans' initial feedback as part of its ongoing evaluation of PG&E's permit exception application) and well MW-FF, as well as to reflect the revised location for electrical node 02 (transformer and electrical panel).
BOD	ES-4B	Updated	This figure was updated to show the following: • A design of the Soil Processing Area (located west of Moabi Regional Park) as presented during the 90% RTC process • A straightened driveway into the Soil Processing Area – this was done for simplicity and to make the vehicle pathway further from the bat roosting location in the BNSF Railway overcrossing at National Trails Highway • A V-ditch (and fenceline) that does not cut into the slope located on the east-southeast of the Construction Headquarters (CHQ).
BOD	2.4-5A	Updated	This figure was updated to remove the CDFW jurisdictional area previously shown in Arizona.
BOD	3.6-1	Updated	Same changes as BOD Figure ES-4A.
BOD	3.5-9A, 3.5-9B	Updated	These figures were updated as follows: 1. Made the entrance curved into the CHQ instead of going straight south. 2. Corrected the color of select portions of access routes for consistency with the figure legend. 3. Added access to the temporary Informational Outreach trailer at Moabi Regional Park (to be located in the RV parking area just north and west of the intersection of Park Moabi Road and National Trails Highway). 4. Added temporary access for use during construction only for certain monitoring wells located in the floodplain (MW-A, MW-B, MW-C, MW-D, MW-H, and MW-O). The color blue is used to denote a "temporary access for use during construction only." 5. Corrected the color of the access to MW-Y from light green to blue. 6. Removed two magenta-colored "Existing Access Route" lines from two respective surface water sampling locations (SW-1 and SW-2) because these are not vehicle access routes.
BOD	ES-14	Updated	This figure was updated to show a V-ditch (and fenceline) that does not cut into the slope located on the east-southeast of the CHQ.
O&M Manual Volume 1	2.1-1	Updated	Same changes as BOD Figure ES-4A.
O&M Manual Volume 1	7.4-1A, 7.4-1B	Updated	Same changes as BOD Figures 3.5-9A and 3.5-9B.

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Final Design Document	Item Number	New or Updated?	Description of New or Updated Items
C/RAWP	3.1-1	Updated	Same changes as BOD Figure ES-4A.
C/RAWP	3.1-2	Updated	Same changes as BOD Figure ES-4B. In addition, the location of a temporary Information Outreach Trailer is also shown in the RV parking area just north and west of the intersection of Park Moabi Road and National Trails Highway.
C/RAWP	3.2-1	Updated	Same changes as BOD Figures ES-4A and 3.6-1.
C/RAWP	3.3-1	Updated	This figure was corrected to add Pipeline P (pipeline from conditioned water tank to TCS wastewater discharge tank) and show the correct T1 call-out.
C/RAWP	4.1-2	Updated	Same changes as BOD Figure ES-4A and C/RAWP Figure 3.1-1.
C/RAWP	4.2-1	Updated	Same changes as C/RAWP Figure 3.1-2.
C/RAWP	4.2-2	Updated	Same changes in BOD Figure ES-14.
C/RAWP	4.2-2B	Updated	This visualization was updated to show the following: • A design of the Soil Processing Area (located west of Moabi Regional Park) as presented during the 90% RTC process, and • A straightened driveway into the Soil Processing Area – this was done for simplicity and to make the vehicle pathway further from the bat roosting location in the BNSF Railway overcrossing at National Trails Highway.
C/RAWP	4.2-3	Updated	Same changes as BOD Figures 3.5-9A and 3.5-9B. Also added an access route to the temporary Information Outreach Trailer located in the RV parking area just north and west of the intersection of Park Moabi Road and National Trails Highway.
Exhibits			
C/RAWP	3.1-1	Updated	Same changes as BOD Table ES-1.
Plans (BOD Appendices D1 and D2)			
Appendix D2, Part 1	Table D1-24	Updated	This table was updated to remove the reference to the Capstone microturbine and added the Cummins reciprocating internal combustion engine (RICE) electrical generator. Also added omitted equipment and footnotes, as well as a sound datasheet from Cummins.
Appendix D2, Part 2	C-07-02	Updated	This drawing was updated to add Pipeline P and show the correct T1 call-out.
Appendix D2, Part 2	C-15-05	Updated	This drawing was corrected to reflect the design presented during the 90% RTC process, and to straighten the driveway into the Soil Processing Area for simplicity and to make the vehicle pathway further from the bat roosting location in the BNSF Railway overcrossing at National Trails Highway.

TABLE 1-2
Summary of Updated Tables, Figures, Exhibits, and Plans in this Document
Supplemental and Errata Submittal for the Final (100%) Basis of Design and Construction/Remedial Action Work Plan for the Final Groundwater Remedy
PG&E Topock Compressor Station, Needles, California

Final Design Document	Item Number	New or Updated?	Description of New or Updated Items
Appendix D2, Part 2	C-15-01 through 04, C-15-08, E-15-03, and F-15-01	Updated	These drawings were corrected to move the V-ditch (and fenceline) away from the slope located east-southeast of the CHQ.

Notes:

BOD = *Basis of Design Report/Final (100%) Design Submittal for the Final Groundwater Remedy* (CH2M HILL 2015a)
C/RAWP = *Construction/Remedial Action Work Plan for the Final Groundwater Remedy* (CH2M HILL 2015b)
O&M Manual = *Operation and Maintenance Manual Final (100%) Design Submittal for the Final Groundwater Remedy* (Appendix L of the BOD document)

SECTION 2
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_______.2016. Subject: Agency Directives on Topock Groundwater Remediation Project Model Revisions. Letter from Aaron Yue/DTSC and Pamela Innis/DOI to Yvonne Meeks/PG&E. October 4.

Updated Text

Updated text for the:

- Basis of Design Report/Final (100%) Design Submittal for the Final Groundwater Remedy (100% BOD)
- O&M Manual (Appendix L of the100% BOD)

Updated Text for the 100% BOD (shown in red font)

3.5.1 Electrical Power Supply and Distribution

It is estimated that the groundwater remedy facilities in California could require up to ~~4.3~~5.1 million kilowatt-hours (KWh) of electricity annually (see Appendix D, drawing E-00-~~34~~33 for electrical load details). The primary power supply source for the remedy facilities in California will be power generated by the PG&E Topock Compressor Station. Two new natural gas engine-driven generators with associated switchgear and auxiliary systems will be installed in the existing Auxiliary Building, which houses the existing generators and generator switchgear. This location was selected due to its close proximity to the existing generators and the remedy system. A new power supply conduit will run underground from the electrical switchgear inside the Auxiliary Building to a connection point outside the nearby Remedy-produced Water Conditioning Building (see Figure 3.5-1). The existing switchgear in the existing Auxiliary Building will be replaced/enhanced with new switchgear to enable full integration with the existing equipment and increase power reliability for the remediation facilities. To free up the space for the new generators to be installed inside the Auxiliary Building, the existing air compressors will be consolidated with the existing air dryer in a new Air Compressor Building, located just to the east of their current location. This new air compressor location is preferred by the Compressor Station staff for ease of operation and maintenance of both the power and the compressed air systems.

Secondary power supply can be power generated from small photovoltaic solar panels at the workshop building and parking shade structure at Moabi Regional Park, and at select remote well locations. In addition, a portable, rental backup generator of similar make and model of the existing generator (Isuzu Model 6WG1X) will be mobilized onsite as needed during project implementation to provide power. A connection panel is included in the final design (see Appendix D, Drawing E-00-51, Detail 4) and space has been reserved for the portable rental generator (see Figure 3.5-1).

The power supply for the new agitator and pumps at the TCS evaporation ponds (see Exhibit 3.4-2) (0.020 million kWh per annum) will be a new natural gas-fueled reciprocating internal combustion engine (RICE) electrical power generator housed in a new enclosed utility building located within the TCS evaporation ponds fence line. Auxiliary equipment planned for installation at the TCS evaporation ponds (e.g., lighting, controls, sensors, security cameras, and valve actuators) will be supplied with 24-volt direct current power by new thermoelectric generators installed in a secure fenced area adjacent to the new utility building. A transfer switch will provide for the flexibility of supplying power to the auxiliary equipment from the RICE.

For the freshwater supply well (HNWR-1A) in Arizona, the power supply source will be power directly provided by Mohave Electric Cooperative (1.4 million kWh per annum).

For the Moabi Regional Park facilities, the primary power supply would be provided by the City of Needles with backup power via an on-site diesel generator. The electrical load is estimated to be 1.3 million kWh annually during remedy construction and 0.85 million kWh during remedy operation.

Updated Text for the O&M Manual (shown in red font)

2.4 Power Supply and Distribution

At the final design stage, it is estimated that the groundwater remedy facilities in California could require up to ~~4.3~~5.1 million kilowatt-hours of electricity annually (see Appendix A, drawing E-00-33 for energy usage calculations). The primary power supply source for the remedy facilities in California will be power generated by the PG&E Topock Compressor Station. For the freshwater supply well (HNWR-1A) in Arizona, the power supply source will be power provided by Mohave Electric Cooperative (1.4 million kWh per annum). Secondary power supply can be generated from small photovoltaic solar panels at the workshop building and parking shade structure at Moabi Regional Park, and at select remote well locations. In addition, a portable, rental backup generator of similar make and model of the existing generator (Isuzu Model 6WG1X) will be mobilized onsite as needed during project implementation to provide power. The power supply for planned improvements at the TCS evaporation ponds and for the Moabi Regional Park facilities are discussed in Sections 2.7 and 2.8, respectively. An uninterruptible power supply (UPS) is also provided for key equipment such as control systems.

Updated 100% BOD Table

TABLE ES-1 **FOR BREVITY, ONLY REVISED PORTIONS OF TABLE SHOWN HERE; REVISED INFORMATION SHOWN IN RED**

Summary of Engineering Design Parameters and Key Remedy Features

Groundwater Remedy Basis of Design Report/ Final (100%) Design

PG&E Topock Compressor Station, Needles, California

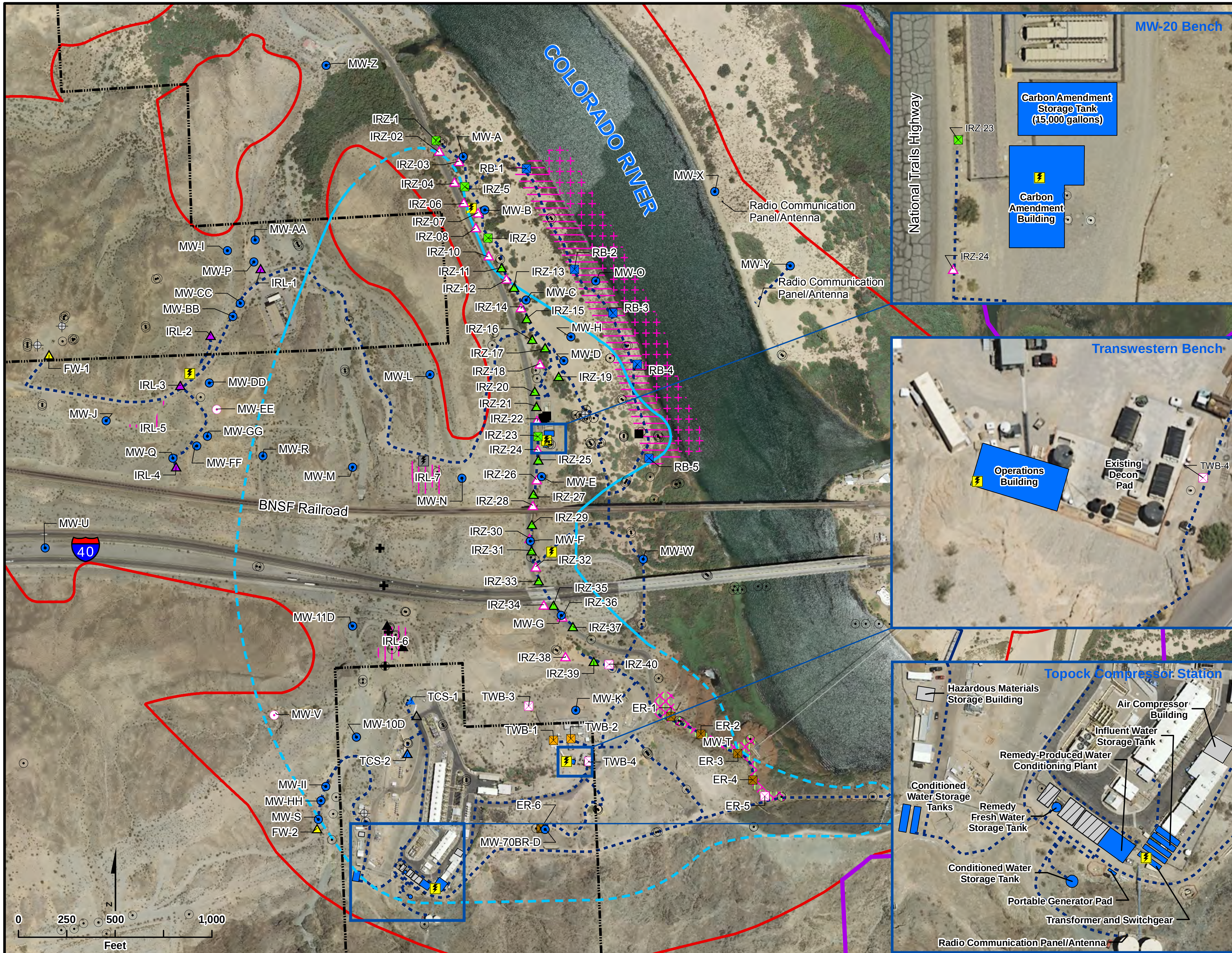
Remedy Feature	Design Parameters/Quantity	Location
Piping corridor (water pipes, electrical conduits, fibers, etc.)	• Approximately ~~121,700~~ 127,500 feet (ft) of ~~water/liquid/utility pipes~~ fluid piping, and approximately ~~97,000~~ 124,000 ft of ~~electrical~~ conduits ~~and cables~~. Most of ~~conveyance pipes/~~ the fluid piping and conduits will be belowground, in approximately 43,200 linear feet of trenches.	See Figure ES-4A and 4D for general piping layout.

Updated Figures

Updated figures for the:

- Basis of Design Report/Final (100%) Design Submittal for the Final Groundwater Remedy (100% BOD)
- O&M Manual (Appendix L of the 100% BOD)
- Construction/Remedial Action Work Plan for the Final Groundwater Remedy

Updated 100% BOD Figures



LEGEND

- Property Boundaries
- Area of Potential Effects (APE)
- EIR Project Area

Existing Wells:
- Extraction Well
- Injection Well
- Monitoring Well
- Water Supply Well

Provisional Wells:
(Items in Pink are Provisional)
- Extraction Well
- Injection Well
- Monitoring Well
- Area for East Ravine (ER) Well (ER-7 to ER-11)
- Area for Potential Slant Well Screens
- Area for Inner Recirculation Loop (IRL) Wells
- Area for River Bank Extraction Wells

Planned Wells:
- Extraction, East Ravine
- Extraction, National Trails Highway (NTH) In-situ Reactive Zone (IRZ)
- Extraction, Riverbank
- Extraction, Transwestern Bench
- Injection, Freshwater
- Injection, Inner Recirculation Loop
- Injection, NTH IRZ
- Injection, Topock Compressor Station
- Remedy Monitoring Well
- Recirculation Well
- Area for Monitoring Well MW-T

Pipeline Corridor for Remedy
- Aboveground Pipe
- Underground Pipe/Conduit

Remedy Facilities
- Planned Transformer
- Future Provisional Transformer
- Proposed Remedy Structure
- Contingent Freshwater Pre-injection Treatment System
- New Compressor Station buildings (not part of Remedy)
- Approximate extent of hexavalent chromium [Cr(VI)] concentrations exceeding 32 micrograms per liter (µg/L) at any depth ingroundwater based on fourth quarter 2013 sampling events. Dashed where based on limited data.

Note:
1. Note that in compliance with EIR mitigation measure CUL-1a-9, as well as PA and CHPMP mitigation measures, the pipeline along the dirt road west of National Trails Hwy is located in an existing, previously disturbed, access road. In addition, the location of the road and pipeline was field verified and does not create any direct physical impact or effect on the Topock Maze, as it is manifested archaeologically, in compliance with EIR mitigation measure CUL-1a-10, PA, and CHPMP mitigation measures.
2. All well and structure locations are approximate.

FIGURE ES-4A
GENERAL REMEDY SYSTEM LAYOUT - CALIFORNIA
GROUNDWATER REMEDY BASIS OF DESIGN REPORT FINAL (100%) DESIGN
PG&E TOPOCK COMPRESSOR STATION, NEEDLES, CALIFORNIA

CH2MHILL

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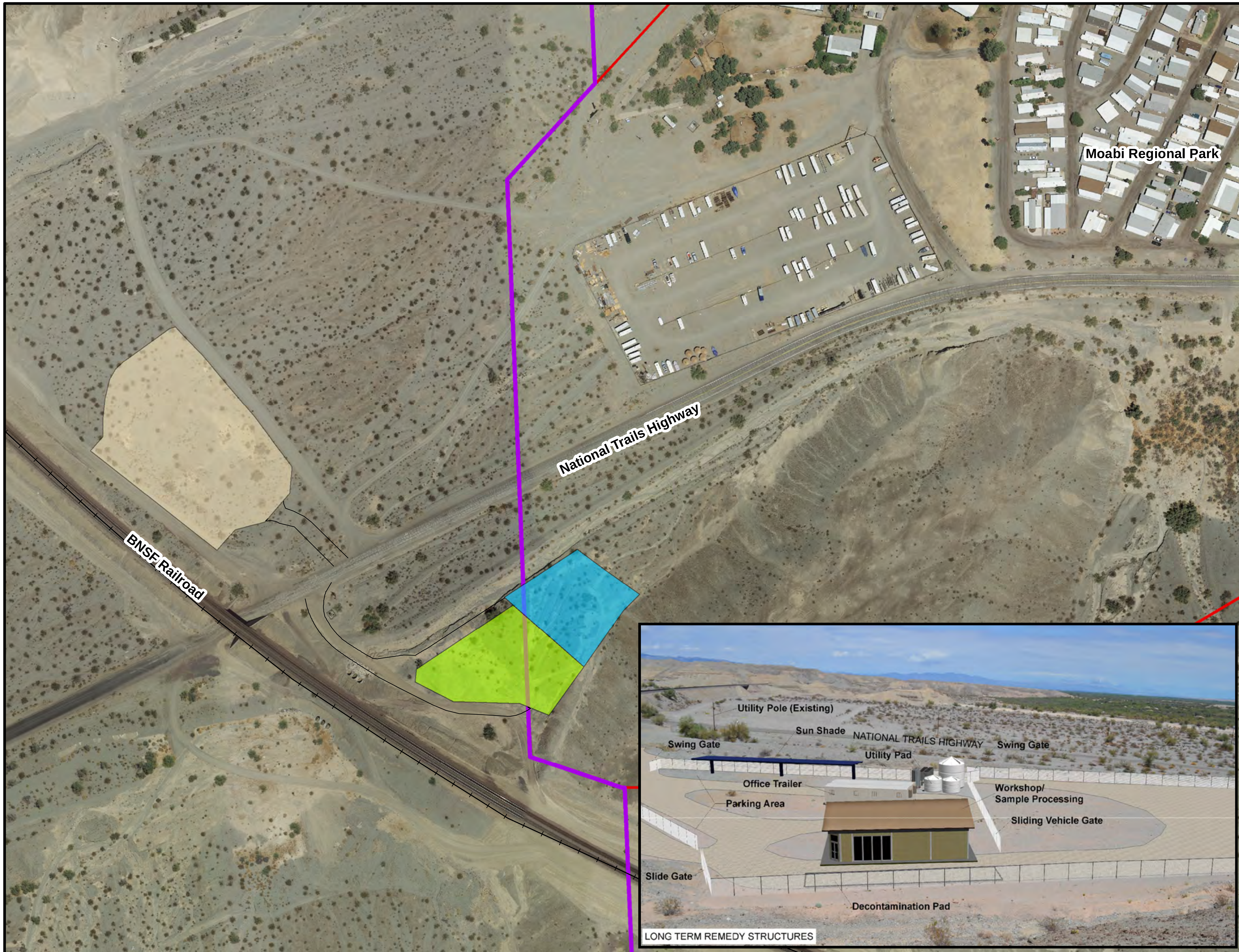
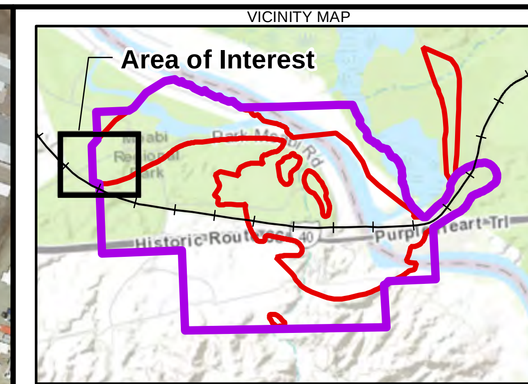


VICINITY MAP



LEGEND

- Soil Processing Area (2.56 Acres Approximate)
- Temporary Construction Laydown Area (1.05 Acres Approximate)
- Longterm Remedy Support Area (0.8 Acres Approximate)
- Area of Potential Effects (APE)
- EIR Project Area

Notes:
1. Descriptions of activities/functions anticipated for the construction support areas are included in the Construction/Remedial Action Work Plan.
2. Descriptions of activities/functions anticipated for the long-term remedy support areas are included in Section 3.5 of the BOD, and Section 2.8 of the O&M Plan (Volume 1 of the O&M Manual)

N

0 90 180 360 Feet

Service Layer Credits: Sources: Esri, HERE, DeLorme, Intermap, increment P Corp., GEBCO, USGS, FAO, NPS, NRCAN, GeoBase, IGN, Kadaster NL, Ordnance Survey, Esri Japan, METI, Esri China (Hong Kong), swisstopo, MapmyIndia, © OpenStreetMap contributors, and the GIS

FIGURE ES-4B
GENERAL REMEDY SYSTEM LAYOUT - MOABI REGIONAL PARK

GROUNDWATER REMEDY BASIS OF DESIGN REPORT
FINAL (100%) DESIGN, PG&E TOPOCK COMPRESSOR STATION,
NEEDLES, CALIFORNIA

CH2MHILL

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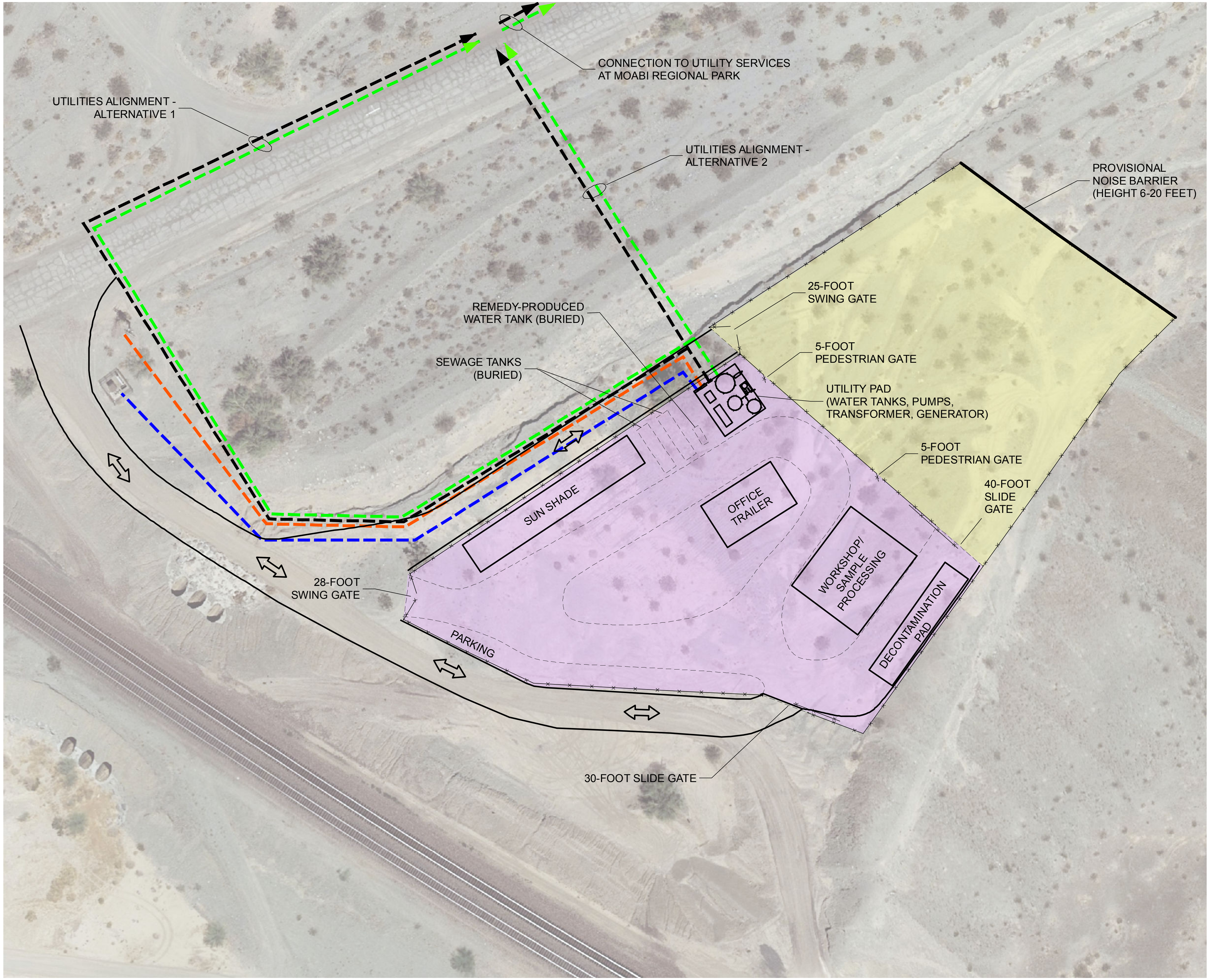

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Legend

- Future Potential Fire Water Connections
- Future Potential Sanitary Sewer Connections
- Future Potential Water Connection
- Anticipated Electrical and Telecom Connection*
- Fenceline
- Temporary Construction Laydown Area (1.05 acres approx.)
- Long Term Remedy Support Area (0.8 acres approx.)

Notes:

1. All remedy structure locations are approximate. Only long-term remedy support area structures/ features are shown on this figure.
2. Descriptions of activities/functions anticipated for the construction support areas are included in the Construction/Remedial Action Work Plan.
3. Descriptions of activities/functions anticipated for the long-term remedy support areas are included in Section 3.5 of the BOD and the O&M Manual.
4. Temporary storage/conex boxes (not shown) may be used within the fenced Construction Headquarters.

* Final locations will be determined by Needles

N

0 60 120 180

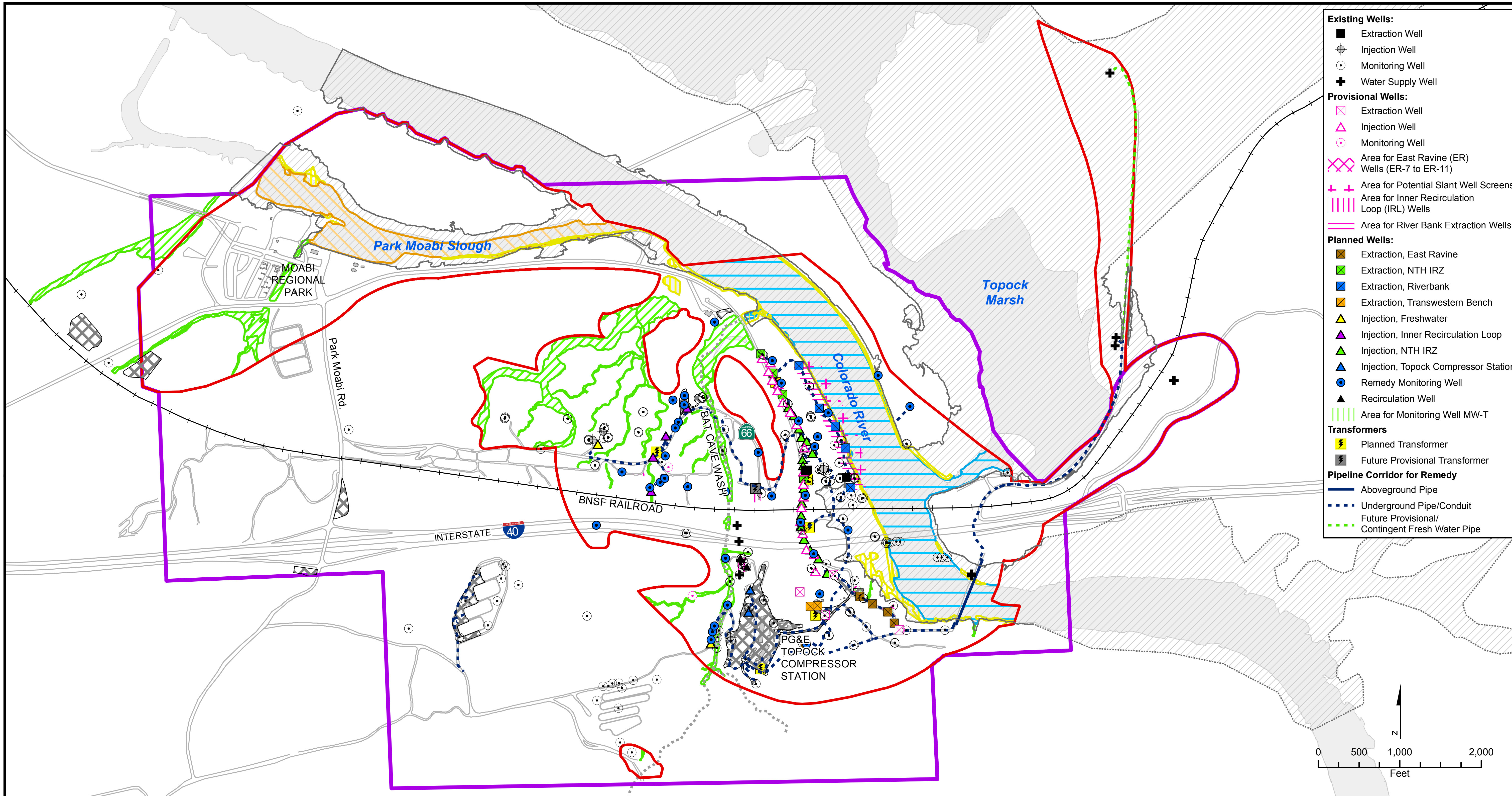
1 " = 60 '

GROUNDWATER REMEDY BASIS OF DESIGN REPORT
FINAL (100%) DESIGN
PG&E TOPOCK COMPRESSOR STATION
NEEDLES, CALIFORNIA

DETAILED LAYOUT OF THE CONSTRUCTION HEADQUARTERS AND LONG-TERM REMEDY SUPPORT AREA – MOABI REGIONAL PARK

ARCADIS Design & Consultancy for natural and built assets

FIGURE
ES-14



LEGEND

- Compressor Station Fence Line
- Area of Potential Effects (APE)
- EIR Project Area
- Moabi Regional Park Facilites
- 100yr. Floodplain*

CDFW Jurisdiction Areas

- CDFW Ephemeral Stream
- CDFW Riparian
- Colorado River
- Park Moabi Slough

Notes:

1. 100-year Floodplain/Floodway Elevation on California side of the Colorado River is 463.9NAVD (FEMA San Bernardino County, CA, Colorado River, Table 11, Effective 8/28/2008), and on the Arizona side of the Colorado River is 465.3NAVD (FEMA Mohave County, AZ, Colorado River, Table 10, Effective 8/28/2008).

* Where the 100-year flood limit is dashed, this information is taken from the Flood Insurance Rate Map (FIRM) found on the Federal Emergency Management Agency (FEMA) website at http://www.msc.fema.gov. Map ID 04015C5650H and 04015C5675H, February 20, 2013.

2. Note that in compliance with EIR mitigation measure CUL-1a-9 as well as PA and CHPMP mitigation measures, the pipeline along the dirt road west of National Trails Highway is located in an existing, previously disturbed, access road. In addition, the location of the road and the pipeline was field verified and does not create any direct physical impact or effect on the Topock Maze, as it is manifested archaeologically, in compliance with EIR mitigation measure CUL-1a-10 and PA and CHPMP mitigation measures.

FIGURE 2.4-5A
JURISDICTIONAL WATERS OF THE STATE AND WETLANDS IN PROJECT AREA
GROUNDWATER REMEDY BASIS OF DESIGN REPORT
FINAL (100%) DESIGN
PG&E TOPOCK COMPRESSOR STATION,
NEEDLES, CALIFORNIA

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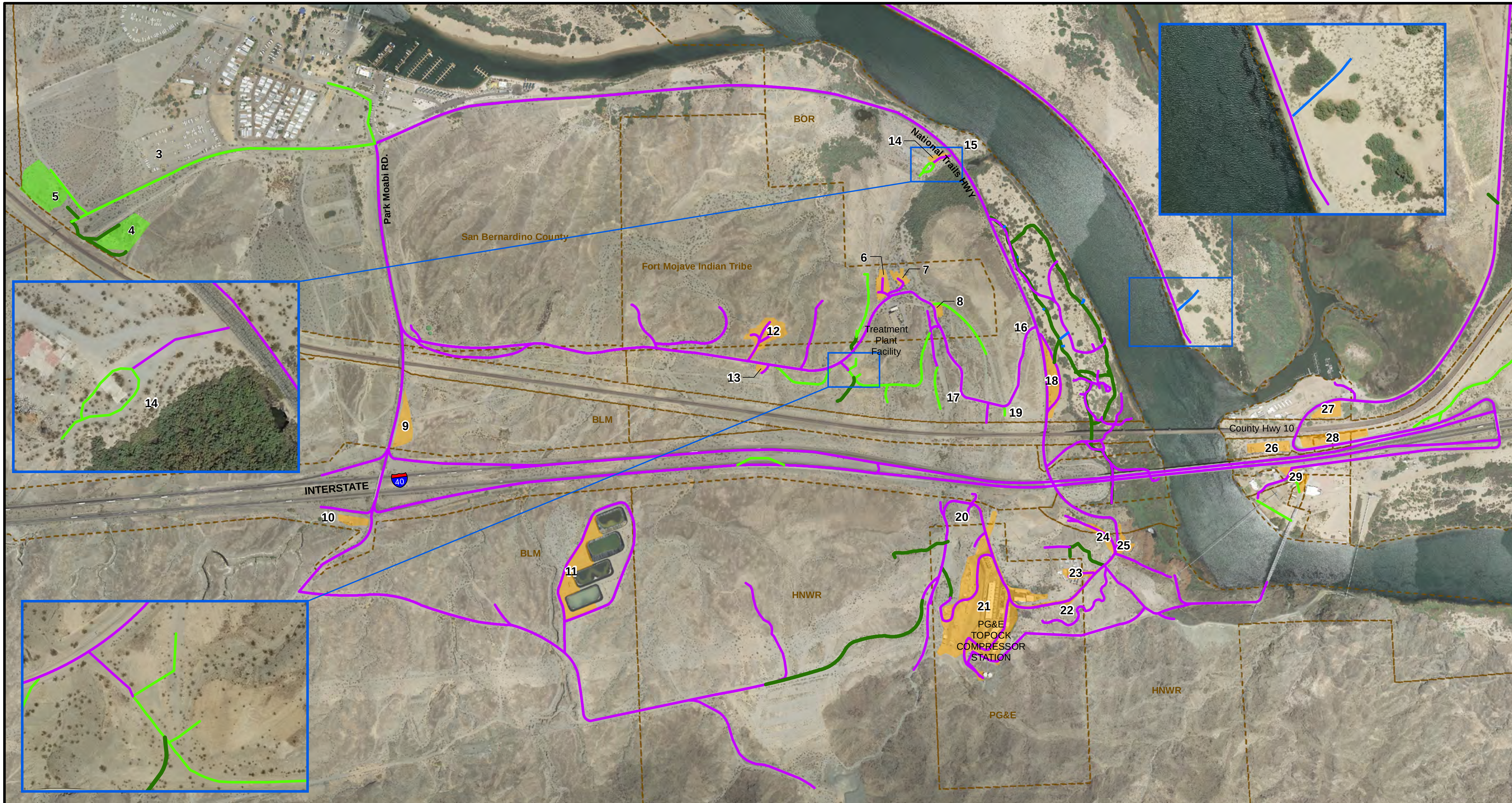

LEGEND

- Existing Access Route (will continue to be used for remedial activities)
- Existing Route (proposed to be used as is for access to remedial activities)
- Roads to be improved or constructed for groundwater remedy
- Temporary Construction Access
- Proposed Staging Areas for Remediation Project
- Proposed Soil Processing (Area #5) and Construction Headquarter (Area #4) for Remediation Project

Notes:

1. Area #3 will not be used as the Construction Headquarter (CHQ). The CHQ will be moved to Area #4.
2. Area #4 will be used as the primary truck inspection area. Areas #9, 18, and 23 or other staging areas might also be used depending on the specific construction activity.
3. Decontamination pads will be located in Area #4 (Construction Headquarters), Area #21 (Topock Compressor Station), and Area #23 (Transwestern Bench).
4. Areas #15, 16, 17, 19, and 20 will not be used as staging areas. Areas #16, 17, and 19 may be part of the primary work zones for remedy infrastructure along the access road.
5. Area #20 may be part of the primary work zone for installation of future provisional well IRL-6 (if determined to be needed in the future) and associated piping/concrete/vault.
6. Public roadways outside of the EIR project area and the APE can also be used for remedy implementation.

N

0 900

Feet

FIGURE 3.5-9A
PROPOSED ACCESS ROUTES FOR REMEDY FEATURES - CALIFORNIA

GROUNDWATER REMEDY BASIS OF DESIGN REPORT
FINAL (100%) DESIGN
PG&E TOPOCK COMPRESSOR STATION,
NEEDLES, CALIFORNIA

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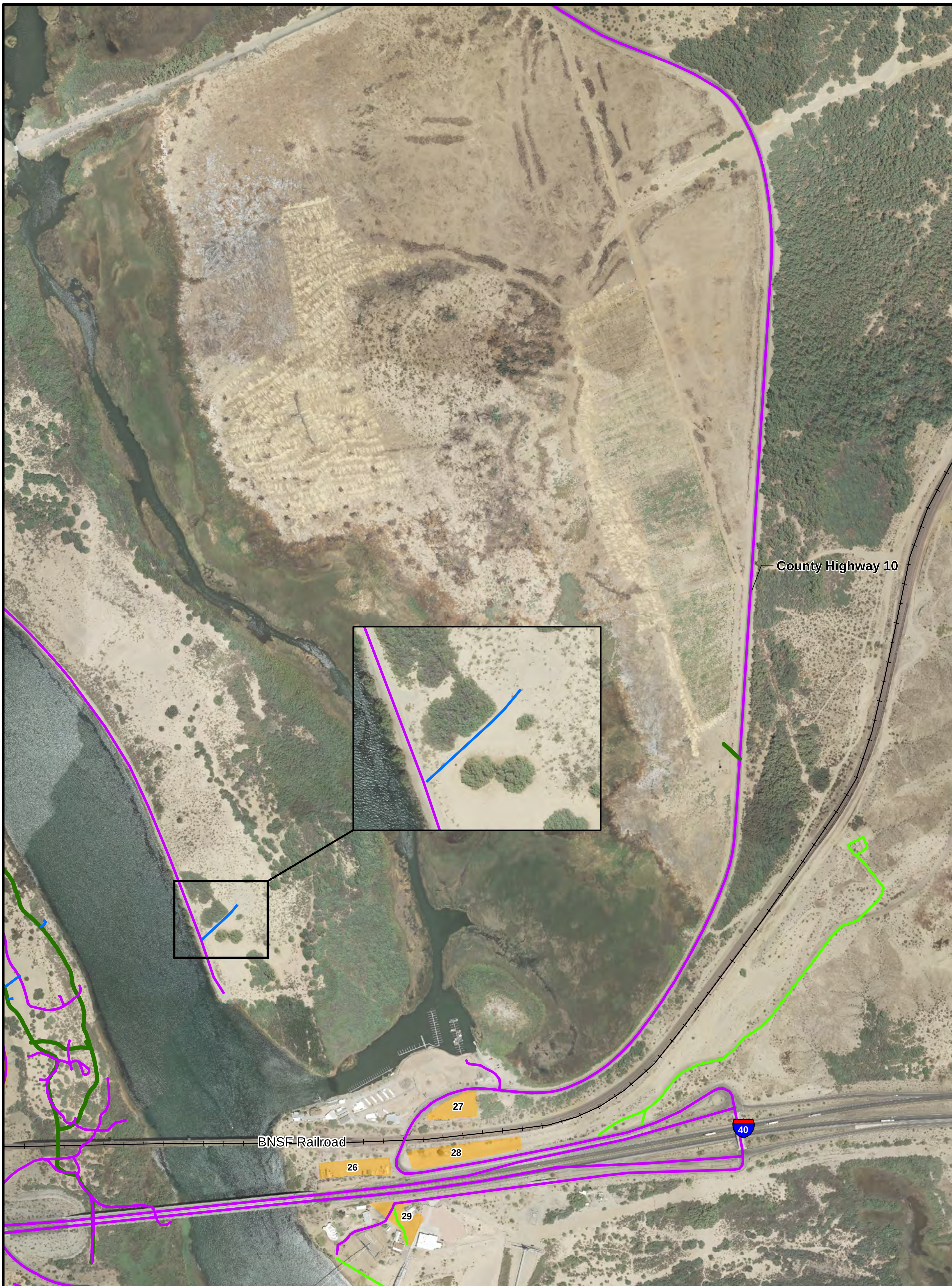
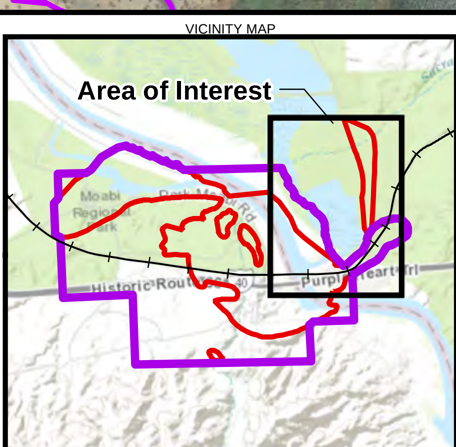


VICINITY MAP



LEGEND

- Existing Access Route (will continue to be used for remedial activities)
- Existing Route (proposed to be used as is for access to remedial activities)
- Roads to be improved or constructed for groundwater remedy
- Temporary Construction Access
- Proposed Staging Areas for Remediation Project (see Table 3.5-1 for a description of proposed use for staging areas)

N

0 200 400 800 Feet

Notes:
1. Locations for access routes are approximate.
2. Public roadways outside of the EIR project area and the APE can also be used for remedy implementation.

Service Layer Credits: Sources: Esri, HERE, DeLorme, Intermap, increment P Corp., GEBCO, USGS, FAO, NPS, NRCAN, GeoBase, IGN, Kadaster NL, Ordnance Survey, Esri Japan, METI, Esri China (Hong Kong), swisstopo, MapmyIndia, © OpenStreetMap contributors, and the GIS User Community

FIGURE 3.5-9B
PROPOSED ACCESS ROUTES FOR REMEDY FEATURES - ARIZONA
GROUNDWATER REMEDY BASIS OF DESIGN REPORT
FINAL (100%) DESIGN
PG&E TOPOCK COMPRESSOR STATION
NEEDLES, CALIFORNIA

CH2MHILL

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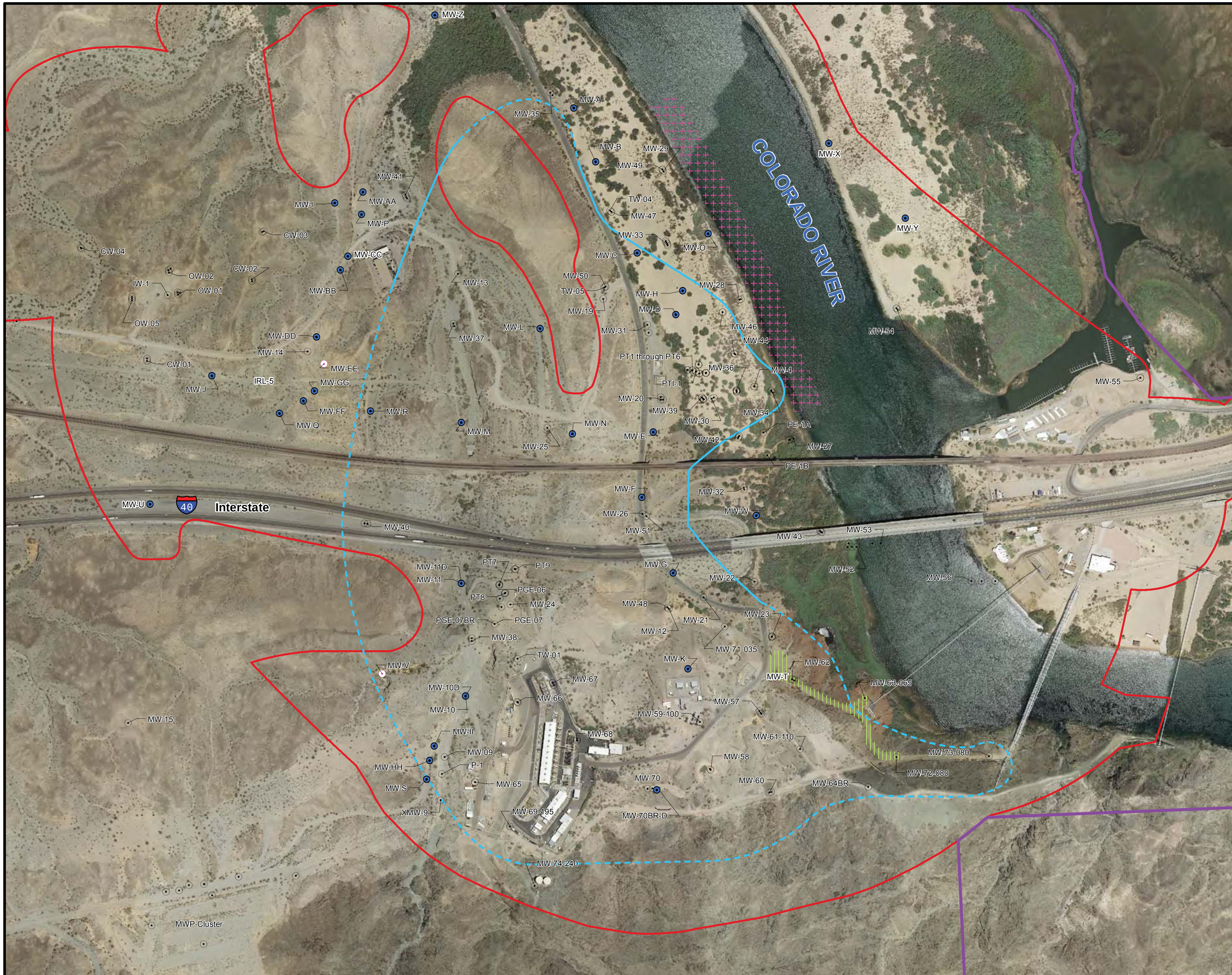


LEGEND

- Area of Potential Effects (APE)
- EIR Project Area

Existing Wells:

- Monitoring Well

Provisional Wells:

- Monitoring Well
- Area for Potential Slant Well Screens

Planned Wells:

- Remedy Monitoring Well
- Area for Monitoring Well MW-T
- Approximate extent of hexavalent chromium [Cr(VI)] concentrations exceeding 32 micrograms per liter (µg/L) at any depth in groundwater based on fourth quarter 2013 sampling events. Dashed where based on limited data.

Monitoring Objectives Summary[1]	Well ID	Estimated Saturated Thickness Above Bedrock	Estimated Number of Monitoring Intervals	Potential Screen Length in Each Interval	Optimal Well Design	Alternate Well Design
Observe specific distribution of substrate, by-products, and chromium across the aquifer thickness	C, D, E, F, G, H, I, J, M, P, Q, R, and W	< 100 feet	1 to 2	10 to 20	Conventional, Nested	Multilevel
		100 to 280 feet	2 to 4	10 to 50	Nested	Conventional, Multilevel
Monitor water levels and average water quality near extraction wells at the northern end of the IRZ line, river bank (both the CA and AZ sides), and TW Bench	A, B, H, K, O, T, W, X, Y, 70BR-D, and potential slant wells	< 100 feet	1 to 2	10 to 50	Conventional, Nested	Multilevel
		100 to 350 feet	2 to 4	10 to 50	Nested	Conventional, Multilevel
Monitor average changes in chromium plume as the remediation progresses	L, N, U, V, Z, 10D, and 11D	90 to 390 feet	1 to 4	10 to 50	Conventional, Nested	Multilevel
Monitor water levels	J, Q, and S	70 to 220 feet	2 to 4	20 to 50	Nested	Conventional, Multilevel
Monitor potential migration of arsenic from freshwater injection wells	AA, BB, CC, DD, EE, FF, GG, HH, II	90 to 280 feet	1 to 3	20 to 50	Conventional, Nested	Multilevel
Monitor potential COPC migration	I, J, U, V, W	30 to 280 feet	1 to 4	10 to 50	Conventional, Nested	Multilevel

Notes:
[1] Basis for type of monitoring can be found in the O&M Manual (Appendix L) Volume 2, Tables 2.1-2 (Monitoring Program Wells and Surface Water Sampling Points) and 2.6-1 (Monitoring Program Wells and Surface Water Sampling Points for COPC

Note:
All planned and provisional monitoring well locations are approximate.

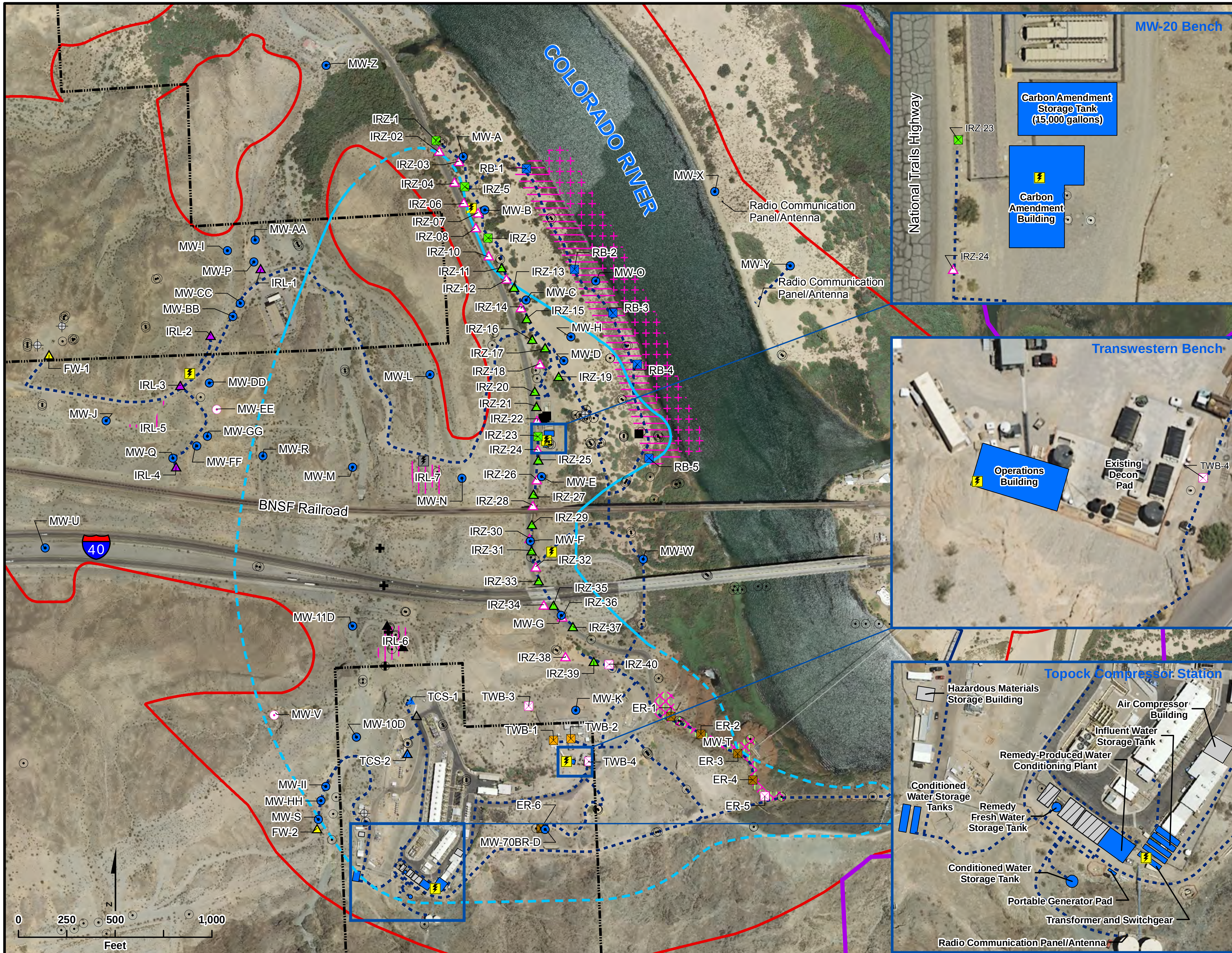
N

0 250 500 1,000 Feet

FIGURE 3.6-1
PROPOSED MONITORING WELL NETWORK
GROUNDWATER REMEDY BASIS OF DESIGN REPORT
FINAL (100%) DESIGN
PG&E TOPOCK COMPRESSOR STATION,
NEEDLES, CALIFORNIA

CH2MHILL

Updated O&M Manual Figures



LEGEND

- Property Boundaries
- Area of Potential Effects (APE)
- EIR Project Area

Existing Wells:

- Extraction Well
- Injection Well
- Monitoring Well
- Water Supply Well

Provisional Wells:
(Items in Pink are Provisional)

- Extraction Well
- Injection Well
- Monitoring Well
- Area for East Ravine (ER) Well (ER-7 to ER-11)
- Area for Potential Slant Well Screens
- Area for Inner Recirculation Loop (IRL) Wells
- Area for River Bank Extraction Wells

Planned Wells:

- Extraction, East Ravine
- Extraction, National Trails Highway (NTH) In-situ Reactive Zone (IRZ)
- Extraction, Riverbank
- Extraction, Transwestern Bench
- Injection, Freshwater
- Injection, Inner Recirculation Loop
- Injection, NTH IRZ
- Injection, Topock Compressor Station
- Remedy Monitoring Well
- Recirculation Well
- Area for Monitoring Well MW-T

Pipeline Corridor for Remedy

- Aboveground Pipe
- Underground Pipe/Conduit

Remedy Facilities

- Planned Transformer
- Future Provisional Transformer
- Proposed Remedy Structure
- Contingent Freshwater Pre-injection Treatment System
- New Compressor Station buildings (not part of Remedy)
- Approximate extent of hexavalent chromium [Cr(VI)] concentrations exceeding 32 micrograms per liter (µg/L) at any depth ingroundwater based on fourth quarter 2013 sampling events. Dashed where based on limited data.

Note:

1. Note that in compliance with EIR mitigation measure CUL-1a-9, as well as PA and CHPMP mitigation measures, the pipeline along the dirt road west of National Trails Hwy is located in an existing, previously disturbed, access road. In addition, the location of the road and pipeline was field verified and does not create any direct physical impact or effect on the Topock Maze, as it is manifested archaeologically, in compliance with EIR mitigation measure CUL-1a-10, PA, and CHPMP mitigation measures.
2. All well and structure locations are approximate.

FIGURE 2.1-1
GENERAL REMEDY SYSTEM LAYOUT - CALIFORNIA

GROUNDWATER REMEDY OPERATION AND MAINTINANCE MANUAL
VOLUME 1: OPERATION AND MAINTANCE PLAN
PG&E TOPOCK COMPRESSOR STATION, NEEDLES, CALIFORNIA

CH2MHILL

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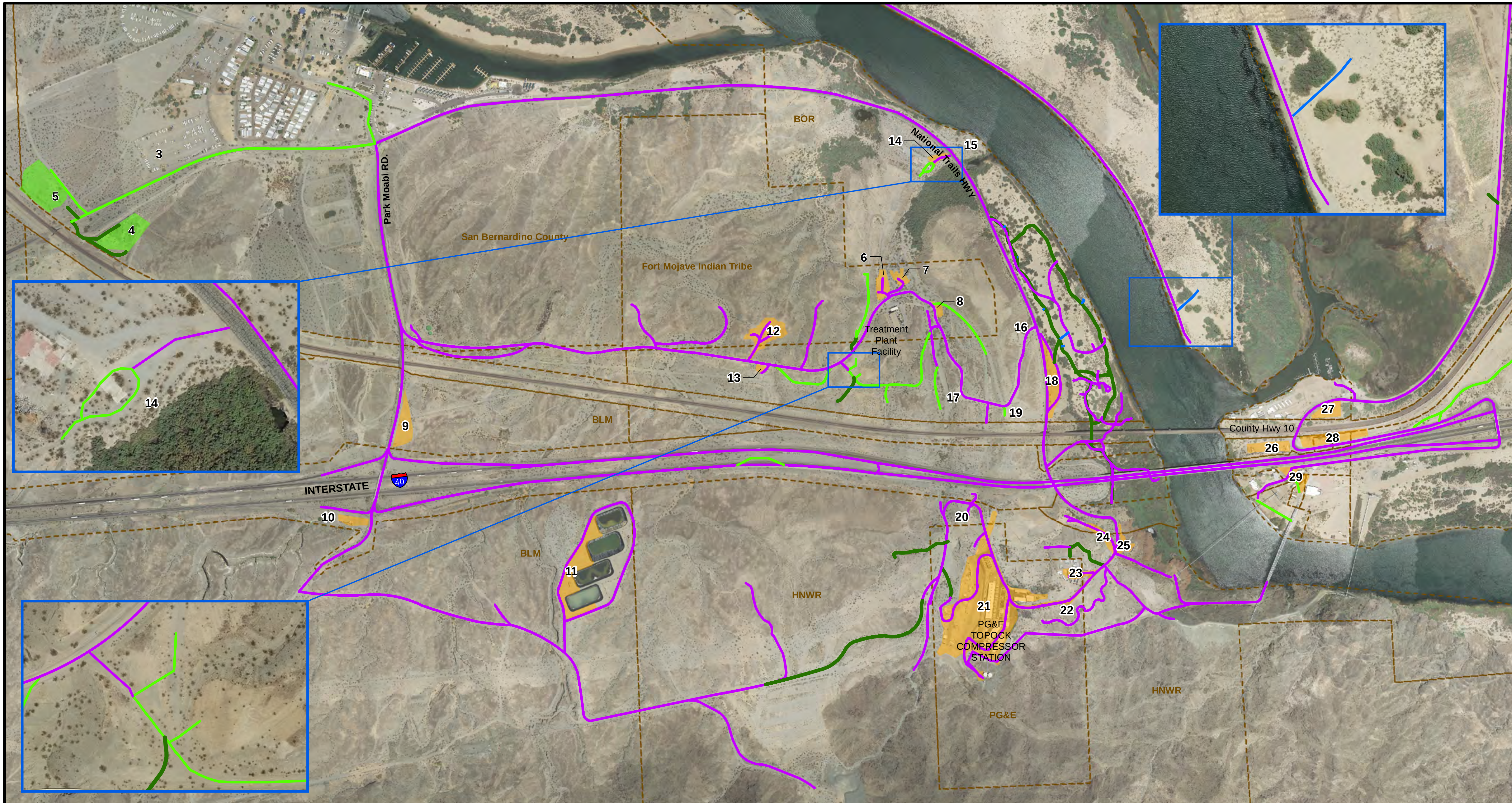


LEGEND

- Existing Access Route (will continue to be used for remedial activities)
- Existing Route (proposed to be used as is for access to remedial activities)
- Roads to be improved or constructed for groundwater remedy
- Temporary Construction Access
- Proposed Staging Areas for Remediation Project
- Proposed Soil Processing (Area #5) and Construction Headquarter (Area #4) for Remediation Project

Notes:

1. Area #3 will not be used as the Construction Headquarter (CHQ). The CHQ will be moved to Area #4.
2. Area #4 will be used as the primary truck inspection area. Areas #9, 18, and 23 or other staging areas might also be used depending on the specific construction activity.
3. Decontamination pads will be located in Area #4 (Construction Headquarters), Area #21 (Topock Compressor Station), and Area #23 (Transwestern Bench).
4. Areas #15, 16, 17, 19, and 20 will not be used as staging areas. Areas #16, 17, and 19 may be part of the primary work zones for remedy infrastructure along the access road.
5. Area #20 may be part of the primary work zone for installation of future provisional well IRL-6 (if determined to be needed in the future) and associated piping/concrete/vault.
6. Public roadways outside of the EIR project area and the APE can also be used for remedy implementation.

N

0 900

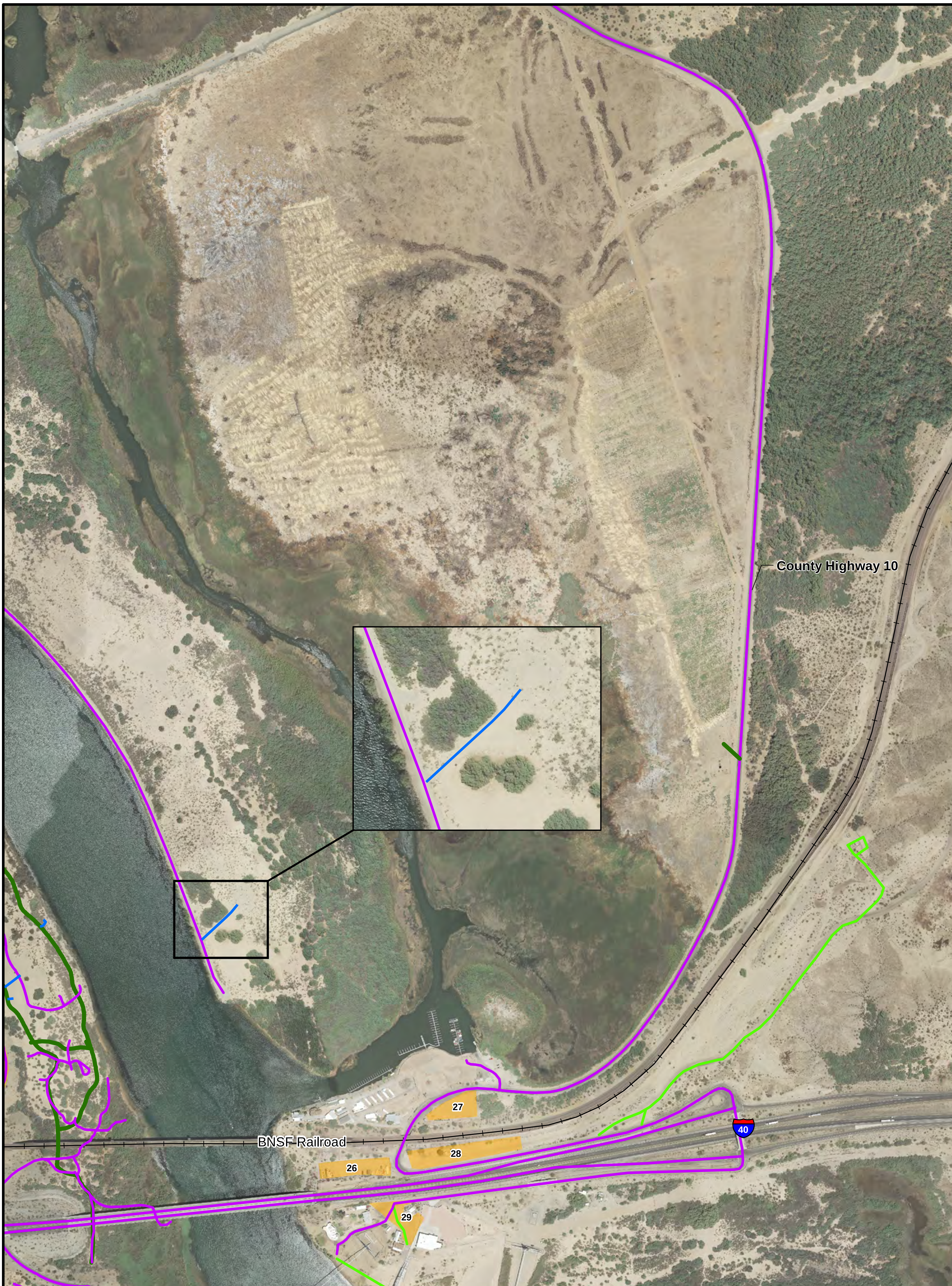
Feet

FIGURE 7.4-1A
PROPOSED ACCESS ROUTES FOR REMEDY FEATURES - CALIFORNIA

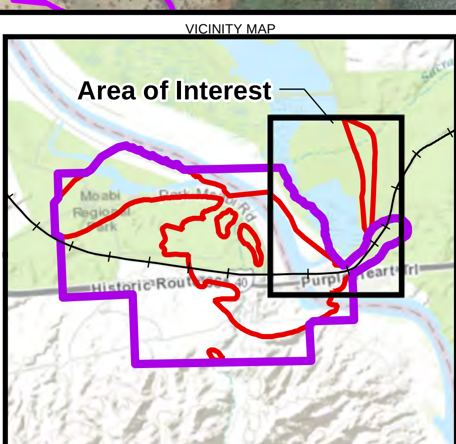
GROUNDWATER REMEDY OPERATION AND MAINTENANCE MANUAL VOLUME 1: OPERATION AND MAINTENANCE PLAN
PG&E TOPOCK COMPRESSOR STATION
NEEDLES, CALIFORNIA

CH2MHILL

\\Brookside\GIS_SHARE\ENBG\00_Proj\P\PGE\Topock\MapFiles\2016\EIR\Design_100_Errata\FIG741A_PropAccessRoutes.mxd Date Saved: 11/4/2016 1:07:00 PM



VICINITY MAP



LEGEND

- Existing Access Route (will continue to be used for remedial activities)
- Existing Route (proposed to be used as is for access to remedial activities)
- Roads to be improved or constructed for groundwater remedy
- Temporary Construction Access
- Proposed Staging Areas for Remediation Project (see BOD Table 3.5-1 for a description of proposed use for staging areas)

N

0 200 400 800 Feet

Notes:
1. Locations for access routes are approximate.
2. Public roadways outside of the EIR project area and the APE can also be used for remedy implementation.

Service Layer Credits: Sources: Esri, HERE, DeLorme, Intermap, increment P Corp., GEBCO, USGS, FAO, NPS, NRCAN, GeoBase, IGN, Kadaster NL, Ordnance Survey, Esri Japan, METI, Esri China (Hong Kong), swisstopo, MapmyIndia, © OpenStreetMap contributors, and the GIS User Community

FIGURE 7.41B
PROPOSED ACCESS ROUTES FOR REMEDY FEATURES - ARIZONA

GROUNDWATER REMEDY OPERATION AND MAINTENANCE MANUAL
VOLUME 1: OPERATION AND MAINTENANCE PLAN
PG&E TOPOCK COMPRESSOR STATION
NEEDLES, CALIFORNIA

CH2MHILL

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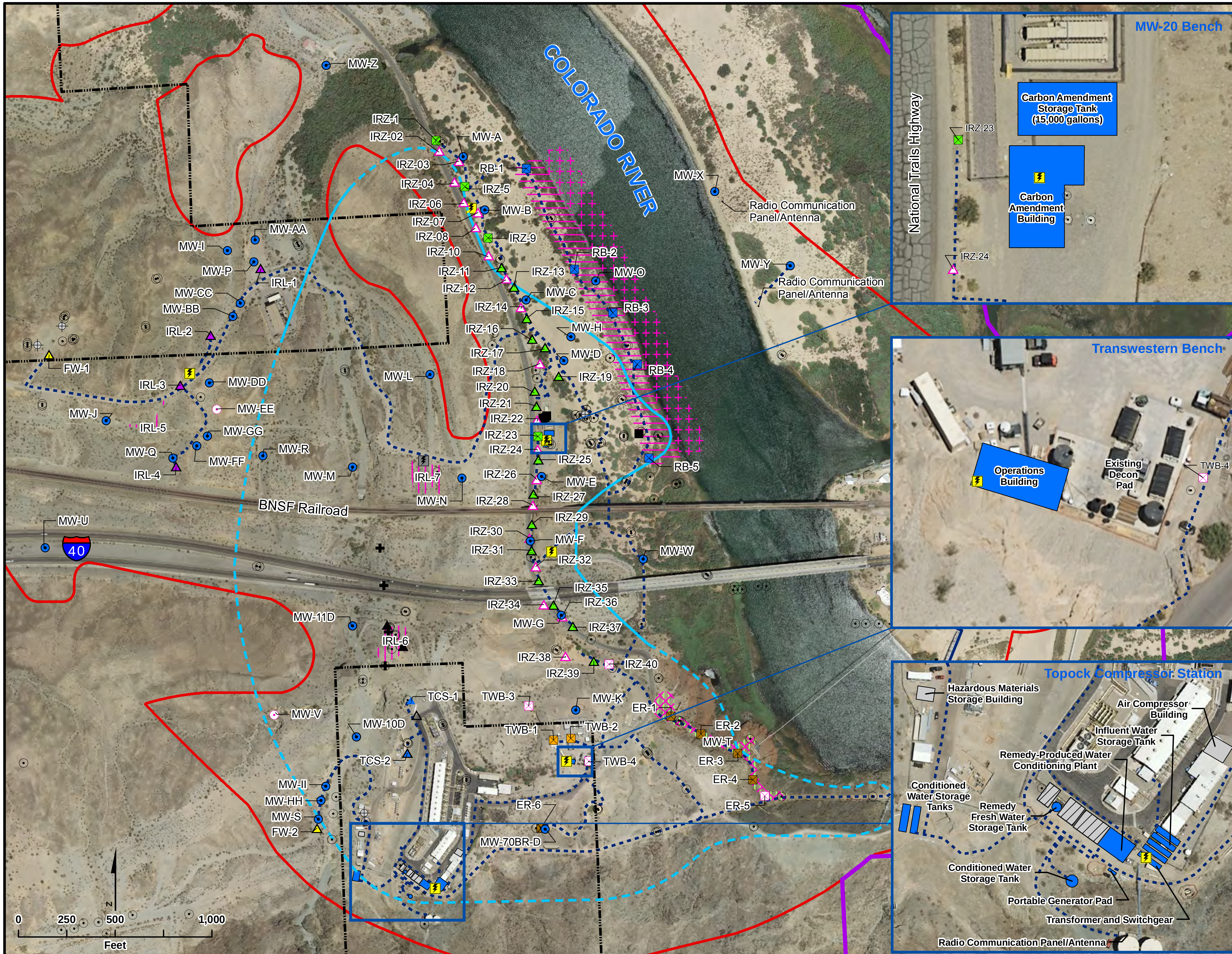
Updated C/RAWP Figures



LEGEND

Property Boundaries
Area of Potential Effects (APE)
EIR Project Area

Existing Wells:
- Extraction Well
- Injection Well
- Monitoring Well
- Water Supply Well

Provisional Wells:
(Items in Pink are Provisional)
- Extraction Well
- Injection Well
- Monitoring Well
- Area for East Ravine (ER) Well (ER-7 to ER-11)
- Area for Potential Slant Well Screens
- Area for Inner Recirculation Loop (IRL) Wells
- Area for River Bank Extraction Wells

Planned Wells:
- Extraction, East Ravine
- Extraction, National Trails Highway (NTH) In-situ Reactive Zone (IRZ)
- Extraction, Riverbank
- Extraction, Transwestern Bench
- Injection, Freshwater
- Injection, Inner Recirculation Loop
- Injection, NTH IRZ
- Injection, Topock Compressor Station
- Remedy Monitoring Well
- Recirculation Well
- Area for Monitoring Well MW-T

Pipeline Corridor for Remedy
- Aboveground Pipe
- Underground Pipe/Conduit

Remedy Facilities
- Planned Transformer
- Future Provisional Transformer
- Proposed Remedy Structure
- Contingent Freshwater Pre-injection Treatment System
- New Compressor Station buildings (not part of Remedy)

Approximate extent of hexavalent chromium [Cr(VI)] concentrations exceeding 32 micrograms per liter (µg/L) at any depth ingroundwater based on fourth quarter 2013 sampling events. Dashed where based on limited data.

Note:
1. Note that in compliance with EIR mitigation measure CUL-1a-9, as well as PA and CHPMP mitigation measures, the pipeline along the dirt road west of National Trails Hwy is located in an existing, previously disturbed, access road. In addition, the location of the road and pipeline was field verified and does not create any direct physical impact or effect on the Topock Maze, as it is manifested archaeologically, in compliance with EIR mitigation measure CUL-1a-10, PA, and CHPMP mitigation measures.
2. All well and structure locations are approximate.

FIGURE 3.1-1
GENERAL REMEDY SYSTEM LAYOUT - CALIFORNIA
GROUNDWATER REMEDY CONSTRUCTION/
REMEDIAL ACTION WORK PLAN
PG&E TOPOCK COMPRESSOR STATION,
NEEDLES, CALIFORNIA

CH2MHILL

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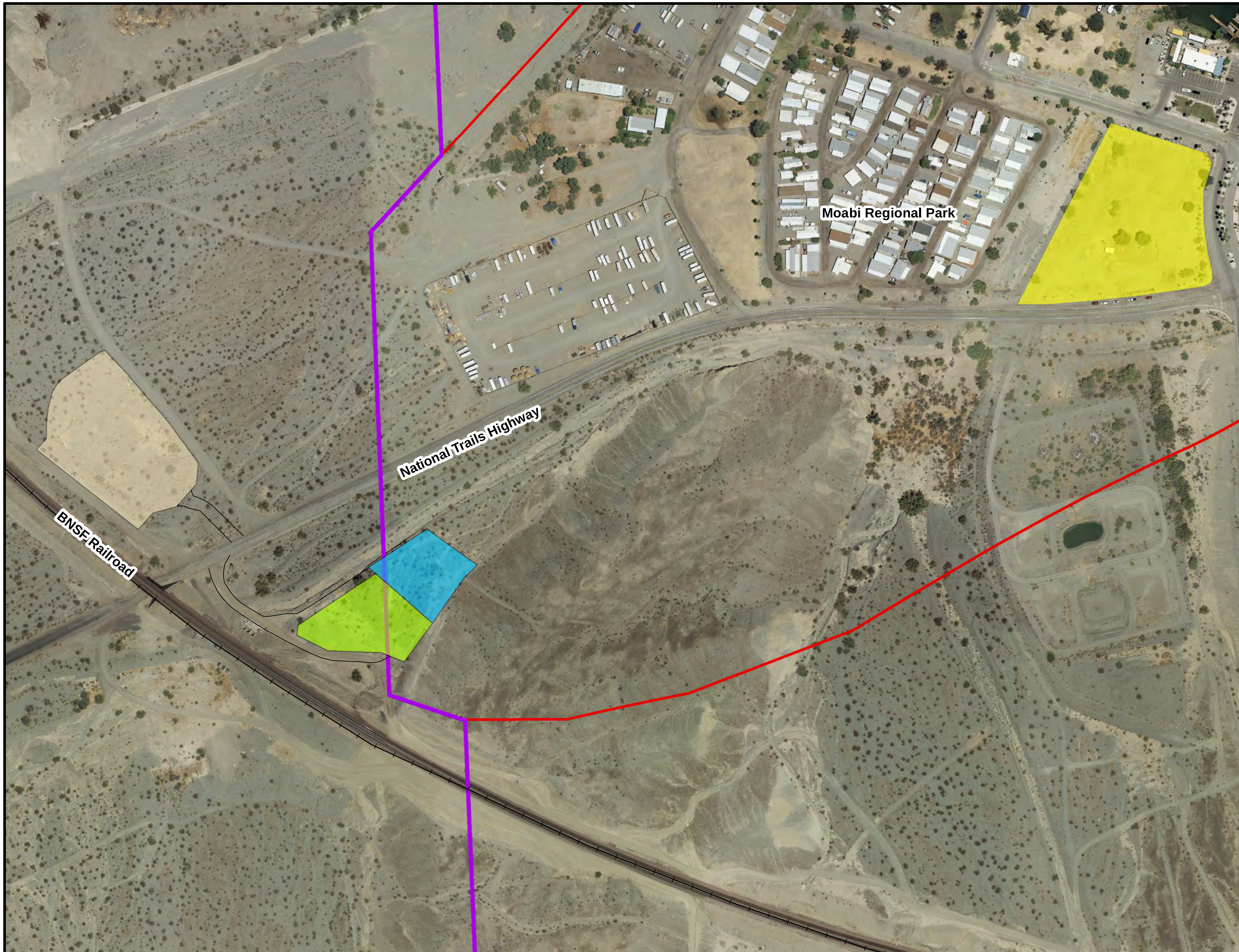
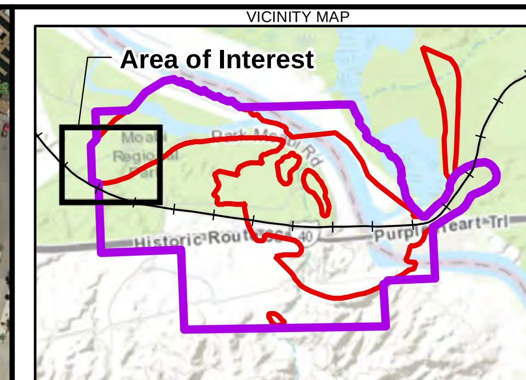


VICINITY MAP



LEGEND

- Soil Processing Area (2.56 Acres Approximate)
- Temporary Construction Laydown Area (1.05 Acres Approximate)
- Longterm Remedy Support Area (0.8 Acres Approximate)
- Area for Temporary Informational Outreach Trailer
- Area of Potential Effects (APE)
- EIR Project Area

Notes:

1. Descriptions of activities/functions anticipated for the construction support areas are included in the Construction/Remedial Action Work Plan.
2. Descriptions of activities/functions anticipated for the long-term remedy support areas are included in Section 3.5 of the BOD, and the O&M Manual.
3. The temporary informational outreach trailer is anticipated to support increased stakeholder and/or visitor interest at the onset of construction activities.

N

0 115 230 460 Feet

Service Layer Credits: Sources: Esri, HERE, DeLorme, Intermap, increment P Corp., GEBCO, USGS, FAO, NPS, NRCAN, GeoBase, IGN, Kadaster NL, Ordnance Survey, Esri Japan, METI, Esri China (Hong Kong), swisstopo, MapmyIndia, © OpenStreetMap contributors, and the GIS

FIGURE 3.1-2
GENERAL REMEDY SYSTEM LAYOUT - MOABI REGIONAL PARK

GROUNDWATER REMEDY CONSTRUCTION/
REMEDIAL ACTION WORK PLAN
PG&E TOPOCK COMPRESSOR STATION,
NEEDLES, CALIFORNIA

CH2MHILL

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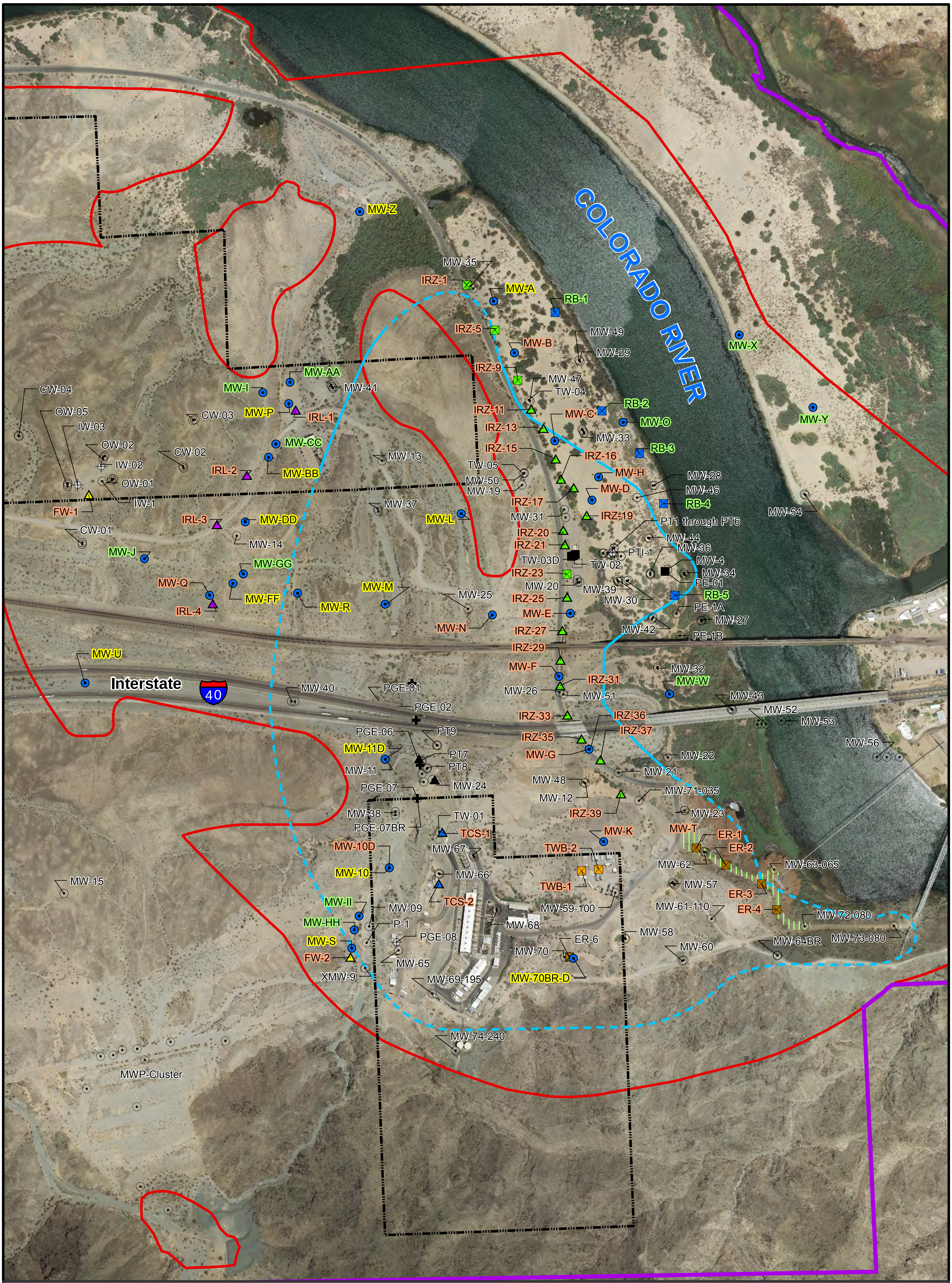


LEGEND

- Property Boundaries
- Area of Potential Effects (APE)
- EIR Project Area

Existing Wells:

- Extraction Well
- Injection Well
- Monitoring Well
- Water Supply Well

Well Category Highlighting:
Yellow Highlighting for Well Category 1
Green Highlighting for Well Category 2
Orange Highlighting for Well Category 3

Planned Wells:

- Extraction, East Ravine
- Extraction, National Trails Highway (NTH) In-situ Reactive Zone (IRZ)
- Extraction, Riverbank
- Extraction, Transwestern Bench
- Injection, Freshwater
- Injection, Inner Recirculation Loop
- Injection, NTH IRZ
- Injection, Topock Compressor Station
- Remedy Monitoring Well
- Recirculation Well
- Area for Monitoring Well MW-T

Approximate extent of hexavalent chromium [Cr(VI)] concentrations exceeding 32 micrograms per liter (µg/L) at any depth ingroundwater based on fourth quarter 2013 sampling events. Dashed where based on limited data.

Note:
All well and structure locations are approximate.

0 220 440 880 Feet

N

FIGURE 3.2-1
ESTIMATED APPROACH TO WELL NETWORK CONSTRUCTION
GROUNDWATER REMEDY CONSTRUCTION/ REMEDIAL ACTION WORK PLAN
PG&E TOPOCK COMPRESSOR STATION, NEEDLES, CALIFORNIA

CH2MHILL

Path: \\Brookside\GIS_SHARE\ENBG\00_Proj\P\PGE\Topock\MapFiles\2016\EIR\Design_100_Errata\FIG321_CRAWP.mxd

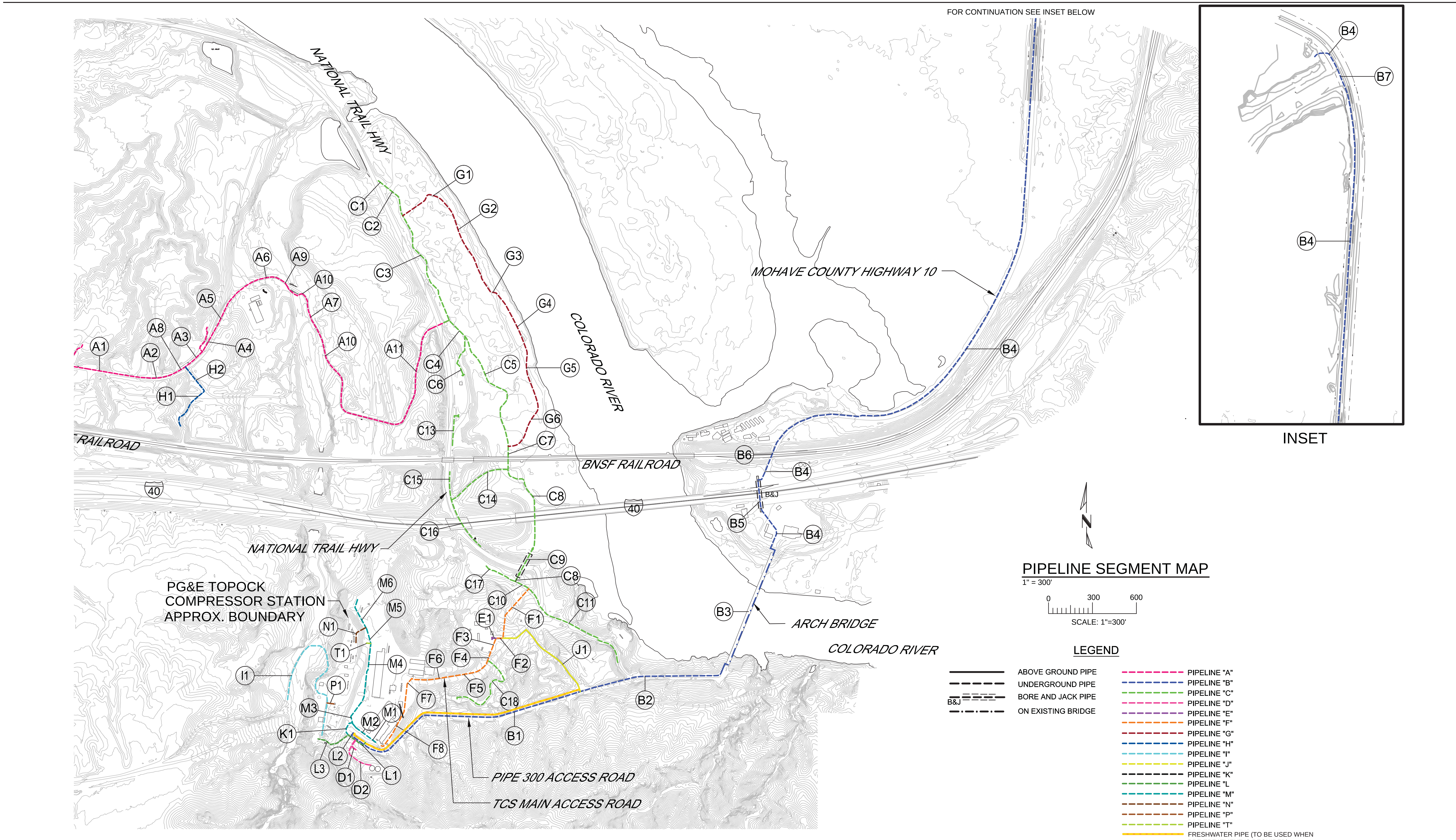
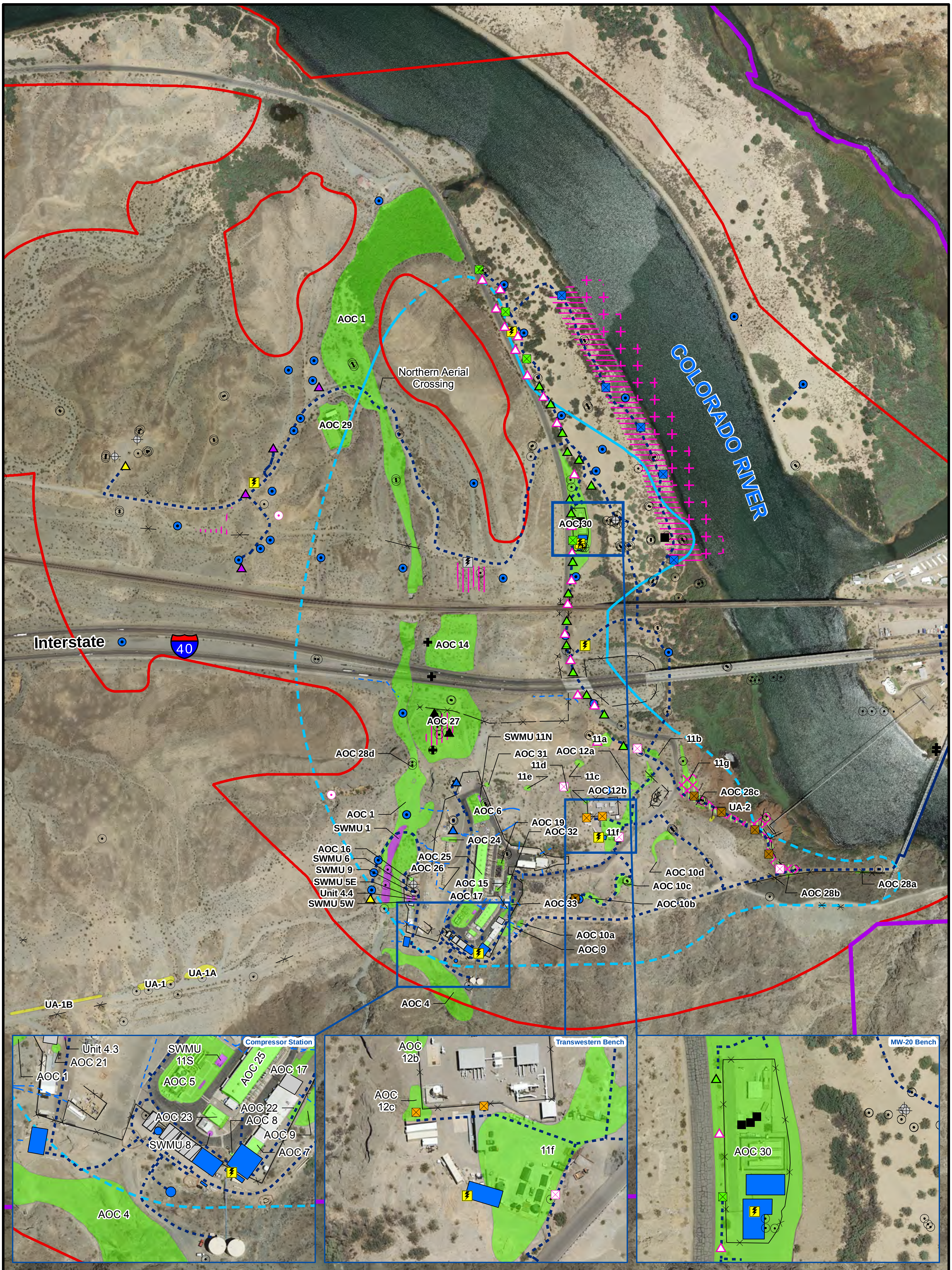


FIGURE 3.3-1
KEY PIPELINE MAP
GROUNDWATER REMEDY CONSTRUCTION/REMEDIAL ACTION WORK PLAN
PG&E TOPOCK COMPRESSOR STATION,
NEEDLES, CALIFORNIA

CH2MHILL.



LEGEND

Existing Wells:
- Extraction Well
- Injection Well
- Monitoring Well
- Water Supply Well

Provisional Wells:
- Extraction Well
- Injection Well
- Monitoring Well
- Area for East Ravine (ER) Wells (ER-7 to ER-11)
- Area for Potential Slant Well Screens
- Area for Inner Recirculation Loop (IRL) Wells
- Area for River Bank Extraction Wells

Planned Wells:
- Extraction, East Ravine
- Extraction, National Trails Highway (NTH) In-situ Reactive Zone (IRZ)
- Extraction, Riverbank
- Extraction, Transwestern Bench
- Injection, Freshwater
- Injection, Inner Recirculation Loop
- Injection, NTH IRZ
- Injection, Topock Compressor Station
- Remedy Monitoring Well
- Recirculation Well
- Area for Monitoring Well (MW-T)

Transformers
- Planned Transformer
- Future Provisional Transformer

- Site Fence Boundary
- Stormwater Piping Below Ground
- Stormwater Piping Above Ground

Pipeline Corridor for Remedy
- Aboveground Pipe
- Underground Pipe/Conduit
- Area of Potential Effects (APE)
- EIR Project Area

Work Areas
- Solid Waste Management Unit (SWMU)
- Area of Concern (AOC)
- Other

Remedy Facilities
- Proposed Remedy Structure
- Contingent Freshwater Pre-injection Treatment System

Approximate extent of hexavalent chromium [Cr(VI)] concentrations exceeding 32 micrograms per liter (µg/L) at any depth in groundwater based on fourth quarter 2013 sampling events. Dashed where based on limited data.

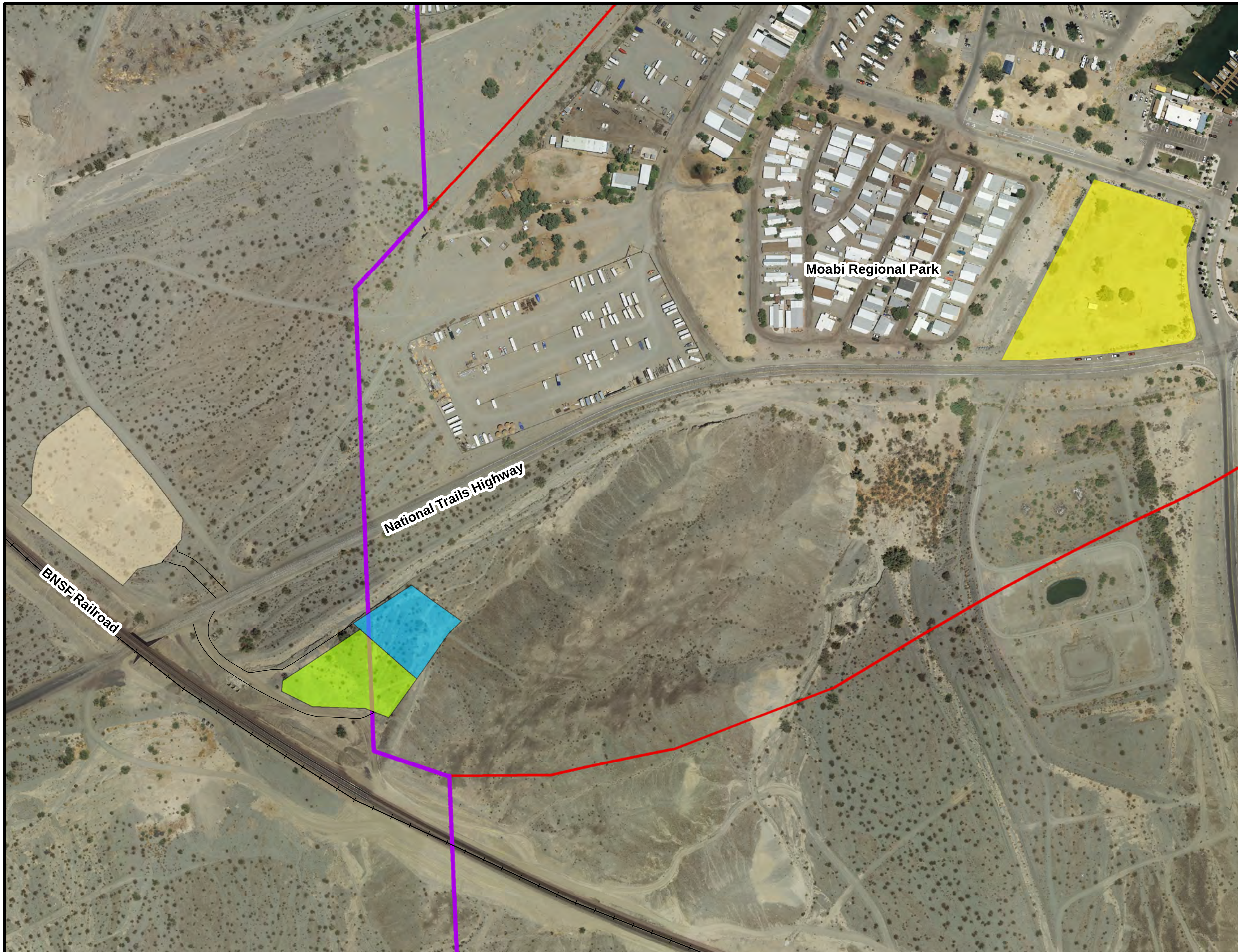
Notes:
1. All wells and remedy structure locations are approximate.
2. AOC 13 consists of the current and former unpaved areas within the fence line.AOC 18 consists of the hazardous waste transference pipelines and cooling tower blowdown pipelines.

N

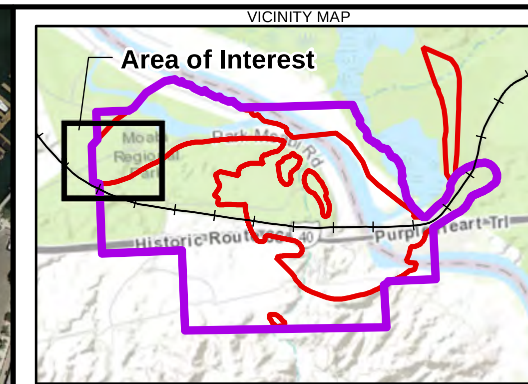
0 550

Feet

FIGURE 4.1-2
MAP OF SOLID WASTE MANAGMENT UNITS (SWMUS) AND AREAS OF CONCERN (AOCS)
GROUNDWATER REMEDY CONSTRUCTION/ REMEDIAL ACTION WORK PLAN
PG&E TOPOCK COMPRESSOR STATION, NEEDLES, CALIFORNIA



VICINITY MAP



LEGEND

- Soil Processing Area (2.56 Acres Approximate)
- Temporary Construction Laydown Area (1.05 Acres Approximate)
- Longterm Remedy Support Area (0.8 Acres Approximate)
- Area for Temporary Informational Outreach Trailer
- Area of Potential Effects (APE)
- EIR Project Area

Notes:

1. Descriptions of activities/functions anticipated for the construction support areas are included in the Construction/Remedial Action Work Plan.
2. Descriptions of activities/functions anticipated for the long-term remedy support areas are included in Section 3.5 of the BOD, and the O&M Manual.
3. The temporary informational outreach trailer is anticipated to support increased stakeholder and/or visitor interest at the onset of construction activities.

N

0 115 230 460 Feet

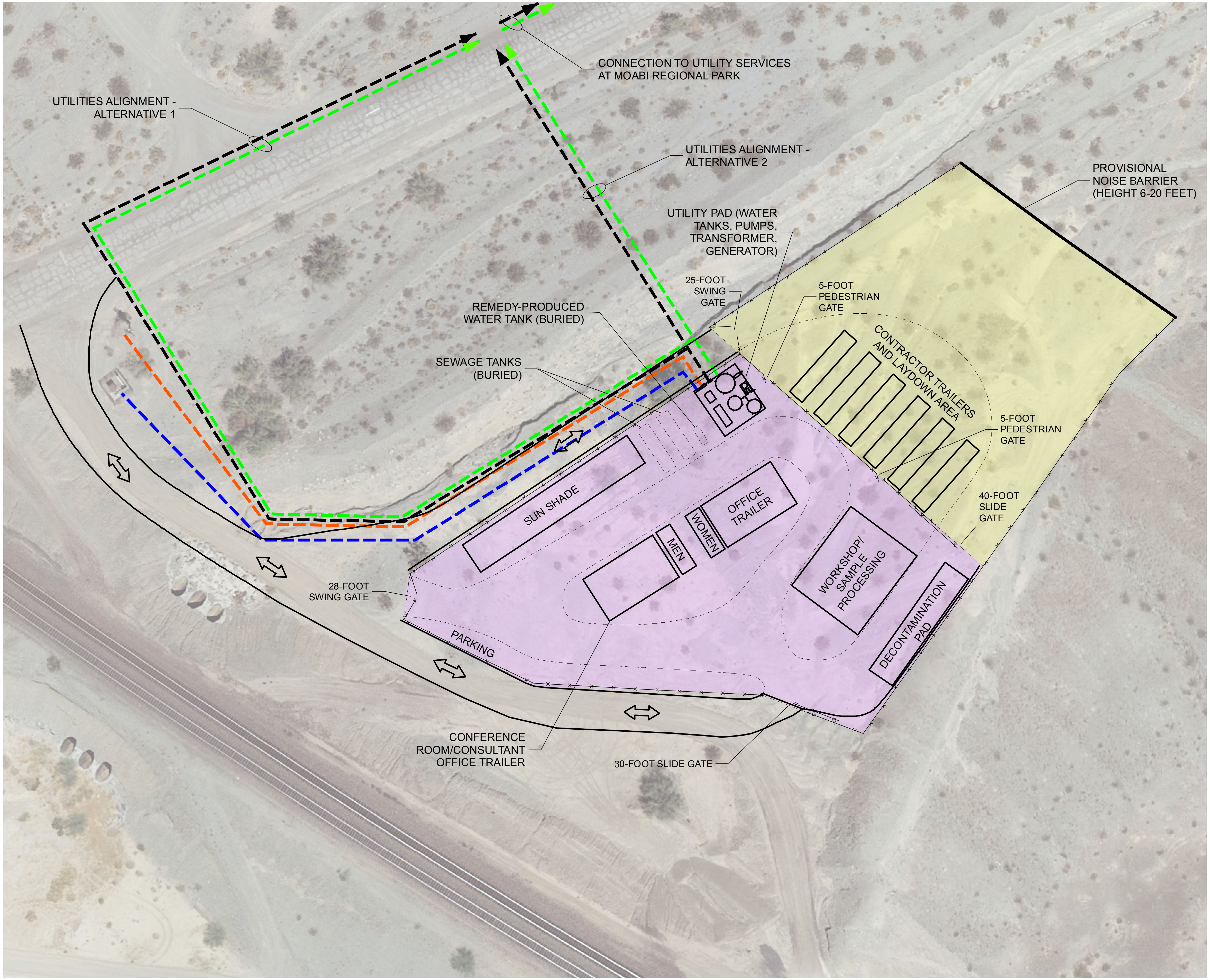
Service Layer Credits: Sources: Esri, HERE, DeLorme, Intermap, increment P Corp., GEBCO, USGS, FAO, NPS, NRCAN, GeoBase, IGN, Kadaster NL, Ordnance Survey, Esri Japan, METI, Esri China (Hong Kong), swisstopo, MapmyIndia, © OpenStreetMap contributors, and the GIS

FIGURE 4.2-1
LOCATIONS OF CONSTRUCTION FACILITIES IN MOABI REGIONAL PARK

GROUNDWATER REMEDY CONSTRUCTION/
REMEDIAL ACTION WORK PLAN
PG&E TOPOCK COMPRESSOR STATION
NEEDLES, CALIFORNIA

CH2MHILL

Path: \\Brookside\GIS_SHARE\ENBG\00_Proj\P\PGE\Topock\MapFiles\2016\EIR\Design_100_Errata\FIG421_CRAWP.mxd



Legend

- Future Potential Fire Water Connections
- Future Potential Sanitary Sewer Connections
- Future Potential Water Connection
- Anticipated Electrical and Telecom Connection*
- Fenceline
- Temporary Construction Laydown Area (1.05 acres approx.)
- Long Term Remedy Support Area (0.8 acres approx.)

Notes:

1. All remedy structure locations are approximate.
2. Descriptions of activities/functions anticipated for the construction support areas are included in the Construction/Remedial Action Work Plan.
3. Descriptions of activities/functions anticipated for the long-term remedy support areas are included in Section 3.5 of the BOD and the O&M Manual.
4. Temporary storage/conex boxes (not shown) may be used within the fenced Construction Headquarters.

* Final locations will be determined by Needles

N

0 60 120 180

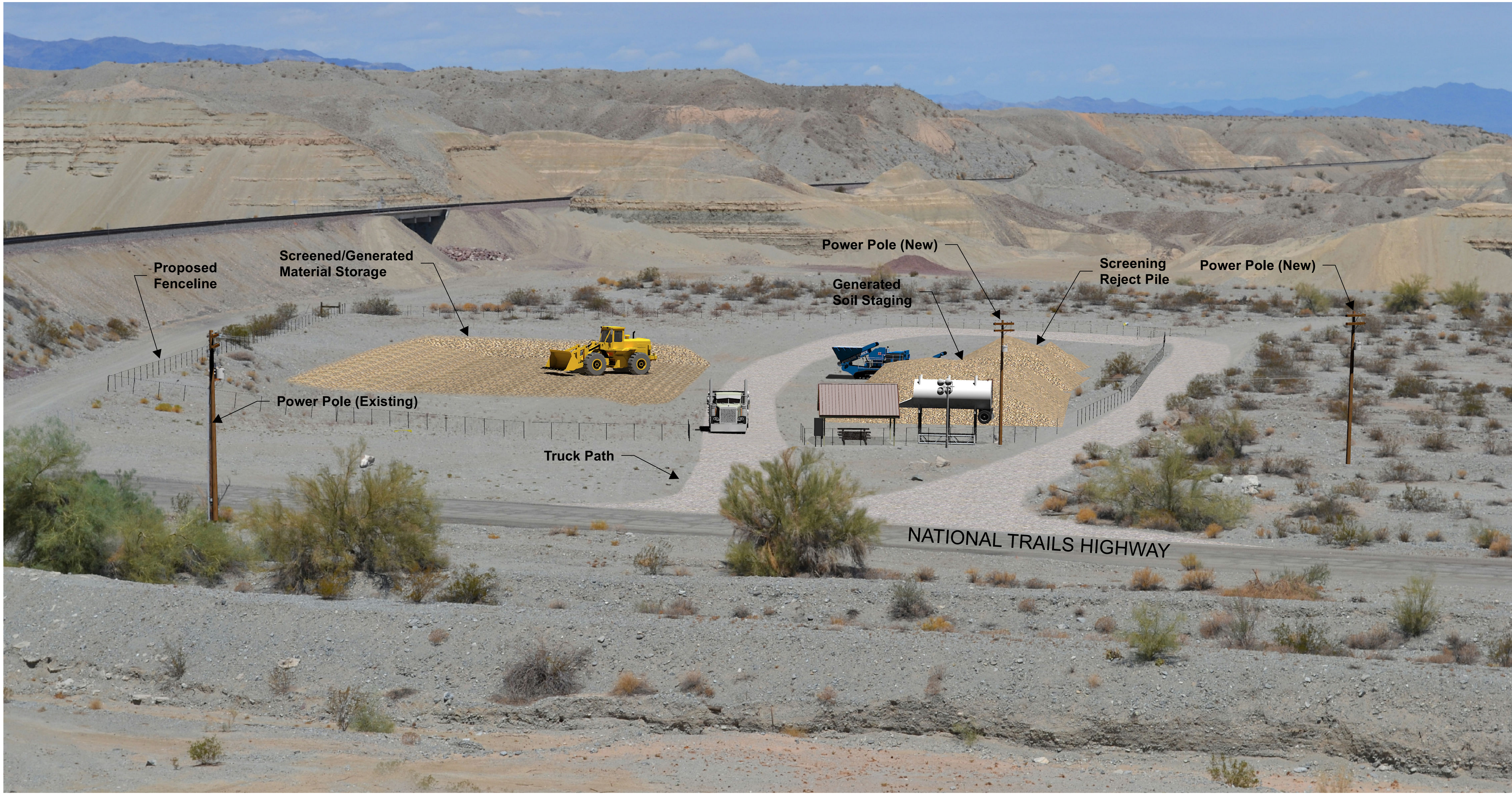
1 " = 60 '

PACIFIC GAS AND ELECTRIC COMPANY
TOPOCK COMPRESSOR STATION
NEEDLES, CALIFORNIA
GROUNDWATER REMEDY CONSTRUCTION/REMEDIAL ACTION WORK PLAN

CONSTRUCTION HEADQUARTERS SPATIAL PLANNING

ARCADIS Design & Consultancy for natural and built assets

FIGURE **4.2-2**



Notes:

1. Soil storage may also occur at the soil processing area.

2. This visualization is intended to facilitate understanding of typical layout/activities/equipment that may occur at the Temporary Soil Processing Yard. Final layout of the temporary yard will be determined by the construction contractor. There may be more or less activities/equipment during the construction period.

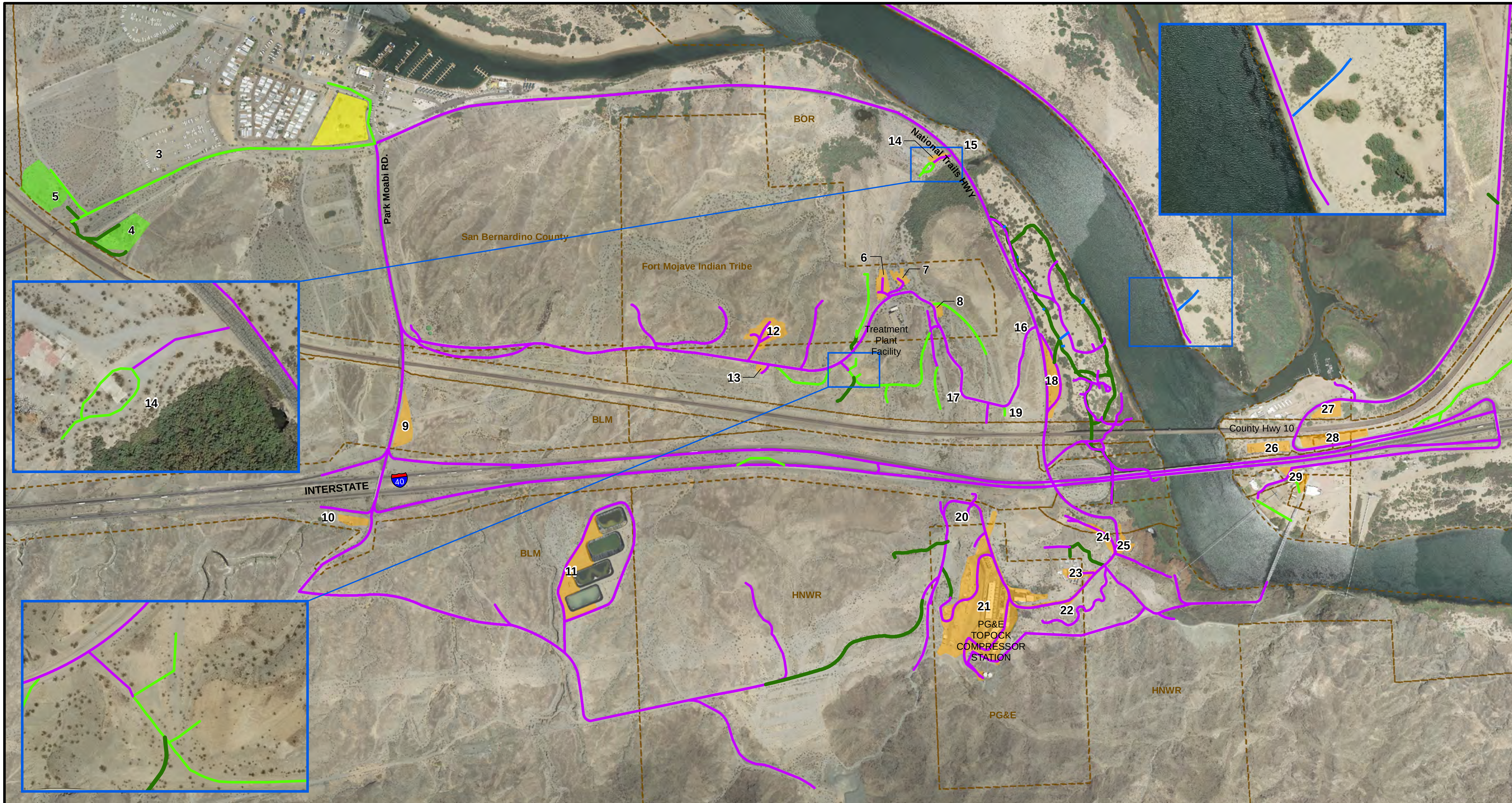
PACIFIC GAS AND ELECTRIC COMPANY
TOPOCK COMPRESSOR STATION
NEEDLES, CALIFORNIA
GROUNDWATER REMEDY CONSTRUCTION/REMEDIAL ACTION WORK PLAN

PHOTO SIMULATION OF TEMPORARY SOIL PROCESSING AREA IN MOABI REGIONAL PARK

ARCADIS Design & Consultancy for natural and built assets

FIGURE
4.2-2B

CITY: Novi DIV: ENV DB: TRY PIC: PM: TM: TR: PROJECT NUMBER: RC000753.0026.0004
D:\GIS\Project Files\Toprock\4B_Layout.mxd PLOTTED: 6/23/2016 3:35:17 PM BY: TYarbrough



LEGEND

- Existing Access Route (will continue to be used for remedial activities)
- Existing Route (proposed to be used as is for access to remedial activities)
- Roads to be improved or constructed for groundwater remedy
- Temporary Construction Access
- Proposed Staging Areas for Remediation Project
- Proposed Soil Processing (Area #5) and Construction Headquarter (Area #4) for Remediation Project
- Area for Temporary Informational Outreach Trailer

Notes:

1. Area #3 will not be used as the Construction Headquarter (CHQ). The CHQ will be moved to Area #4.
2. Area #4 will be used as the primary truck inspection area. Areas #9, 18, and 23 or other staging areas might also be used depending on the specific construction activity.
3. Decontamination pads will be located in Area #4 (Construction Headquarters), Area #21 (Topock Compressor Station), and Area #23 (Transwestern Bench).
4. Areas #15, 16, 17, 19, and 20 will not be used as staging areas. Areas #16, 17, and 19 may be part of the primary work zones for remedy infrastructure along the access road.
5. Area #20 may be part of the primary work zone for installation of future provisional well IRL-6 (if determined to be needed in the future) and associated piping/concrete/vault.
6. Public roadways outside of the EIR project area and the APE can also be used for remedy implementation.

N

0 900

Feet

FIGURE 4.2-3
CONSTRUCTION SITE PLAN AND ACCESS ROUTES
GROUNDWATER REMEDY CONSTRUCTION/ REMEDIAL ACTION WORK PLAN
PG&E TOPOCK COMPRESSOR STATION
NEEDLES, CALIFORNIA

CH2MHILL

\\Brookside\GIS_SHARE\ENBG\00_Proj\P\PGE\Topock\MapFiles\2016\EIR\Design_100_Errata\FIG423_AccessRoutes.mxd Date Saved: 11/14/2016 9:28:18 AM

Updated C/RAWP Exhibit

EXHIBIT 3.1-1 **FOR BREVITY, ONLY REVISED PORTIONS OF TABLE SHOWN HERE; REVISED INFORMATION SHOWN IN RED**

Summary of Engineering Design Parameters and Key Remedy Features

Groundwater Remedy Construction/Remedial Action Work Plan

PG&E Topock Compressor Station, Needles, California

Remedy Feature	Design Parameters/Quantity	Location
Piping corridor (water pipes, electrical conduits, fibers, etc.)	• Approximately ~~121,700~~ 127,000 feet (ft) of ~~water/liquid/utility pipes~~ fluid piping and approximately ~~97,000~~124,000 ft of ~~electrical~~ conduits ~~and cables~~. ~~Over 95% of conveyance pipes/~~Most of the fluid piping and conduits will be below ground, in approximately 43,200 linear feet of trenches.	See Figures 3.1-1 and 3.1-3 for general piping layout.

BOD Appendix A13
Assessment of Biological Resources for Additional Potential Environmental Impact Areas

- Technical Memorandum: Assessment of Biological Resources for Additional Potential Environmental Impact Areas: Final Groundwater Remedy, Topock Compressor Station, California
- Minor Updates to the Additional Biological Resources Survey for Additional Potential Environmental Impact Areas Technical Memorandum

Technical Memorandum: Assessment of Biological Resources for Additional Potential Environmental Impact Areas: Final Groundwater Remedy, Topock Compressor Station, California

Topock Project Executive Abstract

Document Title:	Date of Document: August 25, 2016
Assessment of Biological Resources for Additional Potential Environmental Impact Areas: Final Groundwater Remedy, Topock Compressor Station, California Final Document? ☒ Yes ☐ No	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: Letter report	Action Required: ☒ Information Only ☐ Review & Comment Return to:________________ 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: Biological Reports	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? This technical memorandum was requested by DTSC to support the Groundwater Remedy EIR. Not performing the survey and preparing this report would impede analysis associated with the Groundwater Remedy EIR.	Other Justification/s: ☐ Permit ☒ Other / Explain: Requested by DTSC

Brief Summary of attached document:

The purpose of this technical memorandum is to provide an assessment of biological (plant and wildlife) conditions within a series of new areas that were added to the original Groundwater Remedy Project Area. The initial set of additional areas were investigated in May 24 and 25, 2016 and the remaining areas were investigated on July 7 and 8, 2016. The majority of the additional areas are classified as Developed/Disturbed including Areas 1, 2, 3b, 3e, 3f, 4, and 7. The remaining additional areas have some type of plant community associated with them as follows: Areas 3a, 3c, and 3d are classified as Creosote Bush Scrub; Area 6 is comprised primarily of Salt Cedar and Salt Cedar/Screwbean Mesquite with a narrow band of California bulrush along Topock Marsh to the east; and Area 5 plant communities include Quailbush Scrub, Salt Cedar/Athel Tamarisk, Blue Palo Verde, and Creosote Bush Scrub. No evidence of desert tortoise use was observed in any of the additional areas surveyed. A dead Lucy's warbler fledgling was observed on July 7, 2016 beneath a power line within Area 5 in Arizona. While no nests were observed in the vicinity, this finding was in an area with potentially suitable nesting habitat (i.e., dense tamarisk scrub with mesquite). This information was used to update GIS database layers in the recently added areas for protected vegetation, wildlife, and waters of the United states and California.

Written by: PG&E

Recommendations:

This report is for information only.

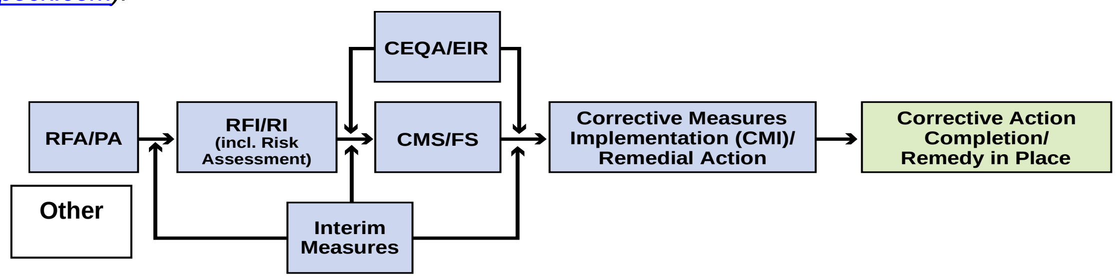
How is this information related to the Final Remedy or Regulatory Requirements:

The survey and this report provides information to support the Groundwater Remedy EIR analysis.

Other requirements of this information?
None.

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).



Version 10

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

Assessment of Biological Resources for Additional Potential Environmental Impact Areas: Final Groundwater Remedy, Topock Compressor Station, California

PREPARED FOR: Virginia Strohl/PG&E

COPY TO: Marjorie Eisert/CH2M HILL (CH2M)

PREPARED BY: Russell Huddleston, Steve Long, Mia Marek /CH2M and Brandy McWain / Transcon Environmental, Inc. (Transcon)

DATE: August 25, 2016

Introduction

In conformance with direction from the Department of Toxic Substances Control (DTSC), this technical memorandum presents additional details on biological resources for areas located either outside of the original Environmental Impact Report (EIR) Project Area or located in areas where DTSC requested additional surveys (Figure 1), and includes approximately an additional 100 acres. This additional 100 acreage includes proposed access routes, additional staging and laydown area, as well as potential mitigation sites. Some of these areas have been included in previous biological resources surveys, others have not.

Consistent with the recent Assessment of Biological Resources for the Proposed Construction Headquarters and Soil Management Areas (CH2M, 2015), this Technical Memorandum provides general information of the flora and fauna observed in the additional 100 acres and provides supplemental information on the following biological resources and documents:

- Special-Status Plants
  - Topock Groundwater Remediation Project Revised Floristic Survey Report, December 30, 2013
  - Assessment of Biological Resources for the Proposed Construction Headquarters and Soil Management Areas: Final Groundwater Remedy, Topock, Technical Memorandum, December 4, 2014
- Ethnobotanical Plants
  - Revised Final - Topock Groundwater Remediation Project Ethnobotany Survey Report, January 15, 2014
  - Supplemental Ethnobotanical Plant Surveys for the Pacific Gas and Electric Company's Topock Compressor Station, San Bernardino County, California, February 28, 2014
- Wetlands and Waters
  - *Wetlands and Waters of the United States, Final Delineation for the Topock Compressor Station Groundwater Remediation Project, San Bernardino County, California*, April 18, 2014

- *Riparian Vegetation and California Department of Fish and Wildlife Jurisdiction for the Topock Compressor Station Groundwater Remediation Project San Bernardino County, California*, May 9, 2014

Methods

Focused biological surveys of the additional 100 acres were completed by CH2M biologists Russell Huddleston, Steve Long and Mia Marek, and TRANSCON wildlife biologist Brandy McWain on May 24 and 25, and July 7 and 8, 2016. The primary objective of the focused survey was to systematically walk the additional areas to identify significant biological resources not documented in previous environmental reports and documents. Methodology specific to each of these focused surveys is provided in the following sections.

Special Status Plants

Because of the seasonal timing of the surveys, a comprehensive survey of flora was not possible; however, any perennial species (e.g., trees, shrubs, and cacti) included as a special-status plants in the EIR were mapped using the GPS. Additionally, overall plant species richness was recorded during the survey (Table 1). Given the developed and disturbed nature of the most of these areas, these observations were considered adequate to characterize the flora of the additional potential impact areas.

A plant species was considered to be special-status if it met one or more of the following criteria:

- Listed, proposed, or candidate for listing as rare, threatened or endangered under the Federal or State Endangered Species Acts
- Listed under the California Desert Native Plants Act (CNDPA)
- California Rare Plant Ranked (CRPR) 1, 2, 3, or 4 by the California Native Plant Society (CNPS) in its Online Inventory of Rare and Endangered Plants of California (CNPS, 2015)
- Listed by the Bureau of Land Management (BLM) as a Sensitive Plant (BLM, 2015)

The California Deserts Native Plants Act (CDNPA) is included in Division 23 of the California Food and Agriculture Code. In general, the CDNPA prohibits the harvest, transport, and sale of certain desert plants without a valid permit from the county in which the collecting will occur. This regulation also prohibits the destruction, excavation, damage, and removal of certain plants without a valid permit. Under Section 80117, activities such as land clearing for surveys, building sites, roads, or other rights-of-way by the landowner or by his or her agent are not prohibited as long as the native plants are not transported from the land or offered for sale, and as long as the county is given 10 days' notice prior to any such activity.

Ethnobotanical Plants

A plant species was considered culturally significant if it occurred on the list of Colorado River Indian Ethnobotany in the Appendix PLA in the EIR (AECOM, 2011). Any live species included in Appendix PLA observed in the additional surveys areas were mapped with a Trimble ® GeoXT GPS.

Desert Tortoise

Surveys were conducted at each site for the Mojave desert tortoise (*Gopherus aggassizi*). The May survey was conducted during the spring active season of the U.S. Fish and Wildlife Service survey protocol; however, the July survey occurred outside of the active season. Each location was walked to search for any sign of desert tortoise, including live observations, carcasses and bones, burrows, and/or scat. Transect intervals were dependent on the size of the site, characteristics of the landscape, sign observations, and accessibility. Ten-meter interval transects were used at Area 3a and Area 3e due to the large size of the survey areas and the easily-accessible characteristics of the landscape. Progressively wider transects were conducted at Area 3a when no desert tortoise sign was observed. In area 3b the fenced area surrounding the evaporation ponds was surveyed with 100 percent coverage. The washes around the evaporation ponds outside of the fence were surveyed, as well as the dirt road, and any accessible washes adjacent to the dirt road.

Ten-meter interval transects were used in Area 3a and Area 3e because of the large size of the survey areas and the easily accessible characteristics of the landscape. Progressively wider transects were conducted at Area 3a when no desert tortoise sign was observed. In Area 3b, the fenced area surrounding the evaporation ponds was surveyed with 100 percent coverage. The washes around the evaporation ponds outside of the fence were surveyed, as well as the dirt road and any accessible washes adjacent to the dirt road. Area 3c was too small to walk 10-meter transects, but was covered 100 percent by survey. Area 3d consisted of steep slopes and accessibility was limited; therefore, 10-meter transects were not utilized, but sections of the area that were accessible were covered 100 percent. Sections that could not be walked were surveyed using binoculars from accessible vantage points, including the wash adjacent to the site. In area 3f the margins of the dirt roads were walked to observe the surrounding habitat. The irregular shape of survey areas 4 and 5 did not allow for 10-meter transect spacing, but survey coverage was 100 percent. Area 6 was not considered suitable habitat nor was it adjacent to suitable habitat so 10-meter transect spaced surveys were not performed. Area 7 consisted of an unnamed road adjacent to the Colorado River and was also not suitable habitat. The area was walked with 100 percent survey coverage.

Birds and Other Wildlife

Other potential special-status and protected wildlife species that could occur within the project area include: Southwestern willow flycatcher (*Empidonax traillii extimus*), Arizona Bell's vireo (*Vireo bellii arizonae*), Western yellow-billed cuckoo (*Coccyzus americanus occidentalis*), California black rail (*Laterallus jamaicensis coturniculus*), Yuma clapper rail (*Rallus longirostris yumanensis*), Western least bittern (*Ixobrychus exilis hesperis*), Crissal thrasher (*Toxostoma crissale*), Sonoran yellow warbler (*Dendroica petechial sonorana*), Lucy's warbler (*Oreothlypis luciae*), ring-tail cat (*Bassariscus astutus*), Nelson's big horn sheep (*Ovis canadensis nelsoni*) and Townsend's big-eared bat (*Corynorhinus townsendii*) (CH2M, 2014a).

The survey evaluated habitat at each site, but no protocol-level surveys were performed for the above-listed species. Trees and dense vegetation were carefully scanned from strategic viewpoints with binoculars to identify avian species. Incidental observations of other wildlife including bird nests, reptiles, small mammals, burrows, tracks, and scat were also noted.

Wetlands and Waters

Wetlands and waters in additional survey areas 3e, 5 and 6 had been previously been delineated and mapped as part of the April 2014 wetland delineation (CH2M, 2014b). A formal wetland delineation was not completed as part of the surveys, however, any new drainage features were mapped based on the extent of defended bed and bank characteristics within the survey area. The western edge of Topock Marsh in survey area 6 was generally delineated along the boundary between the Tamarix scrub habitat and the willow/emergent marsh vegetation.

Results

The following sections provide a general description of the area as well as the results of the field surveys. Representative site photographs are provided in Attachment A.

General Site Descriptions and Vegetation Types

The additional areas are for the most part, expansions of impact areas that had been previously surveyed. These sites include the paved and unpaved roadways, vehicle turnaround locations, additional staging areas, additional well locations and potential mitigation planting areas. Mapped plant communities for the EIR survey area as well as the additional survey locations are shown in Figure 2 and a list of plant species observed is provided in Table 1. As shown on Figure 2, the majority of the additional areas are classified as Developed/Disturbed including Areas 1, 2, 3b, 3e, 3f, 4, and 7. The remaining additional areas have some type of plant community associated with them as follows: Areas 3a, 3c, and 3d are classified as Creosote Bush Scrub; Area 6 is composed primarily of Salt Cedar and Salt Cedar/Screwbean Mesquite with a narrow band of California bulrush along Topock Marsh to the east; and Area 5 plant communities include Quailbush Scrub, Salt Cedar/Athel Tamarisk, Blue Palo Verde, and Creosote Bush Scrub.

Area 1

Area 1 includes 0.45-acre along the Oatman Highway and a small portion of a gravel access road on the Havasu National Wildlife Refuge (Figure 3). This area may be used for vehicle turnaround. Vegetation is sparse in this area as the road shoulders along the Oatman Highway appear to be routinely graded and maintained by the county road department. A large stand of Athel tamarisk (*Tamarix aphylla*) is present immediately north of the gravel road on the west side of the highway and creosote bush (*Larrea tridentata*) with cattle saltbush (*Atriplex polycarpa*) are present along the east side of the survey area.

Area 2

Area 2 includes the Highway 40 – Oatman Highway interchange immediately south of the EIR study area (Figure 4). This 4.32 – acre area consists almost entirely of paved roadways and sparsely vegetated road shoulders.

Area 3a

Area 3a includes 9.76 acres of un-paved access roads east of Park Moabi Road as well as an area identified as a potential mitigation planting location for unavoidable impacts to trees and other sensitive vegetarian (Figure 5). Vegetation on the gravelly slopes adjacent to the roadway and within the potential mitigation area consists primarily of creosote bush scrub which is characterized by creosote bush, white bursage (*Ambrosia dumosa*), white rhatany (*Krameria bicolor*), brittlebush (*Encelia farinosa*), and beavertail (*Opuntia basilaris*).

Area 3b

Area 3b includes 15.40 acres that consist of an un-paved gravel access road south of Interstate 40 that leads to the existing fenced enclosure that surrounds the evaporation ponds (Figure 6). The access roads and the areas around the fenced evaporation ponds are largely devoid of vegetation with the exception of sparse scattered herbaceous plants and the occasional creosote bush. Surrounding vegetation consists of creosote bush scrub.

Area 3c

Area 3c includes a 0.11 acre section of Bat Cave wash, located to the southwest of the compressor station (Figure 7). Although at the edge of the initial EIR project area, this portion of Bat Cave wash was included in the initial floristic surveys. Vegetation is generally sparse within this section of the wash and includes brittlebush, sweetbush (*Bebbia juncea*), catclaw acacia (*Senegalia greggii*), and Emory rock daisy (*Perityle emoryi*). Species along the rocky slopes above the wash include pygmy-cedar (*Peucephyllum schottii*), buckwheat (*Eriogonium thomasii, E. tricopies*), and beavertail.

Area 3d

Area 3d includes 0.36 acre of a steep rocky slope south of the compressor station (Figure 8). The rocky slope in this area is sparsely vegetated primarily with scattered creosote bush, buckwheat, Emory rock daisy, and ovate plantain (*Plantago ovata*) among other sparse herbaceous plants. There is a small ephemeral drainage that flows into Bat Cave wash just outside the southern edge of this area.

Area 3e

Area 3e is located next to a quarry site in a small valley that is approximately 0.3 miles southwest of the compressor (Figure 9). This 3.13-acre area is characterized by creosote bush scrub vegetation with scattered catclaw acacia. The eastern portion is covered by rocks from the gravel quarry and is devoid of vegetation. There is an ephemeral wash, a continuation of the Bat Cave Wash drainage system, in the north central part of the site.

Area 3f

Area 3f included 7.28 acres of un-paved access roads to the south and east of the evaporation ponds that extend to the east towards Bat Cave wash, the quarry and to some existing well locations (Figure 10). Vegetation adjacent the roads consists of creosote bush scrub.

Area 4

Area 4 includes a 0.27 acre site located on the southwest side of three large drainage culverts located under the Burlington Northern Santa Fe (BNSF) railroad tracks (Figure 11). The survey area is largely devoid of vegetation. The surrounding area is characterized by blue palo verde (*Parkinsonia florida*) trees with scattered honey mesquite (*Prosopis glandulosa*), cheesebush (*Ambrosia salsola*), creosote bush, brittlebush, and sweetbush.

Area 5

Area 5 includes 5.33 acres to the east of the Oatman Highway and west of the BNSF railroad tracks (Figure 12). This survey area includes access roads to the railroad tracks as well as right-of way associated with an overhead electric transmission line. Vegetation in the surrounding areas is characterized by dense salt cedar (*Tamarix ramosissima*) and Athel tamarisk with scattered honey mesquite and blue palo verde as well as more open areas with creosote bush scrub. Portion of the survey area, particularly under the power lines are characterized by bush seepweed (*Suaeda moquinii*).

Area 6

Area 6 includes 51.94 acres located on the east side of the Colorado River across from the Park Moabi campground (Figure 13). This consists of dredge sands with scattered arrow weed (*Pluchea sericea*) and salt cedar. The western side of this survey area was characterized by dense salt cedar thickets with scattered honey mesquite and arrow weed. This area was burned in the April 2016 wildfire, but numerous seedlings and re-sprouts were evident at the time of the July survey. The Topock marsh is located along the western border of this survey. Marsh vegetation includes California bulrush (*Schoenoplectus californicus*), common reed (*Phragmites australis*), narrow leaf cattail (*Typha angustifolia*), and sand-bar willow (*Salix exigua*), with some marsh fleabane (*Pluchea odorata*), and marsh penny wort (*Hydrocotyle verticillata*).

Area 7

Area 7 includes approximately 1500 feet (0.31 acre) of the gravel road along the Colorado River to the north of Area 6 (Figure 14). Dredge sands are present on the east side of the road and the rip-rap banks of the Colorado River extends along the west side of the road. The roadway itself is devoid of vegetation with scattered arrow weed, tamarisk, screwbean mesquite (*Prosopis pubescens*) and honey mesquite present in the areas along the roadway.

Table 1. Plant Species Observed in the Additional Survey Areas

Scientific Names	Common Names	Sites
AMARANTHACEAE	**AMARANTH FAMILY**	
Tidestromia oblongifolia	Honeysweet	3a, 3b, 3f, 5
APIACEAE	**CARROT FAMILY**	
Hydrocotyle verticillata	marsh pennywort	6
APOCYNACEAE	**MILKWEED FAMILY**	
Asclepias subulata	*rush milkweed*	3f
Funastrum hirtellum	climbing-milkweed	3d
ASTERACEAE	**SUNFLOWER FAMILY**	
Ambrosia dumosa	white bursage	3a, 3d
Ambrosia salsola	cheesebush	2, 3a, 3e, 3f, 4, 6
Bebbia juncea var. *aspera*	sweetbush	2, 3a, 3c, 3d, 3e, 3f, 4, 6
Calycoseris wrightii	white tackstem	3b
Chaenactis carphoclinia	pebble pincushion	3a
Encelia farinose	Brittlebush	2, 3a, 3c, 3d, 3e, 3f, 4
Geraea canescens	desert sunflower	1, 2, 3b,
Palafoxia arida	Spanish needle	1, 2, 3e, 6
Pectis papposa var. *papposa*	chinch-weed	1, 2
Perityle emoryi	Emory’s rock daisy	3c, 3d
Peucephyllum schottii	pygmy-cedar	3c
Pluchea odorata	marsh fleabane	6
Pluchea sericea	arrowweed	6, 7
Psathyrotes ramosissima	velvet turtleback	1, 2
Stephanomeria pauciflora	skeletonweed	2, 6
BORAGINACEAE	**BORAGE FAMILY**	
Cryptantha angustifolia	narrow-leaved cryptantha	1, 2, 3a, 3b, 3e, 6
Heliotropium curassavicum	alkali heliotrope	6
Phacelia crenulata ssp. *ambigua*	notch-leaved phacelia	2, 3a, 3c, 3d, 6
Tiquilia plicata	fanleaf crincklemat	6

Table 1. Plant Species Observed in the Additional Survey Areas

Scientific Names	Common Names	Sites
BRASSICACEAE	**MUSTARD FAMILY**	
Brassica tournefortii	Saharan mustard	1, 2, 3e, 6
Sisymbrium orientale	Oriental hedge-mustard	1, 2
CACTACEAE	**CACTUS FAMILY**	
Ferocactus cylindraceus var. *cylindraceus*	California barrel cactus	3d
Opuntia basilaris var. *basilaris*	beavertail	3c, 3d, 3e, 3f
CHENOPODIACEAE	**GOOSEFOOT FAMILY**	
Atriplex polycarpa	cattle saltbush	2, 5
Atriplex lentiformis	big saltbush	5
Chenopodium album	white goosefoot	1, 2, 4
Salsola tragus	Russian thistle	1, 5, 6
Suaeda moquinii	bush seepweed	5
EUPHORBIACEAE	**SPURGE FAMILY**	
Chamaesyce polycarpa	small-seeded spurge	1, 2, 3a, 3b, 3e, 3f, 4
FABACEAE	**LEGUME FAMILY**	
Dalea mollis	hairy indigo-pea	1
Dalea mollissima	downy dalea	3b, 3d
Marina parryi	Parry's marina	4
Parkinsonia florida	blue palo verde	2, 3a, 3e, 4
Prosopis glandulosa var. *torreyana*	honey mesquite	3a, 3f, 4, 5, 6, 7
Prosopis pubescens	screwbean mesquite	8
Senegalia greggii	catclaw acacia	3c, 3e
GENTIANACEAE	**GENTIAN FAMILY**	
Eustoma exaltatum	catchfly gentian	6
LAMIACEAE	**MINT FAMILY**	
Hyptis emoryi	desert-lavender	3c, 3d, 3e
MALVACEAE	**MALLOW FAMILY**	
Sphaeralcea ambigua var. *ambigua*	apricot mallow	3e
NYCTAGINACEAE	**FOUR-O-CLOCK FAMILY**	
Abronia villosa	sand verbena	2
Allionia incarnata var. *incarnata*	trailing windmills	1, 2
Boerhavia wrightii	Wright’s spiderling	2, 3d
Mirabilis laevis var. *retrorsa*	retrorse desert four-o'clock	3e

Table 1. Plant Species Observed in the Additional Survey Areas

Scientific Names	Common Names	Sites
ONAGRACEAE	**EVENING PRIMROSE FAMILY**	
Chylismia brevipes	golden suncup	3a, 3b
PHRYMACEAE	**LOPSEED FAMILY**	
Mimulus sp.	monkey flower	6
PLANTAGINACEAE	**PLANTAIN FAMILY**	
Mohavea confertiflora	Mojave ghost-flower	3b
Plantago ovata	ovate plantain	2, 3b, 3c, 3d, 3e, 3f
POLYGONACEAE	**BUCKWHEAT FAMILY**	
Chorizanthe brevicornu var. *brevicornu*	brittle spineflower	3a, 3c, 3e
Chorizanthe corrugata	wrinkled spineflower	3b
Chorizanthe rigida	rigid spineflower	3b, 3e, 3f
Eriogonum deflexum var. *deflexum*	flat-crown buckwheat	1, 3c, 3e
Eriogonum inflatum var. *inflatum*	inflated desert trumpet	3d, 6
Eriogonum thomasii	Thomas's wild buckwheat	3a, 3b, 3c, 3d, 3e
Eriogonum trichopes	little desert buckwheat	3a, 3b, 3c
RESEDACEAE	**MIGNONETTE FAMILY**	
Oligomeris linifolia	linear-leaved oligomeris	2, 3b, 3c, 3d, 3e, 3f
SALICACEAE	**WILLOW FAMILY**	
Salix exigua	sand-bar willow	6
SOLANACEAE	**NIGHTSHADE FAMILY**	
Nicotiana obtusifolia	desert tobacco	3c, 3e
Physalis crassifolia	thick-leaf ground cherry	3c, 3d, 3e, 4
TAMARICACEAE	**TAMARISK FAMILY**	
Tamarix aphylla	athel tamarisk	1, 3e, 5
Tamarix ramossisima	salt cedar	5, 6, 7
ZYGOPHYLLACEAE	**CALTROP FAMILY**	
Larrea tridentata	creosote bush	2, 3a, 3b, 3d, 3e, 3f, 4, 5, 6
Tribulus terrestris	puncture vine	1, 2, 3b, 4
MONOCOTS		
CYPERACEAE	**SEDGE FAMILY**	
Schoenoplectus californicus	California bulrush	6
POACEAE	**GRASS FAMILY**	
Aristida adscensionis	six-weeks three awn	2, 3a, 3d

Table 1. Plant Species Observed in the Additional Survey Areas

Scientific Names	Common Names	Sites
Arundo donax	giant reed	6
Bouteloua barbata ssp. *barbata*	six weeks gamma	1, 2, 4
Phragmites australis	common reed	6
Schismus barbatus	Mediterranean grass	1, 2, 3a, 3b, 3c, 3e, 4, 5, 6, 7
TYPHACEAE	**CATTAIL FAMILY**	
Typha angustifolia	narrow-leaved cattail	6

Special Status Plants and Ethnobotanical Plants

No rare threatened or endangered plants were observed in the additional survey areas. Trees and shrubs protected under the CDNPA identified during the survey include blue palo verde, catclaw acacia, honey mesquite, screwbean mesquite, beavertail, California barrel cactus (*Ferocactus cylindraceus*), and silver cholla (*Cylindropuntia echinocarpa*).

Culturally sensitive plant species observed included blue palo verde, honey mesquite, cattle saltbush (*Atriplex polycarpa*), big saltbush (*Atriplex lentiformis*), and desert tobacco (*Nicotiana obtusifolia*). Many of the palo verde and all of the honey mesquite trees consisted of small saplings found along roadways, disturbed areas and in the 2016 burn area on the east side of the Colorado River. Other sites contained larger, more mature trees.

The plant species observed as well as in which survey area are listed in Table 2 and the locations of the plants within or immediately adjacent to the survey area shown in Figures 3 – 14.

Table 2. Special-Status and Ethnobotanical Plants Observed

Species	Survey Area(s)	Figure(s)
Blue palo verde[a,b]	2, 3a, 3b, 3e, 4, 5	4, 5, 6, 9, 11, 12
Honey Mesquite[a,b]	3a, 3f, 5, 6, 7	5, 10, 12, 13, 14
Screwbean Mesquite[a,b]	7	14
Catclaw acacia[a]	3a (outside area), 3e	5, 9
California barrel cactus[a]	3d	8
Silver cholla[a]	3a	5
Beavertail[a]	3d, 3f	8, 10
Cattle Saltbush[b]	1, 2	3, 4
Big saltbush[b]	5	12
Desert Tobacco[b]	3e	9

[a] The California Deserts Native Plants Act.

[b] Ethnobotanical Plant.

Desert Tortoise

Consistent with previous protocol and non-protocol desert tortoise surveys in the Project Area, no desert tortoise or any sign of desert tortoise (e.g., scat or remains) was detected during the surveys. Overall the survey areas consisted of poor quality habitat dominated by mixed creosote bush scrub with a rocky substrate, roadsides and dredge sands that are not conducive for the construction of burrows. Much of the survey area has been previously disturbed from BNSF railway activities, Interstate 40, and numerous off-highway vehicle trails. Furthermore, the sites are within an area of fragmented habitat, and are separated from surrounding tortoise habitat by the BNSF railway, National Trails Highway, Interstate 40, and developments in Moabi Regional Park. Only three of the area were considered to provide suitable desert tortoise habitat; Areas 3b, 3d, and 3f and the only suitable burrows were observed in the ephemeral washed in the area surrounding the evaporation ponds (Area 3b), but there was no evidence of active desert tortoise in this area.

Birds and Other Wildlife

A list of wildlife species observed during the survey is provided in Table 1. The surveys evaluated the habitat at each site and no sites included suitable habitat for any special-status and protected wildlife species. During the May surveys a black-necked stilt nest with two eggs was observed on the dried residue near the center of one of the evaporation ponds (Figure 6). An inactive, hanging nest was observed within a palo verde tree just northwest of Area 4. Based on the remnant feathers and nest construction, it was tentatively identified as a cactus wren (*Campylorhynchus brunneicapillus*) nest. Numerous large trees are present in the area around Area 5, but no nests were observed in this area during the survey. The black-necked stilt and cactus wren are not special-status species.

A dead Lucy’s warbler was observed beneath the power lines in Area 5, possibly the result of a collision with the overhead power lines in this area. No nests were observed in the immediate vicinity of the dead bird; however, potentially suitable nesting habitat in tamarisk thickets with mesquite occurs in the surrounding areas.

The Lucy’s warbler is a California Department of Fish and Wildlife Bird Species of Special Concern (Priority 3) and can be found in California during the summer breeding season (mid-April to early July). In California, this species occurs in areas along the lower Colorado and other desert riparian areas within the Mojave Desert. Lucy’s warbler habitat includes mesquite bosques, preferring honey mesquite thickets (*Prosopis glandulosa*), with moderate use of tamarisk, screw bean mesquite (*Prosopis pubescens*), and cottonwood-willow areas. This species is a common cavity nester, and frequently uses nests excavated by Ladder-backed woodpeckers (*Picoides scalaris*). Nesting season in the Project Area begins about mid-March and continues through the end of July (Otahal, 2006; Zeiner et al., 1990).

There are no California Natural Diversity Database occurrences in the area; however, a dead Lucy’s warbler fledgling was observed during biological surveys of the project area. Although the individual was observed on the Arizona side of the Colorado River, the species may be present within suitable habitat on both sides of the River. In California, there is suitable habitat for this species within the mouth of Bat Cave Wash. In Arizona, there is suitable habitat along both sides of the Oatman-Topock Highway.

PG&E has developed a Bird Impact Avoidance and Minimization Plan to avoid impacts to avian species during project activities (CH2M, 2014a). A summary of the main Avoidance and Minimizations Measures that would minimize risk to the Lucy’s warbler, as well as other special status avian species that may be encountered, include the following:

- Preconstruction surveys should be performed prior to ground-disturbing or noise-generating activities conducted between March 15 and September 30.

- The location of any active nest shall be flagged, mapped, and communicated to the project foreperson. For each identified active nest, the biologist will record species, nest location, behavior, site conditions, estimated date of nest establishment, and estimated fledge date.
- Buffers of up to 500 feet will be established around all identified special status specie's active nests to avoid impacts (for the Lucy's warbler, the buffer is up to 75 feet).
- All personnel involved shall be required to attend a worker education program prior to working onsite and outside of fenced areas. New employees shall receive training prior to working onsite.
- Any dead or injured special status bird species found in the project area shall be reported to the PG&E project biologist, U.S. Fish and Wildlife Service, California Department of Fish and Wildlife, and BLM.

The tamarisk thicket (prior to the 2016 wildfire) as well as the Topock Marsh habitat on the east of Area 6 provide habitat for the southwest willow flycatcher and Yuma clapper Rail. These areas are included in ongoing protocol surveys for these species.

Other observations included burrow/den structures in and around Area 3d that could potentially be used by ring-tailed cats (*Bassariscus astutus*).

Table 3. Wildlife Species Observed

Scientific Names	Common Names	Sites
BIRDS		
Fulico americana	American coot	6
Himantopus mexicanus	Black-necked stilt	3b
Campylorhynchus brunneicapillus	Cactus wren	4
Quiscalus quiscula	Common grackle	6
Corvus corax	Common raven	4
Phalacrocorax auritus	Double-crested cormorant	3b, 6
Ardea alba	Great egret	6
Geococcyx californianus	Greater roadrunner	2, 5, 6
Charadrius vociferus	Killdeer	3b
Oreothlypis luciae	Lucy's warbler	5
Zenaida macroura	Mourning dove	3b
Cathartes aura	Turkey vulture	3b, 3f
Zenaida asiatica	White-winged dove	5, 6
REPTILES		
Masticophis flagellum	Coachwhip	3a
Dipsosaurus dorsalis	Desert iguana	2
Uta stansburiana	Side-blotched lizard	2, 3b, 3d, 3e
Aspidoscelis tigris	Western whiptail	2, 3b, 3c

Table 3. Wildlife Species Observed

Scientific Names	Common Names	Sites
AMPHIBIANS		
Rana catesbeiana	American bullfrog	6
Anaxyrus punctatus	Red spotted toad	3b
MAMMALS		
Sylvilagus auduboni	Desert cottontail	6

Wetlands and Waters

Several ephemeral drainage feature are present in the additional survey areas, many of these features have been previously delineated and mapped, others are extensions of previously mapped features and a few are previously un-mapped. Descriptions of these features are provided below; acreages and figure numbers are provided in Table 4.

There is an ephemeral wash feature near the east side of Area 3a that flows under the BNSF Railroad track via a 10-foot diameter cement culvert. From the culvert outfall the 20 to 30-foot wide open gravel channel flows north for approximately 350 feet where it then opens up into a broad low area before passing under the gravel roadway via two 48-inch diameter culverts and eventually flows into Park Moabi Slough. The wash located on the west of the railroad track was included in the wetland delineation report (CH2M, 2014b)

Area 3c is located within the southern part of Bat Cave Wash. At this location the channel is approximately 30 feet wide and sparely vegetated with Emory rock daisy and brittlebush. A small patch of Catclaw acacia is present in the wash on the southwest side of Area 3c survey boundary. CH2M, 2014b).

There is a small ephemeral wash, tributary to Bat Cave Wash that runs along the southern edge of area 3d. This feature is on average approximately 6 feet wide with a coble-gravel substrate that is largely devoid of vegetation. This feature is located outside of the boundary of area 3d, but was not previously mapped and was therefore included as part of this assessment.

A small drainage channel, included in the wetland delineation report (CH2M, 2014b) is present in area 3e. This ephemeral rocky channel is on average 5 feet wide and is largely devoid of vegetation.

Area 4 includes 3 10-foot diameter corrugated metal culverts under the BNSF railroad tracks. The drainage channel extending north from the culvert outfalls was mapped as part of the wetland delineation report (CH2M, 2014b). The area on the southwest side of the culverts was not previously mapped. This section of the drainage lacks a defined bed and bank channel and is more of a low, broad topographic swale that conveys water into the culverts. There is a small area of scour near the northern most of the three culverts, but no other evidence of a defined ordinary high water mark in this area. The area immediately east of the culverts was largely devoid of vegetation.

Area 5 includes a low open sandy ephemeral drainage that flows through semi-circular culvert under the BNSF railroad just east of the survey area. The drainage lacks defined channel banks and is characterized more by a low swale with sandy substrates that are relatively devoid of vegetation. The drainage swale dissipates into sheet flow on the east side of Oatman Highway and has no apparent hydrologic connection to the Topock Marsh and was therefore not considered to be a jurisdictional Waters of the U.S. This drainage feature was included in the wetland delineation report (CH2M, 2014b).

There is a portion of the Topock Marsh along the eastern side of Area 6. Vegetation in this area consists of patches of sand bar willow as well as emergent vegetation such as narrow-leaf cattail and California bulrush.

Table 4. Waters and Wetlands

Feature ID	Acreage	Figure	Wetlands or Other Waters of the United States
RIVERINE WETLANDS			
Area 3a – R4SB3A Ephemeral Wash / Drainage		5	Waters of the United States
Area 3c – R4SB3A Bat Cave Wash		7	Waters of the United States
Area 3d – R4SB3A Ephemeral Wash / Drainage		8	Waters of the United States
Area 3e – R4SB3A Ephemeral Wash / Drainage		9	Waters of the United States
Area 4 – R4SB3A Ephemeral Wash / Drainage		11	Waters of the United States
PALUSTRINE WETLANDS			
Area 6 – PEMH Topock Marsh		13	Wetland / Waters of the United States
Total			
OTHER WATER FEATURES			
Area 5 – Ephemeral Drainage		12	Non-Tributary Drainage

References

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Figures

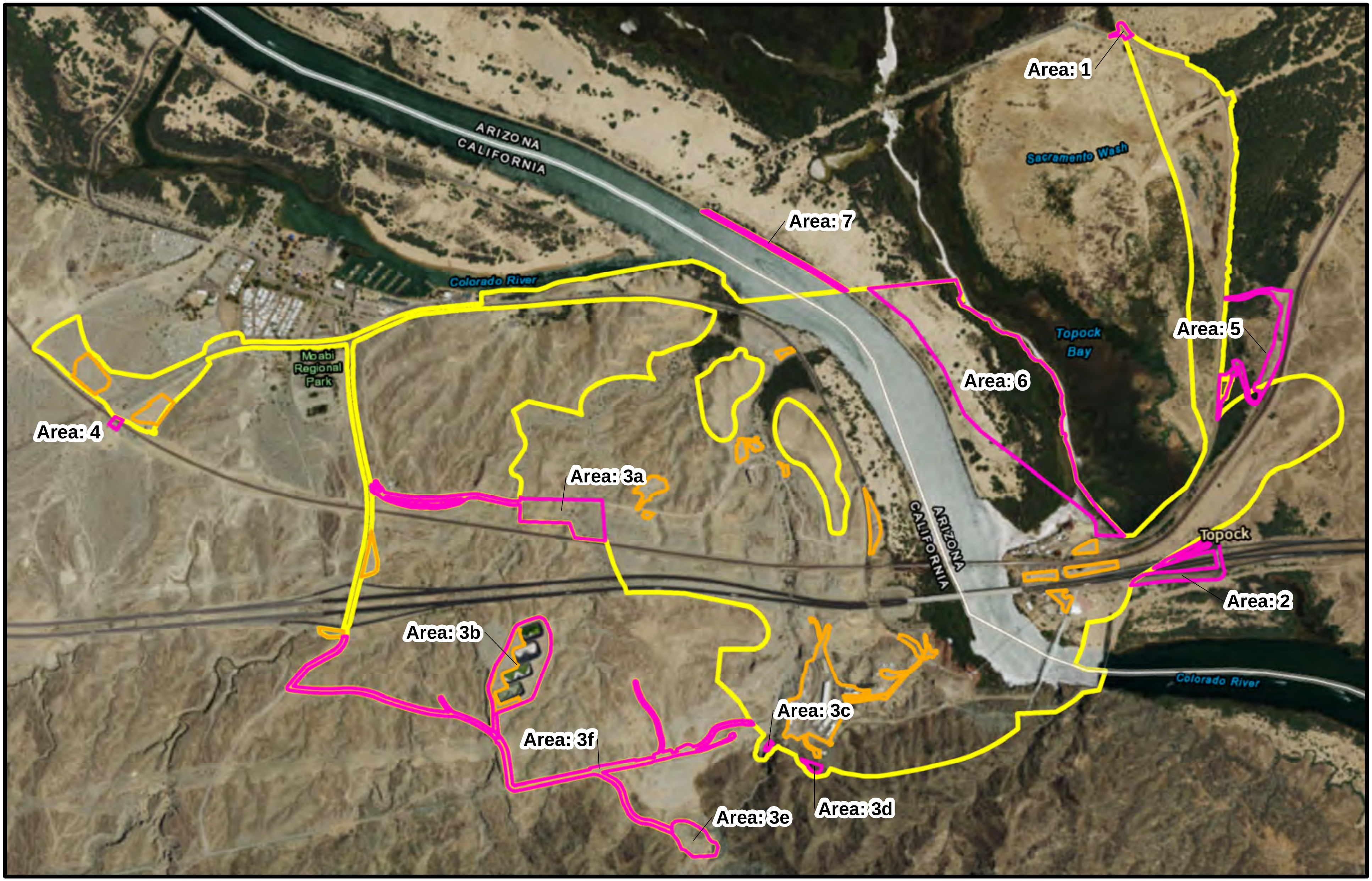

FIGURE 1
SURVEY AREAS 2016
FINAL GROUNDWATER REMEDY
HAVASU NATIONAL WILDLIFE REFUGE
PG&E TOPOCK COMPRESSOR STATION,
NEEDLES, CALIFORNIA

CH2MHILL

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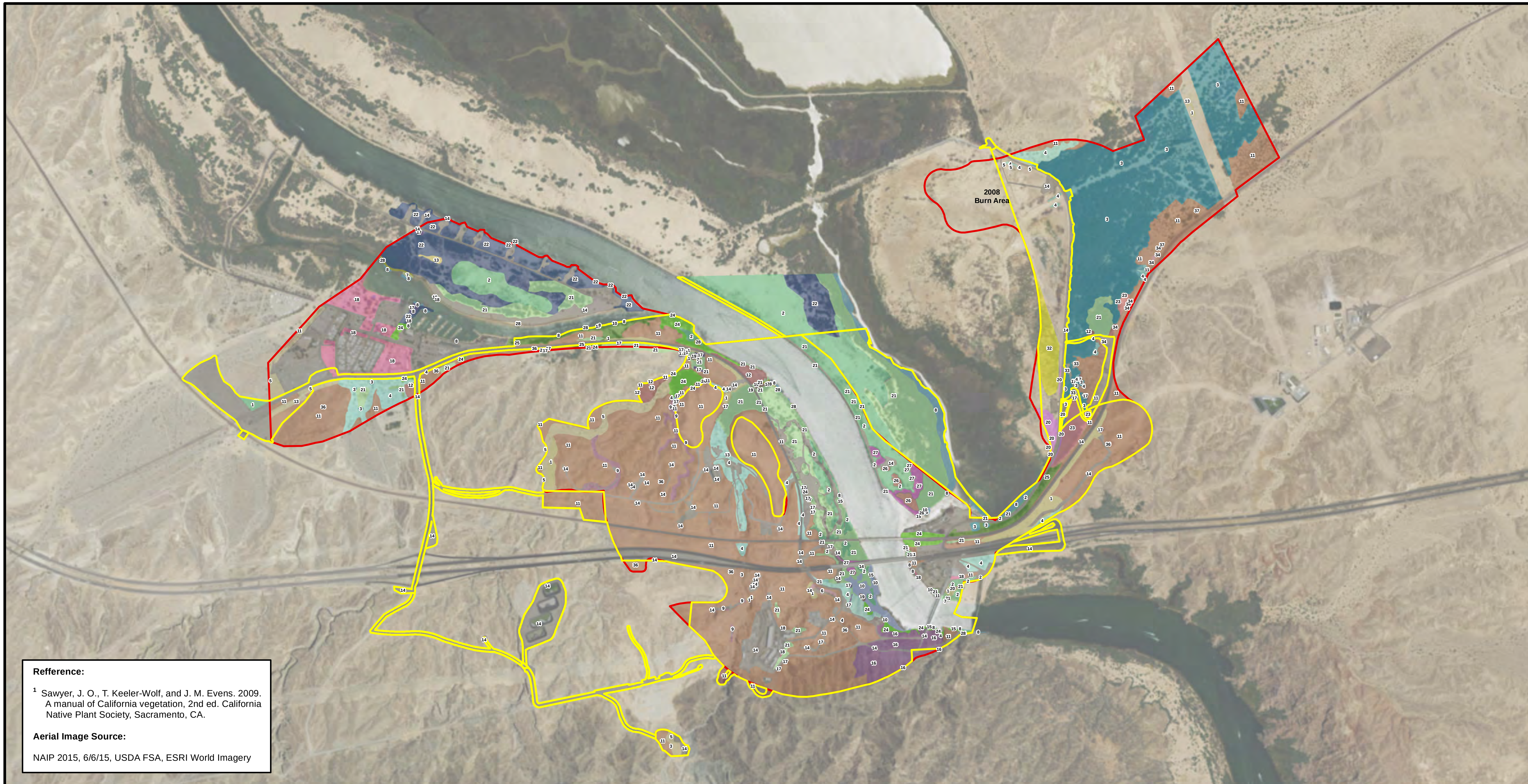

Refference:

[1] Sawyer, J. O., T. Keeler-Wolf, and J. M. Evens. 2009. A manual of California vegetation, 2nd ed. California Native Plant Society, Sacramento, CA.

Aerial Image Source:

NAIP 2015, 6/6/15, USDA FSA, ESRI World Imagery

LEGEND

- Revised EIR Project Area
- EIR Project Area (2013)

Vegetation Types

- Desert Lilly
- Allscale Scrub (MCV2[1]: Allscale scrub)
- Arrow Weed (MCV2: Arrow weed
- Athel Tamarisk (MCV2: Tamarisk thickets)[3]
- Blue Paloverde (MCV2: Blue palo verde-Ironwood woodland)[4]
- Blue Paloverde/Catclaw Acacia (MCV2: Blue palo verde-Ironwood
- Blue Paloverde/Honey Mesquite (MCV2: Blue palo verde woodland)[6]
- Broad-leaved Cattail (MCV2: Cattail marshes)[7]
- California Bullrush (MCV2: California bulrush marsh)[8]
- Catclaw Acacia (MCV2: Catclaw acacia thorn
- Common Reed (MCV2: Common reed marshes)[10]
- Creosote bush scrub (MCV2:Creosote bush scrub)[11]
- Creosote Bush/Cattle Saltbush (MCV2: Allscale
- Desert Smoke Tree (MCV2: Blue palo verde-Ironwood woodland)[13]
- Developed/Disturbed[14]
- Giant Reed (MCV2:Giant reed breaks)[15]
- Hillside Paloverde (MCV2: Foothill palo verde desert scrub)[16]
- Honey Mesquite (MCV2: Mesquite bosque)[17]
- Landscaped[18]
- Open Water [19]
- Quailbush Scrub (MCV2: Quailbush scrub)[20]
- Salt Cedar (MCV2: Tamarisk thickets)[21]
- Salt Cedar/Arrow Weed (MCV2: Tamarisk/Arrow weed thickets)[22]
- Salt Cedar/Athel Tamarisk (MCV2: Tamarisk thickets)[23]
- Salt Cedar/Honey Mesquite (MCV2: Tamarisk thickets/Mesquite bosque)[24]
- Salt Cedar/Honey Mesquite/Blue Paloverde (MCV2: Tamarisk thickets/Mesquite bosque/Blue palo verde-Ironwood woodland)[25]
- Salt Cedar/Screwbean Mesquite (MCV2: Tamarisk thickets/ Screwbean mesquite bosque)[26]
- Screwbean Mesquite (MCV2: Screwbean mesquite bosque)[27]
- Wetland [28]

N

0 1,000 2,000 Feet

FIGURE 2
VEGETATION COMMUNITIES IN PROJECT AREA

FINAL GROUNDWATER REMEDY
HAVASU NATIONAL WILDLIFE REFUGE
PG&E TOPOCK COMPRESSOR STATION,
NEEDLES, CALIFORNIA

CH2MHILL

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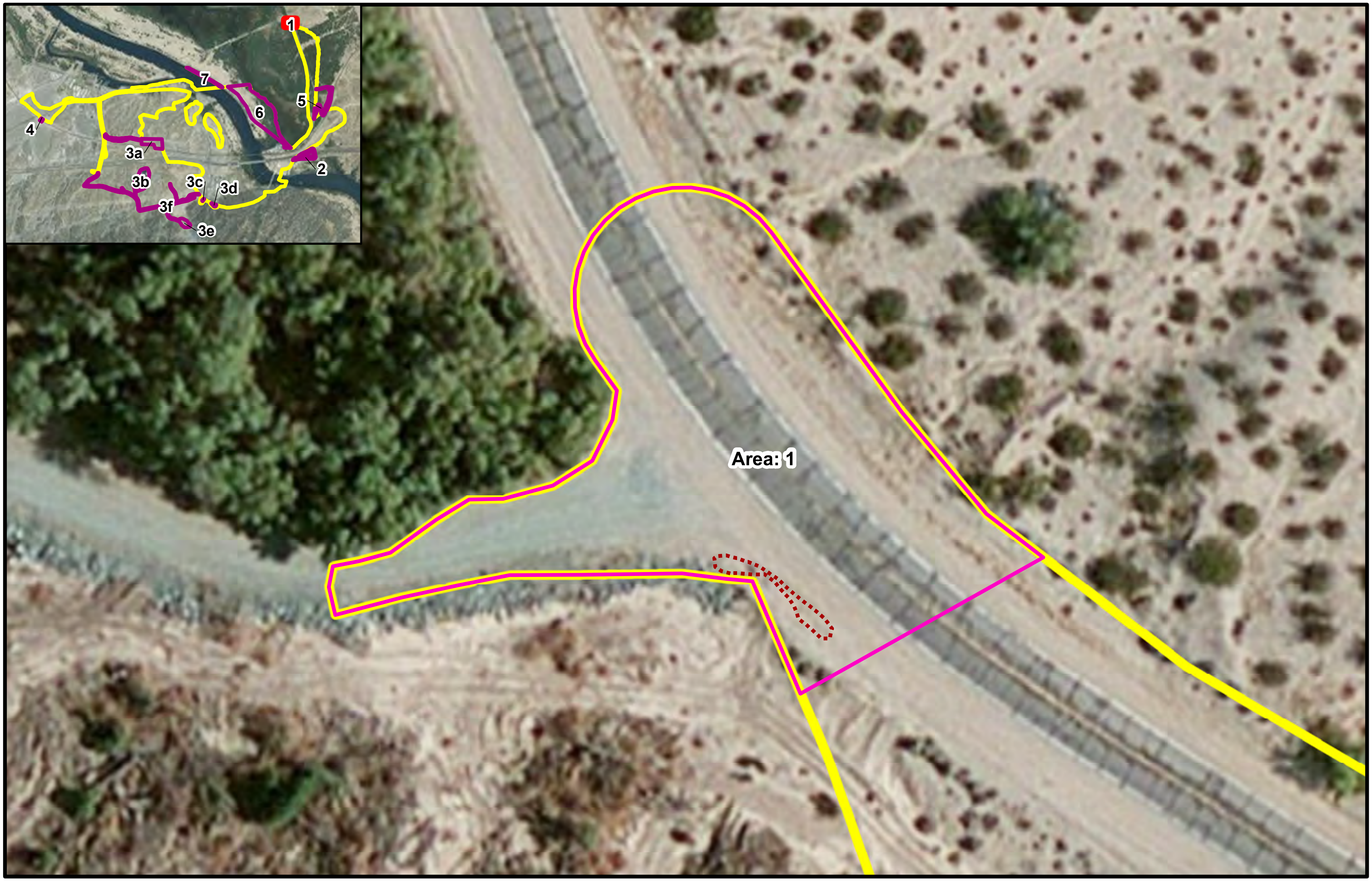

LEGEND

Sensitive Plants

Cattle saltbrush

Site Features

Additional Survey Area

Revised EIR Project Area

N

0 25 50 Feet

FIGURE 3:
AREA 1 – SENSITIVE PLANTS

FINAL GROUNDWATER REMEDY
HAVASU NATIONAL WILDLIFE REFUGE
PG&E TOPOCK COMPRESSOR STATION,
NEEDLES, CALIFORNIA

CH2MHILL

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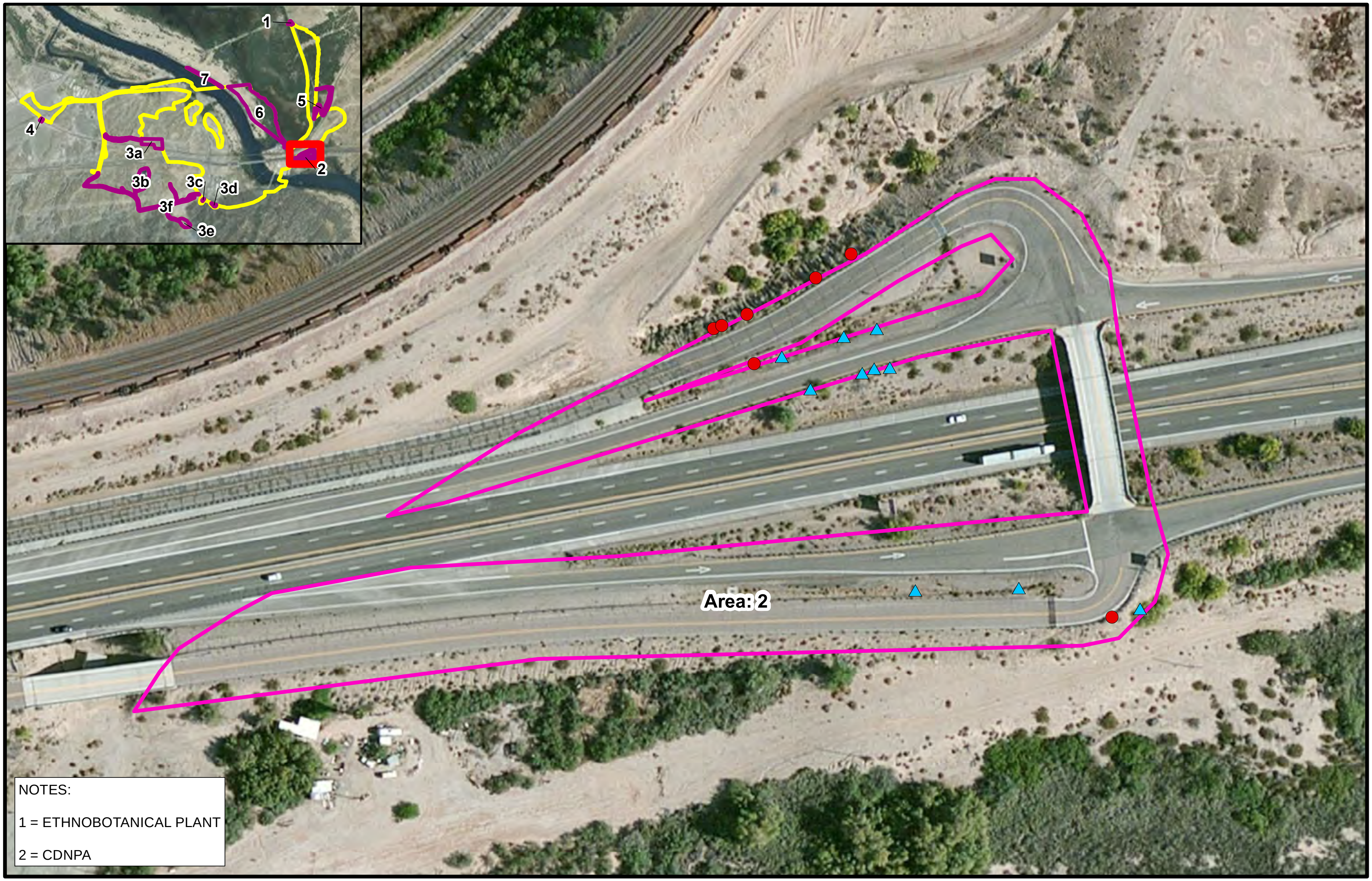

LEGEND

Sensitive Plants
- Cattle saltbush
- Blue palo verde (1,2)

Site Features
- Additional Survey Area
- Revised EIR Project Area

N

0 70 140 Feet

FIGURE 4:
AREA 2 – SENSITIVE PLANTS

FINAL GROUNDWATER REMEDY
HAVASU NATIONAL WILDLIFE REFUGE
PG&E TOPOCK COMPRESSOR STATION,
NEEDLES, CALIFORNIA

CH2MHILL

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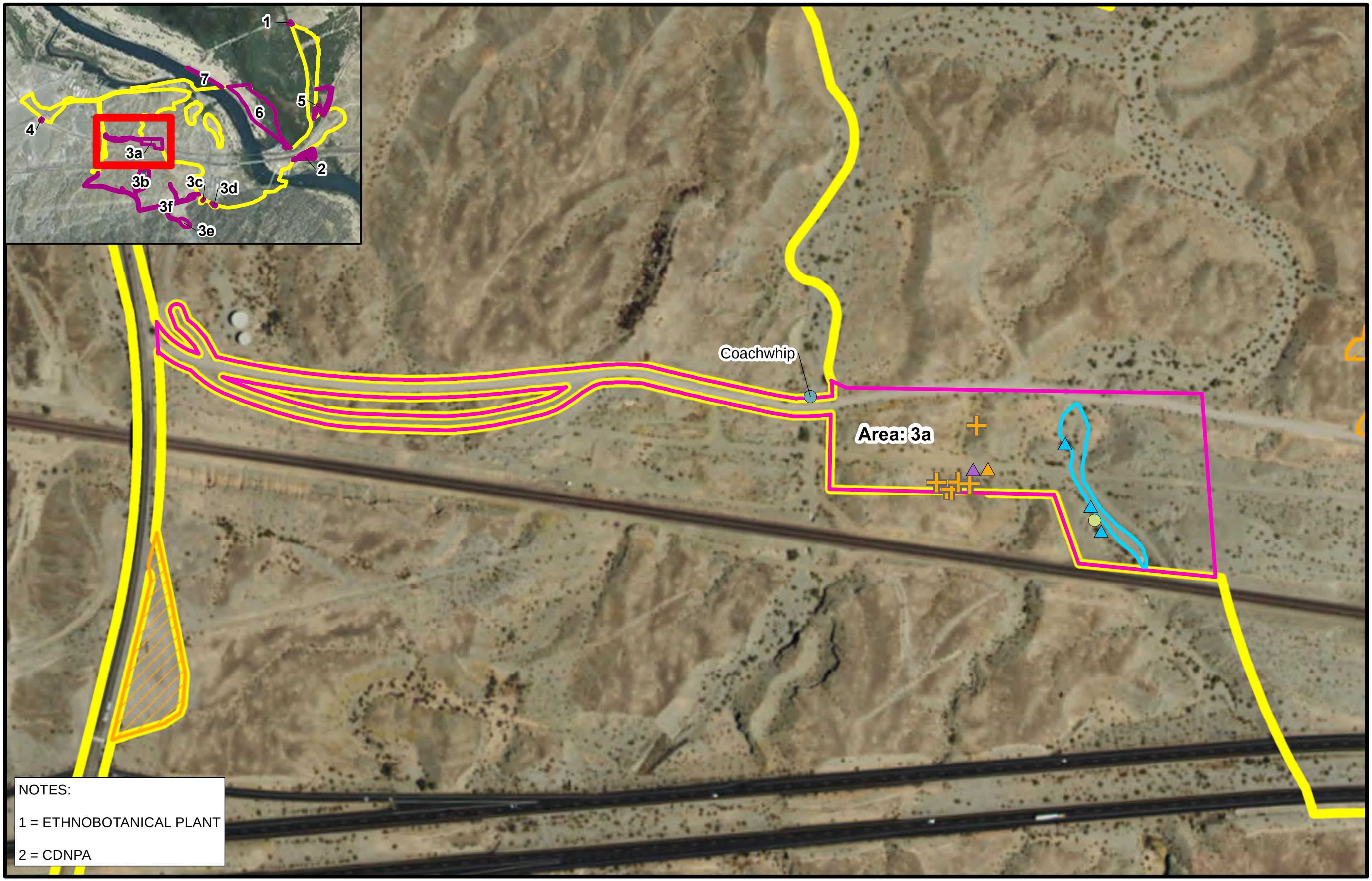

LEGEND

Sensitive Plants
- Blue palo verde (1, 2)
- Catclaw acacia (2)
- Western honey mesquite (1,2)
- Silver cholla (2)

Wildlife
- Coachwhip

Waters and Wetlands
- R4SB3A - Ephemeral Wash/Drainage

Site Features
- Additional Survey Area
- Staging Area
- Revised EIR Project Area

N

0 170 340 Feet

FIGURE 5:
AREA 3A – WILDLIFE, SENSITIVE PLANTS, AND WATERS AND WETLANDS
FINAL GROUNDWATER REMEDY
HAVASU NATIONAL WILDLIFE REFUGE
PG&E TOPOCK COMPRESSOR STATION,
NEEDLES, CALIFORNIA

CH2MHILL

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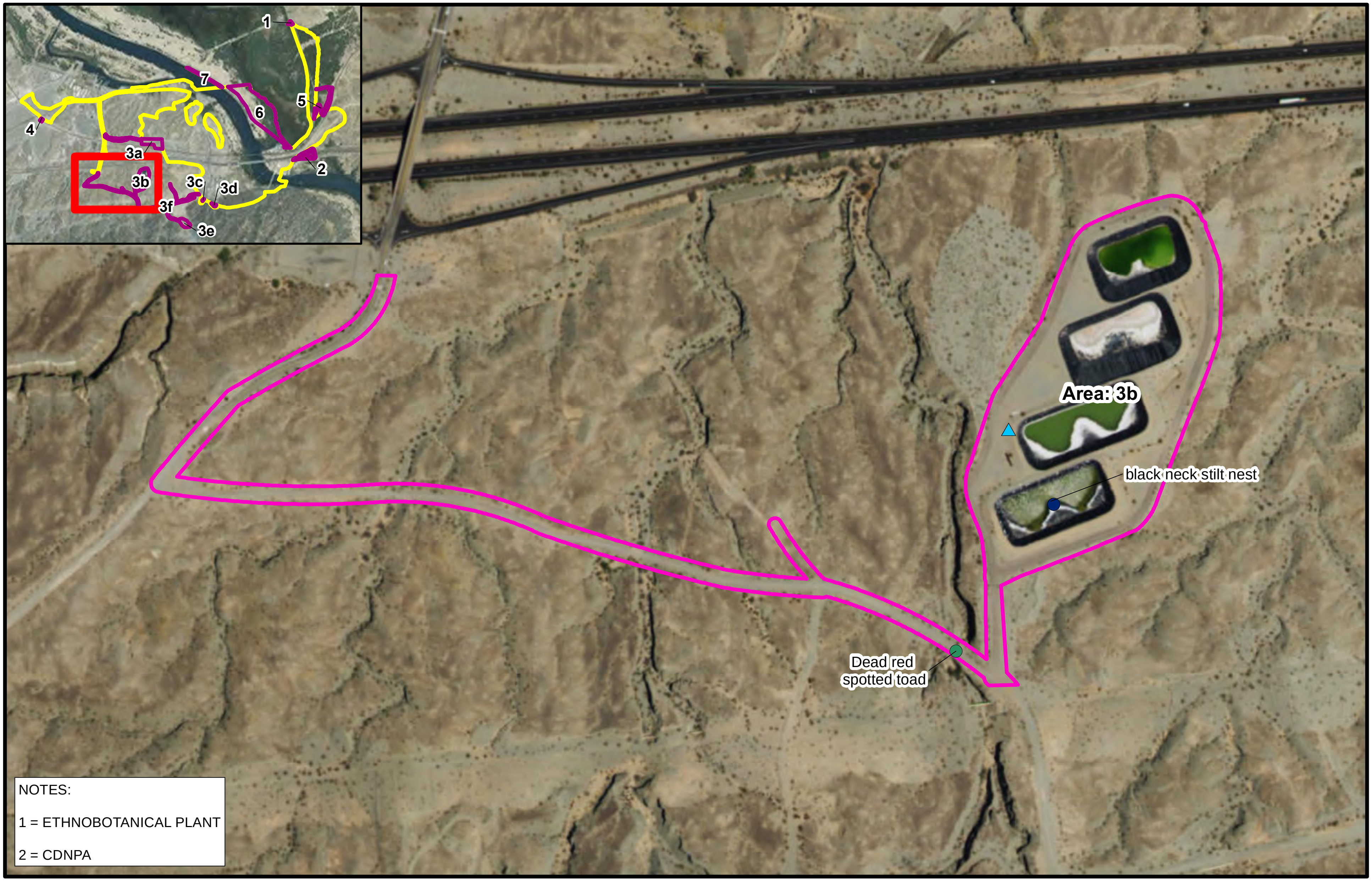

LEGEND

Sensitive Plants
- Blue palo verde (1, 2)

Wildlife
- Dead red spotted toad
- Black-neck stilt nest

Site Features
- Additional Survey
- Staging Area
- Revised EIR Project Area

N

0 190 380 Feet

FIGURE 6:
AREA 3B – WILDLIFE AND SENSITIVE PLANTS

FINAL GROUNDWATER REMEDY
HAVASU NATIONAL WILDLIFE REFUGE
PG&E TOPOCK COMPRESSOR STATION,
NEEDLES, CALIFORNIA

CH2MHILL

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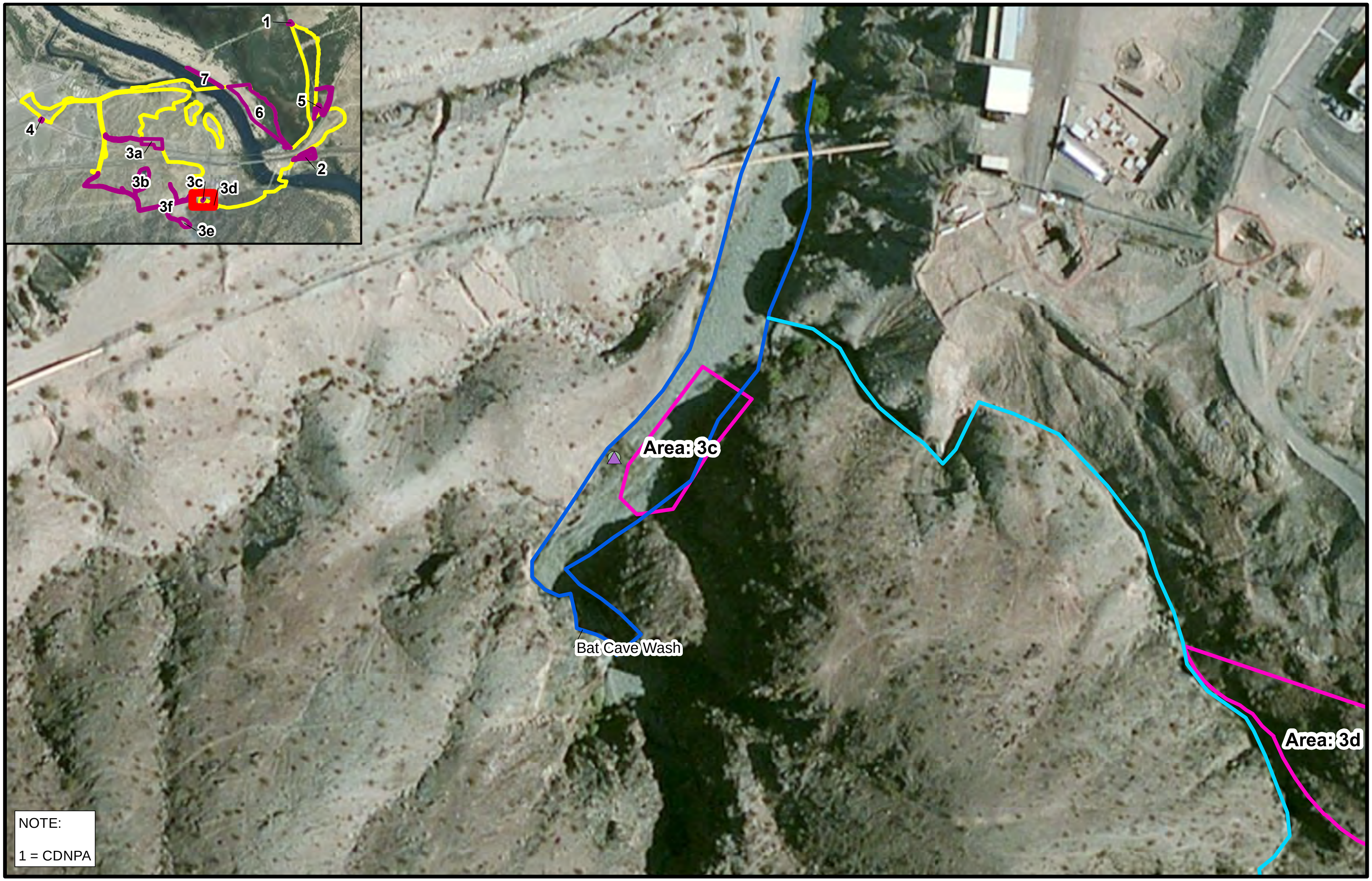

LEGEND

Sensitive Plants

▲ **Catclaw acacia (1)**

Waters an Wetlands

Bat Cave Wash: R4SB3A - Ephemeral Wash / Drainage

R4SB3A - Ephemeral Wash/Drainage

Site Features

Additional Survey Area

Staging Area

Revised EIR Project Area

N

0 50 100 Feet

FIGURE 7: AREA 3C – SENSITIVE PLANTS AND WATERS AND WETLANDS

FINAL GROUNDWATER REMEDY
HAVASU NATIONAL WILDLIFE REFUGE
PG&E TOPOCK COMPRESSOR STATION,
NEEDLES, CALIFORNIA

CH2MHILL

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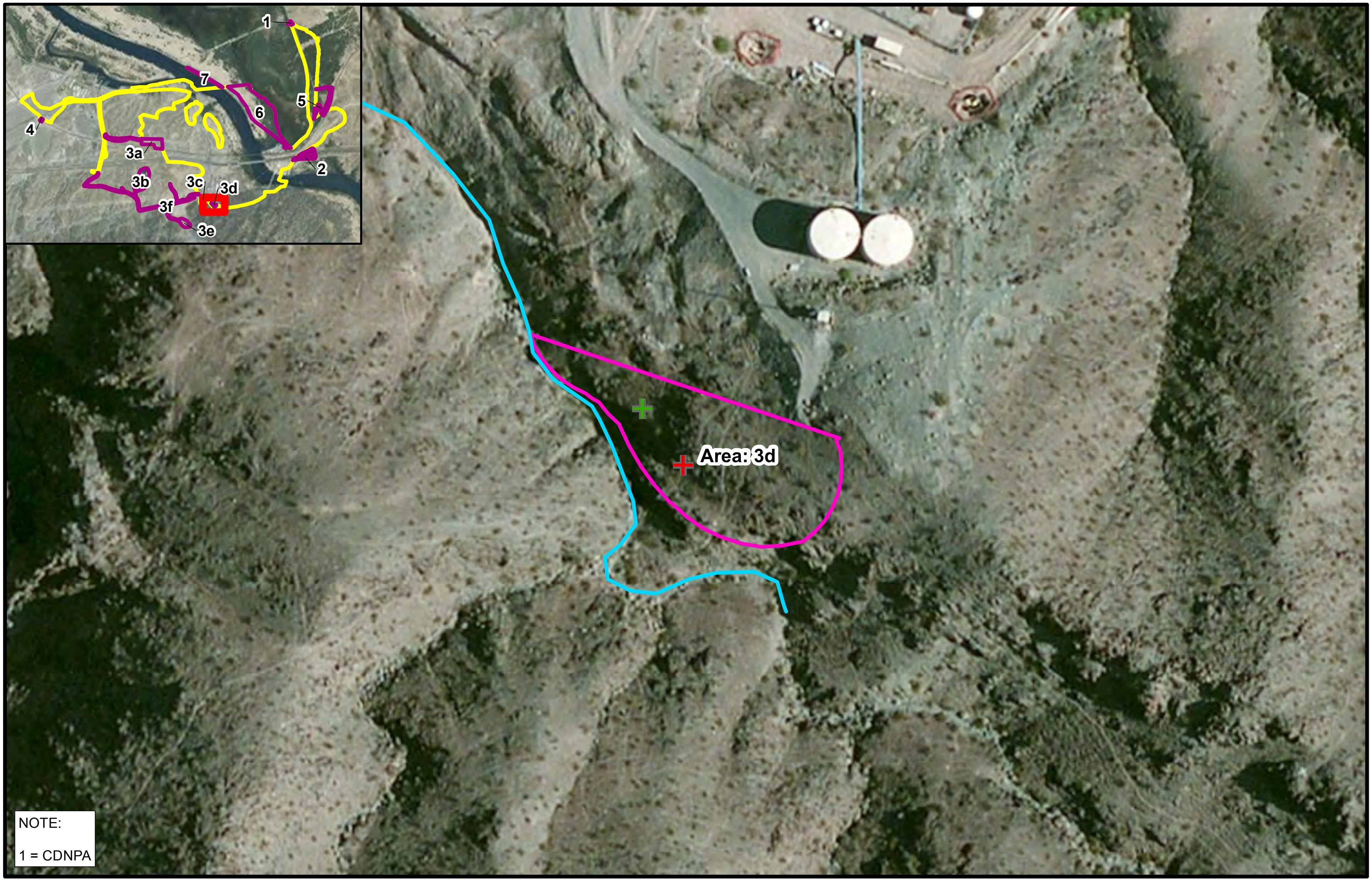

LEGEND

Sensitive Plants
- Beavertail prickly pear (1)
- California barrel cactus (1)

Waters and Wetlands
- R4SB3A – Ephemeral Wash/Drainage

Site Features
- Additional Survey Area
- Staging Area
- Revised EIR Project Area

N

0 50 100 Feet

FIGURE 8:
AREA 3D – SENSITIVE PLANTS AND WATERS AND WETLANDS
FINAL GROUNDWATER REMEDY
HAVASU NATIONAL WILDLIFE REFUGE
PG&E TOPOCK COMPRESSOR STATION,
NEEDLES, CALIFORNIA

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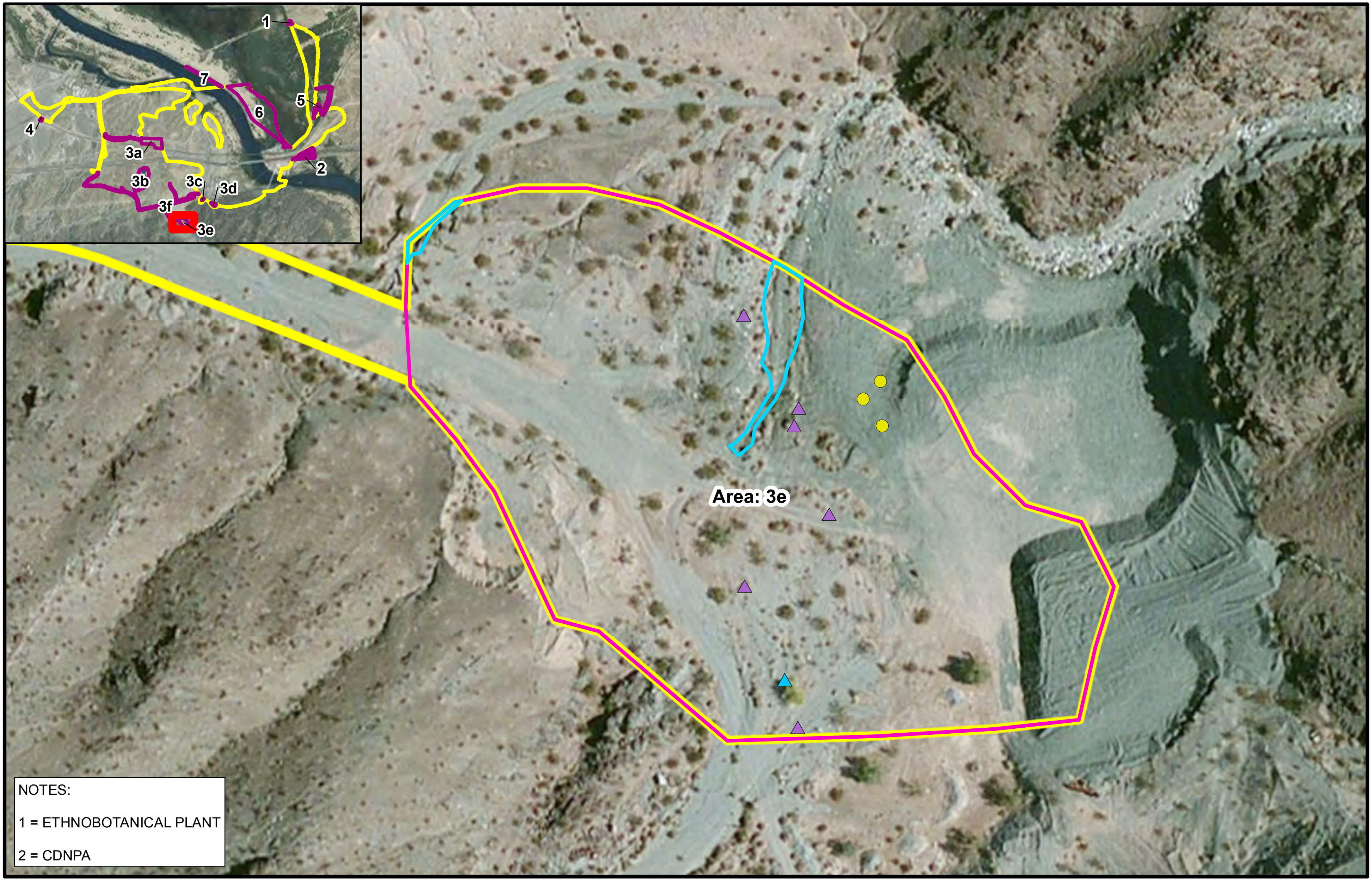

LEGEND

Sensitive Plants
- Catclaw acacia (2)
- Desert tobacco (1)
- Blue palo verde (1,2)

Waters and Wetlands
- R4SB3A – Ephemeral Wash/Drainage

Site Features
- Additional Survey Area
- Revised EIR Project Area

N

0 50 100 Feet

FIGURE 9:
AREA 3E – SENSITIVE PLANTS AND WATERS AND WETLANDS

FINAL GROUNDWATER REMEDY
HAVASU NATIONAL WILDLIFE REFUGE
PG&E TOPOCK COMPRESSOR STATION,
NEEDLES, CALIFORNIA

CH2MHILL

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LEGEND

Sensitive Plants
- Beavertail prickly pear (2)
- Western honey mesquite (1, 2)

Site Features
- Additional Survey Area
- Staging Area
- Revised EIR Project Area

N

0 200 400 Feet

FIGURE 10:
AREA 3F – SENSITIVE PLANTS
FINAL GROUNDWATER REMEDY
HAVASU NATIONAL WILDLIFE REFUGE
PG&E TOPOCK COMPRESSOR STATION,
NEEDLES, CALIFORNIA

CH2MHILL

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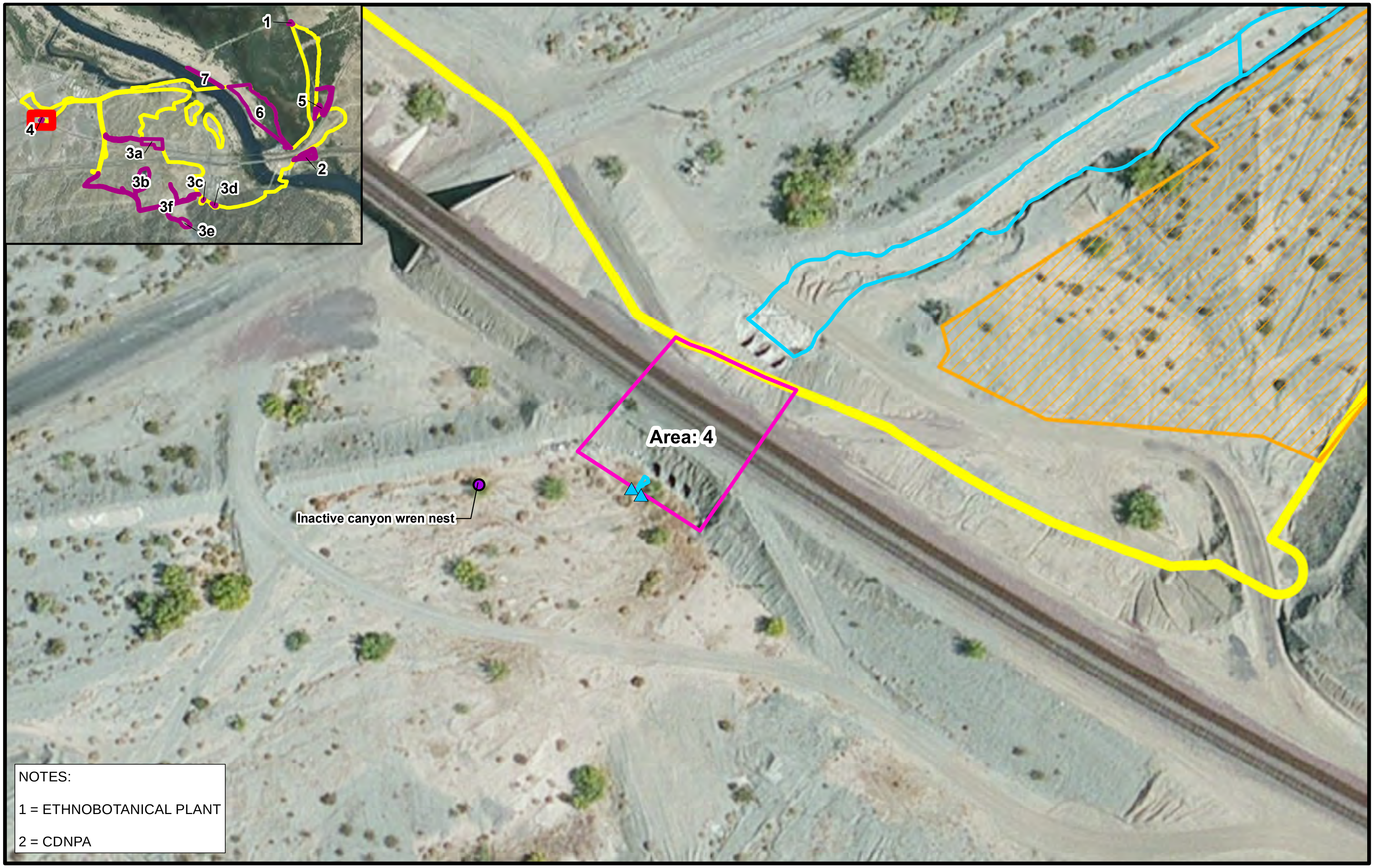

NOTES:

1 = ETHNOBOTANICAL PLANT

2 = CDNPA

LEGEND

Wildlife

- Inactive canyon wren nest

Sensitive Plants

- Blue palo verde (1,2)

Waters and Wetlands

- R4SB3A - Ephemeral Wash/Drainage

Site Features

- Additional Survey Area
- Staging Area
- Revised EIR Project Area

N

0 50 100 Feet

FIGURE 11:
AREA 4 – WILDLIFE, SENSITIVE PLANTS AND WETLANDS AND WATERS

FINAL GROUNDWATER REMEDY
HAVASU NATIONAL WILDLIFE REFUGE
PG&E TOPOCK COMPRESSOR STATION,
NEEDLES, CALIFORNIA

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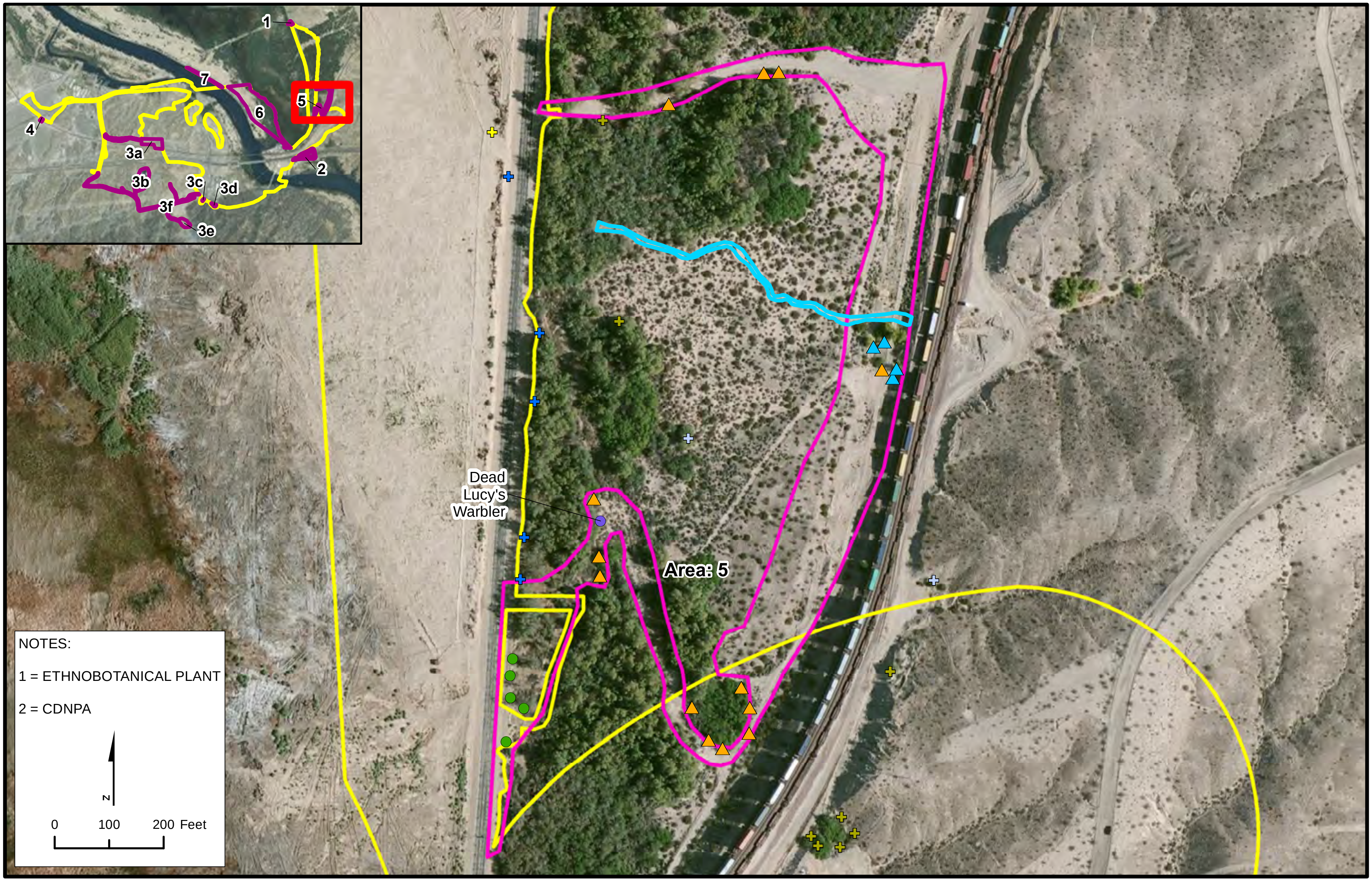

LEGEND

Sensitive Plants
- Big saltbush (1)
- Beavertail prickly pear (2)
- Blue palo verde (1,2)
- Western honey mesquite (1, 2)

Wildlife
- Dead Lucy's Warbler

Previous Survey Data (2014)
- Blue Palo Verde
- Desert Tobacco
- Honey Mesquite
- Big Saltbush

Site Features
- Additional Survey
- Revised EIR Project Area

Wetlands & Waters
- R4SB4A - Ephemeral Wash/Drainage

FIGURE 12:
AREA 5 – WILDLIFE AND SENSITIVE PLANTS AND WATERS AND WETLANDS

FINAL GROUNDWATER REMEDY
HAVASU NATIONAL WILDLIFE REFUGE
PG&E TOPOCK COMPRESSOR STATION,
NEEDLES, CALIFORNIA

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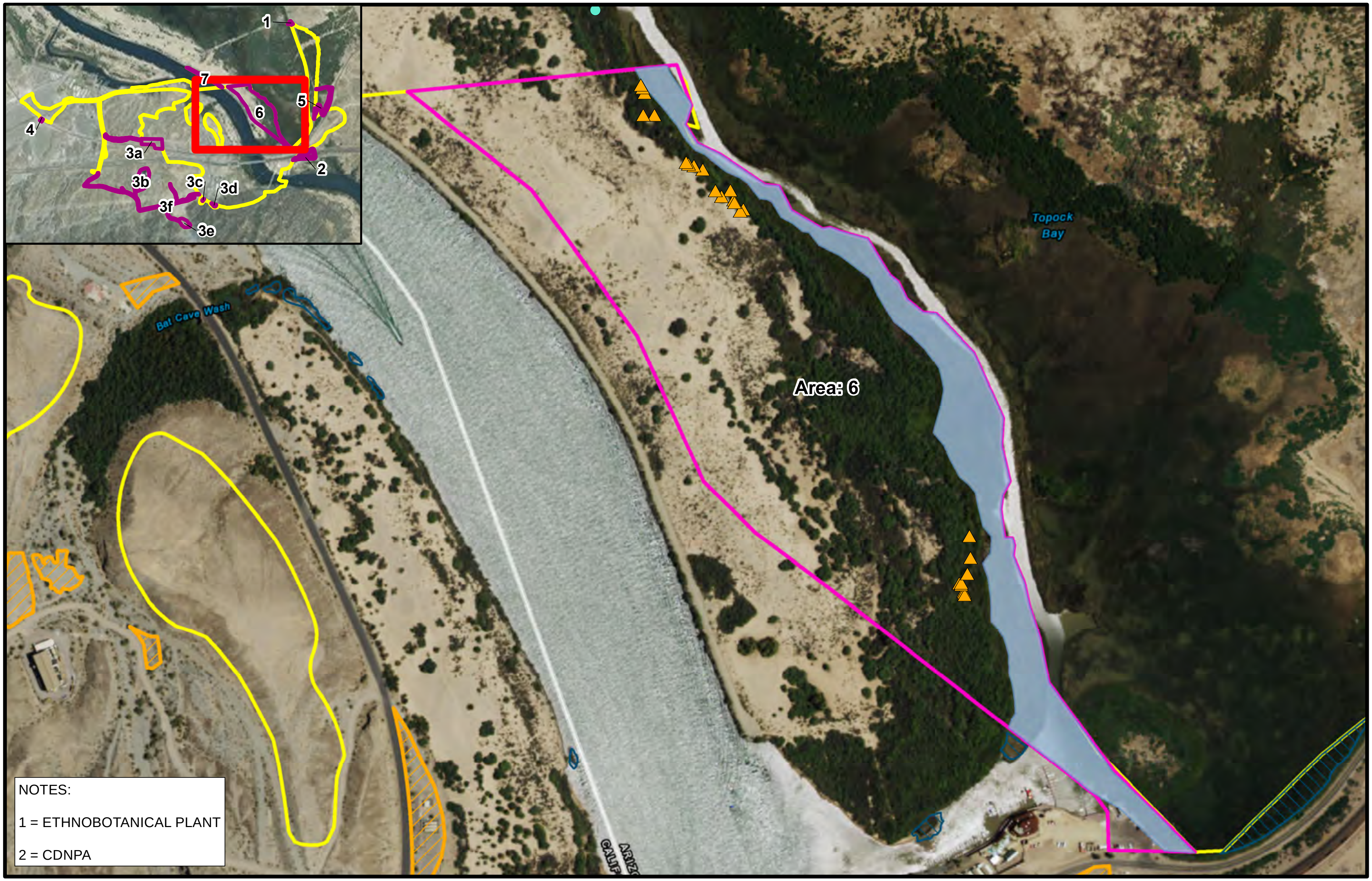

LEGEND

Sensitive Plants

- Western honey mesquite (1, 2)

Site Features

- Additional Survey Area
- Staging Area
- Revised EIR Project Area
- PEMH - Topock Marsh

N

0 250 500 Feet

FIGURE 13:
AREA 6 – SENSITIVE PLANTS AND WETLANDS AND WATERS
FINAL GROUNDWATER REMEDY
HAVASU NATIONAL WILDLIFE REFUGE
PG&E TOPOCK COMPRESSOR STATION,
NEEDLES, CALIFORNIA

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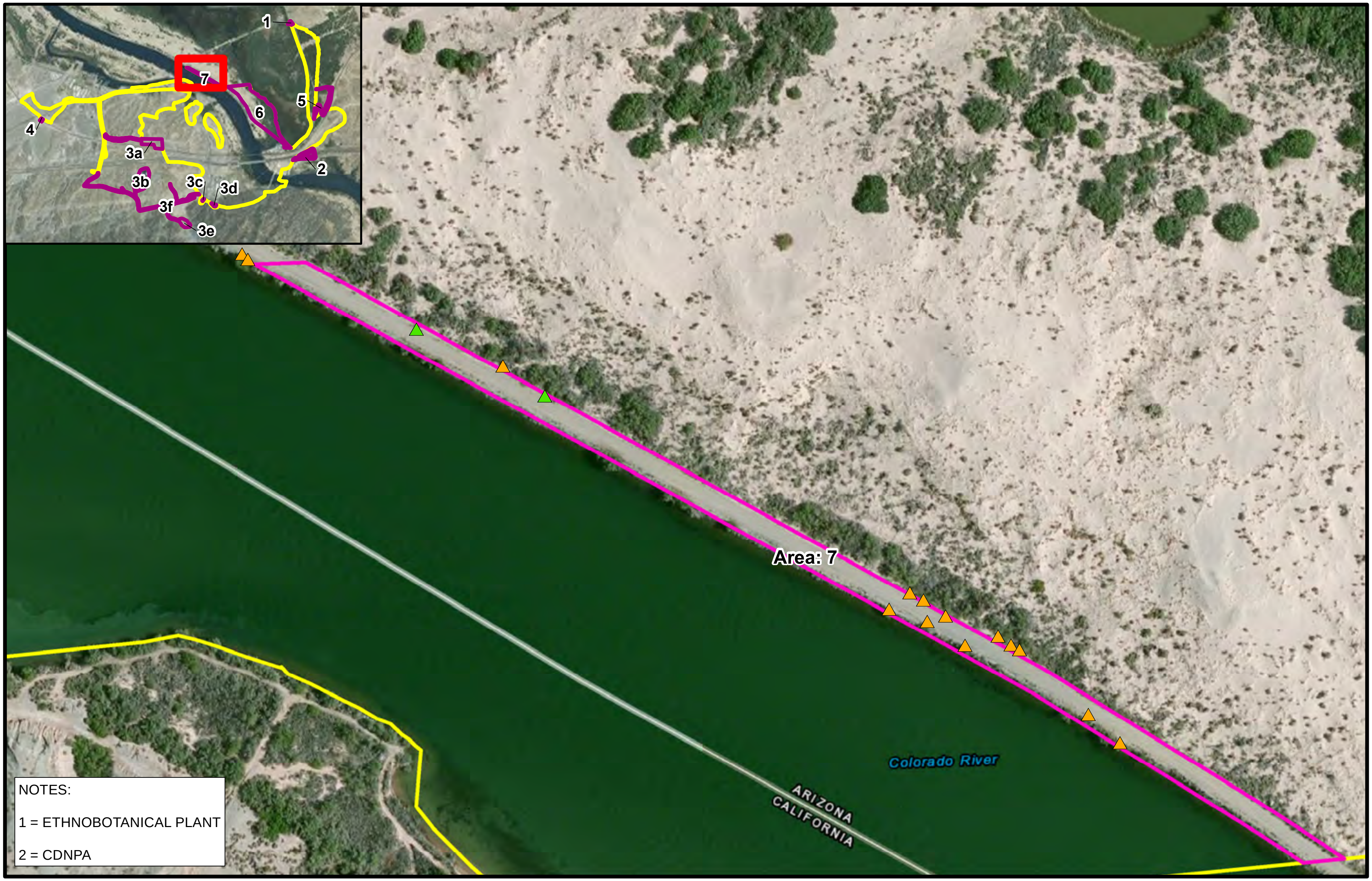

LEGEND

Sensitive Plants
- Western honey mesquite (1, 2)
- Screwbean mesquite (1, 2)

Site Features
- Additional Survey Area
- Revised EIR Project Area

N

0 100 200 Feet

FIGURE 14:
AREA 7 – SENSITIVE PLANTS
FINAL GROUNDWATER REMEDY
HAVASU NATIONAL WILDLIFE REFUGE
PG&E TOPOCK COMPRESSOR STATION,
NEEDLES, CALIFORNIA

CH2MHILL

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Attachment A
Representative Site Photographs

Area 1 – Looking southeast along the Oatman Highway

Area 1 – Looking northwest at the service road entrance and turnoff intersecting with the Oatman Highway

Area 2 – Looking east at the north side interchange of the Oatman Highway with Interstate 40.

Area 2 – Looking east at the south side interchange of the Oatman Highway with Interstate 40.

Area 3a – Looking west down the service road.

Area 3a – Looking south at the culvert outfall under the railroad tracks.

Area 3b – Looking west down the service road that leads to the evaporation ponds.

Area 3b, looking north from the entrance into the evaporation ponds.

Area 3c – Looking south the Bat Cave Wash streambed

Area 3d – Looking northwest at rocky slope on the south side of the compressor station

Area 3d – Looking east-southeast at the ephemeral wash / drainage south of the survey area

Area 3e – looking east-southeast at the quarry site.

Area 3f – looking east along existing access road.

Area 4 – looking north at the culvert inflow under the railroad tracks.

Area 5 –access route along power lines on the east side of the Oatman Highway

Area 5 – Looking north along access route parallel to the railroad tracks.

Area 6 – burned salt cedar on the west side of the Topock Marsh.

Area 6 – Looking north at the Topock Marsh along the east side of the survey area.

Area 6 – Looking south at dredge sands with scattered arrowweed.

Area 7 – Looking north along existing access road.

Minor Updates to the Additional Biological Resources Survey for Additional Potential Environmental Impact Areas Technical Memorandum

Pacific Gas and Electric Company

Memorandum

Date:	November 17, 2016	**File #:**	Topock Final Groundwater Remediation Project BOD Errata
To:	To the File		
From:	Virginia Strohl/ PG&E Senior Terrestrial Biologist		
Subject:	Minor Updates to Four Bat Documents and the Assessment of Biological Resources for Additional Potential Environmental Impact Areas Technical Memorandum		

This memo serves to provide a minor update and a correction on information included in five biological reports for the BOD Errata document that was prepared for the Final Groundwater Remedy project at the Topock Compressor Station. The reports, correction and updated information are listed below:

1) On August 26, 2016, PG&E submitted a technical memorandum entitled Assessment of Biological Resources for Additional Potential Environmental Impact Areas: Final Groundwater Remedy, Topock Compressor Station, California (CH2M HILL 2016) that summarizes results from the May 24-25 and July 7-8, 2016 biological resources surveys (non-protocol floristic, mature plans, ethnobotanical plants, jurisdictional waters, and non-protocol desert tortoise) of the additional areas considered for the EIR Project Area. An error was noted during the preparation of this BOD Errata document on page 2, 3rd paragraph, 3rd bulleted item, as follows: 'California Rare Plant Ranked (CRPR) 1~~,~~ or 2~~, 3, or 4~~ by the California Native Plant Society (CNPS) in its Online Inventory of Rare and Endangered Plants of California (CNPS, 2015).'

2) There are four documents related to bat surveys, potential impacts and proposed protective measures for special-status bat species and maternity roosts. One of the bat species addressed in these documents is the Townsend's big-eared bat (*Corynorhinus townsendii*) and in the documents it was noted that the bat has candidate species status under the California Endangered Species Act. However, on October 20, 2016 the Fish and Game Commission voted to adopt the recommendation from the California Department of Fish and Wildlife to not list this species. The status of Townsend's big-eared bat should therefore be California Species of Special Concern in all four of the following documents:

    a) A report entitled *Bat Surveys of the Topock Compressor Station Soil Investigation and Groundwater Remediation Project Areas, San Bernardino County, California* (P.E. Brown and W.E. Rainey 2015) assessed the potential for special-status bat species roosting and foraging in the project area.

b) A report entitled *Topock Compressor Station Summer Roosting Bat Surveys and Potential Project Impacts, Final Report* (H. T. Harvey and Associates 2015) summarized survey results and identified bat roost locations during a period from July 20 through 28, 2015 and on the night of September 25, 2015. The report also supports future appropriate mitigation measures to avoid or minimize potential impacts that would be associated with groundwater remedy activities.

c) *A report entitled Topock Compressor Station Spring 2016 Roosting Bat Surveys Report* (H. T. Harvey and Associates 2016) summarized survey results for the spring 2016 bat roost surveys and includes the locations of roosts found through previous surveys to provide a comprehensive coverage of the roost survey results through the spring of 2016.

d) A letter from Dr. Dave Johnston of H.T. Harvey and Associates to Ms. Marjorie Eisert of CH2M HILL dated June 27, 2016, that outlines recommended protective measures to avoid and minimize the potential impacts of groundwater remediation activities on special-status bat species and bat maternity roosts.

BOD Appendix A14
Bat Surveys and Proposed Protective Measures for Roosting Bats

- Bat Surveys of the Topock Compressor Station Soil Investigation and Groundwater Remediation Project Areas, San Bernardino County, California
- Topock Compressor Station Summer Roosting Bat Surveys and Potential Project Impacts, Final Report
- Topock Compressor Station Spring 2016 Roosting Bat Surveys Report
- PG&E Topock Compressor Station—Proposed Protective Measures for Roosting Bats
- Minor Updates to Four Bat Documents

Bat Surveys of the Topock Compressor Station Soil Investigation and Groundwater Remediation Project Areas, San Bernardino County, California

EN1031161134BAO

Topock Project Executive Abstract

Document Title: Bat Surveys of the Topock Compressor Station Soil Investigation and Groundwater Remediation Project Areas Final Document? ☒ Yes ☐ No	Date of Document: July 7, 2015 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: Report	Action Required: ☒ Information Only ☐ Review & Comment Return to:________________________ 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: Biological Reports	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? This report was requested by DTSC to support the Soil Investigation EIR. Not performing the survey and preparing this report would impeded analysis associated with the Soil Investigation EIR.	Other Justification/s: ☐ Permit ☒ Other / Explain: Requested by DTSC

Brief Summary of attached document:

The purpose of these surveys were to assess the potential for special-status bat species roosting and foraging habitat in the area identified for the Topock Compressor Station Soil Investigation and Groundwater Remediation Project areas. The initial bat survey was conducted on January 29 and 30, 2015 by Dr. Pat Brown and Dr. William Rainey at a time of year when many of the bat species that could be expected in the area would not be present. However, the initial survey was used to assess habitat conditions and to plan more definitive surveys in the spring. Based on the potential bat roosting habitat observations of the winter site visit, acoustic monitoring and mist-netting surveys were conducted from April 27 through May 1, 2015 to identify bats utilizing the Project areas. Possibly eleven bat species were detected acoustically in the project areas including the following special-status species: cave myotis (*Myotis velifer*), Townsend's big-eared bat (*Corynorhinus townsendii*), pallid bat (*Antrozous pallidus*), Pocketed free-tailed bat (*Nyctinomops femorosaccus*), and Western mastiff bat (*Eumops perotis*). The Townsend's big-eared bat is a candidate species with the California Department of Fish and Wildlife. Included in the report is an assessment and recommended mitigation measures.

Written by: PG&E

Recommendations:

This report is for information only.

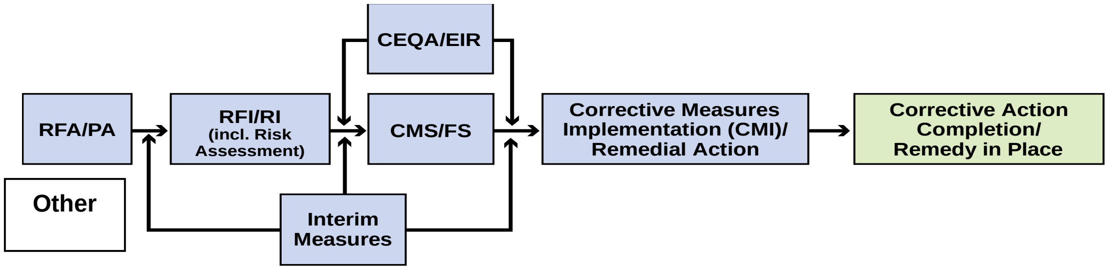
How is this information related to the Final Remedy or Regulatory Requirements:

The survey and this report provides information to support the Soil Investigation EIR and Groundwater EIR analysis.

Other requirements of this information?
None.

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

Version 10

Bat Surveys of the Topock Compressor Station Soil Investigation and Groundwater Remediation Project Areas

San Bernardino County, California

Prepared for:

CH2M HILL, Inc.
2485 Natomas Park Drive, Suite 600
Sacramento, California 95833

Prepared by:

Patricia E. Brown, Ph.D.
134 Eagle Vista
Bishop, CA 93514

William E. Rainey, Ph.D
2556 Hilgard Ave.
Berkeley, CA 94709

June 25, 2015

INTRODUCTION

The goal of the current surveys was to assess the potential for special-status bat species roosting and foraging habitat in the area identified for the Topock Compressor Station Soil Investigation and Groundwater Remediation Project Areas (Figure 1). Townsend's big-eared bat (*Corynorhinus townsendii*) is currently a California Department of Fish and Wildlife Candidate for Threatened or Endangered status. Two lactating female Townsend's big-eared bat were mist-netted within five miles of the Project area at Beal Lake Riparian and Marsh Project on Havasu National Wildlife Refuge (HNWR) by the Bureau of Reclamation (BR) biologists in June 2014 and 2015 (A.Calvert, pers. comm).

Based on research conducted by Dr. Brown along the Lower Colorado River between 1968 to the present utilizing roost surveys, mist netting and acoustic recordings, the bat species listed in Table 1 could occur at some season in the project areas. Many of the species that could occur in the Topock project areas are crevice-roosting species, and potential roosting habitat occurs in locations scattered throughout the project areas, including the sides of Bat Cave Wash, the East Ravine and the red rock exposed adjacent to the Lower Colorado River near the pipeline crossing. The larger cavities in the banks along Bat Cave Wash downstream from the Topock Compressor Station and within the rock face adjacent to the Colorado River near the outlet of the East Ravine could provide roosting habitat for Townsend's big-eared bat. Possible impacts to bats would be largely through removal of foraging habitat or disturbance of roosting habitat. Direct impacts would be to species that roost in rocks or crevices in wash walls during soil or water sampling activities.

SURVEY METHODS

A preliminary winter survey was conducted January 29 and 30, 2015 to assess the potential for bat roosting and foraging habitat on the Project site. The preliminary winter survey visited the Soil Investigation Project Area and the portions of the Groundwater Remediation Project Area that were outside of the Soil Investigation Project Area (Figure 1). Over the course of the two days, we viewed all of the areas that could be potentially affected by the proposed soil investigation and groundwater remediation projects and determined which areas would be the focus of spring studies to evaluate the most likely bat roosting habitats. The weather was cool with rain predicted. Six Anabat SD1 and SD2 ultrasound detectors (Photograph 1) were placed before dark on January 29 in areas with potential for roosting or foraging (Figure 2 and Table 2). Most of the areas where the detectors were placed were close to the sides of washes with potential bat roosting habitat. The detectors were removed after six hours when rain began before midnight, because they were not protected within waterproof containers, and because bat activity is inhibited by rain. The prediction of more rain on January 30 precluded further acoustic surveys.

Based on the potential bat roosting habitat observations of the winter site visit, acoustic monitoring was conducted from April 27-May 1, 2015 to sample bats utilizing the Project Areas. Passive acoustic monitors consisted of a sealed enclosure containing a battery, broadband frequency-dividing ultrasound detector and a programmable data storage device (Anabat II and CF-ZCAIM; Titley Electronics, Ballina, NSW, Australia), with an extension cable to a microphone in a weather shroud with a flat acoustic reflector and bracket. These were deployed in twelve locations for five nights (Figure 2 and Table 2). The microphone and reflector assembly was elevated approximately 3 ft above the terrain on a metal stake (Figures 4-7). The ZCAIM in a unit placed in the East Ravine (Photograph 2) failed and no signals were recorded. In addition to the long-term installations, from two to five short-term SD1 or SD2 Anabat detectors were placed for two to four hours near the mist-net stations or visual observation areas on April 28-May 1, 2015 (Figure 2 and Table 2).

Echolocation is a sensory modality similar in many ways to vision in terms of how information contained in the returning echoes is processed and used. Echolocation is not analogous to communication signals where the information conveyed by the sounds will consistently identify an individual of a species. Within anatomical constraints, a single bat species will typically emit a variety of echolocation signals tailored to the perceptual task (obstacle avoidance, foraging, etc.) in different habitats (cluttered environments, open air, over water; see Schnitzler and Kalko 2001). Different species of bats can use similar echolocation signals in similar tasks. Most species of bats emit some call types that are distinctive within a local species assemblage, but often there is overlap among species using similar call frequencies. The information is still valuable in determining habitat use by bats. Communication signals produced by bats are generally lower in frequency and can be diagnostic of the species (Brown 1976).

Identification of call sequence files combined software filter based screening using Analook W 4.4u (available at www.hoarybat.com/Beta) with user examination and active labeling of the data. Acoustic data sets inevitably contain call sequences of widely varying quality. Some are recognizable as bats in a particular frequency range, but are fragmentary and not assignable to a single species. An issue remaining even when call sequence quality is adequate is that call repertoires of some species overlap substantially, so that some sequences from those taxa are not reliably separable, leading to use of multispecies categories. In this analysis the common multi-species acoustic categories are M50 (typically steep *Myotis* calls that end near 50 kHz) and in the Project Areas could include two species of *Myotis* (California and Yuma myotis); M40 (typically steep *Myotis* calls that end near 40 kHz) and in the Project Areas could include two species of *Myotis* (Arizona and Cave myotis); hoary and pocketed free-tailed bats (Laci/Nyfe) emit relatively flat calls at 16-18kHz); and Q25 calls in the 25-35 kHz range that are attributable to several mid-frequency larger species (mainly Mexican free-tailed, pallid and big brown bats in this area). Call sequences were consistent with those of pocketed free-tailed bats and the rocky cliffs offer good roosting habitat. Though characteristic sequences that would have clearly separated hoary bats were not obtained, they may also have been present. The overlap in call characteristics of these two species make confirmation of the presence of hoary bats unresolved at this time. Diagnostic mid-frequency sequences were recorded for Mexican free-tailed bats, but there were numerous additional non-diagnostic 25-35 kHz (Q25) sequences that could be assigned to this species but may also be from others (e.g., big brown or pallid bats). We have retained the Q25 category in the data table to show relative mid-size bat activity among sites. Values in Table 3 showing species relative activity are counts of one minute intervals during the night that had at least one identified sequence file for a species or multispecies category (activity index of Miller 2001). Further discussion of methods and most filters are available from Rainey *et al*. (2009).

Mist nets were set on the evenings of April 28-30 for 3-4 hours after sunset in areas that potentially had bat roosting habitat and where the terrain and vegetation would funnel bats (Figure 2). On April 28 and 30, nets were positioned across the south (upstream) side of the four drainage culverts for Bat Cave Wash under Interstate 40 (Photograph 6); on April 28 a mist net was spread across Bat Cave Wash upstream of the Topock compressor station where the canyon narrows; on April 29, four nets were spread in narrow sections of the East Ravine; and on April 30 a net was erected across the large cement conduit under the railroad trestle over Bat Cave Wash (Photograph 7).

Visual observations for emerging bats were conducted on the evening May 1, starting at dusk and continuing for about 90 minutes. Six people using night vision goggles (NVG) augmented with auxiliary infrared lights (IR), watched the steep sections of cliff/banks with cavities and crevices in different areas of Bat Cave Wash.

RESULTS

Possibly eleven bat species were detected acoustically within the Project Areas---four species in January and an additional seven in the April surveys (Tables 1 and 3). Many of the bat species that could use the site for foraging and/or roosting are inactive during the cooler winter months. The 106 call minutes recorded over about six hours on the six detectors during the January surveys probably were predominantly produced by three species that are typically winter active (canyon bats, Mexican free-tailed bats and California myotis). Yuma myotis may have been a source for 50 kHz calls along with California myotis, but winter occurrences of Yuma myotis along the Lower Colorado River (LCR) are rarer. Neither pallid bats nor big brown bats are winter active, so the Q25 calls were most likely produced by Mexican free-tailed bats. The most call minutes (43.3%) representing all species categories were recorded at Station 12 above Bat Cave Wash near the PG&E Compressor Station.

Of the 8892 call minutes for eleven long-term detector stations set on April 27 that could be assigned to a bat species or species group, 1841 call minutes (20.7%) were recorded by the detector at Station 14 at the rocky portion of Bat Cave Wash upstream of the PG&E Compressor Station. Other locations with higher levels of bat activity were Station 4 in Bat Cave Wash north of the railroad crossing (13.4%); Station 13 (Photograph 3) above Bat Cave Wash near the PG&E Compressor Station (12.7%) and Station 19 (Photograph 4) along the LCR near the pipeline crossing (11.4%). Of the detector minutes at all long-term locations, the majority were identified as canyon bats (40.6%) and California or Yuma myotis or M50 (40.2%) sequences. These species were recorded at all stations, with the most call minutes at Station 14 at the upper end of Bat Cave Wash where the rocky canyon opens out into the broader wash and funnels flying bats. The short term detectors deployed at various study locations from April 28-May 1 followed a similar activity detection pattern to the long-term stations, with the most calls/night being recorded at Station 14 or at the stations (5, 7, and 8) next to the railroad and I-40 culverts where bats flying up and down the wash were funneled. Some rarer species on the long-term detectors stations (such as western mastiff bats, M40 or Laci/Nyfe) were not recorded in the short term stations.

Five species and 48 individuals (Townsend’s big-eared bat, pallid bat, Mexican free-tailed bat, California and Yuma myotis) were captured in the mist nets in Bat Cave Wash in April (Table 4). Only male Mexican free-tailed bats and one male Townsend’s big-eared bat (Photograph 8) were captured, while pregnant and/or lactating females of the other three species were caught in addition to males. The highway and railroad culverts in Bat Cave Wash were regular flight paths and provided excellent locations for low-flying bat capture, while the open terrain in the East Ravine permitted bats to easily avoid the nets. The times in Table 4 next to the name of the netting site refer to the period that the nets were open, while the times next to the species and sex of the different categories of bats refer to the time brackets during which they were captured. Between Bat Cave Wash and the East Ravine, 108 mist net hours (number of nets times the number of hours that the nets were open) were logged over three nights.

During the visual observations with NVGs on the evening of May 1, no mass bat exodus was observed from the banks of Bat Cave Wash. However the limited field of view with the NVGs required constant scanning of the cliff faces, and it would have been easy to miss bats, especially when the viewer was 100 feet or more from the crevices of interest in the wash cliff. Approximately five bats were observed emerging from the cliff immediately upstream (south) of Interstate 40 on the west side of Bat Cave Wash, near where mist nets had been set on previous nights. From the size of the bats and manner of flight, these may have been from the maternity colony of Yuma myotis that were captured just after dusk on both nights of netting.

DISCUSSION

Bat Cave Wash and the East Ravine provide the best foraging habitat for most of the vespertilionid bats (including Townsend's big-eared bat) and California leaf-nosed bats (*Macrotus californicus*) in the microphyllic woodland of palo verde (Photograph 4) and ironwood trees. Several potential species occurring in the Project Areas were not recorded during the current survey (such as California leaf-nosed bats) and it is possible that a longer term acoustic monitoring program may discover them. Skalak *et al*. (2012) analyzed data from a 14 month acoustic monitoring project with 7-9 bat detectors similar to those used in this survey at fixed locations in the Nevada desert separated by several km in order to determine the number of species detected in relation to the number of monitors and duration of sampling. Among their conclusions was that monitoring with multiple detectors at fixed sites for 2-5 nights in summer will yield the 'common' species (60% of number of taxa detected in more extended monitoring). This provides a perspective on the detection rate of the species assemblage found in the brief study conducted for one night in January and five nights in April at the Project Areas. Another five species could occur in the Topock Project Areas at some season, but were not detected in the current survey (Table 1).

Many of the species that occur on the Topock site are crevice-roosting species, and potential roosting habitat occurs in locations scattered throughout the Project Areas, including the sides of Bat Cave Wash, the East Ravine and the red rock exposed adjacent to the Lower Colorado River near the pipeline crossing. The larger cavities in the banks of Bat Cave Wash and in rock faces adjacent to the Lower Colorado River (LCR) near the outlet of the East Ravine could provide roosting habitat for Townsend's big-eared bat. The natural history of the eleven species mist-netted and/or detected acoustically is discussed below, as well as the five additional species that could occur on the project area at some season.

Townsend's big-eared bat (*Corynorhinus townsendii*): The determining factor in the distribution of this species in the Western United States tends to be the availability of cave-like roosting habitat (Pierson, 1998). Population concentrations occur in areas with substantial surface exposures of cavity forming rock (e.g., limestone, sandstone, gypsum or volcanic) and in old mining districts (Genter, 1986; Graham, 1966; Perkins *et al*. 1994; Perkins and Levesque, 1987). From the perspective of many bat species, old mines are cave habitat and are now sheltering many large colonies (Tuttle and Taylor, 1994; Altenbach and Pierson 1995; Brown *et al*., 1992, 1993).

This sensitive species has declined in numbers across the western United States, as documented in the Conservation Assessment and Strategy (Pierson *et al*. 1999) prepared by scientists and land managers for the Idaho Conservation Effort. The Western Bat Working Group (WBWG) rates *Corynorhinus* at high risk of imperilment across its range, and it is currently a CDFW Candidate for Threatened or Endangered status in California. Earlier studies by Pierson and Rainey (1996a) for the California Department of Fish and Game (now Wildlife) showed marked population declines in many areas of California. Although several causative factors are identified, roost disturbance or destruction appears to be the most important reason for the decline. In another report, Pierson (1998) suggested that a combination of restrictive roost requirements and intolerance to roost disturbance or destruction has been primarily responsible for population declines of Townsend's big-eared bats in most areas. The tendency for this species to roost in highly visible clusters on open surfaces near roost entrances makes them particularly vulnerable to disturbance. Additionally, low reproductive potential and high roost fidelity increase the risks for the species. In all but two of 38 documented cases, roost loss in California was directly linked to human activity (e.g., demolition, renewed mining, entrance closure, human-induced fire, renovation, or roost disturbance; Pierson and Rainey, 1996a).

The intense recreational use of caves and mines in California provides one explanation for why most otherwise suitable, historically significant roosts are currently unoccupied. Townsend's big-eared bats are so sensitive to human disturbance that a single entry into a maternity roost can cause a colony to abandon or move to an alternate roost (Graham, 1966; Stebbings, 1966; Stihler and Hall, 1993). Abandoned mines are also at risk from closure for hazard abatement, renewed mining and reclamation. Liability and safety concerns have led to extensive mine closure programs in western states, particularly on public lands, often without consideration for the biological values of old mines. The installation of bat-compatible gates on mines can protect the bats and exclude humans from hazardous mines.

Along the LCR, all known roosts (historic and current) are in abandoned mines. Grinnell (1914) first discovered the "pale lump-nosed bat" in the Riverside Mountains roosting "at the end of a sloping drift in the Steece copper mine". Howell (1920b) visited the Old Senator Mine near the LCR (6 miles north of Potholes) on May 14, 1918 and "found about a hundred females, each with a naked young from a few days old to a quarter grown, clinging to the roof of a gallery at the two-hundred-foot level. They were in close formation, but not touching one another, and, although not as wild as *Macrotus,* they were quite ready to fly. The only way we could capture them was wildly to grab at a bunch with both hands." As noted by Stager (1939), cave myotis in the Alice Mine were "rivaled in numbers by *Corynorhinus rafinesquii pallescens* and *Macrotus californicus* only". Stager (pers. com.) describes a cluster of Townsend's big-eared bats 3 x 12 feet across in the main level of the Alice Mine. The estimated cluster density in most maternity colonies is 100 bats/ square foot (Pierson and Rainey, 1996a). At this density, the colony in the Alice Mine in the 1930s would have been over 3000 bats. The last specimen collected from the Alice was in April 1954. When P. Brown first visited the Alice Mine in August 1968, only piles of old guano remained. Now the guano has been trampled to dust by recreational mine explorers.

The proximity of good foraging habitat appears to be a determining factor in roost selection. In recent surveys in the Panamint Mountains, mines with suitable temperatures were occupied by large maternity colonies (>100 bats) only if they were within 3.2 km. (2 miles) of a canyon with water (P. Brown, pers. obs.). Brown *et al.* (1994) determined by radio-telemetry that this species on Santa Cruz Island bypassed the lush introduced vegetation near their day roost, and traveled up to 4.8 km. (3 miles) to feed in native oak and ironwood forest. Although the diet of California populations of Townsend's big-eared bats has not been analyzed, elsewhere this species is a lepidopteran specialist, feeding primarily (>90% of the diet) on medium-sized moths (Dalton *et al*., 1986; Ross, 1967; Sample and Whitmore, 1993; Whitaker *et al*., 1997 and 1981; Shoemaker and Lacki, 1993).

The loss of foraging habitat may be a contributing factor to declines in Townsend's big-eared bat populations along the LCR, where the native floodplain community has been subjected to extensive agricultural conversion, residential building and dams. The dense native vegetation has been removed over the past 50 years. Agricultural spraying for lepidopteran pest species may alter the prey base for big-eared bats (Perkins and Schommer, 1991), and pesticide spraying could also be a factor. Along the relatively pristine floodplain of the Bill Williams River (BWR), Townsend's big-eared bats are mist-netted in the warmer months. Two large maternity colonies (>100 bats) are known to roost in mines within sight of the BWR (Brown, 1996).

One of the restoration activities of the US Bureau of Reclamation (USBR) 2004 Lower Colorado River Multi Species Conservation Program (LCR MSCP) has been the planting of cottonwood and willow near Beal's Lake in the Havasu National Wildlife Refuge (HNWR) across the LCR from the Topock Project Area. Lactating Townsend's big-eared bats have been captured here in June 2014 and 2015 and a post-lactating female in August 2013 on USBR mist-netting surveys (A. Calvert, pers. comm). This site is 7 kilometers (4.5 miles) from the mouth of Bat Cave Wash.

Acoustic studies are usually not the preferred method to determine the presence of Townsend's big-eared bats, since they often glean prey from foliage using low intensity calls that may only be detectable within a few meters. On April 30, 2015 a male Townsend's big-eared bat (Photograph 8) was captured in a mist net set across the concrete culvert (Photograph 7) under the railroad bridge in Bat Cave Wash. During this survey, no definitive Townsend's big-eared bat echolocation calls were recorded on any of the Anabat detectors, even those that were positioned close to the culvert where the Townsend's big-eared bat was mist netted.

Pallid bat (*Antrozous pallidus*): In California, Orr (1954) described the species as occurring in a variety of habitats, including coniferous forests, oak woodlands, brushy terrain, rocky canyons, open farm land, and desert. Roosts are apparently selected on the basis of temperature and proximity to foraging habitat. Radio-tracking studies in the Mojave Desert at Camp Cady near Barstow demonstrated that the bats roost in crevices in granite boulders, between rocks in loosely-cemented conglomerate and in mud solution tubes in badlands formations (Brown and Berry, 1998). In another telemetry study near Coso Hot Springs on the Naval Air Weapons Station (NAWS), China Lake, the bats roosted in historic buildings, mines and crevices in granite boulders (Brown pers. obs.). The only day roost discovered (without radio-telemetry) along the LCR is in the Mountaineer Mine in the Riverside Mountains (Brown and Berry 2003). Pallid bats night-roosting in the mines is a more common occurrence. It is assumed that the bats spend the day in rock crevices and congregate for socialization at night (Lewis, 1994). In the Topock Project Site, the crevices in the sides of Bat Cave Wash and East Ravine offer pallid bat roosting habitat. Pallid bats have been mist-netted at Beal Lake by USBR biologists (Calvert 2012).

The relatively powerful jaws of pallid bats are essential to disable their prey, which include scorpions, solpugids, beetles, grasshoppers, cicadas, katydids and sphinx moths (Barbour and Davis, 1969; Hermanson and O'Shea, 1983) captured on or near the ground. Radio-telemetry (Brown and Grinnell, 1980; P. Brown pers. obs.) and the known behavior of favored prey items suggest pallid bats fly close to the ground, and land on the ground to capture prey. Between foraging bouts, pallid bats may congregate in night roosts in mines, buildings and under bridges where they leave guano and the remains of scorpions, katydids, sphinx moths, Jerusalem crickets, and/or beetles. Hirshfeld *et al*. (1977) found with light tags that night roost sites also included willows in wash vegetation.

In the Topock surveys, one male and three pregnant female pallid bats were captured in the mist nets in Bat Cave Wash spread across the I-40 culverts (Photograph 6) on April 28 (Figure 2 and Table 4). Echolocation and communication signals were recorded at half of the long-term stations, with the majority of the 72 call minutes recorded at Station 9 upstream of the I-40 culverts in Bat Cave Wash and at Station 19 in the red rocks along the LCR (Table 3). Some of the Q25 calls recorded at the long and short term detector stations could be high slope non-diagnostic pallid bat signals.

Often the communication sounds of pallid bats (Brown, 1976; Orr, 1954) are better acoustic tools for identification than the echolocation signals, which can resemble those used by Mexican free-tailed and big brown bats. With sufficient moonlight, pallid bats can navigate visually, use prey-produced sounds to hunt (Bell, 1982), and may not emit echolocation signals. Consequently, the activity of this species may be under-estimated based solely on acoustic detections. This may explain why on April 28 at Station 8 next to the culvert where the pallid bats were mist-netted, no definitive pallid bat calls were recorded.

Bat biologists have noted a definite decline in pallid bat populations in recent years in most areas of California (Miner and Stokes, 2001; P. Brown, pers.obs.) prompting the California Department of Fish and Wildlife to list it as a Species of Special Concern. Population declines in coastal California are associated with the loss of roosting and foraging habitat through urban and suburban development. The status of the pallid bat along the LCR is uncertain.

Yuma myotis (*Myotis yumanensis*): This small myotis species has relatively large feet when compared to California myotis (Barbour and Davis 1969). They can vary in color depending of geographic location from golden to dull brown. Yuma myotis are widely distributed throughout western North America, from Mexico to southern Canada, and found throughout much of California. While it occurs from sea level to >2,500 m in the Sierra Nevada, its maternity colonies (which are typically comprised of 300-1,000 females) are generally confined to elevations below 1,000 m. Yuma myotis form large, conspicuous maternity colonies, in a wide variety of roost sites, often in anthropogenic structures, including barns, dams and bridges, although it will also roost in caves, mines, abandoned swallow nests, and under flaking bark of large snags (Barbour and Davis 1969, Dalquest 1947, Evelyn *et al*. 2004, Rainey and Pierson 1996).

Yuma myotis are more highly associated with open water than any other bat species, and are typically observed flying low over relatively calm water (reservoirs, ponds, or slowly flowing reaches and pools of rivers and streams), feeding primarily on small, emergent aquatic insects, such as midges, mayflies and caddis flies (Barbour and Davis 1969, Dalquest 1947, Rainey and Pierson 1996, van Zyll de Jong 1985, Brigham *et al.* 1992). Yuma myotis is probably the bat species that has most benefited by human activities along the LCR, such as the construction of bridges, dams and lakes. Yuma myotis are now the most common bats along most stretches of the LCR (both visually and acoustically), especially in the vicinity of water impoundments.

While Yuma myotis are morphologically distinct from California myotis (the latter smaller with smaller feet), they are usually grouped acoustically as both emit steep frequency-modulated (FM) signals ending near 45-50 kHz. The shape of some Yuma myotis calls is distinctive, but many are very similar to those of California myotis. Both species are common along the LCR and at Topock and are grouped together as M50 in Table 3. M50 sequences were recorded at all acoustic stations in the current survey in both January and April. After canyon bats, the M50 bats were the second most frequently recorded bat at Topock at the long term stations, with the most call minutes detected at Station 14 below the rocky canyon portion of Bat Cave Wash and at stations upstream and downstream of the railroad and I-40 culverts where bat flight in channeled. At the spring short term stations, M50 was the most numerous category represented. As previously noted, Yuma myotis are not as active in January as California myotis, and the signals recorded then were probably the latter species. Yuma myotis were the most numerous bat species mist-netted in Bat Cave Wash (Photograph 6) over two nights, accounting for 75% of the captures (36 of 48). Of these, 27 were reproductive females (Figure 2 and Table 4).

A Yuma myotis maternity colony was observed roosting in a large metal culvert under Interstate 40 to the west of Bat Cave Wash in August 2014 (Brown, pers. obs.), and exits from the north end of the culvert as they head to forage over the LCR. However the bats captured just after dusk in the culverts under I-40 at Bat Cave Wash were coming from the south, or upstream and heading north towards the LCR, and so probably came from another roost in Bat Cave Wash. Later in the evening, Yuma myotis were captured on the downstream or north side of the mist net, likely as they returned to roosts in Bat Cave Wash.

California myotis (*Myotis californicus*): This small myotis is ubiquitous in most habitats in the Southwest below about 7,000 feet elevation (Barbour and Davis 1969; Krutzsch 1954; Simpson 1993). They roost singly or in small groups in crevices in rocks, mines, trees and manmade structures. While Yuma myotis are usually found near open fresh water, California myotis are recorded in drier habitats where they forage in the open for small moths and dipterans. Using light tags, Hirshfeld *et al.* (1977) found that California myotis frequently night roost on small shrubs, presumably for prey digestion, close to the initial capture site.

Grinnell (1914) only collected four specimens from two localities (at the Needles and upstream of there) near the start of the Lower Colorado Expedition, but believed he "saw the same species at other localities along down the river. Those obtained were shot at late dusk, considerably later in the evening than most of the appearances of *Pipistrellus hesperus*. Instead of flying high, against the sky, as in the case of the latter species, *M.c. pallidus* was almost always foraging low over the bushes of the second bottom, or along shallow washes between clumps of mesquite. "

As noted above, there is extensive structural overlap in the calls of Yuma and California myotis, and both are included in the M50 designation (Table 3). In the current survey, after canyon bats, M50 bats were the second most frequently recorded bat at Topock at the long term stations, with the most call minutes detected at Station 14 below the rocky canyon, and at stations upstream and downstream of the railroad and I-40 culverts where bat flight is channeled. At the spring short term stations, M50 was the most numerous category represented. As previously noted, Yuma myotis are not as active in January as California myotis, and the winter records are probably California myotis. They are generally the "second wave" of bats recorded and observed at Topock, appearing about 30 minutes after the first canyon bat. On April 28, three male and two lactating California myotis were mist-netted at the culverts (Photograph 6) under I-40 (Figure 2 and Table 4).

Mexican free-tailed bat (*Tadarida brasiliensis*): Mexican free-tailed bats can forage over large areas each night, ranging as far as 25 miles from their roosts. They roost in crevices in cliff faces or manmade structures such as bridges and dams (Barbour and Davis 1969; Wilkins 1989). Musgrove (Cockrum *et al.*, 1996) noted 500 Mexican free-tailed bats roosting in crevices above the spillway at Davis Dam in April 1962, with the number increasing to 10,000 in September 1962. This colony was subsequently removed by pest control operators. Musgrove also visited a maternity colony of 400-500 Mexican free-tailed bats in a "sinkhole" 8 miles NE of Topock in Mohave County, AZ on May 13, 1961. Grinnell (1914) reported "seeing this bat at almost every station, as a rule flying high and squeaking loudly". Probably due to their high flight pattern they were difficult to shoot or retrieve, and he only took three specimens during his float trip---two at Mellen (Topock) and one in the Chemehuevi Valley. In appropriate habitat, they can be mist-netted. In the current Topock Project survey, on April 28, 2015 two males were captured in the mist nets set across the I-40 culverts (Figures 2, Photograph 6 and Table

4). This was surprising since the prediction would be that high-flying Mexican free-tailed bats would fly over the freeway rather than in a long culvert under it.

Acoustically, Mexican free-tailed bats often appear to be one of the most ubiquitous bat species, in part due to their loud, low frequency echolocation signals that are detectable over large distances. This species is present on the project area, and echolocation and communication signals were recorded at all long-term stations in the spring. The Q25 designation (Table 3) includes less diagnostic calls of this and other (e.g. pallid and big brown bats) 25-30 kHz mid-frequency species that overlap in signal characteristics. Long-term Stations 13 (Figure 5) and 14 below the rocky portions of Bat Cave Wash had the greatest number of call minutes (Figure 2 and Table 3), with 70 call minutes recorded via the short term detector placed there on April 28. Under a dry waterfall upstream (south) of these stations is a crevice with guano of Mexican free-tailed bats. This species was possibly responsible for the naming of Bat Cave Wash.

Big brown bat (*Eptesicus fuscus*): Big brown bats are relatively large, with glossy deep brown fur and a blunt tragus, a feature which distinguishes it from all *Myotis* species (Barbour and Davis 1969). They are one of the most widely distributed species in the Western Hemisphere, occurring from western South America to northern Canada, and throughout the United States (Hall 1981), and found in almost all habitats in California, from sea level to high elevation (Barbour and Davis 1969). They roost primarily in crevices in trees (particularly snags), old buildings, bridges, rock crevices, caves, and mines (Barbour and Davis 1969, Brigham 1991, Kurta and Baker 1990).

Big brown bats are foraging habitat generalists, feeding aerially over both water and land, in forested and edge situations. They often emerge early (prior to dark) and can be seen foraging high (up to 50 m above the ground), descending later in the evening to 10-15 m (Whitaker et al. 1977). In some habitats they feed predominantly on beetles (Coleoptera), including important forest and agricultural pests (Whitaker 1995).

They are a common species captured by USBR biologists in most or the LCR MSCP restoration sites, including being the most common bat captured in the 2011 surveys at Beal Lake (Calvin 2012). All call sequences were recorded by Brown and Berry (2003) during the warmer months (April-October). This species appears to be locally abundant in restored riparian and agricultural habitats along the LCR drainage. Big brown bats typically echolocate at ca. 25 kHz, and, while some of its calls are distinctive, many are not separable from other 25 kHz species (pallid and Mexican free-tailed bats) that have been included in the Q25 acoustic category. This category was recorded at all long-term detector sites with the greatest number of call minutes at Stations 13 (Photograph 3) and 14 below the rocky portions of Bat Cave Wash (Figure 2 and Table 3).

Canyon Bat (*Parastrellus hesperus*): This common species along the LCR is the smallest of all North American bats, and can be distinguished from California myotis by the club-shaped tragus, compared to the pointed tragus of myotis (Barbour and Davis, 1969). They are often associated with rocky canyons and outcrops (usually at elevations below 2,000 meters), where they can roost in small crevices (Stager, 1943b; Cross, 1965). Grinnell (1914) noted that canyon bats were the most common species observed, and collected (74 specimens) during his 1910 expedition, beginning in February when "ice formed in suitable places----and swarming in the vicinity of The Needles on March 1 to 3. Thenceforth, they were seen at nearly every station all the way down the river. One thing was conspicuously noticeable in regard to occurrence, namely that this bat varied directly in degree of abundance with nearness to cliffs, or hillsides with outcroppings of fractured rock."

Canyon bats have been observed at dusk flying over creosote bush scrub several miles from rocky areas, and it is postulated that they may also roost under rocks or in rodent burrows (Von Bloeker 1932). They emerge early in the evening, often before sunset, and may be active after sunrise. Near rocky canyons, their small fluttery forms can fill the sky in the fading desert light. They are often the first bats captured in the evening in mist nets set over isolated desert water holes (O'Farrell and Bradley, 1970) or across mine entrances. Stomach content analysis suggests that they feed on small swarming insects such as flying ants and mosquitoes (Hayward and Cross, 1979). During cooler winter months, canyon bats hibernate in rock crevices, although on warm winter days, they may emerge to forage during the day. It is reported that females give birth to twins in late May through June, and mothers with their young may roost alone or in groups of less than 10 individuals. The young are volant within a month.

During the current acoustic studies, 3616 distinctive canyon bat call minutes were recorded at all long-term stations, with the most (693) above Bat Cave Wash near the PG&E Compressor Station. Most of the short-term stations in January and April also recorded this species. In fact, this species represented 40% of all call minutes recorded (Table 3). Like Grinnell (1914), we noted an increase in number of calls near rocky habitat. Unexpectedly, they were not captured in mist nets during the April survey.

Western mastiff bat (*Eumops perotis*): Western mastiff bats belong to the free-tail family Molossidae, and are the largest bat species found in North America. They have a 60 cm wingspan and large bonnet-like ears, which extend forward over the eyes and are connected at the midline (Barbour and Davis, 1969; Best *et al*., 1996). Unlike most other North American bat species that mate in the fall, free-tailed bats breed in the early spring and give birth to a single young in the early to mid-summer. Most western mastiff bats give birth by early July (Krutzsch 1955), in colonies generally containing fewer than 100 animals (Barbour and Davis 1969; Howell 1920). Adult males and females may roost together at all times of year (Krutzsch 1955) in contrast to other North American bat species.

Western mastiff bats, a CDFW Species of Special Concern, are found in a variety of biotic environments from low desert scrub to chaparral, oak woodland and ponderosa pine. However, the abiotic components appear to determine their distribution. This crevice-dwelling species predominantly selects cliff faces (granite, sandstone, or columnar basalt) or exfoliating granite boulders (Dalquest 1946; Krutzsch 1955; Vaughan 1959), but also occupies cracks in buildings (Howell 1920; Barbour and Davis 1969) or compact silt on stream channel faces (Daquest 1946). All roosts located in California by Pierson and Rainey (1996b, 1998a) were in crevices at least 10 feet above the ground.

The species appears to forage over open areas (Vaughan 1959; Pierson and Rainey 1998a), and many individuals have been heard feeding over agricultural fields in the Imperial Valley (P. Brown, pers. obs.). In California, western mastiff bats appear to feed primarily on moths (Lepidoptera), but may also take beetles and crickets (Whitaker *et al*., 1977). Western mastiff bats emit a human-audible echolocation call (6.5.-12 kHz and can be detected flying throughout the night. These strong, fast fliers cover an extensive foraging area in the evening. The species has been heard in open desert, at least 24 km from the nearest possible roosting site (Vaughan, 1959). From telemetry of several captured mastiffs, Siders *et a*l. (1999) estimated the capture site to roost distances of 28-29 km in northern Arizona. Often multiple animals are detected together, and this species may travel or forage in groups (E. Pierson, pers. comm, P. Brown pers. obs.). Unlike Mexican free-tailed bats that undertake long seasonal migrations, western mastiff bats move relatively short distances seasonally. Although capable of lowering their body temperatures for short periods of time, they do not undergo prolonged hibernation, and may be periodically active throughout the winter. In Southern California, mastiff bats have been detected at all seasons, although they may change roost sites (Howell, 1920; Krutzsch, 1948 and 1955; Leitner 1966; Barbour and Davis, 1969).

Along the LCR, capture records exist from Yuma (Cockrum, 1960); south of Palo Verde (Eger, 1977), Parker (Sanborn, 1932) and the Bill Williams River (BWR, Brown, 1996). The echolocation calls of western mastiff bats were heard or recorded all along the LCR (Brown and Berry 2003) from Davis Dam to Imperial National Wildlife Refuge (INWR). The bats emitting the calls heard near Davis Dam may be from the large colony located by Musgrove at Keyhole Cave, just south of Union Pass (Cockrum *et al*., 1996). Most calls along the LCR are detected during the warmer months (Brown and Berry 2003).

In the current Topock survey, 19 call minutes of western mastiff bats were detected at seven detector locations (Figure 2 and Table 3), with seven sequences recorded at Station 15 above the East Ravine. No sequences were recorded on the short term detectors in January or April. They could roost up the canyon in Bat Cave Wash or in the Needles formations to the south.

Cave myotis (*Myotis velifer*): The largest myotis species in North America occurs in large colonies (100s to 1000s) in caves and mines across the southwestern United States (Barbour and Davis, 1969). In California, the cave myotis is a CDFW Species of Special Concern, and most records are from the mountains bordering the LCR, with a few isolated specimens from Southern California (Constantine, 1998) and the Kingston Mountains (LACMNH). This species was first collected along the LCR was in 1909 from a warehouse in Needles (Grinnell, 1918). Joseph Grinnell (1914) did not take any cave myotis on his 1910 survey down the LCR. In 1935, Ken Stager (1939) studied this species in several mines in the Riverside Mountains. In the Alice Mine, "*Myotis velifer* was observed throughout the mine in countless hundreds, and was by far the commonest of the seven species known to be occupying the mine. It was rivaled in numbers by *Corynorhinus rafinesquii pallescens* and *Macrotus californicus* only". Vaughan (1954 and 1959), studied California leaf-nosed bats and cave myotis in the Riverside Mountains in the same mine "tunnels" reported by Stager, where "each of several tunnels contained roughly 1000 cave myotis, and each of the other tunnels was inhabited by several hundred individuals".

Several large cave myotis maternity colonies roost in mines bordering the BWR in the vicinity of Planet, Rankin and Lincoln Ranches (Brown, 1996). Here the cottonwoods stretch along the banks of the river, although the trees are not as large or the floodplain as wide as described by Grinnell (1914) or Stager (1939) for the LCR. In 1953, Vaughan (1954 and 1959) noted that "in the Riverside Mountains area, after leaving their daytime retreats, cave myotis usually flew directly down the eastern slope of the range to the floodplain of the Colorado River where they foraged…and where they pursue foraging beats over low vegetation, along files of dense vegetation that line the oxbows and main channel of the river, between the scattered thick patches of vegetation that dot the floodplain, or above bodies of water." Evidently, the insects associated with floodplain riparian habitat are important to cave myotis, and the loss of this habitat is reflected in the decline of the species along the main stem of the LCR.

The Jackpot Mine on the Arizona side in Havasu NWR within a wilderness area south of Needles is the northernmost cave myotis maternity roost on the LCR. Currently about 700-800 cave myotis occupy the site in the warm season. The Jackpot Mine is 6 km (4 miles) southeast of the mouth of Bat Cave Wash. Cave myotis have been mist-netted at Beal Lake by USBR biologists (Calvert 2012). Possibly those bats have commuted about 12 km (8 miles) to the foraging habitat of the restoration area from the Jackpot Mine. During the current acoustic survey of the Topock Project Areas, eighteen M 40 call minutes attributable to cave myotis (steep FM calls ending frequency 40 KHz) were recorded at two locations (Figure 2 and Table 3) primarily at the fenced well enclosure (Station 22, Photograph 5) in Arizona on HNWR (Figure 2 and Table 2) with a few calls recorded along the LCR at site 19 (Photograph 4).

Hoary bat (*Lasiurus cinereus*): This solitary tree-roosting bat species is morphologically and acoustically distinct, at least in many areas of North America. Hoary bats migrate seasonally, both altitudinally and latitudinally, apparently often in aggregations (Grinnell 1918; Krutzsch 1948; Shump and Shump 1982b; Bradley *et al* 1965). A continent wide analysis is provided by Cryan (2003). Most historic California specimen based records are from the winter, with fewer in the spring and fall, and none in the summer (Grinnell, 1918; Vaughan and Krutzsch, 1954). Grinnell (1914) did not collect this species along the LCR, however the current mist-netting program of the USBR biologists capture them in the restoration areas along the LCR, including Beal Lake (Calvert 2012).

In the BWR survey (Brown, 1996), four adult male hoary bats were captured in mist nets at two locations just downstream from Planet Ranch in October. During the telemetry study, the bats were tracked to roosts in the foliage of the cottonwood and willow trees, and even in a palo verde tree in a dry desert wash. Some hoary bat echolocation calls are acoustically distinct, while others not readily distinguishable from those of pocketed free-tailed bats (see below). In the current Topock Project Areas, 32 Laci/Nyfe call minutes were recorded in nine stations, with the most signals detected near the LCR or on the sides of Bat Cave Wash and East Ravine.

Pocketed free-tailed bat (*Nyctinomops femorosaccus*): This slightly larger relative of the Mexican free-tailed bat differs from that species by having its ears joined at the midline (Constantine 1958; Kumirai and Jones 1990). A shallow fold of skin or "pocket" on the uropatagium, near the knee, is usually difficult to locate, and is not a good distinguishing field characteristic. Pocketed free-tailed bats are found at lower elevations in a variety of plant associations (Barbour and Davis 1969; Easterla 1973), and in proximity to roosting habitat in granite boulders, cliffs or rocky canyons. In California, it is associated primarily with creosote bush and chaparral habitats of Lower and Upper Sonoran life zones (Krutzsch, 1948). This crevice-dwelling species has occasionally been found in caves (Dalquest and Hall 1947), and in buildings under roof tiles (Gould 1961). All roosts in California have been in crevices in cliff faces or granite boulders located at least 10 feet (3.5 meters) above the ground (Pierson and Rainey 1998a; K. Miner, pers. comm.; P. Brown, pers. obs.). At one site the, pocketed free-tailed bats share a larger crevice with western mastiff bats, although they appear to be roosting separately. With only a limited number of records for pocketed free-tailed bats from California, it is a CDFW Species of Concern. Krutzsch (1948) documented their occurrence in California from March through August, however recent records from late November suggests the species over-winters in San Diego County (Pierson and Rainey 1998a; K. Miner pers. comm.).

This species was not documented from the LCR drainage until August 1963 when six bats were captured in a mist net at Alamo Crossing along the Bill Williams River (Cockrum *et al.*, 1996). Subsequently, five bats (including a pregnant female and two juveniles) were captured at four locations along the Bill Williams River (Brown, 1996). A suspected roost was located in a cliff face upstream of Planet Ranch; however it was impossible to capture emerging bats. The cliff faces in the Needle Mountain area southeast of Topock could provide ideal roosting habitat.

When emerging from their roosts in the evening, this species frequently makes audible "chattering" communication signals (Krutzsch 1944, 1948; Pierson and Rainey 1998a; K. Miner pers. comm.; P. Brown pers. obs.). It's possible that these sounds were those attributed to Mexican free-tailed bats by Grinnell (1914), however he did not take any specimens during his survey. The frequencies of the calls extend from the upper human audible range (~16 KHz) into the ultrasonic so that some open air search phase calls are audible to people with undamaged hearing. Some pocketed free-tailed are not distinguishable from a subset of hoary bat sequences, so this species can be overlooked in acoustic surveys in areas of possible species distribution overlap such as may occur on the Topock Project Areas. In the current Topock Project area, 32 Laci/Nyfe call minutes were recorded in nine stations, with the most signals detected near the LCR or on the sides of Bat Cave Wash and East Ravine.

Potentially occurring species not definitively detected in current survey

California leaf-nosed bat (*Macrotus californicus*): The California leaf-nosed bat is the most northerly representative of the Phyllostomidae, a predominantly Neotropical family. The type locality of the California leaf-nosed bat is Ft. Yuma, California (Grinnell 1918). This species occurs in the Lower Sonoran life zone in the deserts of California, southern Nevada, Arizona and south to northwestern Mexico (Sonora and Sinaloa) and Baja California (Hall, 1981; Hoffmeister, 1986).

California leaf-nosed bats prefer caves, mines or large cavities for roosting habitat. While they have been found night roosting in buildings or bridges (Hatfield 1937; Brown and Berry, 1998, 2003 and 2004), all major maternity and over-wintering sites are in mines or caves. California leaf-nosed bats neither hibernate nor migrate, and have a narrow thermal-neutral zone. They are incapable of lowering their body temperature to become torpid. No special physiological adaptations occur in this species for desert existence, and behavioral adaptations such as foraging methods and roost selection contribute to their successful exploitation of the temperate zone desert even during the cooler months (Bell *et al*.1986). To remain active yearlong in the temperate zone deserts, California leaf-nosed bats use warm diurnal roosts in caves, mines and buildings with temperatures that often exceed 80º F. Depending on the season, they roost singly or in groups of up to several hundred individuals, hanging separately from the ceiling, rather than clustering. Often the bats hang from one foot, using the other to scratch or groom themselves. Most diurnal winter roosts are in warm mine tunnels at least 100 meters long. At this season, the large colonies of over 1000 bats may contain both males and females, although the sexes may also roost separately. The consistent feature of the areas in the mines used by the bats is warmth and high humidity with no circulating air currents. The temperature of the mines is usually warmer than the annual mean temperature, and the mines may be located in geothermally-heated rock formations (Higgins and Martin 1980). Except for the nightly foraging period, in winter this species inhabits a stable warm environment. Although longevity of California leaf-nosed bats does not approach the 30 or more years documented for temperate zone vespertilionid bats, banded individuals in California have been recaptured after 15 years (Brown and Berry, 1998).

Females congregate in large (>100 bats) maternity colonies in the spring and summer, utilizing different mines or areas within a mine separate from those occupied in the winter, although colonies of only 6-20 bats are also found (Barbour and Davis, 1969; Vaughan, 1959; Brown and Berry, 1998). Within the larger colonies, clusters of five to 25 females will be associated with a single “harem” male that defends the cluster against intruding males (Berry and Brown, 1995). Large male roosts may also form. The single young (weighing 25-30% of the mother’s mass) is born between mid-May and early July, following a gestation of almost 9 months. This species exhibits "delayed development" following ovulation, insemination and fertilization in September (Bradshaw, 1962). In March, with increased temperatures and insect availability, embryonic development accelerates. Since the newborn bats are poikilothermic, the maternity colony is located fairly close to the entrance, where temperatures exceed 90º F and daytime outside temperatures can reach over 120º F in the summer. This allows the bats to use shallow natural rock caves that would be too cold for a winter roost. Maternity colonies disband once the young are independent in late summer (Brown and Berry, 1998).

California leaf-nosed bats feed primarily on large moths and immobile diurnal insects such as butterflies, grasshoppers and katydids which they glean from surfaces (Huey, 1925; Vaughan, 1959). Although they can echolocate, these bats appear to forage by utilizing prey-produced sounds and vision, even at low ambient light levels. The strategy of gleaning larger prey from the substrate as compared to aerial insectivory appears to reduce the total time and energy necessary for foraging (Bell, 1985; Bell and Fenton, 1986). Radio-telemetry studies of California leaf-nosed bats in the California and Arizona deserts indicate that the bats forage among desert wash vegetation within ten miles of their roosts (Brown *et al.* 1993; Dalton *et al.* 2000). The close proximity of foraging areas to the roost is most important in winter, when the bats forage closer to the roost and are above ground for shorter periods than in the summer. The bats emerge from their roosts 30 or more minutes after sunset, and fly near the ground or vegetation in slow, maneuverable flight (Vaughan, 1959; Brown *et al.,* 1993). Shallow caves and mines, buildings and bridges are used by both sexes as night roosts between foraging bouts at all seasons, except for the coldest winter months. Wings and other culled prey parts are found under night roosts.

Within the past 50 years, the range of California leaf-nosed bats has contracted by 50%, and the species no longer occurs outside of desert habitats in California (Brown and Berry 1998 and 2004). It is a CDFW Species of Concern and an evaluation species for the USBR LCR MSCP. The primary factors responsible for the declines are roost disturbance, the closure of mines for renewed mining and hazard abatement, and the destruction of foraging habitat. The combination of limited distribution, restrictive roosting requirements, and the tendency to form large, but relatively few colonies make this species especially vulnerable. The numbers of California leaf-nosed bat appear to be stable in mines near the LCR, as judged by exit counts and banding studies conducted over the last 45 years (Brown and Berry, 2003).

California leaf-nosed bats are primarily visually-orienting, using prey-produced sounds while foraging. When echolocation signals are used, they are of relatively low intensity. Therefore acoustic surveys may not detect this species, and would potentially underestimate their abundance. This species could have been captured in mist nets or detected acoustically in the current Topock Project Areas surveys. Appropriate foraging habitat occurs in Bat Cave Wash, and the nearby Jackpot Mine is a major winter and summer roost. They have been captured in mist nets at Beal Lake by USBR biologists (Calvert 2012).

Arizona myotis (*Myotis occultus*): Like cave myotis, Arizona myotis also emit steep FM calls ending at 40 kHz. However, we have attributed the M40 calls to cave myotis in the current surveys. Arizona myotis had been considered by some to be a subspecies of the little brown bat (*Myotis lucifugus*), and as such was considered to have a much expanded geographic range (Findley and Jones, 1967; Valdez *et al*., 1999). Recent genetic analysis has assigned it specific status (Piaggio *et al*., 2002). When first described in 1905 (Hollister, 1909), it was named Hollister's bat, and the topotype was collected in May 1905, ten miles north of Needles at Ft. Mojave on the California side of the LCR in the "dense cottonwood bottomlands of the Colorado River". In fact, H W Henshaw of the Wheeler Expedition in 1875 had collected a specimen in the "Mojave Desert" and deposited in the U. S. National Museum (Cockrum *et al*. 1996). In May 1910, Joseph Grinnell (1914) on a float trip on the LCR from Needles to Yuma, collected a female Hollister bat four miles south of Potholes "shot at late dusk close to the riverbank between files of cottonwoods, in just the same location as those taken by Hollister". The next five specimens were collected "four miles northeast of Yuma, California" and were "shot over water in a back eddy of the river. Here the bats arrived in considerable numbers at early dusk to drink, flitting down to the water's surface and dipping several times before flying off among the willows and cottonwoods." Grinnell "used a boat in shooting and retrieving the specimens".

In August 1937, Stager (1943a) collected a male Arizona myotis in a mine in the Riverside Mountains, and in 1939 discovered a large maternity colony (~800 bats) roosting between horizontal support beams of a bridge on the LCR at Blythe. Between 1939 and 1945, Drs. Ken Stager and Denny Constantine collected 87 specimens (primarily females) from this bridge (deposited in the LA County Museum of Natural History). The bridge was torn down in the 1950s, and the colony has never been rediscovered.

Since 1945, no more Arizona myotis have been observed or collected from the LCR until mist netting surveys by USBR LCR MSCP biologists captured reproductive females in the cottonwood willow restoration site on the Colorado River Indian Tribes (CRIT) Ahakav Preserve south of Parker (Calvert and Neiswenter 2012). Through telemetry, the bats were tracked to a roost in the skirt of a mature palm tree near the Preserve. Although no Arizona myotis have been captured yet at Beal Lake, as the foraging habitat at restoration area matures the species could be re-colonizing this part of its historic range. However, until the capture of an Arizona myotis, the M40 signals recorded in the Topock Project Areas should probably be attributed to cave myotis.

Western red bat (*Lasiurus blossevillii*): This foliage-roosting species is easily identified both visually and acoustically (Corben pers. comm.). Red bats can generally be distinguished by fur color that can vary from intense red to yellow-brown. There is some sexual dimorphism in the color with males being more intensely colored than females. The lasiurine bat species are distinctive in giving birth to multiple young (Barbour and Davis 1969; Shump and Shump 1982a). Red bats forage on a number of insect taxa, flying at both canopy height and low over the ground (Shump and Shump 1982a). One diet sample from California suggests this species feeds primarily on small moths, but takes a variety of other insects, particularly orthopterans (Ross 1961). Historically associated with sycamore and cottonwood willow riparian systems in California, red bats have become rare as their roosting and foraging habitats have declined throughout the state (Pierson *et al.* 1999). It is a CDFW Species of Concern, and received a high rating for imperilment from the WBWG. Red bats are designated as covered species for the USBR LCR MSCP and have been captured in several of the restoration sites (Calvert 2012; Diamond *et al.* 2013).

This species emits a distinctive echolocation call, which is typified by a "ping-pong" pattern of the terminal frequency from pulse to pulse, generally around a characteristic frequency of ca. 45 kHz. Short sequences can be confused with those of canyon bats. No red bat calls were recorded in the Topock Project Areas during the current survey, but they could fly over the site since roosting and foraging habitat exist along adjacent areas of the LCR.

Western yellow bat (*Lasiurus xanthinus*): This species roost in trees, with preference given to palm trees with intact skirts, although some reports show use of hackberry and sycamore, and even yucca (Higginbotham *et al*., 2000). There is some evidence to support the hypothesis that this species has expanded its range northward in response to the planting of palms along the LCR, using the river as a corridor. Constantine (1966) collected the first yellow bat along the LCR at Yuma, with a subsequent specimen turned in for rabies testing in 1980 from Blythe (Constantine 1998). During the BWR bat survey, Brown (1996) captured one juvenile and two adult male yellow bats near Planet Ranch in October. Williams (2001) studied a resident population in the palm groves of the upper Moapa Valley, where it was the second most abundant bat captured and acoustically detected. Yellow bats are also a covered species for the USBR LCR MSCP and have been captured in several of the restoration sites (Calvert 2012;

Diamond *et al.* 2013). Some palm trees at Moabi Regional Park and Topock Marina could provide roosting habitat.

IMPACTS and MITIGATION

Based on review of the proposed Soil Investigation Project and primarily the location of soil investigation activities, the project is not anticipated to have a significant adverse impact on bats, if done to avoid the maternity season. The noise and vibration generated by the soil investigation activities has not been addressed as part of this study, and therefore the impact to bats at a given distance was not evaluated.

Even though we did not capture a reproductive female, a maternity colony of Townsend's big-eared bats could be present in Bat Cave Wash. This species is difficult to survey due to their low intensity echolocation calls, and their ability to avoid mist nets. The reason that this species is a candidate for listing is mostly due to their intolerance to roost disturbance, especially during the maternity season. When disturbed by human entry into a roost, females have flown away and left their non-volant young to starve. Attempting to find and study a roost site in the largely friable cliff walls of Bat Cave Wash would be difficult and can be potentially disturbing. Most bats change roosts during the maternity period in response to temperature requirements, even without disturbance. Therefore a colony located and designated in one month may have moved to another location by the time that the soil investigation is initiated in that area.

To insure that impacts remain less than significant, it is recommended that any potentially noisy soil investigation activities, in the vicinity of the sides of Bat Cave Wash and within the East Ravine should be scheduled to avoid the maternity season when noise and vibration could be disturbing to the bats, especially Townsend's big-eared bats, unless these activities are critical to meeting the project objectives. If the activities must be done during the maternity period, then the procedures for reducing impacts to bats through monitoring are identified in the next paragraph. The maternity period extends from when pregnant females first aggregate through the weaning of the juvenile bats and dispersal of the colony. Since multiple bat species are involved, with asynchronous reproductive timing, the maternity season in the Topock area is mid-March through August. If spring is "late" and the temperatures are cool through March, the onset of the maternity season may be delayed until around April 1. Since the maternity "season" usually encompasses five months, if the warm spring temperatures begin in mid-March, the maternity season will probably end around mid-August.

If noisy soil investigation activities need to be conducted during the maternity season, the steep wash sides with crevices and possible cavities within 100 feet of the proposed work activity should be watched from sunset for 90 minutes for exiting bats, by a trained observer using a thermal imaging camera. The observations should be made on a night with wind speed less than 10 mph and no rain. If bats are observed exiting from the semi-consolidated sediment or rock, no soil investigations should be conducted the next day. If bats are not observed exiting then the proposed work may proceed the next day. During the current surveys, night vision goggles did not give a wide enough field of view, nor was a permanent record available for later review. For this reason, a thermal imaging camera is recommended. Acoustic recordings are low value for precisely locating an actual roost in a cliff, especially if Townsend's big-eared bats are the target.

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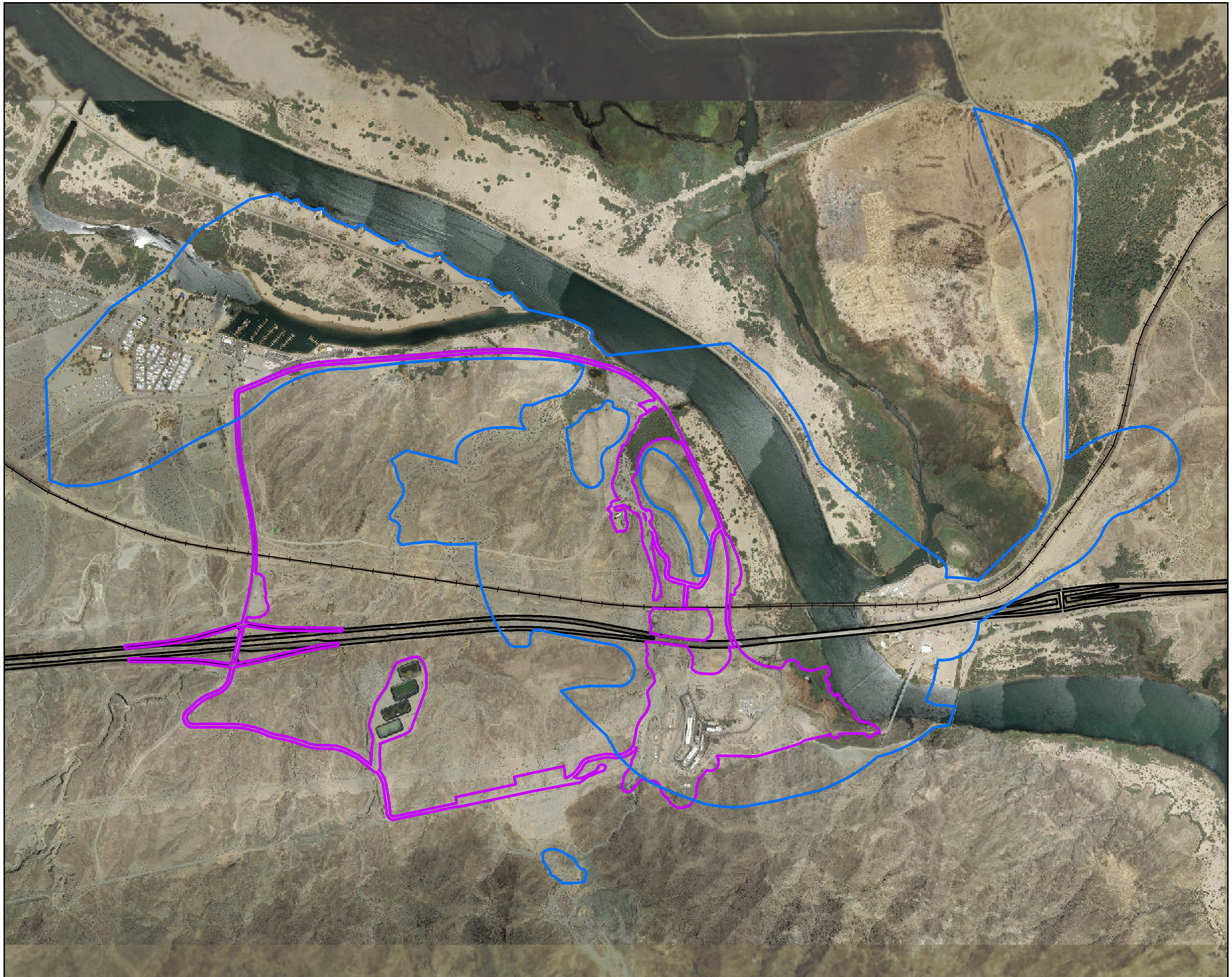
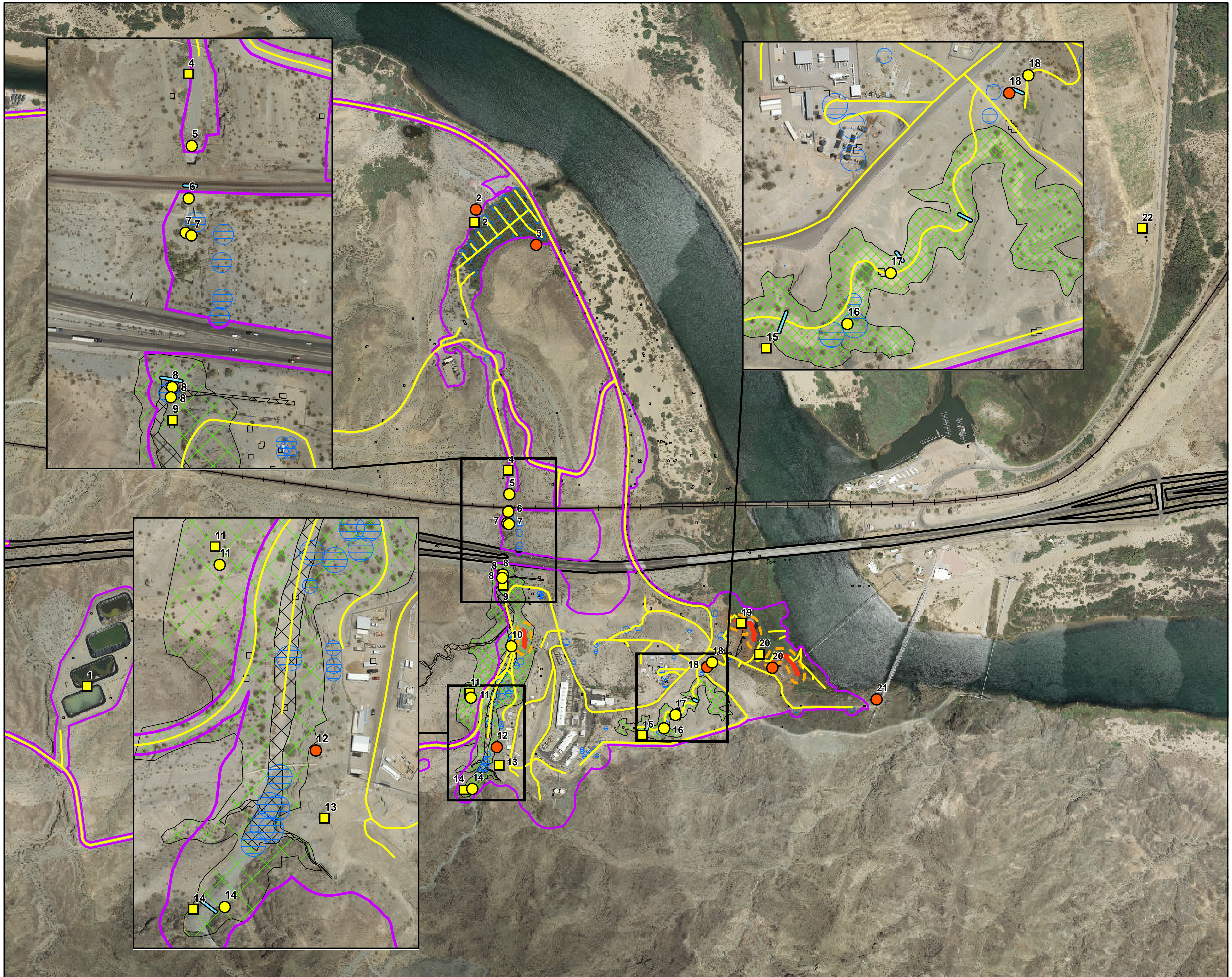


LEGEND
Soil Investigation Project Area
EIR Project Area
RailRoad

0 300 600 1,200
Feet

FIGURE 1
PROJECT AREAS ASSESSED FOR POTENTIAL BAT ROOSTING AND FORAGING HABITAT DURING THE WINTER SURVEY
2015 SPRING BAT SURVEY
PG&E TOPOCK COMPRESSOR STATION, NEEDLES, CALIFORNIA



LEGEND

- Proposed Access Routes
- RailRoad
- 125 sq.ft. Well Buffer
- Soil Investigation Project Area
- Potentially Sensitive Maternal Bat Roosting Habitat
- 50-foot Buffer (added at DTSC's direction)
- Ravine Sideslopes that Represent Potential Additional Bat Roosting Habitat
- Work Areas Where Work May be Limited During Bat Roosting Season (Not bat roosting habitat)
- Sampling Location Impact Area

Anabat Monitoring Stations

- Short-term, Winter 2015
- Short-term, Spring 2015
- Long-term, Spring 2015
- Mist Net Location Spring 2015

Notes:

1. Potentially Sensitive Maternal Bat Roosting Habitat includes areas where cavities appeared large enough to accommodate Townsend's big-ear bat and pallid bats among others. These are the specific locations referred to in the letter report 'Preliminary Habitat Analysis for Bat Use at PG&E Topock Remediation Project, San Bernardino County, CA' (Dr. Pat Brown, dated March 2, 2015)
2. Proposed access routes and sampling locations are taken from the Draft Soil Investigation EIR (DTSC, 2014).

N

0 375 750

Feet

FIGURE 2
TOPOCK PROJECT AREAS AND ACOUSTIC MONITORING STATIONS
2015 SPRING BAT SURVEY
PG&E TOPOCK COMPRESSOR STATION,
NEEDLES, CALIFORNIA

Table 1. Bats Potentially Occurring near the PG&E Topock Remediation Site

Family/Scientific Name	Common Name	USFWS	CDFW
Chiroptera (Bats)			
Phyllostomidae (American leaf-nosed bats)			
Macrotus californicus	California leaf-nosed bat	SC	CSC
Vespertilionidae (Vesper bats)			
Myotis yumanensis	**Yuma myotis**	SC	-
Myotis velifer	**Cave myotis**	SC	CSC
Myotis occultus	Arizona myotis	SC	CSC
Myotis californicus	**California myotis**	-	-
Parastrellus hesperus	**Western canyon bat**	-	-
Eptesicus fuscus	**Big brown bat**	-	-
Lasiurus blossevillii	Western red bat	-	CSC
Lasiurus xanthinus	Southern yellow bat	-	-
Lasiurus cinereus	**Hoary bat**	-	-
Corynorhinus townsendii	**Townsend's big-eared bat**	SC	Candidate T/E
Antrozous pallidus	**Pallid bat**	-	CSC
Molossidae (Free-tailed bats)			
Tadarida brasiliensis	**Mexican free-tailed bat**	-	-
Nyctinomops femorosaccus	**Pocketed free-tailed bat**	-	CSC
Nyctinomops macrotis	Big free-tailed bat	SC	CSC
Eumops perotis	**Western mastiff bat**	SC	CSC

USFWS
U.S. Fish and Wildlife Service
Federal Species of Concern
SC = Former Category 2 candidate

CDFW
California Department of Fish and Wildlife
CSC = California Species of Concern

Bold = Detected in current acoustic survey
RED = Captured in mist nets

Table 2. Anabat Detector Stations During Winter and Spring Surveys, Topock Compressor Station					
map ID	**Site Name**	**lat (N)**	**long (W)**	**elev (m)**	**date(s)**
	January short term				
2	N Margin Mouth of Bat Cave Wash by tamarisk [AOC1]	34.724390	114.494880	143	1/29/2015
3	S Margin Mouth of Bat Cave Wash by tamarisk [AOC7] BCW18	34.723630	114.493420	145	1/29/2015
12	Bat Cave Wash slope above pipe crossing	34.713400	114.494830	181	1/29/2015
18	East Ravine margin [AOC-10D]	34.714890	114.489560	149	1/29/2015
20	On LCR rocky slope N of pipe crossing [ERPW7]	34.714830	114.487950	155	1/29/2015
21	On LCR rocky slope N of Trails Bridge crossing [near 28A]	34.714110	114.485400	148	1/29/2015
	April long term				
1	Evaporation Ponds	34.714940	114.504910	195	4/27-5/1/2015
2	Mouth of Bat Cave Wash by tamarisk	34.724140	114.494930	143	4/27-5/1/2015
4	Bat Cave Wash N of RR crossing	34.719050	114.494310	146	4/27-5/1/2015
9	Bat Cave Wash S of I-40 crossing	34.716700	114.494540	158	4/27-5/1/2015
11	Bat Cave Wash west of compressor station	34.714530	114.495450	173	4/27-5/1/2015
13	Bat Cave Wash, above pipe crossing	34.713030	114.494790	190	4/27-5/1/2015
14	Bat Cave Wash mouth of rocky cyn	34.712560	114.495676	172	4/27-5/1/2015

Table 2. Anabat Detector Stations During Winter and Spring Surveys, Topock Compressor Station					
map ID	**Site Name**	**lat (N)**	**long (W)**	**elev (m)**	**date(s)**
15	Above East Ravine	34.713550	114.491220	163	4/27-5/1/2015
19	On LCR backwater rocky slope S of I-40 bridge	34.715760	114.488680	138	4/27-5/1/2015
20	On LCR rocky slope N of pipe crossing	34.715120	114.488260	138	4/27-5/1/2015
22	Arizona fenced enclosure HNWR	34.723540	114.478430	141	4/27-5/1/2015
April short term					
8	Bat Cave Wash nr S portal I-40 culverts net site	34.716923	114.494532	160	4/28/2015
14	Bat Cave Wash nr dry waterfall at net site	34.712566	114.495468	172	4/28/2015
16	East Ravine arroyo junction from ESE	34.713665	114.490678	164	4/29/2015
17	East Ravine below E side slope with cavities	34.713933	114.490382	158	4/29/2015
18	East Ravine near net site 1	34.714983	114.489428	153	4/29/2015
5	Bat Cave Wash N apron RR culvert	34.718557	114.494302	155	4/30/2015
7	Bat Cave Wash floor trees S of RR culvert	34.717970	114.494377	149	4/30/2015
8	Bat Cave Wash nr S portal I-40 culverts net site	34.716923	114.494532	160	4/30/2015
6	Bat Cave Wash inside S portal of RR culvert	34.718201	114.494341	158	5/1/2015
7	Bat Cave Wash floor trees S of RR culvert	34.717950	114.494332	152	5/1/2015
8	Bat Cave Wash below W side slope with potential roost cavities	34.716853	114.494545	156	5/1/2015

Table 2. Anabat Detector Stations During Winter and Spring Surveys, Topock Compressor Station					
map ID	**Site Name**	**lat (N)**	**long (W)**	**elev (m)**	**date(s)**
10	Bat Cave Wash below slope with potential roost cavities	34.715450	114.494380	157	5/1/2015
11	Bat Cave Wash below E side slope with potential roost cavities	34.714430	114.495423	172	5/1/2015

Table 3. Station number and minutes with acoustical activity for species/acoustic categories, Topock Compressor Station										
Station #	**Date**	**Pahe**	**M50**	**Q25**	**Tabr**	**M40**	**Anpa**	**Laci/Nyfe**	**Eupe**	**Station Total**
January 29 2015 (approx 6hr per station)										
2	1/29/2015	3	21	1	2					27
3	1/29/2015		4	2	3					9
12	1/29/2015	8	4	5	29					46
18	1/29/2015		6							6
20	1/29/2015	1	7	2	2					12
21	1/29/2015	2	3	4	3					12
Species Total		**14**	**45**	**14**	**39**					**112**
April 27-May 1 2015 (5 nights)										
1	4/27-5/1/15	489	227	28	11				1	756
2	4/27-5/1/15	334	83	42	29			1		489
4	4/27-5/1/15	360	741	41	40		3	2	1	1188
9	4/27-5/1/15	144	643	29	5		28			849
11	4/27-5/1/15	182	28	63	51		1	4	1	330
13	4/27-5/1/15	693	30	182	217			9		1131
14	4/27-5/1/15	381	1022	258	179			1		1841
15	4/27-5/1/15	282	63	29	25			5	7	411
19	4/27-5/1/15	389	445	88	53	5	32	2	1	1015
20	4/27-5/1/15	194	93	51	59		7	6	4	414
22	4/27-5/1/15	168	201	64	16	13	1	1	4	468
Species Total		**3616**	**3576**	**875**	**685**	**18**	**72**	**31**	**19**	**8892**

Table 3. Station number and minutes with acoustical activity for species/acoustic categories, Topock Compressor Station										
Station #	**Date**	**Pahe**	**M50**	**Q25**	**Tabr**	**M40**	**Anpa**	**Laci/Nyfe**	**Eupe**	**Station Total**
April 27-May 1 2015 (approx 4 hours per station)										
8	4/28/2015	2	127	14	5					148
14	4/28/2015	12	84		70		2	1		169
16	4/29/2015	22	2							24
17	4/29/2015	15	2							17
18	4/29/2015	45	25		1					71
5	4/30/2015	100	107	6	2					215
7	4/30/2015	88	73	6						167
8	4/30/2015	34	75	2			1			112
6	5/1/2015		55							55
7	5/1/2015	59	53							112
8	5/1/2015	17	38							55
10	5/1/2015	15	40	3						58
11	5/1/2015	11	10	1						22
Species Total		**420**	**691**	**32**	**78**		**3**	**1**		**1225**
Notes:										
Pahe = Parastrellus Hesperus; **M50** = Myotis yumaensis and M. californicus; **M40** = likely M. vellifer; **Anpa** = Antrozous pallidus; **Laci/Nyfe** = Lasiurus cinereus and Nyctinomops femorosaccus; and **Eupe** = Eumops perotis.										

Table 4. Bat Species Observations from Mist Netting Activities - April 28 to 30, 2015, Topock Compressor Station

Location	Date	Time (Hrs)	Species	Number	Sex	Reproductive Status	# Nets	Notes
Culverts under I-40	4/28/2015	1930-2330						
		1946-2317	Myyu	9	F	lactating	4	Most bats heading from south to north (downstream)
		1946-2317	Myyu	8	F	pregnant		All nets placed across upstream side of culverts
		1946-2317	Myyu	2	F	none		
		2200-2317	Myyu	5	M	none		all males captured after 2200
		2008-2109	Myca	2	F	pregnant		
		2116-2157	Myca	3	M	none		
		2148-2223	Anpa	3	F	pregnant		
		2102	Anpa	1	M	testes descended		
		2115-2223	Tabr	2	M	none		
Upper Bat Cave Wash	4/28/2015	1914-2238						
			none				1	below rocky alcove
East Ravine	4/29/2015	1930- 2315						
			none				1	Near large paloverde
			none				1	At turn in wash
			none				1	At crest of berm

Table 4. Bat Species Observations from Mist Netting Activities - April 28 to 30, 2015, Topock Compressor Station								
Location	**Date**	**Time (Hrs)**	**Species**	**Number**	**Sex**	**Reproductive Status**	**# Nets**	**Notes**
			none				1	Across wash
Culverts under 1-40	4/30/2015	1930-2245						
		1945-2145	Myyu	10	F	lactating	4	All nets placed across upstream side of culverts
		1945-2145	Myyu	1	F	none		
		1945-2145	Myyu	1	M	none		
Culvert under BNSF Railroad	4/30/2015	1930-2245					2	2 nets stacked vertically
		2145	Coto	1	M	testes descended		
Total				**48**				
Notes:								
1. Times are based on 24 hour clock (military). Time next to location name = total time nets set. Time next to bat categories=bracket of time when that species category captured								
2) Mist net locations are shown on Figure 2.								
3) Bat species abbreviations: **Myyu** = Yuma myotis; **Myca** = Myotis californicus; **Anpa** = Antrozous pallidus; **Tabr** = Tadarida brasiliensis; and **Coto** = Corynorhinus townsendii.								
4) Other Abreviations: M = male; F = Female.								

PHOTOGRAPH 1
Anabat acoustical detection device.

PHOTOGRAPH 2
Setting up long-term Anabat station in East Ravine, April 27, 2015.

PHOTOGRAPH 3
Long-term Anabat Monitoring Station 13 above Bat Cave Wash near the compressor station. April 27, 2015.

PHOTOGRAPH 4
Long-term Anabat Monitoring Station 19 along Colorado River north of the pipe bridge. April 27, 2015.

PHOTOGRAPH 5
Long-term Anabat Monitoring Station 22 near HNWR-1 well in Sacramento Wash. Moved to inside of closure on following day. April 27, 2015.

PHOTOGRAPH 6
Mist net setup on upstream side of I-40 culverts within Bat Cave Wash. April 28, 2015.

PHOTOGRAPH 7
Mist net setup beneath BNSF railroad crossing over Bat Cave Wash. April 30, 2015.

PHOTOGRAPH 8
Captured Townsend’s big-eared bat. April 30, 2015.

Topock Compressor Station Summer Roosting Bat Surveys and Potential Project Impacts, Final Report

EN1031161134BAO

Topock Project Executive Abstract

Document Title: Topock Compressor Station Summer Roosting Bat Surveys and Potential Project Impacts, Final Report Final Document? ☒ Yes ☐ No	Date of Document: November 5, 2015 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:____________________ 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: Biological Reports	Is this a Regulatory Requirement? ☐ Yes ☒ No If no, why is the document needed? In support of the upcoming Groundwater Remedy EIR and future Groundwater Remedy construction
What is the consequence of NOT doing this item? What is the consequence of DOING this item? This report supports upcoming work associated with the Final Groundwater Remedy. Not performing the survey and preparing this report would impede efforts to better understand and avoid potential impacts to roosting bats.	Other Justification/s: ☐ Permit ☒ Other / Explain: Supports upcoming Final Groundwater Remedy activities.

Brief Summary of attached document:

The goal of the current survey was to build upon the knowledge on bat roosting and foraging habitat in the Final Groundwater Remedy area that was gained from previous surveys conducted in the winter (Brown 2015) and spring (Brown and Rainey, 2015). The main purpose of the current study was to identify actual bat roost locations and to support future appropriate mitigation measures to avoid or minimize potential impacts that would be associated with upcoming Final Groundwater Remedy activities. It also provides an assessment of potential noise impacts from well drilling and sampling equipment. The summer surveys were conducted in the latter portion of the bat roosting season on five nights during a period from July 20 through 28, 2015 and on the night of September 25, 2015. The summer bat surveying activities included mist-netting surveys and radiotracking bats to roost locations, as well as visual and acoustic surveys of bat roost habitats. The assessment of potential impacts to bats from drilling and sampling activities was conducted using acoustic monitoring and a high frequency noise analysis. Mist-netting from July 20 through 28, 2015 captured 6 pallid bats, 10 California myotis, and 38 Yuma myotis. Two post-lactating female pallid bats were radio-tagged and tracked to their roosts, which were identified to the south of the project area in Bat Cave Wash. Visual surveys found additional roosts within Bat Cave Wash and beneath the western end of the BNSF bridge. Acoustical monitoring revealed a cave myotis roost within a brick culvert in Bat Cave Wash beneath the National Trails Highway. The acoustic analysis provides noise attenuation data based on distance from drilling rigs and generators without shielding.

Written by: PG&E

Recommendations:

This report is for information only.

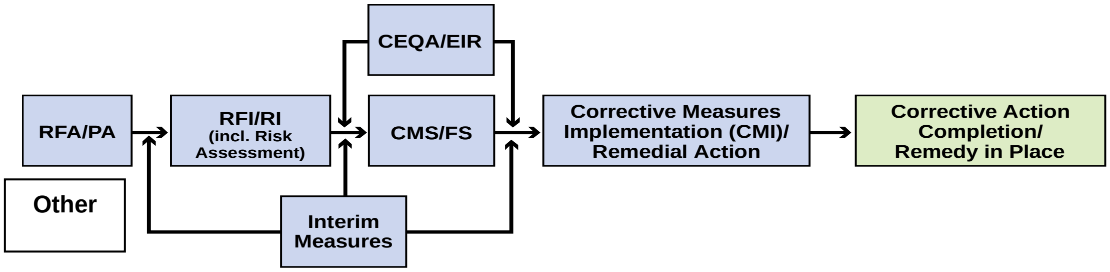
How is this information related to the Final Remedy or Regulatory Requirements:

The survey and this report provides information to support the upcoming Final Groundwater Remedy activities.

Other requirements of this information?
None.

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





H. T. HARVEY & ASSOCIATES
Ecological Consultants

Topock Compressor Station
Summer Roosting Bat Surveys and Potential Project Impacts
Final Report

Project #3740-01

Prepared for:

Pacific Gas and Electric Company

Prepared by:

H. T. Harvey & Associates

November 5, 2015

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List of Preparers

Dave Johnston, Ph.D., Associate Wildlife Ecologist

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Gabe Reyes, M.S., Wildlife Ecologist

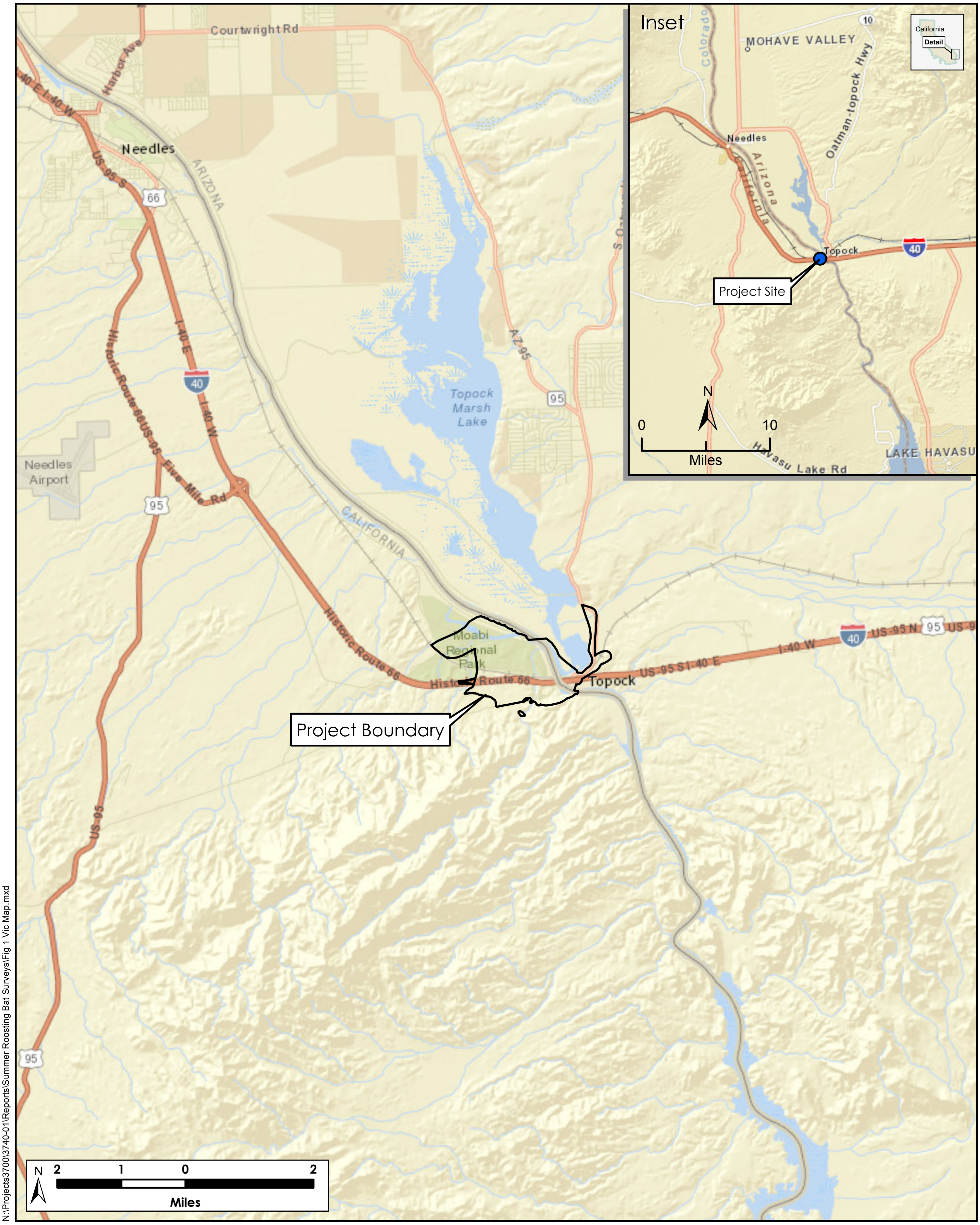
Section 1. Introduction

Pacific Gas and Electric Company's (PG&E's) Topock Compressor Station and adjacent lands (referred to hereafter as the Project site) is a natural gas compressor site located south of Needles, California (Figure 1) near the Interstate 40 crossing of the Colorado River. PG&E is planning to implement a remediation project to address chromium groundwater contamination that may have resulted from past disposal activities at the Project site.

Initial surveys for special-status bats conducted at the Project site by Drs. Patricia Brown and William Rainey last winter (Brown 2015) and spring (Brown and Rainey, 2015) detected four special-status species, Townsend's big-eared bats (*Corynorhinus townsendii*), pallid bats (*Antrozous pallidus*), cave myotis (*Myotis velifer*) and California mastiff bats (*Eumops perotis*) that could potentially establish maternity roosts on the Project site.

As a follow-up to the winter and spring 2015 surveys and as requested by PG&E and CH2M HILL, H. T. Harvey & Associates conducted focused surveys to identify the locations of maternity roosts of special-status bats on the Project site. In addition to the special-status species identified in these reports, we expected that the western red bat (*Lasiurus blossevillii*) could also be present on the Project site based on their range and potential on-site habitat.

The main purpose of the current bat surveys was to develop appropriate mitigation measures to avoid or minimize potential impacts of upcoming groundwater remediation work on bat maternity roosts on the Project site and in the immediate vicinity. The subsequent avoidance and minimization measures from this report would then supersede previous minimization measures that were designed prior to identifying maternity roosts on the Project site. As part of this investigation, H. T. Harvey & Associates ecologists conducted mist-netting, radiotracking, short-term acoustic monitoring, and visual observations at areas supporting potential roosting habitat. This report will summarize our findings for the summer bat roost surveys and potential impacts to bats based on our observations. It also summarizes an assessment of potential impacts to bats from noise generated by well boring and sampling equipment. Following this report, we will provide an additional report that will summarize avoidance and minimization measures for on-site bats.



H. T. HARVEY & ASSOCIATES

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Figure 1. Vicinity Map

Topock Compressor Station Summer Roosting Bat Surveys (3740-01)

November 2015

Section 2. Methods

2.1 Mist-Netting and Radiotelemetry

During the maternity season (March 15th through August 31st), females of some bat species group together in a single roost or cluster of associated roosts to form larger maternity colonies, where they raise their young. These colonies often represent significant populations on a local or regional scale, and some species are particularly susceptible to disturbance while raising their young. To document the locations of maternity roosts on the Project site, we conducted mist-net surveys with the intention of catching lactating females and tracking them back to their maternity colonies. Although our primary aim was to locate maternity roosts for species of special concern (Townsend's big-eared bat, pallid bat, western red bat, and cave bat), we also were interested in assessing the species, sex, and reproductive status of other bats on the Project site.

We conducted mist-netting during the evenings of July 20, 21, 23, 26, and 28, 2015, and during the morning of July 28, 2015. We placed mist nets that ranged from 6 to 12 meters wide and from 2.6 to 5.2 meters tall across natural flyways on the Project site. The 5.2-meter-tall net was operated with a pulley system (Johnston 2001). When mist-netting in the evening, we opened nets at approximately 7:45 p.m. and closed them at approximately 10:00 p.m. When mist-netting in the morning, we set mist nets up before dawn, at approximately 4:45 a.m., and closed them at approximately 6:00 a.m. After nets were opened, we checked them in intervals of 15 minutes or less. We placed each captured bat in a paper or cloth bag, processed it on site, and released it unharmed after data collection. For each individual, we assessed and recorded species, age (adult or sub-adult), forearm length (in millimeters), mass (in grams), and reproductive status (lactating, postlactating, testes descended, or nonreproductive).

To radio track bats, we carefully clipped the fur in the interscapular region of the bat's back and attached Holohil BD-2 radio transmitters (Holohil Systems, Ltd., Carp, Ontario, Canada) using eyelash glue. Each radio tag accounted for less than 5% of an individual's weight. After the radio tag was securely attached we released the bat. The day after capture, we went to the site of release and checked for a signal using radio receivers (R-1000, Communication Specialists, Orange, California), and three-element and five-element Yagi antennas. If we could not detect a signal, we drove or walked to opportunistic areas of high elevation within a 5-mile radius and attempted to locate the signal. After locating the signal, we attempted to locate the roost by systematically determining the direction in which it was strongest and following it in that direction.

2.2 Visual Surveys of Roost Habitat

To locate bat roosts on the Project site, we used both systematic searches and radiotelemetry. We conducted systematic searches by initially searching for suitable roosting habitat during a reconnaissance-level survey in June 2015, and later by also using aerial images in Google Earth. We subsequently visited all suitable locations to conduct in-person evaluations of the sites. We conducted visual observations at known roost sites, as determined by radiotelemetry, and in areas supporting suitable roost habitat, from approximately half an hour before sunset to an hour after sunset. At each location, we watched for emerging bats and kept a tally of how many bats flew out from an emergence spot and how many bats flew back into the same roost opening. To arrive at an approximate total number of bats for each roost, we subtracted the number of bats flying into the roost from the number of bats recorded flying out of the roost.

Based on new project information we received on September 25, 2015, we evaluated one additional section of the railroad and a set of three culverts that had potential to support roosting bats. Both sites are located in the westernmost section of the groundwater remedy project area, west of the Moabi Regional Park. On September 30, 2015, Gabe Reyes, with assistance from Curt Russell of PG&E, visually inspected the westernmost railroad crossing and culverts for signs of roosting bats. Following this inspection, Mr. Reyes and Mr. Russell remained at the sites to watch for bats exiting these features after sunset. Mr. Reyes observed the railroad crossing and Mr. Russell observed the culverts, utilizing night vision goggles.

2.3 Acoustic Monitoring and Analysis

Bats use echolocation calls to detect prey and obstacles as they navigate across landscapes. Although a given species may demonstrate some degree of plasticity in its calls, acoustic parameters, such as call shape, duration, and minimum frequencies, may be used to identify species (Fenton et al. 1995). Therefore, acoustic surveys can be used to help determine many species of bats (Parsons et al. 2000). Two primary technologies exist for recording and analyzing bat calls: zero-crossing and full spectrum. The technology for viewing zero-crossing recordings is well developed; it is easy to quickly view and place species labels on thousands of calls at a time. However, full-spectrum technology provides more detail about specific call characteristics, which can sometimes be critical for distinguishing species with similar call parameters (Fenton 2000). Therefore, to assess bat activity in different areas of the Project site, we used Song Meters (Song Meter SM2 BAT recorders) (Wildlife Acoustics, Concord, Massachusetts, United States), which record compressed files that can be converted to either zero-crossing or full spectrum files.

To determine which bat species were present on the Project site, we deployed eight Song Meters on the Project site from July 20 through July 30, 2015. We programmed the Song Meters according to the default settings provided in the instruction manual, and we manually set the Universal Transverse Mercator coordinates for each detector. We then scheduled the units to record from sunset to sunrise. We attached microphones to microphone cables and secured them approximately 3 feet off the ground to T-posts positioned at a slight angle. We deployed Song Meters throughout the site, concentrating on areas with tamarisk groves, bridges, and rocky outcrops that could provide suitable habitat for maternity roosts and special-status bats.

When we identified possible roost locations but did not conduct visual emergence counts, we deployed detectors for two consecutive nights. When we deployed Song Meters in possible roost locations while conducting simultaneous visual emergence counts, we left detectors out for only the duration of the emergence count.

We analyzed the first hour after and first hour before sunset from all detectors. We analyzed Song Meter data as both full spectrum .wav files in callViewer, v.18.0 (Skowronski and Fenton 2008), and as zero-crossing files in AnaLook, v.3.9c (Titley Electronics, Ballina, New South Wales, Australia). This approach allowed us to move quickly through easily identifiable calls in AnaLook and mark other files for a second analysis in full spectrum.

Whenever possible, we identified bats to species based on the acoustic parameters of shape, minimum frequency, duration, and/or critical frequency. Of the species that use the Project site, several have call characteristics that often overlap with those of other local species (Humboldt State University Bat Lab 2011). Therefore, some bat calls were identified to a group rather than to a species (e.g., Yuma myotis and California myotis). Calls that we could not identify to species were classified as unknown.

Although bat calls cannot be used to identify individuals, the number of calls is commonly used as an index of overall activity at a site (Kunz et al. 1996). We quantified bat activity separately for each species classification by presence/absence within 1-minute periods per night. This method provides more accurate assessments of bat activity than traditional methods of counting individual passes (Miller 2001). We then examined the data for temporal patterns to determine whether there was evidence of an emergence event (e.g., a high number of calls from one species recorded around sunset).

2.4 High Frequency Noise Analysis

One of the main components of assessing how the Project activities may affect roosting bats was by assessing how much ultrasonic noise will be generated by the equipment to be used for these activities. It is our understanding that the two main sources of noise will come from the use of portable generators and borehole drilling, and a third potential source is from construction vehicles including backhoes, cranes, and graders. Drilling rigs and other well maintenance rigs will be used during initial construction, during decommissioning (at the end of Remedy life), and during the intervening O&M period. Most of the other construction equipment will be used during the initial construction and decommissioning phases. The portable generators were specifically included because they are the primary noise-inducing device that will be used routinely throughout the O&M period (for groundwater sampling) that will occur several times each year.

To assess whether or not high frequency noise made by generators will disturb bats, we recorded the ultrasonic noise produced by an operating small generator (Honda EU 2000) simultaneously at three distances (10, 20, and 30 meters) with Song Meter (Song Meter SM2 BAT) bat detectors for one minute. The goal of this assessment was to determine the frequencies produced by the generator and at what distance the sound attenuates to a point where it is not expected to disturb a maternity colony.

Because borehole drilling can potentially encounter larger rocks causing auger bits to "skip" along the surface of the substrate, we predicted that the borehole drilling on the Project site could also potentially generate high frequency sounds as metal scrapes rocks. To duplicate these potential drilling sounds, we recorded ultrasonic sounds at a similar situation. Our H. T. Harvey & Associates field staff positioned three high frequency Song

Meter bat detectors at a borehole drilling site in San Jose, California on September 28, 2015. In addition to recording high frequency sounds from the borehole drilling, we recorded sounds generated by a calibration instrument (Wildlife Acoustics) that emitted 48 decibels (dB) (±4 dB) at the 40 kHz frequency. Due to site constraints, the measurements were taken along a path alongside the rig, which likely provided some acoustical shielding; however, any shielding that dampened the sound was accounted for, and actual dB levels were then estimated by modelling based on attenuation data. H. T. Harvey & Associates hired sound analysis specialists Illingworth and Rodkin, Inc. (Petaluma, California) to analyze the strength of high frequencies generated from this borehole drilling in San Jose and to compensate for any possible shielding effects. The memo from Illingworth and Rodkin, Inc. is included as Appendix B.

Construction vehicles, including backhoes, cranes, and graders, that are required to implement the planned groundwater remedy activities, likely also produce ultrasonic noises that could potentially impact roosting bats. We have not measured the amount of high frequency sound generated by each of the pieces of equipment needed to construct the final remedy. Instead, we rely on published accounts of the amount of low frequency noise these construction vehicles generate to estimate their potential high-frequency output.

Section 3. Results

3.1 Mist-Netting and Radiotelemetry

We conducted five nights and one morning of mist-netting in five locations: two areas in southern Bat Cave Wash and three areas in northern Bat Cave Wash: north and south sides of the Interstate 40 culverts and north side of the Burlington Northern Santa Fe Railway culvert (Figure 2). In total, we captured 54 bats representing three species (Table 1 and Appendix A).

Table 1. Number of Bats Captured by Date, Site, and Species

Date	Site	Pallid bat	California Myotis	Yuma Myotis
July 20, 2015	Bat Cave Wash	3	0	1
July 21, 2015	Bat Cave Wash culverts	2	2	7
July 23, 2015	Bat Cave Wash	1	0	0
July 26, 2015	Railroad culvert	0	5	1
July 28, 2015[1]	Railroad culvert	0	0	2
July 28, 2015	Bat Cave Wash culverts/ railroad culvert	0	3	27

[1]Mist net was deployed in the morning before dawn.

We radio-tagged two postlactating pallid bats and successfully located the first bat's roost along Bat Cave Wash south of the Project site (Figure 2). We observed this first radio-tagged bat emerge from the roost two nights after capture. The second radio-tagged bat flew towards the first bat's roost location. However, the next day after the second bat was radio-tagged, neither bats were located at this pallid bat roost, and we were unable to locate the signals of these bats thereafter.

3.2 Visual Surveys of Roost Habitat

We located seven roosts through visual surveys at 19 locations (Figure 3). We observed approximately five bats emerging from the western bluff of southern Bat Cave Wash and 64 bats emerging from five locations in the railroad bridge (Figure 3). Most of the bridge-roosting bats were observed emerging from the bridge near the western shoreline and the westernmost pier over the Colorado River. We did not identify the exact crevice(s) where the five bats emerged from the western bluff; however, the general location is illustrated on Figure 3.

During mist-net surveys we located a large roost of Yuma myotis in a vertical tube in the easternmost culvert under Interstate 40 at the northern end of Bat Cave Wash (Figure 3). We estimated there were approximately 30 individuals present inside the vertical tube. However, the colony is possibly larger, as we captured 27 Yuma myotis individuals while mist-netting outside the culvert before detecting this roost.

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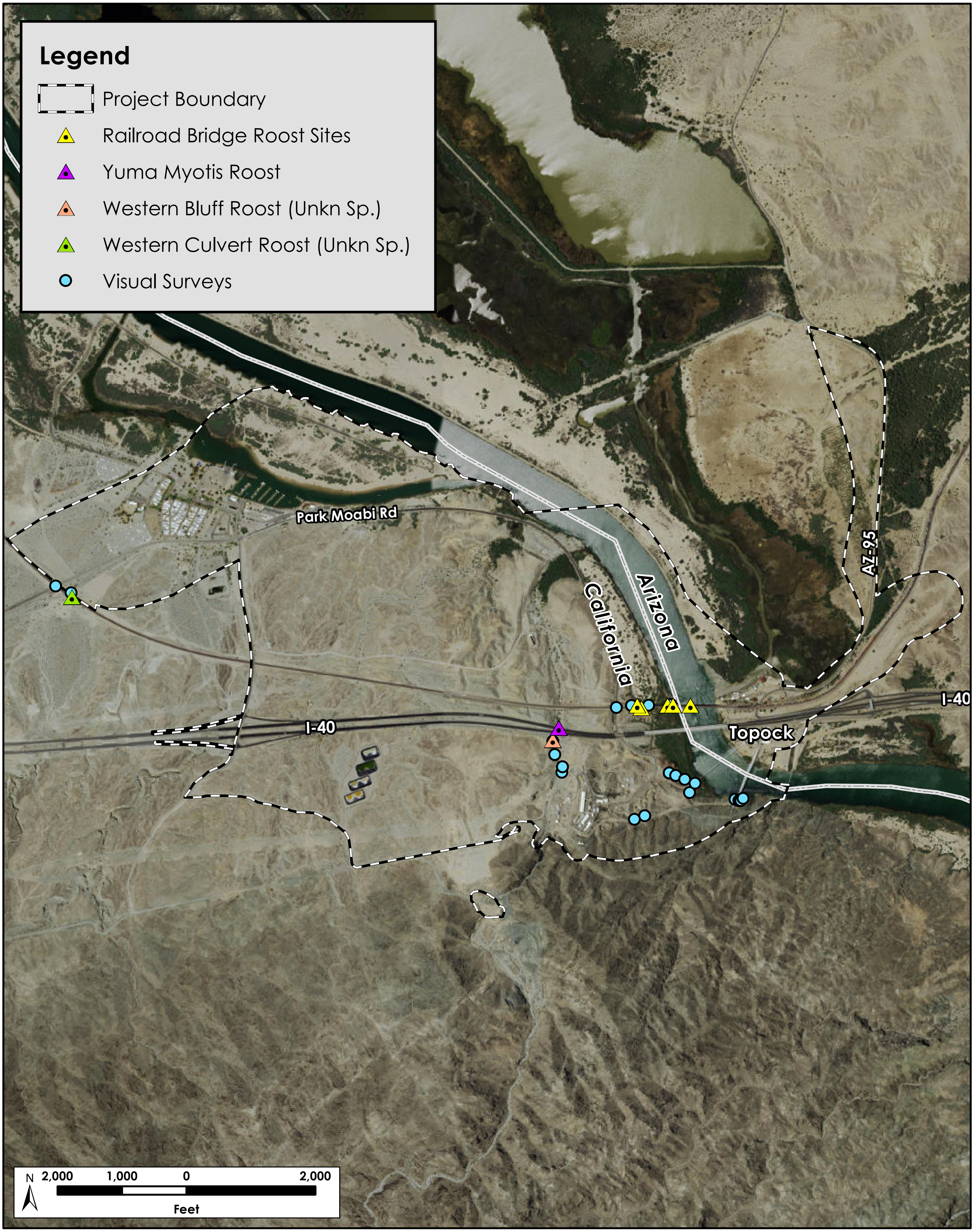
Figure 2. Locations of Mist-nets and Roosts Found Through Telemetry
Topock Compressor Station Summer Roosting Bat Surveys (3740-01)
November 2015



N:\Projects3700\3740-01\Reports\Summer Roosting Bat Surveys\Fig 3 Visual Surveys and Roosts.mxd

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Figure 3. Locations of Visual Surveys and Roosts Found
Topock Compressor Station Summer Roosting Bat Surveys (3740-01)
November 2015

On September 30th, no bats or bat sign were observed during a daytime inspection under the railroad crossing over the western section of National Trails Highway during the initial inspection or during the subsequent exit count. However, suitable roost habitat is present in this structure. No bats were observed during a daytime inspection of the three culverts immediately east of the National Trail Highway railroad crossing; however, approximately 60 guano pellets were observed underneath an area where overlapping sections of the culverts left a gap in the southernmost culvert (Figure 3). We visually surveyed for emerging bats that evening and conducted an acoustic survey at the same time. No bats were observed visually or through the use of bat detectors during the expected emergence time. However, this site is considered to support roosting bats due to the presence of guano and suitable habitat in the culvert. Based on the roost type and the size of the guano pellets, these bats were either crevice-roosting myotis or canyon bats.

3.3 Acoustic Monitoring

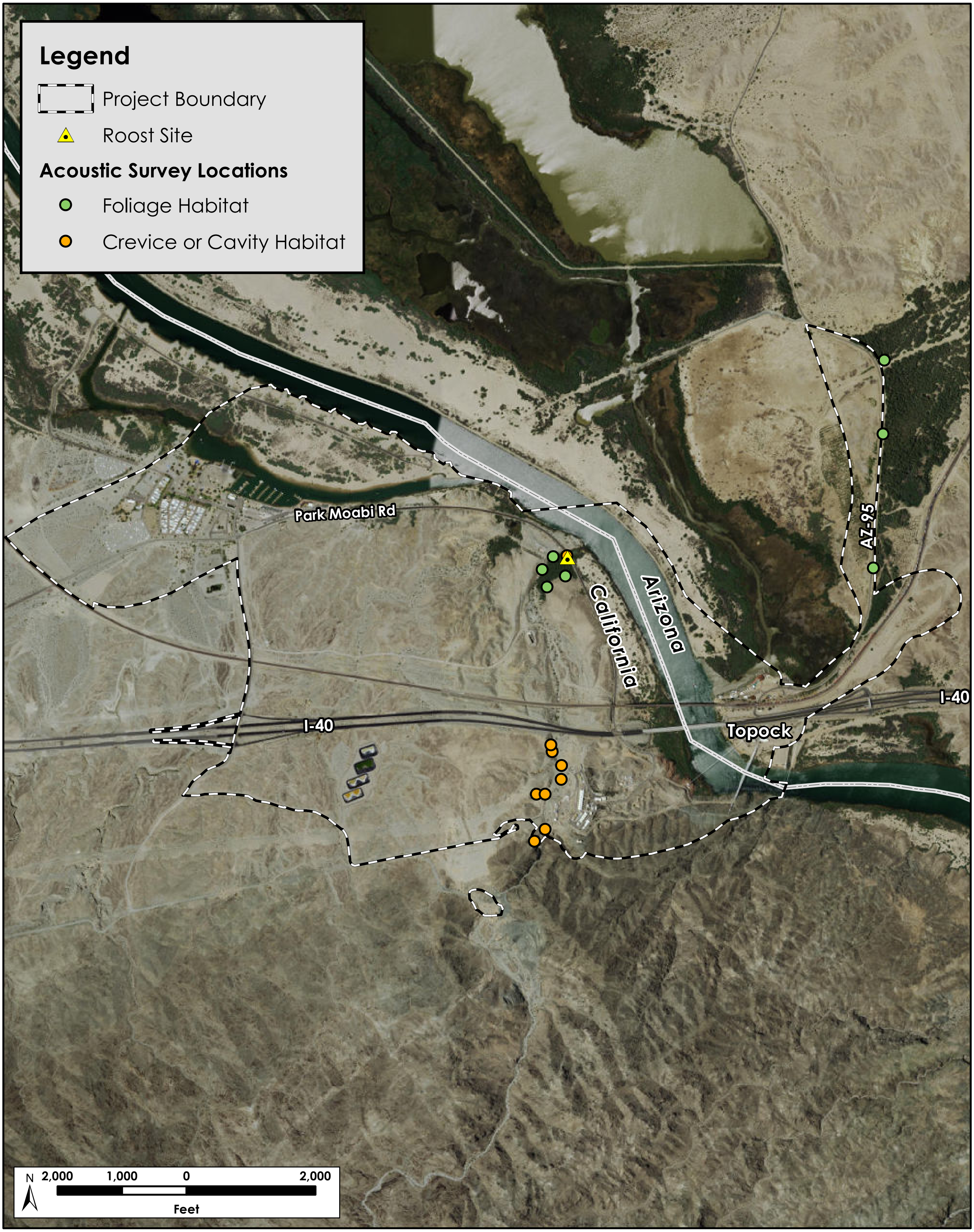
In total we conducted short-term acoustic surveys at 15 locations on the Project site, and covered a variety of potential foliage roosting habitat and crevice or cavity roosting habitats (Figure 4). Using acoustics, we detected seven distinct species of bats at the Project site: big brown bat (*Eptesicus fuscus*), California mastiff bat (*Eumops perotis*), canyon bat (*Parastrellus hesperus*), cave myotis (*Myotis velifer*), Mexican free-tailed bat (*Tadarida brasiliensis*), pallid bat, Townsend's big-eared bat, and one grouped species category, California myotis/Yuma myotis totaling nine species.

3.3.1 Foliage Roosting Habitat

We did not detect western red bats at any of the detectors placed in tamarisk groves in either Arizona or California. There was no on-site roosting habitat for two other foliage roosting bats, the western yellow bat (*Lasiurus xanthinus*) or the silver-haired bat (*Lasionycteris noctivagans*). Hoary bats (*Laisurus cinereus*), a widespread and common foliage roosting species, may roost rarely in the tamarisk grove although we did not detect any bats that were specifically hoary bats (most of this species' calls are difficult to separate from Mexican free-tailed bats). Further, there was no roosting habitat for crevice roosting bats although we did detect crevice-roosting bats that were foraging among these tamarisk trees.

3.3.2 Crevice and Cavity Roosting Habitat

We did not detect any temporal patterns indicative of a maternity colony along Bat Cave Wash or in the red rocks area. Although we detected cave myotis in low numbers at most detectors, we detected a high number of cave myotis passes in the first hour after sunset (8:00 p.m.) at the brick culvert along National Trails Highway (Figure 5). This pattern of high activity, not recorded elsewhere on the Project site for this species, suggests that a maternity colony is close by, possibly inside the brick culvert (Figure 6).



N:\Projects3700\3740-01\Reports\Summer Roosting Bat Surveys\Fig 4 Acoustic Surveys.mxd

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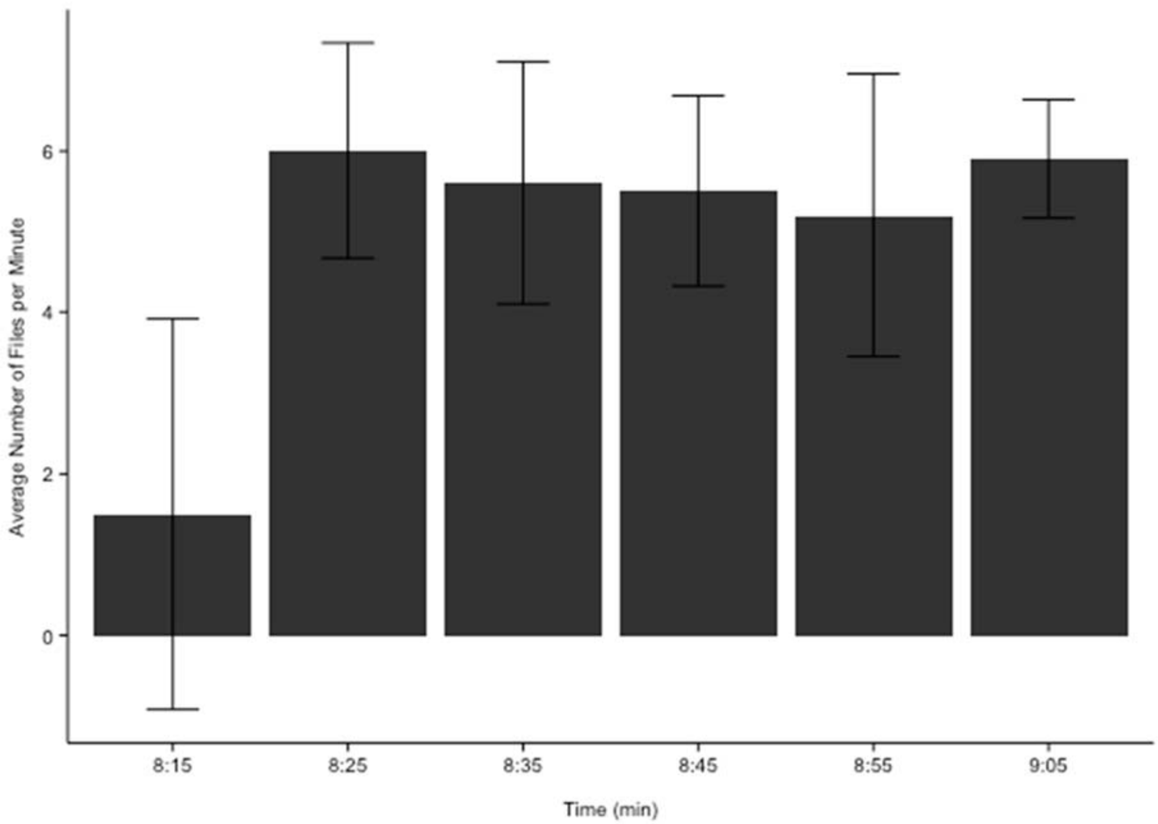
Figure 4. Locations of Acoustic Surveys and Roosts Found
Topock Compressor Station Summer Roosting Bat Surveys (3740-01)
November 2015

Figure 5. Average Cave Myotis Activity Recorded in Ten-Minute Intervals during First Hour after Sunset



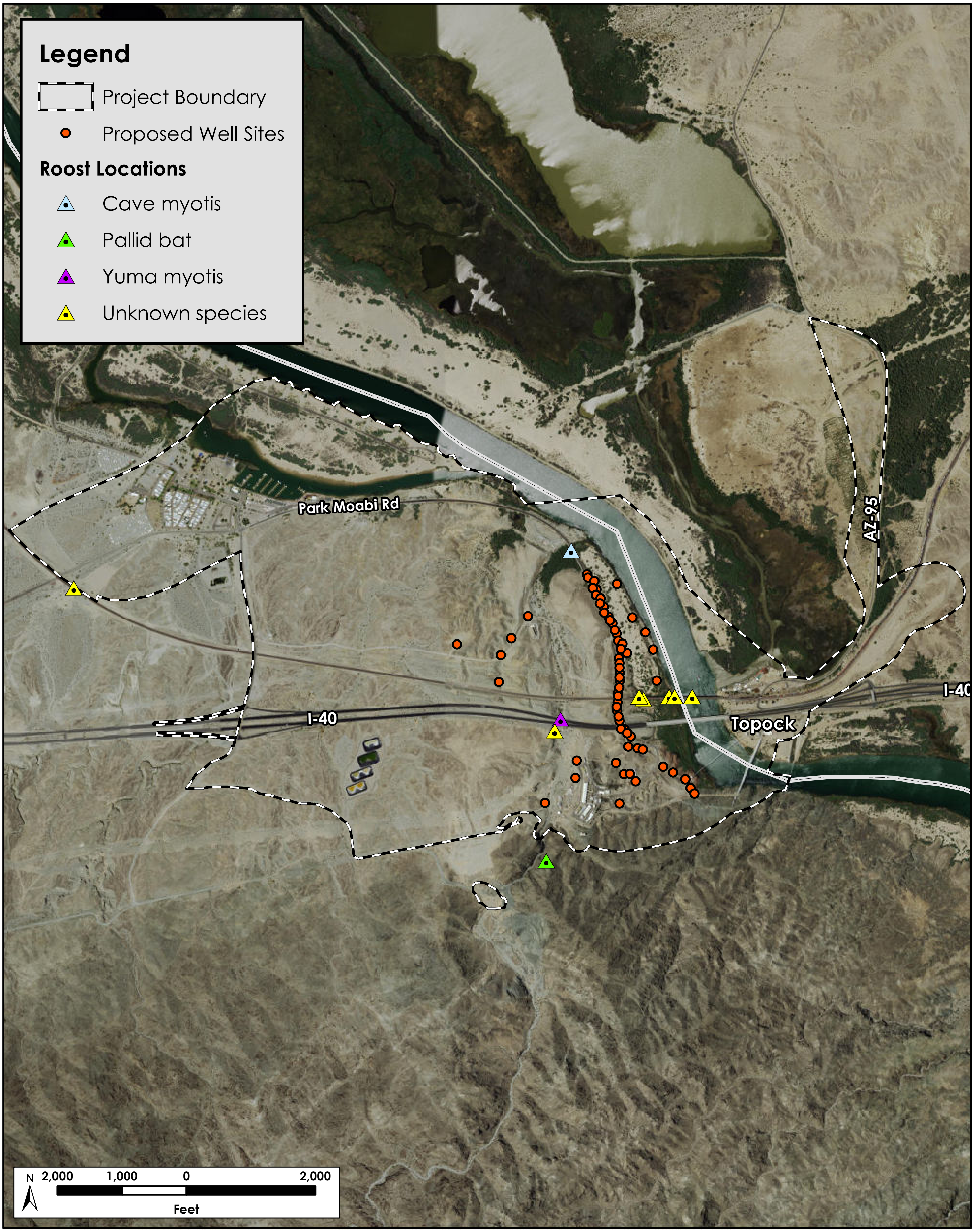


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Figure 6. Locations of All Roosts Found and Proposed Well Sites

Topock Compressor Station Summer Roosting Bat Surveys (3740-01)

November 2015

3.4 High Frequency Noise Analysis

3.4.1 Small Generator Ultrasonic Noise

The small generator emits a significant amount of high frequency noise at close range; however, high frequency sounds attenuate very quickly. Figure 2 shows the sonograms of the generator noise at 10, 20, and 30 meter distances away from the recorders. The sonogram at 10 meters shows quite a bit of noise whereas the recordings at 20 and 30 meters away are minimal. At 30 meters the bat flying noise near the bat detector is louder than the noises made by the generator. (In the sonogram the generator noise is fairly faint, and mostly at about 10 kHz.)

3.4.2 Borehole Drilling Ultrasonic Noise

As indicated in the memo (Appendix B), the highest noise levels were measured in the human audible range (up to 10 kHz) with the second highest dB level at about 20 kHz. At the 60-foot distance drill noise was indistinguishable from ambient conditions at frequencies of 40 kHz and higher, but ambient noise likely influenced the levels at frequencies at and above about 30 kHz (see Table 1 in Appendix B). At a distance of 90 feet, drill noise was indistinguishable from ambient conditions at frequencies of 30 kHz and up, and ambient noise likely influenced the levels at frequencies above about 15 kHz.

Because of site constraints, the measurements were taken along a path around the rig, which likely provided some acoustical shielding at some of these locations. The measured levels at the 10- and 30-foot distances are consistent with the Federal Highway Administration's Roadway Construction Noise Model (RCNM). In addition, the drop off rate over distance, which should be about 6 dB per doubling of distance for the overall dB level, is consistent between the 10- and 30-foot distances. Additional attenuation can be seen in the 60- and 90-foot distance data, where shielding provided about 5 dB of additional attenuation at the 60-foot position and about 14 dB of additional attenuation at the 90-foot position.

Ultrasonic sounds attenuate at a much higher rate than lower frequency sounds. Based on the results at the 10- and 30-foot positions, noise levels drop off by about 7 dB per doubling of distance at 30 kHz and by about 10 dB per doubling at the 40 kHz level (Appendix B, Figures 1 and 2). Using these drop off rates, the sum of the frequencies between 30 and 40 kHz would be below 35 dB at a distance of about 150 feet from the drill.

While not specifically addressed in the noise analysis, other types of construction activities and equipment are expected to have similar potential impacts to roosting and foraging bats.

3.4.3 Backhoe Trenching, Operating Cranes, and Grading

We made no measurements of high frequency noises from backhoe trenching, operating cranes, or grading by tractors. However, these construction activities and likely other construction activities are expected to generate high frequency sounds and could potentially impact roosting and/or foraging bats. Based on the United States Environmental Protection Agency (1971) the maximum noise level (of low frequency sounds) at 50 feet for backhoes is 80 dB, for portable cranes it is 78 dB, and for graders it is 80 dB. Whereas we cannot make inferences specific to various noise levels at different frequencies, there is a reasonable chance that these construction vehicles generate high frequency sounds that will need mitigation to minimize and mitigate for potential impacts to bats.

Section 4. Potential Impacts

High Frequency Noise. Ultrasonic sounds can disturb roosting as well as foraging bats. The operating of small gasoline generators and the drilling of boreholes for wells produce high frequency noises that could potentially affect roosting and foraging bats. Additionally, operating backhoes, cranes, graders, trucks and other construction equipment are expected to make high frequency sounds that could disturb bats that are not normally acclimated to such sounds.

Increase in Light Levels at Night. Whereas a few species of bats benefit from foraging around lights that attract nocturnal insects, many bat species show an aversion to areas with anthropogenic lights. An increase in light values near roosts can potentially increase predation on bats and possibly cause bats to abandon a roost.

Vibration. Construction activities planned to implement the final groundwater remedy, such as grading, truck driving, borehole drilling, and the operation of a crane and backhoe could potentially impact roosting bats.

Increased Human Activities. People tend to be curious about bat roosts and enjoy investigating them, especially during the maternity season. However, such activities can result in disturbing the bats, often leading to mothers abandoning a roost. While most species take their young with them, some species of bats (e.g., Townsend's big-eared bats) abandon the young when they leave the roost.

Pipeline Construction. Because the pipelines will be buried, the noise associated with digging trenches could pose a significant noise disturbance to both the colony of cave myotis along the river and the colony of Yuma myotis under Interstate Highway 40 (Figure 6). These colonies are both in close proximity to proposed pipeline routes.

Building Construction. Several new structures will be constructed on the project site including various water storage units, a water conditioning building, new maintenance facility, new storage building, and several new carbon amendment buildings. These new structures are being built immediately adjacent to the existing structures and no impacts on bats or bat roosts are anticipated.

Soil Processing/Storage Areas. Two areas on the north side of the railroad at National Trails Highway on the northwest portion of the Project area will be set aside for construction-generated soil processing and storage. This work will involve frequent noise disturbance from various equipment (soil screening unit, soil loaders, dump trucks/trailers), and air quality degradation from idling trucks in two associated truck waiting areas. Noise from soil moving and processing equipment could impact the bat roost located in the western culverts adjacent to the soil processing areas, especially during the maternity season. Likewise, diesel from idling trucks in the Truck Waiting Areas, even for as little as 15 minutes at a time, could cause roosting bats to abandon this site.

Temporary Construction Laydown Area & Long Term Remedy Support Areas. A temporary construction storage area will be used and several long term remedy support structures will be constructed west of the mobile home park at Moabi Regional Park. We do not anticipate any potential impact on roosting bats associated with these Project features.

Air Quality Degradation. Idling motor vehicles and generators produce exhaust that can greatly impact roosting bats to the extent that bats will abandon their roost. This is especially true during the maternity season when bats tend to be more sensitive and are more easily disturbed.

Foraging Quality Degradation. We do not anticipate any grading of soils or other activities such as vegetation removal that would lead to significant levels of foraging quality degradation. Through the use of acoustic surveys and mist-netting we were able to identify nine species of bats on the Project site, including three species of special concern. Although we did not detect western red bats in the Project site's tamarisk trees, we believe this species could day roost on the site during other times of the year, especially during spring and fall months. Western red bats have been recorded in various locations along the Colorado River, although they are more typically found roosting in Fremont cottonwood (*Populus fremontii*) (Diamond et al. 2013). Because we observed no western red bat calls from bat detectors, we do not expect this species to raise young (form maternity roosts) on the project site.

Section 5. Conclusions

We located ten bat roosts comprising at least 3 species (cave myotis, Yuma myotis, and pallid bat) on or near the Project site through the use of visual surveys, radio telemetry, and acoustic surveys (Figure 6). Identifying the locations of these summer roosts is critical in determining potential impacts and for developing a minimization and mitigation plan that addresses potential impacts to maternity colonies. Bat colonies, including pallid bat maternity colonies, typically have more than one roost and change their roost site locations over the course of the spring – summer period (Lewis 1995). Therefore, summer roost sites described herein may not necessarily be occupied throughout the maternity season and some colonies are likely to be located at different sites during the earlier spring period. Additionally, there may be some year-to-year variation of roost sites based on the differences in weather from year to year. Of the potential impacts to maternity colonies, we believe the impacts due to high frequency noise from boring wells, monitoring wells with an operating generator, idling diesel vehicles, and the pipeline construction have the greatest potential to impact roosting bats.

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Appendix A. Bat Capture Data

Appendix A. Bat Capture Data

Date	Site	Capture Time	Species	Mass (g)	Forearm (mm)	Sex	Age	Reproductive Status
7/20/2015	Bat Cave Wash	20:30	Pallid bat	11.5	52.05	Female	Adult	Post-lactating
7/20/2015	Bat Cave Wash	20:45	Pallid bat	10.4	49.94	Female	Sub-Adult	Non-reproductive
7/20/2015	Bat Cave Wash	21:10	Pallid bat	12.9	52.1	Female	Adult	Non-reproductive
7/20/2015	Bat Cave Wash	21:38	Yuma myotis	5.6	34	Female	Adult	Non-reproductive
7/21/2015	Bat Cave Wash Culverts	20:20	Yuma myotis	5.2	35.4	Female	Adult	Post-lactating
7/21/2015	Bat Cave Wash Culverts	20:20	Yuma myotis	5.2	35.4	Female	Adult	Post-lactating
7/21/2015	Bat Cave Wash Culverts	20:20	Yuma myotis	5.2	34.35	Female	Sub-Adult	Non-reproductive
7/21/2015	Bat Cave Wash Culverts	20:20	California myotis	3.6	32.3	Female	Adult	Post-lactating
7/21/2015	Bat Cave Wash Culverts	20:20	Yuma myotis	4.3	34	Male	Sub-Adult	Non-reproductive
7/21/2015	Bat Cave Wash Culverts	20:20	Yuma myotis	4.9	34.3	Male	Adult	Non-reproductive
7/21/2015	Bat Cave Wash Culverts	20:20	California myotis	2.9	29	Male	Adult	Non-reproductive
7/21/2015	Bat Cave Wash Culverts	20:55	Pallid bat	12.7	51.2	Male	Adult	Reproductive
7/21/2015	Bat Cave Wash Culverts	20:45	Yuma myotis	3.9	33.3	Female	Sub-Adult	Non-reproductive
7/21/2015	Bat Cave Wash Culverts	21:00	Yuma myotis	5.3	35.15	Female	Adult	Post-lactating
7/21/2015	Bat Cave Wash Culverts	21:25	Pallid bat	15	52.7	Female	Adult	Post-lactating
7/23/2015	Bat Cave Wash	21:00	Pallid bat	14.2	50	Female	Adult	Post-lactating
7/26/2015	RR Culvert	20:25	Yuma myotis	5.2	34.1	Female	Adult	Post-lactating
7/26/2015	RR Culvert	20:30	California myotis	3.4	31.4	Male	Adult	Non-reproductive
7/26/2015	RR Culvert	20:30	California myotis	3.4	31.4	Female	Adult	Post-lactating
7/26/2015	RR Culvert	20:39	California myotis	3.8	31.4	Female	Adult	Non-reproductive
7/26/2015	RR Culvert	20:48	California myotis	2.9	30.6	Male	Adult	Non-reproductive
7/26/2015	RR Culvert	20:55	California myotis	4.2	31.4	Female	Adult	Post-lactating

Appendix A. Bat Capture Data

7/28/2015	RR Culvert	5:10	Yuma myotis	7.3	35.9	Female	Adult	Post-lactating
7/28/2015	RR Culvert	5:10	Yuma myotis	5.3	32.1	Female	Adult	Non-reproductive
7/28/2015	RR/Bat Cave Wash Culverts	19:50	Yuma myotis	5.7	35.2	Female	Adult	Post-lactating
7/28/2015	RR/Bat Cave Wash Culverts	19:50	Yuma myotis	4.8	33.3	Male	Adult	Non-reproductive
7/28/2015	RR/Bat Cave Wash Culverts	19:50	Yuma myotis	6.1	34.4	Female	Adult	Post-lactating
7/28/2015	RR/Bat Cave Wash Culverts	19:50	Yuma myotis	6	35.2	Female	Adult	Post-lactating
7/28/2015	RR/Bat Cave Wash Culverts	19:50	Yuma myotis	5.3	34	Female	Adult	Post-lactating
7/28/2015	RR/Bat Cave Wash Culverts	19:55	Yuma myotis	4.8	33.2	Female	Adult	Post-lactating
7/28/2015	RR/Bat Cave Wash Culverts	19:55	Yuma myotis	5.8	33.9	Female	Adult	Non-reproductive
7/28/2015	RR/Bat Cave Wash Culverts	20:05	Yuma myotis	5.7	34.2	Female	Sub-Adult	Non-reproductive
7/28/2015	RR/Bat Cave Wash Culverts	20:00	Yuma myotis	5.8	34.1	Female	Sub-Adult	Non-reproductive
7/28/2015	RR/Bat Cave Wash Culverts	20:09	Yuma myotis	4.4	34	Male	Adult	Non-reproductive
7/28/2015	RR/Bat Cave Wash Culverts	20:16	Yuma myotis	5.5	35.6	Female	Adult	Post-lactating
7/28/2015	RR/Bat Cave Wash Culverts	20:25	Yuma myotis	4.9	34.4	Female	Adult	Post-lactating
7/28/2015	RR/Bat Cave Wash Culverts	20:20	Yuma myotis	4.7	33.4	Male	Adult	Non-reproductive
7/28/2015	RR/Bat Cave Wash Culverts	20:20	Yuma myotis	5.2	34.2	Male	Adult	Non-reproductive
7/28/2015	RR/Bat Cave Wash Culverts	20:27	Yuma myotis	5.6	34	Female	Adult	Post-lactating
7/28/2015	RR/Bat Cave Wash Culverts	20:35	California myotis	3.4	31.2	Female	Adult	Post-lactating
7/28/2015	RR/Bat Cave Wash Culverts	20:40	California myotis	3.2	31.7	Male	Sub-Adult	Non-reproductive
7/28/2015	RR/Bat Cave Wash Culverts	20:55	Yuma myotis	6.3	34.9	Female	Sub-Adult	Non-reproductive
7/28/2015	RR/Bat Cave Wash Culverts	20:55	California myotis	3.2	30.7	Male	Sub-Adult	Non-reproductive

7/28/2015	RR/Bat Cave Wash Culverts	21:10	Yuma myotis	5.5	34.4	Female	Adult	Post-lactating
7/28/2015	RR/Bat Cave Wash Culverts	21:10	Yuma myotis	5.6	34.6	Female	Sub-Adult	Non-reproductive
7/28/2015	RR/Bat Cave Wash Culverts	21:20	Yuma myotis	5.4	33.9	Female	Adult	Post-lactating
7/28/2015	RR/Bat Cave Wash Culverts	21:20	Yuma myotis	6	33.5	Male	Adult	Non-reproductive
7/28/2015	RR/Bat Cave Wash Culverts	21:35	Yuma myotis	6.9	35.5	Female	Adult	Lactating
7/28/2015	RR/Bat Cave Wash Culverts	21:20	Yuma myotis	6.2	36.6	Male	Adult	Non-reproductive
7/28/2015	RR/Bat Cave Wash Culverts	22:00	Yuma myotis	5.7	35	Female	Adult	Post-lactating
7/28/2015	RR/Bat Cave Wash Culverts	22:00	Yuma myotis	5.5	36	Female	Sub-Adult	Non-reproductive
7/28/2015	RR/Bat Cave Wash Culverts	22:15	Yuma myotis	6.9	35.1	Female	Sub-Adult	Non-reproductive
7/28/2015	RR/Bat Cave Wash Culverts	22:15	Yuma myotis	6.7	35.2	Female	Sub-Adult	Non-reproductive
7/28/2015	RR/Bat Cave Wash Culverts	22:20	Yuma myotis	7.6	34.7	Female	Adult	Post-lactating

Appendix B. Frequency Analysis of Drill Rig Measurements

ILLINGWORTH & RODKIN, INC.
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September 24, 2015

Dave Johnston, Ph.D.
H. T. Harvey & Associates
983 University Avenue Building D
Los Gatos, CA 95032

VIA E-MAIL: djohnston@harveyecology.com

SUBJECT: Frequency Analysis of Drill Rig Measurements

Dear Dave:

This letter presents the results of our noise analysis of the acoustical samples provided to us at distances of 10, 30, 60, and 90 feet from the drill impact location of a CME-95 drill rig. The surface soil was made up of slightly damp dense gravel and sandy soil. We understand that these recordings were made at a sample rate of 192,000 samples per second. Noise levels were calibrated using the provided recording of a 48 dB tone (+/- 4 dB) at 40 kHz. Data were developed with a band width of 750 Hz and were based on representative selections from the provided recordings that were typically 1 to 2 seconds in length. Figures 1 and 2, and Table 1 present the results of this analysis.

Table 1: Measured Noise Level at 10, 30, 60, and 90 feet from CME-95 Drill

	Measured Noise Level, dB				
	Ambient	10 ft	30 ft	60 ft	90 ft
Overall Level	47	88	78	67	55
Sum 30-40 kHz	33	67	54	35	33
30 kHz	20	58	47	26	21
40 kHz	22	53	37	23	22

As indicated by Figure 1, the highest noise levels were measured in the audible range (up to 10 kHz) with a second peak occurring around 20 kHz. At the 60 foot distance, drill noise was indistinguishable from ambient conditions at frequencies of 40 kHz and up and ambient noise likely influenced the levels at frequencies above about 30 kHz. At a distance of 90 feet, drill noise was indistinguishable from ambient conditions at frequencies of 30 kHz and up and ambient noise likely influenced the levels at frequencies above about 15 kHz.

It is our understanding that due to site constraints, the measurements were taken along a path around the rig, which likely provided some acoustical shielding at some of these locations. The measured levels at the 10 and 30 foot distances are consistent with the Federal Highway Administration's Roadway Construction Noise Model (RCNM). In addition, the drop off rate over distance, which would be expected to be about 6 dB per doubling of distance for the overall level, is consistent between the 10 and 30 foot distances. Additional attenuation can be seen in the 60 and 90 foot distance data, where shielding provided about 5 dB of additional attenuation at the 60 foot position and about 14 dB of additional attenuation at the 90 foot position.

Due to air absorption, high frequency sounds drop off at a higher rate than those in the audible range. Based on the results at the 10 and 30 foot positions, noise levels drop off by about 7 dB per doubling of distance at 30 kHz and by about 10 dB per doubling at 40 kHz. Using these drop off rates, it is anticipated that the sum of the frequencies between 30 and 40 kHz would be below 35 dB at a distance of about 150 feet from the drill with no additional shielding.

◆ ◆ ◆

This concludes our analysis. If you have any questions or comments, please do not hesitate to call.

Sincerely,

Dana M. Lodico, PE, INCE Bd. Cert.
Senior Consultant
ILLINGWORTH & RODKIN, INC.

(I&R #15-205)

Figure 1: Drill Rig Noise Levels at Various Distances, 0 to 70 kHz

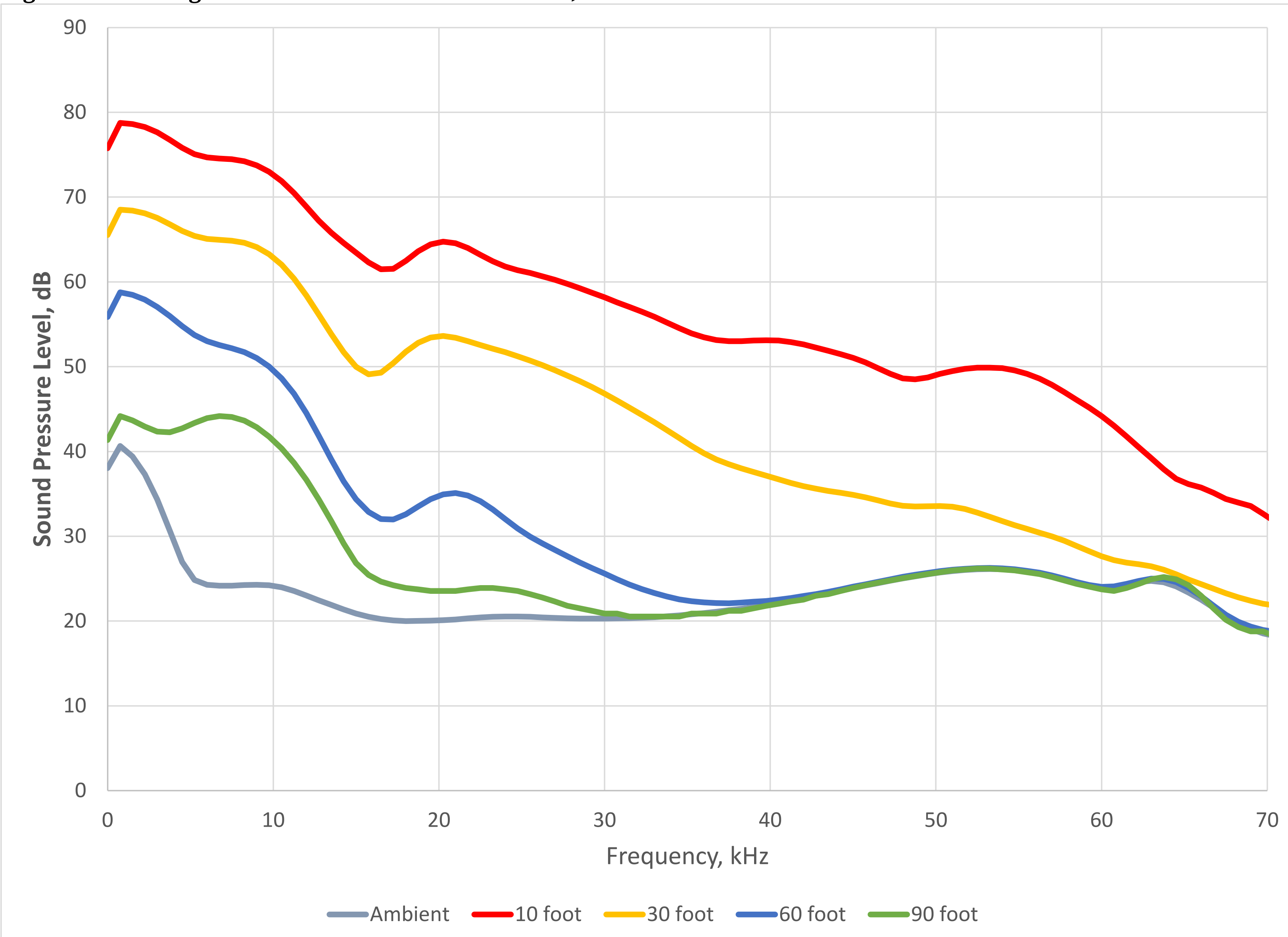
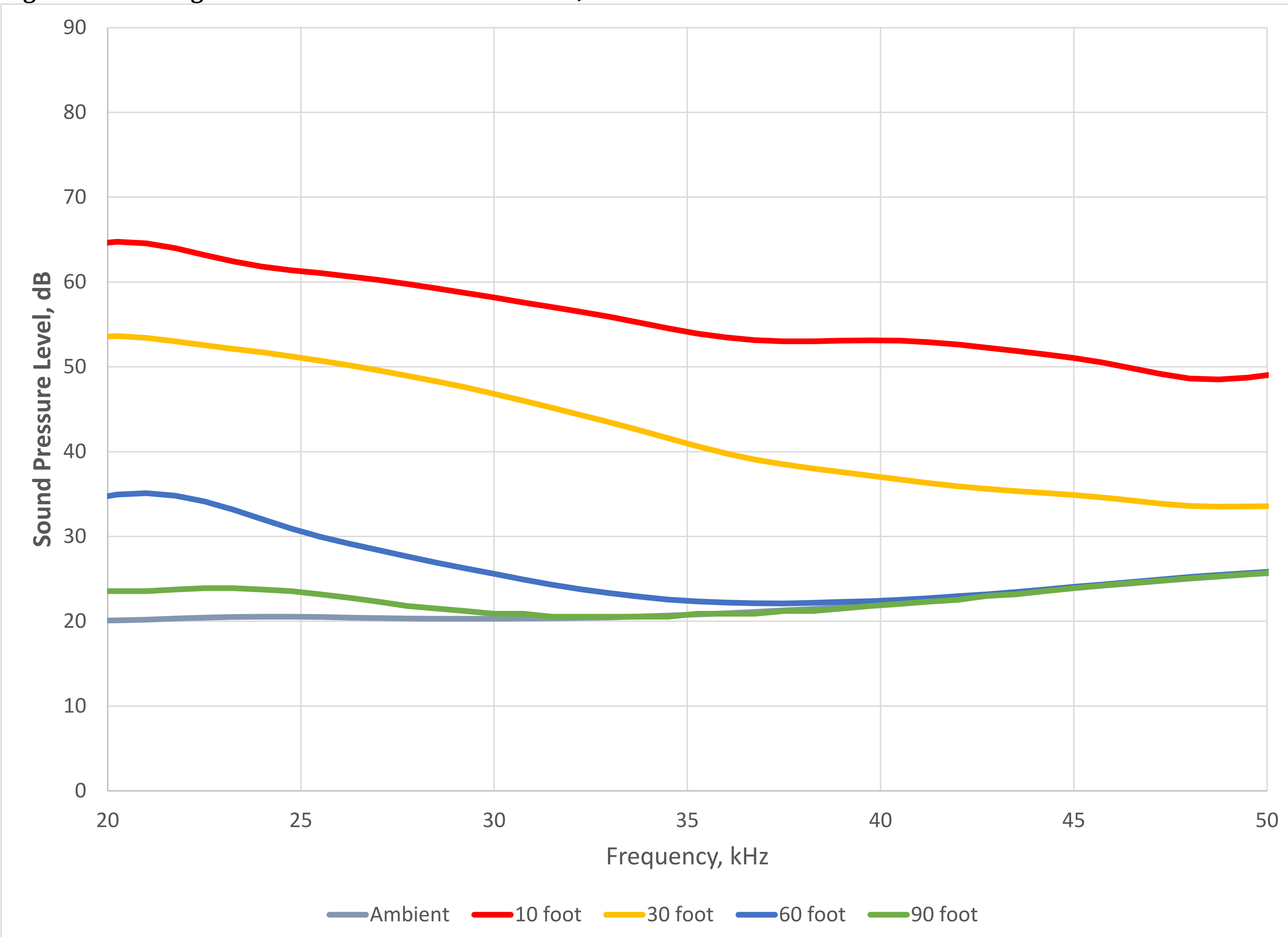


Figure 2: Drill Rig Noise Levels at Various Distances, 20 to 50 kHz



Topock Compressor Station Spring 2016 Roosting Bat Surveys Report

EN1031161134BAO

Topock Compressor Station Spring 2016 Roosting Bat Surveys Report

Project #3740-02

Prepared for:

Pacific Gas and Electric Company

Prepared by:

H. T. Harvey & Associates

August 8, 2016

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List of Preparers

Ron Duke, M.S., President and Principal-in-Charge

Dave Johnston, Ph.D., Associate Wildlife Ecologist

Kim Briones, M.S., Senior Wildlife Ecologist

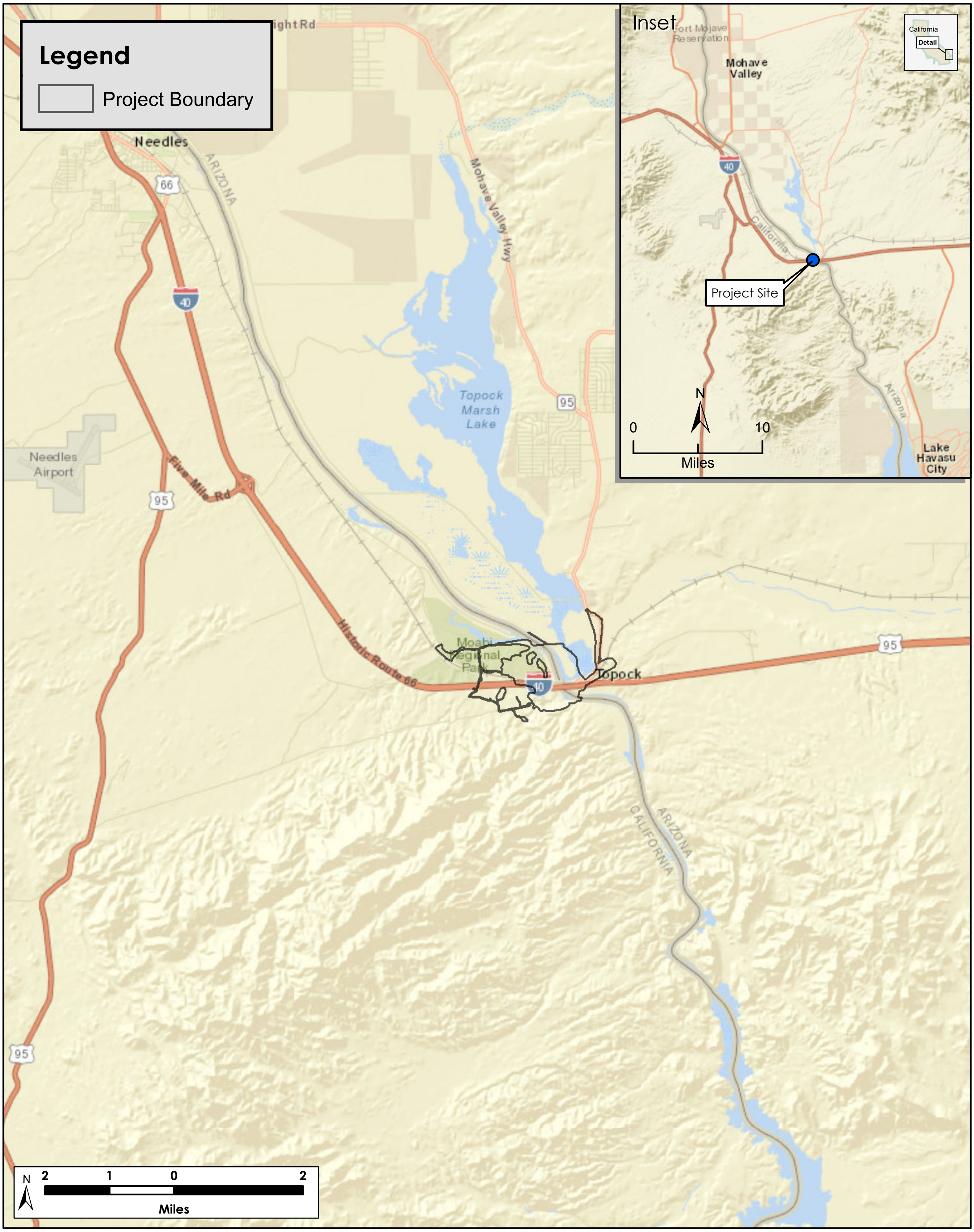
Section 1. Introduction

The land surrounding Pacific Gas and Electric Company's (PG&E's) Topock Compressor Station (referred to hereafter as the Project site) is a site located south of Needles, California (Figure 1) near the Interstate 40 crossing of the Colorado River. PG&E is planning to implement a remediation project to address chromium groundwater contamination that resulted from past disposal activities at the Project site.

Previous surveys for special-status bats were conducted at the Project site by Drs. Patricia Brown and William Rainey during winter 2014-2015 (Brown 2015) and spring 2015 (Brown and Rainey 2015). Additional surveys were conducted in summer 2015 and spring 2016 by Dr. Dave Johnston and other H. T. Harvey & Associates bat biologists (Kim Briones, Gabe Reyes, and Meredith Jantzen) (H. T. Harvey & Associates 2015, 2016). The Brown (2015) and Brown and Rainey (2015) reports detected three special-status species on the Project site that could potentially establish maternity roosts: pallid bat (*Antrozous pallidus*), cave myotis (*Myotis velifer*), and California mastiff bat (*Eumops perotis*). A forth special-status species, Townsend's big-eared bat (*Corynorhinus townsendii*), a candidate species under the California Endangered Species Act (CESA) with the California Department of Fish and Wildlife, was detected on the Project site but it is not expected to establish maternity roost on the site.

As a follow-up to the winter and spring 2015 surveys, H. T. Harvey & Associates conducted focused surveys to identify the locations of maternity roosts of special-status bats on the Project site. In addition to the special-status species identified in the reports of the surveys, we expected that the western red bat (*Lasiurus blossevillii*) and the California leaf-nosed bat (*Macrotus californicus*) could also be present on the Project site based on their range and potential on-site habitat, although habitat for raising young by these species (i.e., maternity roosting habitat) is absent on the Project site.

The main purpose of the spring 2016 bat surveys was to resurvey the Project site to obtain up-to-date information on bat roosts so that the recommended mitigation measures could reflect the current location of bat roosts on or near the Project site. H. T. Harvey & Associates ecologists conducted mist-netting, radio-tracking, short-term acoustic monitoring, and visual observations in areas supporting potential roosting habitat. This report summarizes our findings for the spring 2016 bat roost surveys and includes the locations of roosts found through previous surveys to provide a comprehensive coverage of the roost survey results through spring 2016.



N:\Projects3700\3740-01\02\Reports\Mitigation Report\Fig 1 Vic Map.mxd

H. T. HARVEY & ASSOCIATES
Ecological Consultants

Figure 1. Vicinity Map
Topock Compressor Station Spring 2016 Roosting Bat Surveys Report (3740-02)
August 2016

Section 2. Methods

2.1 Mist-Netting and Radiotelemetry

During the maternity season (March 15 through August 31), females of some bat species group in a single roost or cluster of associated roosts to form larger maternity colonies, where they raise their young. These colonies often represent significant populations on a local or regional scale, and some species are particularly susceptible to disturbance while raising their young. To document the locations of potential maternity roosts on the Project site, we conducted mist-net surveys with the intention of catching lactating females and tracking them back to their maternity colonies. Although our primary aim was to locate potential maternity roosts for special status species (Townsend's big-eared bat, pallid bat, western red bat, and cave bat), we also were interested in assessing the species, sex, and reproductive status of other bats on the Project site.

We conducted mist-netting during the evenings of April 4, 5, 20, and 21, 2016. We had originally planned to conduct all surveys during the week of April 4, but a fire broke out adjacent to the project area, preventing access to parts of the Project site. We resumed work during the week of April 20.

We placed mist nets that ranged from 6 to 12 meters wide and from 2.6 to 5.2 meters tall across natural flyways on the Project site. The 5.2-meter-tall net was operated with a pulley system (Johnston 2001). When mist-netting in the evening, we opened nets at approximately 7:45 p.m. and closed them at approximately 10:00 p.m. After nets were opened, we checked them at intervals of 15 minutes or less. We placed each captured bat in a paper or cloth bag, processed it on site, and released it unharmed after data collection. For each individual, we assessed and recorded species, age (adult or subadult), forearm length (in millimeters), mass (in grams), and reproductive status (lactating, postlactating, testes descended, or nonreproductive).

To radio-track bats, we carefully clipped the fur in the interscapular region of the bat's back and attached Holohil BD-2 radio transmitters (Holohil Systems, Ltd., Carp, Ontario, Canada) using eyelash glue. Each radio tag accounted for less than 5% of an individual's weight. After the radio tag was securely attached, we released the bat. The day after capture, we went to the site of release and checked for a signal using radio receivers (R-1000, Communication Specialists, Orange, California), and three-element and five-element Yagi antennas. If we could not detect a signal, we drove or walked to opportunistic areas of high elevation within a 5-mile radius and attempted to locate the signal. After locating the signal, we attempted to locate the roost by systematically determining the direction in which the signal was strongest and following it in that direction.

2.2 Visual Surveys of Roost Habitat

To confirm the presence of previously located bat roosts on the Project site, we revisited previously observed roost sites and new sites with suitable habitat that were included in the updated footprint of the Project site (Figures 2a, 2b). We therefore conducted visual observations from approximately half an hour before sunset to an hour after sunset. At each location, we watched for emerging bats and kept a tally of how many bats flew out from an emergence spot and how many bats flew back into the same roost opening. To arrive at an approximate total number of bats for each roost, we subtracted the number of bats flying into the roost from the number of bats recorded flying out of the roost. For bridges, we used several observers to cover the multiple areas of potential roosting habitat.

2.3 Acoustic Monitoring and Analysis

Bats use echolocation calls to detect prey and obstacles as they navigate across landscapes. Although a given species may demonstrate some degree of plasticity in its calls, acoustic parameters, such as call shape, duration, and minimum frequencies, may be used to identify species (Fenton et al. 1995). Therefore, acoustic surveys can be used to help determine many species of bats (Parsons et al. 2000). Two primary technologies exist for recording and analyzing bat calls: zero-crossing and full spectrum. The technology for viewing zero-crossing recordings is well developed; it is easy to quickly view and place species labels on thousands of calls at a time. However, full-spectrum technology provides more detail about specific call characteristics, which can sometimes be critical for distinguishing species with similar call parameters (Fenton 2000). Therefore, to assess bat activity in different areas of the Project site, we used Song Meters (Song Meter SM2 BAT recorders) (Wildlife Acoustics, Concord, Massachusetts, United States), which record compressed files that can be converted to either zero-crossing or full-spectrum files.

To determine which bat species were present on the Project site, we deployed six Song Meters on the site from April 19 through April 20, 2016. We programmed the Song Meters according to the default settings provided in the instruction manual, and we manually set the Universal Transverse Mercator coordinates for each detector. We then scheduled the units to record from sunset to sunrise. We attached microphones to microphone cables and secured them approximately 3 feet off the ground to T-posts positioned at a slight angle. We deployed Song Meters throughout the site, concentrating on areas with tamarisk groves, bridges, and rocky outcrops that could provide suitable habitat for maternity roosts and special-status bats.

When we deployed Song Meters in possible roost locations while conducting simultaneous visual emergence counts, we left detectors out for only the duration of the emergence count.

We conducted acoustic monitoring at three new sites and nine sites that had been previously monitored during summer 2015 (Figure 3). The new sites were located at the quarry (southern end of Bat Cave Wash), the western culverts, and the small western railroad bridge. The previously monitored sites included three sites along the Sacramento Wash tamarisk grove in Arizona; the tamarisk grove near the National Trails Highway viaduct on Bat Cave Wash; three sites under the railroad bridge along the banks of the Colorado River; the middle portion of Bat Cave Wash at the southern Project boundary; and the north end of Bat Cave Wash at Interstate 40. We did not spread out bat detectors in Bat Cave Wash as we had in 2015; instead, we focused acoustic monitoring on the north and middle sections of the wash, where two roost sites were suspected but not confirmed during the summer 2015 surveys. We placed one detector at the quarry in an effort to assess pallid bat activity and movement through this area.

We analyzed data obtained during the first hour after sunset from all detectors. We analyzed Song Meter data as .wav files in Sonobat (Szewczak 2015).

Whenever possible, we identified bats to species based on the acoustic parameters of shape, minimum frequency, duration, and/or critical frequency. Of the species that occur in the region, several have call characteristics that often overlap with those of other local species (Szewczak and Weller 2011). Therefore, some bat calls were identified to a group rather than to a species (e.g., 30-40-kilohertz [kHz] group for Mexican free-tailed bats and big brown bats). Calls that we could not identify to species or group were classified as unknown and not considered further.

Although bat calls cannot be used to identify individuals, the number of calls is commonly used as an index of overall activity at a site (Kunz et al. 1996). We quantified bat activity separately for each species classification by presence/absence within 1-minute periods per night. This method provides more accurate assessments of bat activity than traditional methods of counting individual passes (Miller 2001). We then examined the data for temporal patterns to determine whether there was evidence of an emergence event (e.g., a high number of calls from one species recorded around sunset).

Section 3. Results

3.1 Mist-Netting and Radiotelemetry

We conducted five nights of mist-netting in four locations: three areas in southern Bat Cave Wash and two areas in northern Bat Cave Wash. In total, we captured 27 bats representing four species (Table 1 and Appendix A).

Table 1. Number of Bats Captured by Date, Site, and Species

Date	Site	Pallid Bat	Mexican Free-Tailed Bat	California Leaf-Nosed Bat	Yuma Myotis
April 4, 2016	Bat Cave Wash	0	1	0	0
April 5, 2016	Bat Cave Wash	0	0	0	0
April 6, 2016	Bat Cave Wash	0	0	0	0
April 19, 2016	Bat Cave Wash	0	0	4	0
April 20, 2016	Bat Cave Wash, near Viaduct	0	0	0	4
April 21, 2016	Bat Cave Wash, at Viaduct	2	0	0	16

In addition to Table 1 above, Appendix 1 provides specific data for each individual caught.

On April 4, we captured a Mexican free-tailed bat (*Tadarida brasiliensis mexicanus*) immediately south of the Project site in Bat Cave Wash near a night roost.

On April 5 and early on April 6, we deployed a macronet 20 feet by 50 feet; however, bats appeared to avoid the net, likely because the net was visible to them in this setting. No bats were caught on either date.

On April 19, we captured four California leaf-nosed bats, the first capture records for this specific area along the Colorado River and for the Project site. We attached radio-transmitters to two pregnant females, hoping to locate a maternity roost, but we were unable to locate a roost in the ensuing days of searching for roost sites. These bats were caught early in the evening on the upstream side of nets, suggesting that they were coming from their day roost site south or west of the Project site. Because they were caught on the extreme southern boundary of the Project site, and no maternity roosting habitat occurs on the Project site, these bats presumably came from a maternity colony off site and well south of the project area. The nearest known roost is in Arizona, approximately 5 miles to the southeast.

On April 20, we captured four Yuma myotis (*Myotis yumanensis*), and on April 21, we captured an additional 16 Yuma myotis and two pallid bats, all within the immediate vicinity of the viaduct at the north end of Bat Cave Wash at its confluence with the Colorado River. Because of their special status, we attached radio transmitters to both of the pallid bats. We observed the bats flying south, but we were unable to locate either bat the following day.

3.2 Visual Surveys of Roosts

We confirmed seven roosts (Roosts 3, 4, 5, 6, 7, 8, and 10) during our spring 2016 surveys through visual observations (Figure 2). Bats were not observed exiting Roost 1 where we had located a pallid bat roost through radio telemetry during the summer 2015 bat surveys. Nonetheless, this roost site is likely used by significant portions of a maternity colony intermittently through parts of the maternity season and should be treated as a maternity roost. We also could not confirm Roost 2 comprising approximately five bats that emerged from the western bluff of southern Bat Cave Wash observed during the summer 2015 visual surveys. However, this small area of burrows on the steep sides of the Bat Cave Wash may represent a seasonal or intermittent roost; therefore, we believe that this location should be treated as a roost site unless otherwise indicated through specific preconstruction bat surveys conducted no more than 3 days before construction activities begin. We reconfirmed roost 3 of Yuma myotis in a vertical tube in the easternmost culvert under Interstate 40 at the northern end of Bat Cave Wash (Figure 2). A total of 36 bats were observed emerging from five locations (Roosts 4, 5, 6, 7, and 8) in the railroad bridge (Figure 2) during our April 18, 2016, survey. Most of the bridge-roosting bats were observed emerging from the bridge on the California side in a similar distribution as observed in 2015. No bats were observed roosting inside the viaduct at the northernmost section of Bat Cave Wash. Large numbers of acoustic detections observed during the summer 2015 bat surveys suggested that the cave myotis (*Myotis velifer*) roosted at this structure. However, upon close inspection, we observed no potential roosting habitat for this species, and an emergence survey confirmed that no bats were roosting at this structure. Rather, this species likely roosts south of the viaduct and the Project site and was detected as it commuted through the viaduct to the Colorado River. Roost 9 occurs in the southeasternmost steel culvert of three culverts, under a railroad crossing (Figure 2).

On April 20, 2016, we reconfirmed that Roost 9 is an active roost of a small number of individuals based on the fresh guano we observed below the roost. On April 21, 2016, we observed Mexican free-tailed bats and a small myotis roosting between beams on the underside of a small railroad bridge in the western portion of the Project site (roost 10). That evening, we monitored bats emerging from this site and counted approximately 75 bats between 7:15 and 8:15 p.m. Sunset was at 7:20 p.m., and the last bat we observed to emerge from the bridge emerged at approximately 7:45 p.m. (Figure 2).

Existing Wells:

- Extraction Well
- Injection Well
- Monitoring Well
- Water Supply Well

Provisional Wells:

(Items in Pink are Provisional)

- Extraction Well
- Injection Well
- Monitoring Well
- Area for East Ravine (ER) Well
- Area for Potential Slant Well Screens
- Area for Inner Recirculation Loop (IRL) Wells
- Area for River Bank Extraction Wells

Planned Wells:

- Extraction, East Ravine
- Extraction, National Trails Highway (NTH) In-situ Reactive Zone (IRZ)
- Extraction, Riverbank
- Extraction, Transwestern Bench
- Injection, Freshwater
- Injection, Inner Recirculation Loop
- Injection, NTH IRZ
- Injection, Topock Compressor Station
- Remedy Monitoring Well
- Recirculation Well
- Area for Monitoring Well MW-T

Pipeline Corridor for Remedy

- Aboveground Pipe
- Underground Pipe/Conduit

Remedy Facilities

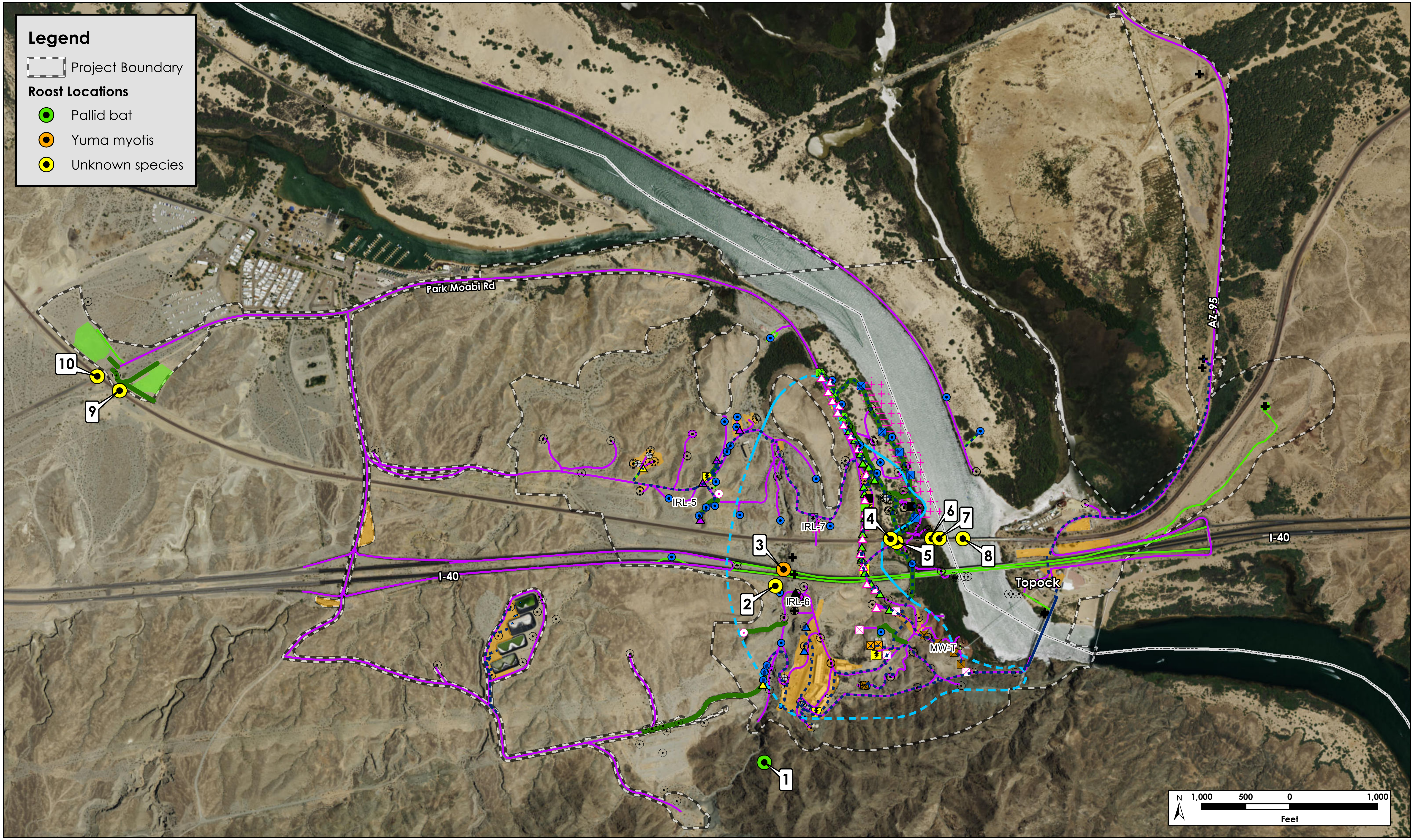
- Planned Transformer
- Future Provisional Transformer
- Proposed Remedy Structure
- Roads to be Improved or Constructed for Groundwater Remedy Use
- Existing Access Route (will continue to be used for remedial activities)
- Existing Route (proposed to be used as is for access to remedial activities)
- Proposed Soil Processing (Area #5) and Construction Headquarter (Area #4) for Remediation Project
- Proposed Staging Areas for Remediation Project (see Table 3.5-1 for description of use of staging areas)

N:\Projects3700\3740-01\02\Reports\Mitigation Report\Fig 3a Site Plan Legend.mxd

H. T. HARVEY & ASSOCIATES
Ecological Consultants

Figure 2a. Site Plan Legend

Topock Compressor Station Spring 2016 Roosting Bat Surveys Report (3740-02)
August 2016



N:\Projects3700\3740-01\02\Reports\Mitigation Report\Fig 3b Visual Surveys and Roosts.mxd

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Figure 2b. Roost Locations
Topock Compressor Station Spring 2016 Roosting
Bat Surveys Report (3740-02)
August 2016

3.3 Acoustic Monitoring

In total, we conducted short-term acoustic surveys at 12 locations on the Project site, which covered a variety of potential foliage roosting habitat and crevice- or cavity-roosting habitats (Figure 3), and we analyzed 2,019 acoustic call files. Using acoustic surveys, we detected seven distinct species of bats at the Project site: pallid bat (*Antrozous pallidus*), western red bat, canyon bat (*Parastrellus hesperus*), Mexican free-tailed bat, Yuma myotis, western small-footed bat (*Myotis ciliolabrum*), and California myotis (*Myotis californicus*). We did not detect any cave myotis during the spring surveys. Our results are organized into the two available bat roosting habitats on the Project site.

3.3.1 Foliage Roosting Habitat

We detected several western red bat calls in the tamarisk grove near the viaduct on Bat Cave Wash, under the railroad bridge on the western banks of the Colorado River, and along the tamarisk groves in Arizona. Although closely associated with mature cottonwood (*Populus fremontii*) and sycamore trees (*Platinus occidentalis*), western red bats have been documented roosting in nonnative trees, such as tamarisk, particularly in larger stands (Pierson et al. 2004). The habitat along the banks of the Colorado River under the railroad bridge is degraded, and bats are expected to forage there but not roost. The tamarisk groves associated with the viaduct and along the National Trails Highway in Arizona make up dense areas of foliage, providing potential roosting habitat. We therefore expect western red bats to roost there during the migratory spring and fall seasons, although we do not expect this species to raise young on the Project site. In 2015, we detected no western red bats during our summer surveys. Western red bat detections along the Colorado River are expected in spring because this species is known to migrate along the Colorado River.

There was no on-site roosting habitat for two other foliage roosting bats: the western yellow bat (*Lasiurus xanthinus*) and the silver-haired bat (*Lasionycteris noctivagans*). The hoary bat (*Laisurus cinereus*), a widespread and common foliage roosting species, may roost rarely in the tamarisk grove, although we did not detect any bats that were clearly identifiable as hoary bats (most of this species' calls are difficult to separate from those of Mexican free-tailed bats). Further, there was no roosting habitat for crevice roosting bats, although we did detect crevice-roosting bats that were foraging among these tamarisk trees.

3.3.2 Crevice- and Cavity-Roosting Habitat

We detected Yuma myotis, canyon bats, California myotis, and Mexican free-tailed bats while monitoring at the three new acoustic monitoring sites. Bat species we detected were as follows:

- **South end of Bat Cave Wash:** We detected canyon bats, California myotis, and Yuma myotis, which could be roosting in the wash and foraging and commuting through the area. We did not detect any pallid bat calls.

N:\Projects3700\3740-01\02\Reports\Mitigation Report\Fig 3 Acoustic Monitoring Sites.mxd

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Figure 3. Locations of Acoustic Monitoring Stations
Topock Compressor Station Spring 2016 Roosting
Bat Surveys Report (3740-02)
August 2016

- **North end of Bat Cave Wash at Interstate 40:** We detected high numbers of calls from canyon bats and California myotis, which could be roosting in the wash. We detected fewer calls from Mexican free-tailed bats and pallid bats, which may have been foraging or commuting through the area.
- **Middle section of Bat Cave Wash:** We detected California myotis, canyon bat, and pallid bat calls at the middle section of Bat Cave Wash, and several indistinguishable 30-kHz calls (pallid bat, Mexican free-tailed bat/big brown bat). Pallid bats are likely roosting in this portion of the wash, but this was not evident from the acoustic data.
- **Westernmost railroad culverts:** We detected a high number of calls from canyon bats and fewer Yuma myotis. Both species could roost during the day or night in the culverts or could simply be foraging or commuting through this area.
- **Western railroad bridge:** We detected a high number of calls from Yuma myotis, California myotis, Mexican free-tailed bats, and canyon bats while monitoring the western railroad bridge. We expect Yuma myotis, California myotis, and Mexican free-tailed bats to roost in this bridge, but canyon bats do not roost in bridges and were likely commuting under the bridge and headed toward the Colorado River.
- **Railroad bridge along banks of Colorado River:** Cavity- and crevice-roosting bats detected included canyon bats, Mexican free-tailed bats, several indistinguishable 30- to 40-kHz bats (Mexican free-tailed bats/big brown bats), and one pallid bat call. Each of these species may roost in the bridge.

With the exception of western red bats, our species detections at the repeated acoustic monitoring sites did not differ from those observed during the summer 2015 acoustic surveys.

Cavity- and crevice-roosting species detected in the tamarisk in Arizona included canyon bats, 40-kHz bats, Mexican free-tailed bats, and Yuma myotis. Nonfoliage-roosting species detected near the viaduct on Bat Cave Wash included Yuma myotis and a few Mexican free-tailed bats. Because the tamarisk in these areas lacked suitable cavity- or crevice-roosting habitat, these detections likely indicate that these species were foraging or commuting through these areas. Overall, detector data did not reveal any temporal patterns indicative of a maternity colony in any of the areas we monitored. Visual surveys served as the most reliable method for confirming the presence of a maternity or nonmaternity colony roost.

Section 4. Conclusions

We confirmed the locations of eight bat roosts used by at least two species (Yuma myotis and Mexican free-tailed bat) during our spring 2016 surveys. Several of the active roosts may have been composed of Yuma myotis, California myotis or Mexican free-tailed bats, but because these roost counts were based only on visual counts of bats exiting their roosts, we cannot separate them out to species. It was not practical to place bat detectors at each of these roosts to help determine the species of bats coming from some roosts because several were inaccessible (e.g., they were located on the railroad bridge high above the Colorado River). Based on the roosting habitat requirements for the special status species of bats found on site, none of the roosts labelled as "unknown species" represent roosts from special status species.

We also included the two roosts (roosts 1 and 2) that were active during the summer 2015 surveys (but not the spring 2016 surveys) because roosts 1 and 2 are potentially occupied intermittently through the spring-summer period (Figure 2). Identifying the locations of these spring roosts is helpful for developing a protective measures plan that addresses potential impacts on maternity colonies. Bat colonies, including pallid bat maternity colonies, typically have more than one roost and change their roost site locations over the course of the spring-summer period (Lewis 1995). Therefore, the spring roost sites described in this report may not necessarily be occupied throughout the maternity season, and some colonies are likely to be located at different sites during the summer period. Additionally, there may be some year-to-year variation of roost sites based on the differences in weather.

HT Harvey prepared a letter for CH2M on June 27, 2016 proposing protective measures for potential impacts from the Groundwater Remedy project to roosting bats that have been identified from survey results to date, including this report, as well as measures that would be implemented prior to construction to prevent impacts to roosting bats in locations that were not recorded during surveys.

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Appendix A. Bat Capture Data

Date	Site	Capture Time	Species	Mass (g)	Forearm (mm)	Sex	Age	Reproductive Status	Notes
4/4/2016	Bat Cave Wash	22:00	Mexican free-tailed bat	11.3	43.0	Male	Adult	Non-reproductive	
4/19/2016	Bat Cave Wash	20:20	California leaf-nosed bat	13.2	49.94	Female	Sub-Adult	Non-reproductive	
4/192016	Bat Cave Wash	20:20	California leaf-nosed bat	15.0	52.1	Female	Adult	Non-reproductive	
4/19/2016	Bat Cave Wash	22:05	California leaf-nosed bat	13.7	49.7	Male	Adult	Non-reproductive	
4/5/2016	Bat Cave Wash Viaduct	20:05	California leaf-nosed bat	13.9	51.5	Female	Adult	Post-lactating	
4/20/2016	Bat Cave Wash Viaduct	19:41	Yuma myotis	5.6	33.9	Female	Adult	Non-parous	
4/20/2016	Bat Cave Wash Viaduct	21:05	Yuma myotis	3.9	31.3	Female	Adult	Non-reproductive	
4/20/2016	Bat Cave Wash Viaduct	21:05	Yuma myotis	3.8	31.3	Female	Adult	Non-reproductive	
4/20/2016	Bat Cave Wash Viaduct	21:15	Yuma myotis	6.1	32.5	Male	Adult	Non-reproductive	
4/21/2016	Bat Cave Wash Viaduct	19:30	Yuma myotis	2.7	34.2	Male	Adult	Non-reproductive	Very old!*
4/21/2016	Bat Cave Wash Viaduct	19:30	Yuma myotis	5.2	34.0	Female	Adult	Non-reproductive	

Appendix 1. Bat Capture Data

4/21/2016	Bat Cave Wash Viaduct	19:40	Yuma myotis	4.4	34.0	Female	Adult	?	
4/21/2016	Bat Cave Wash Viaduct	19:30	Yuma myotis	5.3	35.5	Female	Adult	?	
4/21/2016	Bat Cave Wash Viaduct	19:40	Yuma myotis	5.0	35.3	Female	Adult	?	
4/21/2016	Bat Cave Wash Viaduct	19:40	Yuma myotis	5.6	35.5	Female	Adult	?	
4/21/2016	Bat Cave Wash Viaduct	19:40	Yuma myotis	5.1	35.1	Female	Adult	?	
4/21/2016	Bat Cave Wash Viaduct	19:49	Yuma myotis	5.3	35.0	Female	Adult	?	Wing hole
4/21/2016	Bat Cave Wash Viaduct	19:50	Yuma myotis	4.4	33.2	Female	Adult	?	
4/21/2016	Bat Cave Wash Viaduct	20:10	Yuma myotis	5.7	34.0	Female	Adult	P	
4/21/2016	Bat Cave Wash Viaduct	19:40	Yuma myotis	5.5	35.0	Female	Adult	?	
4/21/2016	Bat Cave Wash Viaduct	19:50	Yuma myotis	4.6	34.6	Male	Adult	Non-reproductive	

Appendix 1. Bat Capture Data

4/21/2016	Bat Cave Wash Viaduct	19:50	Yuma myotis	4.7	33.6	Female	Adult	?	
4/21/2016	Bat Cave Wash Viaduct	20:15	Yuma myotis	5.7	33.9	Female	Adult	?	
4/21/2016	Bat Cave Wash Viaduct	21:15	Yuma myotis	6.5	35.0	Female	Adult	P	
4/21/2016	Bat Cave Wash Viaduct	21:20	Yuma myotis	6.4	35.8	Female	Adult	?	
4/21/2016	Bat Cave Wash Viaduct	20:10	Pallid Bat	13.0	52.5	Female	Adult	?	A00353 recapture
4/21/2016	Bat Cave Wash Viaduct	20:20	Pallid Bat	14.4	52.2	Female	Adult	?	A00357 recapture

PG&E Topock Compressor Station—Proposed Protective Measures for Roosting Bats

EN1031161134BAO

H. T. HARVEY & ASSOCIATES
Ecological Consultants

June 27, 2016

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CH2M Hill
2485 Natomas Park Drive, Suite 600
Sacramento, CA 95833

Subject: PG&E Topock Compressor Station—Proposed Protective Measures for Roosting Bats (Project 3740-02)

Dear Ms. Eisert:

As a follow-up to our summer roosting bat survey report, H. T. Harvey & Associates is providing this letter report of protective measures to avoid and minimize the potential impacts of upcoming groundwater remediation activities on special-status bat species and bat maternity roosts. Pacific Gas and Electric Company (PG&E) is planning to implement a remediation project to address chromium groundwater contamination that may have resulted from past disposal activities at its Topock Compressor Station project site. For our purposes, the *study area* consists of the project site and adjacent lands, located south of Needles, California (Figure 1), near the Interstate 40 crossing of the Colorado River.

This report focuses on the potential impacts on bats that may result from the groundwater remediation project as defined in the *Final Basis of Design Report/Final (100%) Design for the Final Groundwater Remedy* (Final BOD Report) and recommend protective measures for potential impacts on bats associated with high- and low-frequency noise disturbance, air degradation, artificial light levels, and increased human activity. The use of various kinds of equipment, including large trucks and heavy construction equipment, has been factored into these protective measures. We do not anticipate that any adverse effects on bats will result from increased vibration; construction of new buildings or remedy structures located at or near the compressor station, Transwestern Bench, or MW-20 Bench; temporary laydown areas; or long-term remedy support areas. Likewise, we do not anticipate any adverse effects on bat foraging habitat.

We identified 10 roost locations on the project site or in the vicinity: in lower Bat Cave Wash, south of the project boundary (roost 1); lower Bat Cave Wash, south of Interstate 40 (roost 2); the easternmost culvert under Interstate 40 (roost 3); the western culvert (railroad) roost (roost 9); the western railroad bridge over National Trails Highway (roost 10); and five locations along the railroad bridge near or over the Colorado River (roosts 4 - 8) (Figures 2a and 2b). We did not detect any roosts in the Red Rock area or the East Ravine, adjacent to the Colorado River. Species-specific and site-specific considerations that informed the recommended protective measures are discussed under "Species Considerations" below.

PROTECTIVE MEASURES

The following protective measures would apply to project activities primarily during the maternity season (March 15–August 31). Buffer distances recommended in the measures are summarized in Table 1.

Minimize High- and Low-Frequency Noise Disturbance. Project activities that will result in high- or low-frequency noise disturbance include the use of generators and drill rigs for well construction and monitoring, the operation of non-construction and construction vehicles, and pipeline trenching.

Construction Trucks and Heavy Equipment

It is impractical to attempt to measure the noise levels of all potential noise-generating equipment that could be used on the project site. However, based on the loudest anticipated equipment, we recommend maintaining at least a 90-foot buffer around each of roost sites 2–10 during the maternity season when construction vehicles, heavy equipment other than generators, and other noise-generating equipment including in the Construction Trucks and Heavy Equipment category (Table 2) are being used. (See Figure 2b for roost sites.) For roost site 1 and any Townsend's big-eared bat (*Corynorhinus townsendi*) roost that may be encountered, we recommend 200 feet because of the sensitivities of the species involved. Trucks idling for more than 2 minutes will have to position themselves no closer than 250 feet from active maternity colonies (Table 1).

Pedestrian Traffic and Water Sampling Equipment, and Small Vehicles

Based on our sound data from the Honda EU 2000 generator (Figure 3), we recommend that small generators operate at least 65 feet away from bat roosts during the maternity season. At this distance, the noise generated by the Honda EU 2000 would have minimal impact on roosting bats, and is not likely to have an adverse impact on roosting bats. We have the same recommendation for the other equipment in the Pedestrian Traffic and Water Sampling category (Table 2).

Because non-construction vehicles (i.e., cars and utility task vehicles [UTVs]) also could produce high-frequency noise, we recommend that these vehicles remain at least 65 feet away from known roosts during the maternity season. The exception to this buffer zone is when cars travel under the railroad bridges on National Trails Highway. These cars are generally moving quickly under the bridges and are not expected to create much high frequency noise while passing under the bridges.

Drilling, Trenching, and Small Equipment

Because borehole drills could encounter large rocks, causing auger bits to "skip" along the surface of the substrate and thus generate high-frequency sounds, H. T. Harvey & Associates hired sound analysis specialists Illingworth and Rodkin, Inc. (Petaluma, California), to analyze the strength of high frequencies generated by borehole drilling in substrate similar to that found on the Topock project site (*Topock Compressor Station Summer Roosting Bat Surveys Final Report*, H. T. Harvey & Associates 2015). Because of air absorption, high-frequency sounds drop off at a higher rate than sounds in the audible range. Based on the results at the 10- and 30-foot positions, noise levels drop off by about 7 decibels (dB) per doubling of distance at 30 kilohertz (kHz), and by about 10 dB per doubling at 40 kHz. Using these drop-off rates, it is anticipated that the sum of the frequencies between 30 and 40 kHz would be below 35 dB at a distance of about 150 feet from the drill, with no additional shielding. Most bats emit sounds of about 110 dB, measured at the source, and the echo returns from between 2 and 40 meters at about 65 dB. Full signal jamming occurs at about 65 dB, so we believe noises at about half that level (at the 35-dB level) would not present a problem for foraging bats. We therefore recommend that borehole drilling be conducted at least 150 feet away from active roosts during the maternity season.

Because pipeline trenching also entails rock scraping that presumably produces similar ultrasound noises as borehole drilling, we recommend maintaining a buffer of 150 feet between trenching and active bat roosts during the maternity season. Although larger equipment such as heavy construction vehicles typically make the loudest low frequency noises, in our experience the size of the equipment doesn't typically correlate to the amount of high frequency noise that bats are sensitive to. Many bats do not hear below 4 kHz while humans typically do not hear above 20 kHz where bats operate.

Protective Measures for the Use of Equipment

Table 2 lists typical equipment that can be expected to be used during the groundwater remediation project. Each type of equipment is listed by disturbance type and, in some cases, the activity and the equipment used are combined when the activity itself generates the potential disturbance (e.g., pedestrian traffic and water sampling equipment are *combined*).

Eliminate or Reduce Light Levels at Night. If possible, no artificial lighting should be used for project activities during nighttime hours (half an hour after sunset to half an hour before sunrise). If artificial sources of light are needed, any floodlights should be adjusted so that the angle of the beam is less than 70 degrees and directed away from roost sites (London Biodiversity Partnership; http://www.lbp.org.uk/downloads/Publications/Management/lighting_and_bats.pdf.) All nighttime lights should be directed downward if possible. If lighting is required for minimum safety and security purposes, light barriers can be used to reduce the potential for light to reach roosts. For example, if lights are needed to ensure safety of a work area, the light could be positioned so that a hillside blocks the light reaching the roosts sites. Smaller barriers, such as plywood sheeting, can be used, but lighting should not surround a roost within the given buffer zones. Lights with high blue-white or ultraviolet content should be avoided. A review of lighting and impacts to bats is provided in the following publications: Fure, Alison. 2006. Bats and lighting. The London Naturalist, No. 85, 2006. http://www.lbp.org.uk/downloads/Publications/Management/lighting_and_bats.pdf. When using nighttime lighting as outlined above, a buffer of 250 feet must be maintained between every light source and roost sites 2 through 9, and a buffer of 400 feet must be maintained between every light source and roost sites 1 and 10, which support California species of special concern (Table 1), and any Townsend big-eared bat roost that may be encountered.

Minimize Effects of Increased Human Activities. Pedestrians should not approach active roosts, especially during the maternity season, and a 65-foot buffer should be maintained between roosts and foot traffic. Humans tend to talk at fairly low (less than 4-kHz) frequencies, and bats are not as sensitive to these low-frequency sounds. Therefore, exceptions can be made for brief periods when maintaining a 65-foot buffer is not possible. Under no circumstances should workers or visitors shine flashlights into or toward an active roost.

Minimize Air Quality Degradation near Roosts. Project activities that will generate exhaust include generators, drill rigs, and idling trucks and other vehicles. Stationary heavy equipment vehicles, large generators, and large idling trucks producing diesel exhaust should not operate for more than 2 minutes within 250 feet of a bat roost (Table 1). Construction trucks and heavy equipment, and small vehicles that move through an area, have smaller buffer zones (Table 1). An idling truck under a roost (e.g., a stationary diesel truck under Roost 4, 5, 9, or 10) can asphyxiate bats as exhaust moves up from the truck into the roost area. Heavy equipment vehicles (e.g., large diesel-fueled construction vehicles) should not operate within 90 feet of a bat roost except when said vehicles travel under the railroad bridges on National Trails Highway. These vehicles are generally moving quickly under the bridges and are not expected to accumulate exhaust in a given area. Under no circumstances should vehicles idle their engine while under a bridge.

SPECIES CONSIDERATIONS

As described in the *Topock Compressor Station Summer Roosting Bat Surveys Final Report*, we located a roost of pallid bats (*Antrozous pallidus*), a California species of special concern; Yuma myotis (*Myotis yumanensis*); and several roosts of unknown species (likely Yuma myotis or California myotis [*Myotis californicus*]) (Figure 2b). With the exception of pallid bats, the species detected are common and do not have any special status. Although we did not observe a roost site for the Townsend's big-eared bat, which is a candidate for protection as a threatened or endangered species under the California Endangered Species Act (CESA), the loss or disturbance of a single bat would be considered *take* under CESA. Additionally, project-related disturbances could result in the direct loss of a maternity colony of any bat species.

A summary of potential adverse effects on each species, and proposed species-specific avoidance and protective measures, are provided below.

Pallid Bat. Several pallid bats were captured in Bat Cave Wash, and one postlactating female was successfully tracked to her roost in the southern part of the wash. This roost was located near the southern end of Bat Cave Wash (Figure 2b). Further attempts to relocate this bat at the same roost or to other roost sites in the study area were unsuccessful, which suggests that this bat either moved elsewhere in the wash, moved deeper in the substrate, or moved too far away to detect. Although no other pallid bat roosts were located during the summer bat surveys, suitable roosting habitat is present at the southern end of the wash where it narrows. We did not find any suitable roosting habitat for a maternity colony of pallid bats elsewhere in study area.

Based on the location of the known pallid bat roost and the presence of suitable habitat in the southern portion of the wash, project activities are not expected to have any impacts on this species; there is a sufficient buffer between the known and potential roost habitat and proposed well sites. Well drilling (or monitoring and subsequent monitoring) in the vicinity of this roost can proceed at any time of the year as long as the buffer distances listed in Table 1 are observed.

Cave Myotis (*Myotis velifer*)**.** Cave myotis were detected acoustically in low numbers throughout the study area and in high numbers outside the brick culvert (viaduct) along the National Trails Highway. Although acoustic detectors at the brick culvert recorded a pattern of bat calls that suggests that a cave myotis maternity roost occurs near the structure, there is no habitat for the cave myotis in this brick culvert. Because no roosting habitat for this species occurs on or near the project site, these bats presumably roost as a colony outside of the project site.

California Leaf-nosed Bat (*Macrotis californicus*). During the early spring 2016 bat surveys, three California leaf-nosed bats were caught in Bat Cave Wash outside the project boundary (between the Quarry and the southern boundary of the project site). Because bats were caught on the south facing side of a net and because suitable maternity colony roosting habitat does not occur on the project site, we believe these bats day roost to the south of the project site in the Sawtooth Mountain Range. Therefore, the California leaf-nosed bat is not expected to day roost on the project site.

Yuma Myotis. During the summer bat surveys, we located a large roost of approximately 30 or more Yuma myotis in a vertical tube in the easternmost culvert under Interstate 40, in upper Bat Cave Wash (Figure 2b). Because this roost is located directly underneath Interstate 40, the colony is likely accustomed to some level of sustained noise. Further, these bats may be somewhat tolerant of occasional pedestrian traffic in the culvert below their roost. However, for well drilling or other activities in the vicinity of Yuma myotis roosts, the buffer distances listed in Table 1 for Yuma myotis roosts should be observed.

Townsend's Big-Eared Bat. Although a small number of Townsend's big-eared bat acoustic recordings were documented, no individuals were captured during the summer bat surveys, and visual surveys did not detect any roosting activity in the study area. In the previous report, *Bat Surveys of the Topock Compressor Station Soil Investigation and Groundwater Remediation Project Areas,* the authors Dr. Patricia Brown and Dr. William Rainey suggested that the larger rock cavities in Bat Cave Wash and the Red Rock area adjacent to the Colorado River appeared to be the most likely areas in which this species could roost; however, we did not observe any bats emerging from either area. We did not detect any bat activity in the Red Rock area during visual emergence surveys there, nor did we see any Townsend's big-eared bats emerge from the rocky areas of Bat Cave Wash during visual emergence surveys in the upper portion of the wash. None of these areas appeared to be appropriate maternity colony habitat for the Townsend's big-eared bat; rather, only marginal potential habitat exists in a few areas of Bat Cave Wash for single males and dispersed individuals. Nonetheless, this species is a candidate for protection as a threatened or endangered species under CESA, so an adverse effect on a single individual is considered significant. Because this species tends to be very sensitive to even small amounts of disturbance, a hypothetical roost site is assumed herein, to provide for the possibility that an individual or colony may be detected in the future. However, the only potential on-site roosting habitat is of marginal quality at best, and a maternity colony of this species is not expected to occur on the project site.

Other Roosts of Unidentified or Mixed Species. During the 2015 summer bat surveys, we observed unidentified bats emerging from Bat Cave Wash and the railroad bridge (Figure 2b). We observed five bats of an unidentified species emerging from a roost along the western bluff of upper Bat Cave Wash, on the south side of Interstate 40, but the exact site of emergence was not identified. Additionally, we observed 64 bats emerging from five locations along the railroad bridge. Species most likely using the crevices of the wash cliffs are canyon bats (*Parastrellus hesperus*) and pallid bats. Species that might roost under the railroad bridge are Mexican free-tailed bats (*Tadarida brasiliensis*), pallid bats, Yuma myotis, and big brown bats (*Eptesicus fuscus*). Although we mapped the locations of these roosts, the exact numbers and locations of roosting bats within the Bat Cave Wash and along the bridge will likely vary during the life of the project, owing to the abundance of alternate roost sites and these species' tendency to switch roosts.

Roost 9 occurs in the southeastern-most steel culvert of three culverts, under a railroad crossing and in proximity to the Soil Processing and Construction Headquarters areas. Based on daytime surveys on April 20, 2016, a small number of unidentified Myotis (presumably California or Yuma myotis) day roost at this site. If the location of this roost potentially encroaches into the buffer zones for the nearby Construction Headquarters, bats can be safely excluded after the maternity season (August 31) and before bats go into hibernation or torpor (October 31) through the use of a one-way door. Exclusion of bats should be performed only by a person with a Memorandum of Understanding through the California Department of Fish and Wildlife to handle bats in California or someone who is so licensed by the State of California to do so. After bats are safely excluded, fast drying foam should be used to fill the void to prevent bats from re-entering the cavity. Because the existing nearby bat roost (number 10) in the railroad bridge over the National Trail Highway provides ample roosting habitat for additional bats, no additional bat roosting habitat (e.g., bat houses) would be needed.

On April 21, 2016 we monitored bats emerging from the railroad bridge (roost 10) also in close proximity to the Soil Processing and Construction Headquarters areas and counted approximately 75 bats between 7:15 and 8:15 PM. Sunset was at 7:20 PM and the last bat we observed to emerge from the bridge was at approximately 7:45 PM. A bat detector recorded calls from Yuma myotis, California myotis, canyon bats, and Mexican free-tailed bats. None of the species detected within this first hour of activity included bat species of special concern. Based on daytime visual observations of clusters of Yuma myotis and Mexican free-tailed bats on April 19, 2016, we believe there are small maternity colonies of these species on the bridge, and Table 1 would apply.

Several well sites, the Construction Headquarters, and the Soil Processing Area are situated near where bats emerged from railroad bridges on the California and Arizona sides of the Colorado River. Bats roosting under the railroad bridge are subjected to frequent noise and vibrations from trains that travel across the bridge. As such, these bats are likely accustomed to low- and high-frequency noises, and additional noises generated by drilling and well monitoring are not expected to disturb bats roosting on this structure. However, diesel trucks and other motorized equipment could produce exhaust that drifts up to these roosts; therefore, engines producing exhaust must not operate within the buffer zones for more than a two-minute period as indicated in Table 1. Because of the abundance of alternate roost sites under the bridge and the bats' tendency to switch roosts, buffers should be observed along the length of the bridge in which there is vehicle access.

The Arizona portion of the project site (outside of the railroad bridge over the Arizona side of the river) includes only marginal roosting habitat, at best, for bats. Immediately east of historic US Route 66 and the eastern boundary for the Arizona portion of the project area, a grove of tamarisk trees provides potential habitat for the western red bat (*Lasiurus blossevillii*). In summer 2015 we did not detect western red bats from the detectors placed in tamarisk groves in either Arizona or California. There was no on-site roosting habitat for two other foliage roosting bats, the western yellow bat (*Lasiurus xanthinus*) or the silver-haired bat (*Lasionycteris noctivagans*). Hoary bats (*Laisurus cinereus*), a widespread and common foliage roosting species, may roost rarely in the tamarisk grove although we did not detect any bats that were specifically hoary bats (most of this species' calls are difficult to separate from Mexican free-tailed bats). Further, there was no roosting habitat for crevice roosting bats among tamarisk trees within buffer areas of wells located in Arizona, although we did detect crevice-roosting bats forage among these trees.

Because roosting bats, including maternity colonies, switch roosts, especially on a season-by-season basis, we recommend identifying roost locations at least once each for the spring and summer periods of the maternity season once every three years. Because western red bats could potentially also breed in the large tamarisk groves located in Arizona, we recommend acoustic surveys for a minimum of three consecutive nights during fair weather (above 50° Fahrenheit, no rain or high winds) during the summer maternity season once every three years. If western red bats are recorded acoustically, an attempt to locate active roost sites is recommended to establish appropriate buffer zones around each roost. If known roost sites do not change locations after three sets of surveys (over the course of nine years) roosts should be surveyed for spring and summer periods once every five years thereafter. Knowing the exact locations of active roosts will allow construction ground water and monitoring activities to continue while implementing the appropriate buffers. Additionally, we recommend construction monitoring to ensure that construction and monitoring activities stay within the appropriate buffer zones, and ensure that roost locations remain the same (i.e., that bats do not move into new roosts where they could be adversely affected).

Please feel free to contact me at 408.458.3226 or djohnston@harveyecology.com, or Kim Briones at 408.458.3263 or kbriones@harveyecology.com, with any questions you may have regarding this letter report on protective measures.

Sincerely,

Dave Johnston, Ph.D.
Associate Ecologist and Bat Biologist

Attachments (Figures 1–3, Tables 1 and 2)

Table 1. Roost Site and Recommended Buffer Distance between Activity/Equipment and Roosts

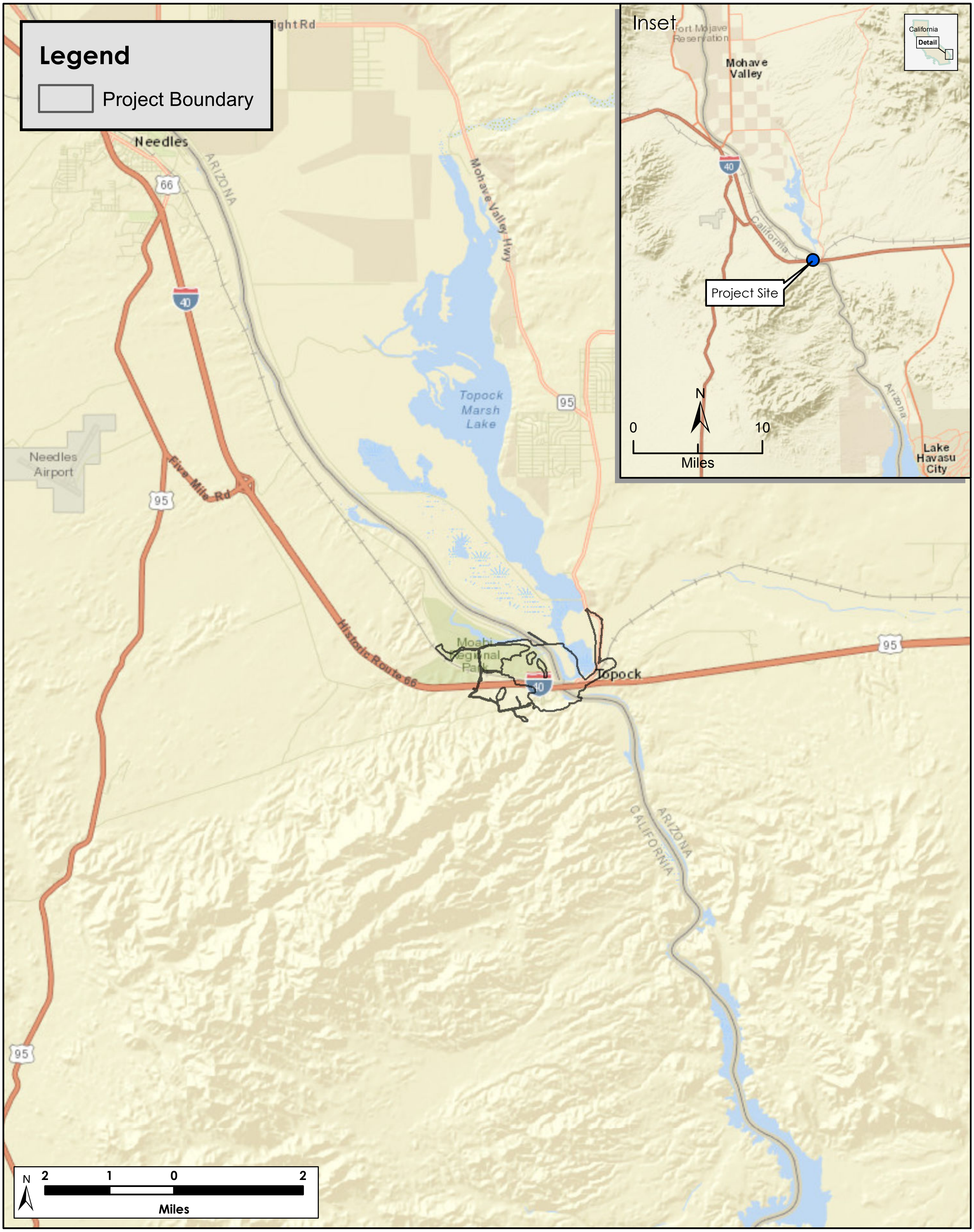
Roost Site Number and Species	Distance between Activity/Equipment and Roosts in Feet					
	Construction Trucks and Heavy Equipment	Small Vehicles	Drilling, Trenching, and small equipment	Light Source	Pedestrian Traffic and Water Sampling Equipment	Stationary Diesel Exhaust Sources > 2 minutes
1. Pallid bat	120	90	150	400	65	250
2. Unkn sp.	90	65	150	250	65	250
3. Yuma myotis	90	65	150	250	65	250
4. Unkn sp.	90	65	150	250	65	250
5. Unkn sp.	90	65	150	250	65	250
6. Unkn sp.	90	65	150	250	65	250
7. Unkn sp.	90	65	150	250	65	250
8. Unkn sp.	90	65	150	250	65	250
9. Unkn sp.	90	65	150	250	65	250
10. Yuma myotis, Mexican free-tailed bat	90	65	150	250	65	250
Hypothetical roosting Townsend's big-eared bat	400	200	200	400	200	250

Table 2. Typical Equipment Listed by Disturbance Type
Other types of equipment may be used in addition to listed equipment

Disturbance Type	Equipment
Construction Trucks and Heavy Equipment; Stationary Exhaust Sources occurring > 2 minutes	Boom/crane truck Water trucks Front-end crawler loader Reachfork Scissor lifts Boom lifts Dump truck Pull behind water buffalo Fresh water storage tanks Vactor truck 18-wheel flatbed trucks Roll off bin trucks Trucks to transport liquid waste and solid waste Compactor Loader Scraper Vacuum/soft dig truck) Dump trailer with tractor truck Articulated dump/haul truck Front end loader Soil compactor Rough terrain/telescopic fork lift Concrete truck Concrete truck with boom Pipe laying machine Pipe welding machine Fuel/grease truck Mechanics truck Crane Walk-behind soil compactor Tractor trailers Mud recycling truck/trailer Man lift
Small Vehicles	Pick-ups and support trucks UTVs

Table 2 (continued)

Disturbance Type	Equipment
Drilling, Trenching, and Light Equipment	Excavator with pulverizer Excavator with shear or bucket and thumb Excavator breaker Backhoe Portable crushers GradeAll Trenching machine Excavator with hoe ram Bulldozer with rippers Road grader Drill rig Auger boring machine Welding torch Portaband saws Hoses Pumps Mechanical hand cutting tools Concrete saw
Water Sampling Equipment with Pedestrian Traffic	WQ instruments with flow through cells Turbid meter 200 ft water level indicator Hand held instruments 200 gallon capacity purge tanks Back-up 2 inch pump and controller Hand tools Submerged pump for sampling powered either by electric line, battery or small generator that emits 59 decibel or less at 33 meters



N:\Projects3700\3740-01\02\Reports\Mitigation Report\Fig 1 Vic Map.mxd

H. T. HARVEY & ASSOCIATES
Ecological Consultants

Figure 1. Vicinity Map
Topock Compressor Station Proposed Bat Mitigation Measures (3740-02)
June 2016

Existing Wells:

- Extraction Well
- Injection Well
- Monitoring Well
- Water Supply Well

Provisional Wells:

(Items in Pink are Provisional)

- Extraction Well
- Injection Well
- Monitoring Well
- Area for East Ravine (ER) Well
- Area for Potential Slant Well Screens
- Area for Inner Recirculation Loop (IRL) Wells
- Area for River Bank Extraction Wells

Planned Wells:

- Extraction, East Ravine
- Extraction, National Trails Highway (NTH) In-situ Reactive Zone (IRZ)
- Extraction, Riverbank
- Extraction, Transwestern Bench
- Injection, Freshwater
- Injection, Inner Recirculation Loop
- Injection, NTH IRZ
- Injection, Topock Compressor Station
- Remedy Monitoring Well
- Recirculation Well
- Area for Monitoring Well MW-T

Pipeline Corridor for Remedy

- Aboveground Pipe
- Underground Pipe/Conduit

Remedy Facilities

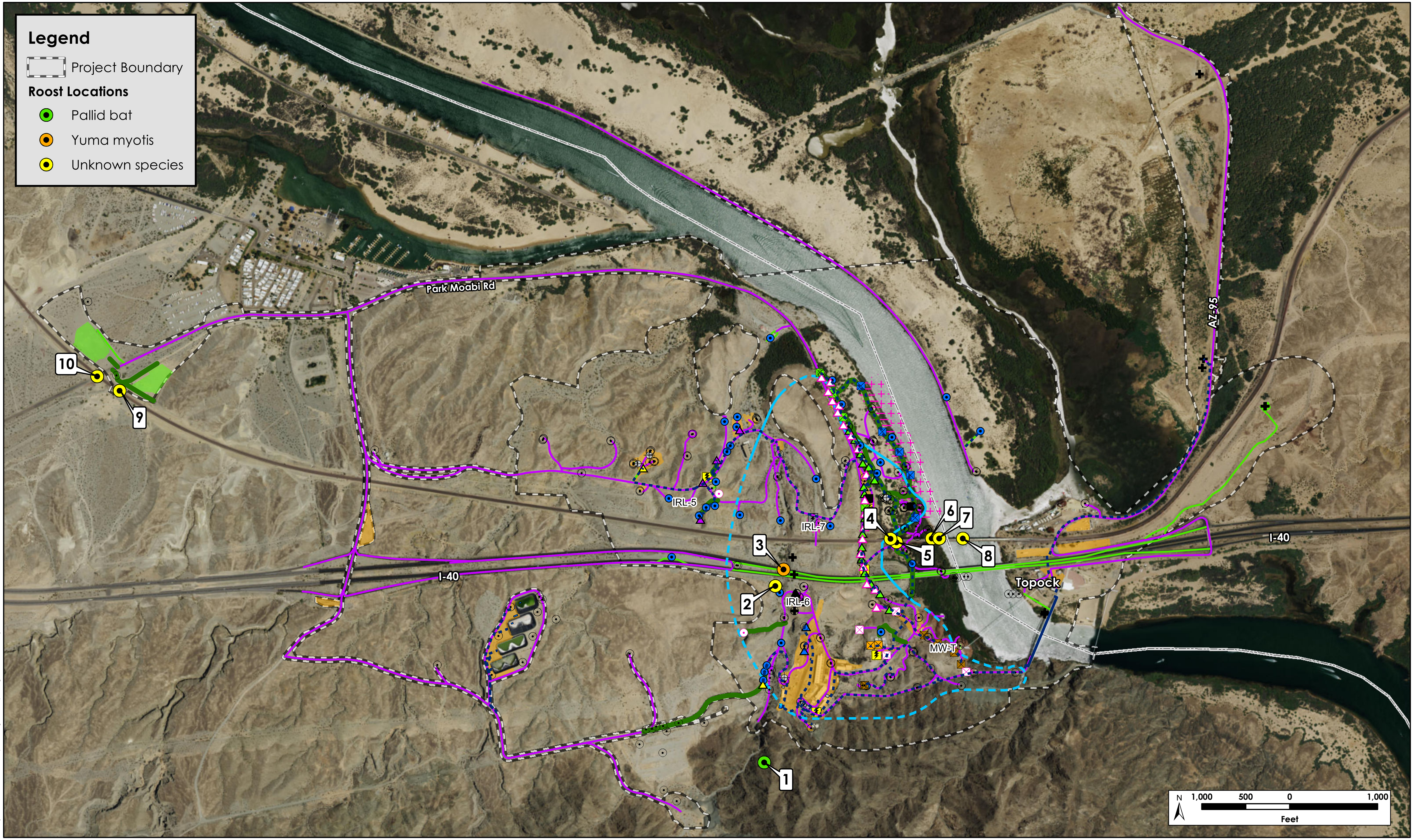
- Planned Transformer
- Future Provisional Transformer
- Proposed Remedy Structure
- Roads to be Improved or Constructed for Groundwater Remedy Use
- Existing Access Route (will continue to be used for remedial activities)
- Existing Route (proposed to be used as is for access to remedial activities)
- Proposed Soil Processing (Area #5) and Construction Headquarter (Area #4) for Remediation Project
- Proposed Staging Areas for Remediation Project (see Table 3.5-1 for description of use of staging areas)

N:\Projects3700\3740-01\02\Reports\Mitigation Report\Fig 2a Site Plan Legend.mxd

H. T. HARVEY & ASSOCIATES
Ecological Consultants

Figure 2a. Site Plan Legend

Topock Compressor Station Proposed Bat Mitigation Measures (3740-02)
June 2016



N:\Projects3700\3740-01\02\Reports\Mitigation Report\Fig 3b Visual Surveys and Roosts.mxd

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Figure 2b. Locations of Visual Surveys and Roosts Found
Topock Compressor Station Proposed Bat Mitigation Measures (3740-02)
June 2016

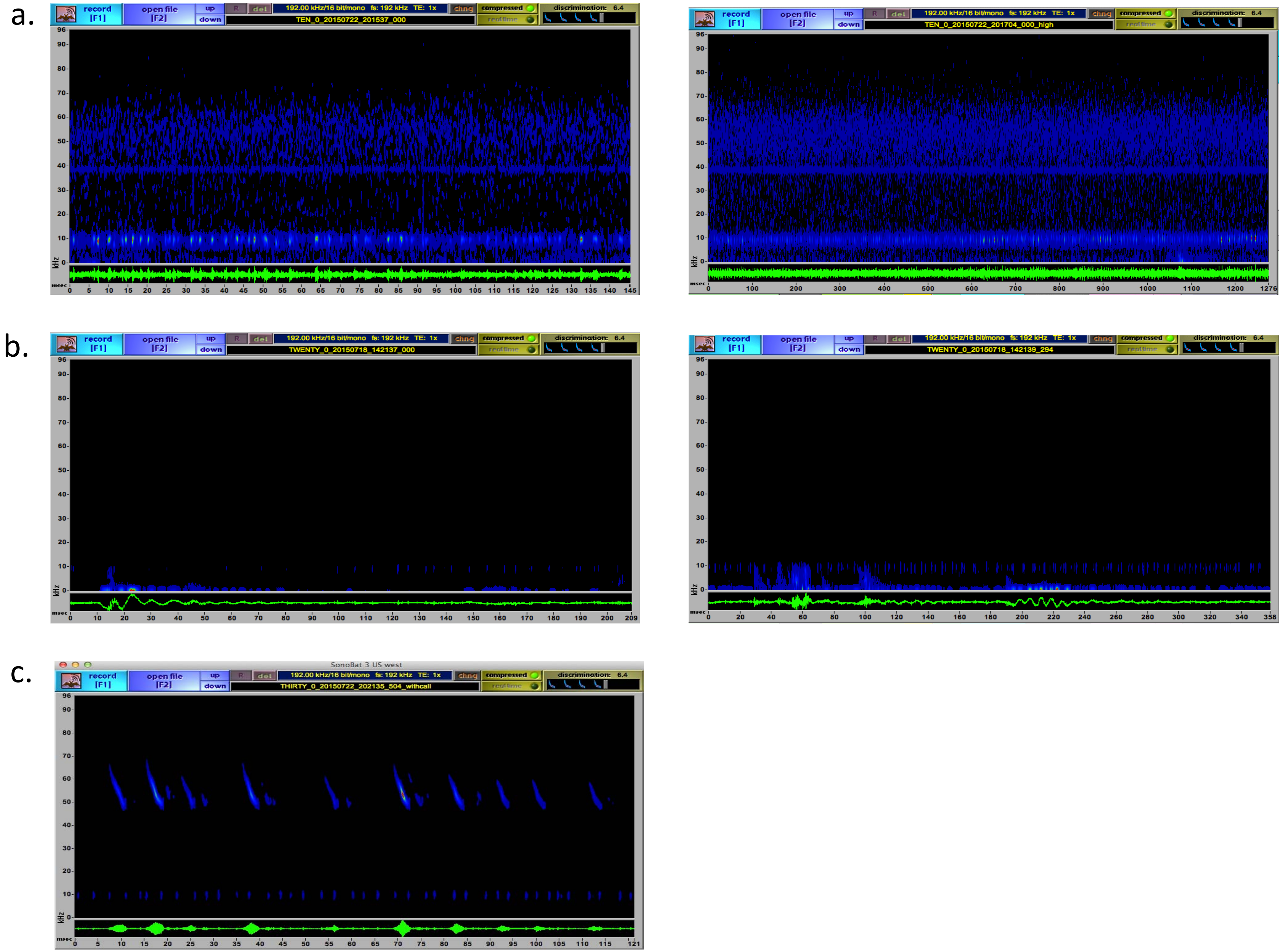

Figure 3. Portable generator ultrasonic sonograms.

Panels are as follows: a) ultrasonic recording output at 10 meters, b) ultrasonic recording output at 2 meters, and c) ultrasonic recording output at 30 meters.

Minor Updates to Four Bat Documents

Pacific Gas and Electric Company

Memorandum

Date: November 17, 2016

File #: Topock Final Groundwater Remediation Project BOD Errata

To: To the File

From: Virginia Strohl/ PG&E Senior Terrestrial Biologist

Subject: Minor Updates to Four Bat Documents and the Assessment of Biological Resources for Additional Potential Environmental Impact Areas Technical Memorandum

This memo serves to provide a minor update and a correction on information included in five biological reports for the BOD Errata document that was prepared for the Final Groundwater Remedy project at the Topock Compressor Station. The reports, correction and updated information are listed below:

1) On August 26, 2016, PG&E submitted a technical memorandum entitled Assessment of Biological Resources for Additional Potential Environmental Impact Areas: Final Groundwater Remedy, Topock Compressor Station, California (CH2M HILL 2016) that summarizes results from the May 24-25 and July 7-8, 2016 biological resources surveys (non-protocol floristic, mature plans, ethnobotanical plants, jurisdictional waters, and non-protocol desert tortoise) of the additional areas considered for the EIR Project Area. An error was noted during the preparation of this BOD Errata document on page 2, 3rd paragraph, 3rd bulleted item, as follows: 'California Rare Plant Ranked (CRPR) 1~~,~~ or 2~~, 3, or 4~~ by the California Native Plant Society (CNPS) in its Online Inventory of Rare and Endangered Plants of California (CNPS, 2015).'

2) There are four documents related to bat surveys, potential impacts and proposed protective measures for special-status bat species and maternity roosts. One of the bat species addressed in these documents is the Townsend's big-eared bat (*Corynorhinus townsendii*) and in the documents it was noted that the bat has candidate species status under the California Endangered Species Act. However, on October 20, 2016 the Fish and Game Commission voted to adopt the recommendation from the California Department of Fish and Wildlife to not list this species. The status of Townsend's big-eared bat should therefore be California Species of Special Concern in all four of the following documents:

   a) A report entitled *Bat Surveys of the Topock Compressor Station Soil Investigation and Groundwater Remediation Project Areas, San Bernardino County, California* (P.E. Brown and W.E. Rainey 2015) assessed the potential for special-status bat species roosting and foraging in the project area.

b) A report entitled *Topock Compressor Station Summer Roosting Bat Surveys and Potential Project Impacts, Final Report* (H. T. Harvey and Associates 2015) summarized survey results and identified bat roost locations during a period from July 20 through 28, 2015 and on the night of September 25, 2015. The report also supports future appropriate mitigation measures to avoid or minimize potential impacts that would be associated with groundwater remedy activities.

c) *A report entitled Topock Compressor Station Spring 2016 Roosting Bat Surveys Report* (H. T. Harvey and Associates 2016) summarized survey results for the spring 2016 bat roost surveys and includes the locations of roosts found through previous surveys to provide a comprehensive coverage of the roost survey results through the spring of 2016.

d) A letter from Dr. Dave Johnston of H.T. Harvey and Associates to Ms. Marjorie Eisert of CH2M HILL dated June 27, 2016, that outlines recommended protective measures to avoid and minimize the potential impacts of groundwater remediation activities on special-status bat species and bat maternity roosts.

BOD Appendix A15
Archaeological and Historical Resources Surveys/Assessment and Reporting

- Chronology of Archaeological and Historical Resources Survey/Assessment and Reporting Since Final Design
- Topock Compressor Station Groundwater Remediation Project, Archaeological and Historical Resources Assessment of Proposed Monitoring Well MW-U

BOD APPENDIX A15

Chronology of Archaeological and Historical Resources Survey/Assessment and Reporting Since Final Design

Below is a chronology of archaeological and historical resources surveys, assessment, and reporting performed since the Final Design (November 2015) in support of the groundwater remedy design and the preparation of the Subsequent Environmental Impact Report (SEIR).

- Archaeological and Historical Survey for Additional EIR Areas
  - The field survey was conducted on June 28-29, 2016.
  - On September 12, 2016, PG&E submitted a report summarizing the survey results to the U.S. Bureau of Land Management (BLM) and California Department of Toxic Substances Control (DTSC) titled *Additional Archaeological/Historical Survey Report, Subsequent Environmental Impact Report for the Topock Compressor Station Final Groundwater Remediation Project, San Bernardino County, CA and Mohave County, Arizona* (AE 2016b). The report contains confidential information and is therefore not included in this appendix.
- Archaeological and Historical Resources Assessment of Monitoring Well MW-U
  - A desktop assessment was conducted at Caltrans' request in July-August 2016.
  - On August 16, 2016, PG&E submitted a report titled *Topock Compressor Station Groundwater Remediation Project - Archaeological and Historical Resources Assessment of Proposed Monitoring Well MW-U* (AE 2016a) to Caltrans. The report is also included in this appendix.
- Annual Monitoring Events
  - The annual field monitoring events were conducted in October 2015 and October 2016. The October 2015 monitoring event was noted in the 100% BOD (CH2M HILL 2015a).
  - On December 1, 2015, PG&E submitted the 2015 Annual Cultural Resources Monitoring Report (AE 2015a) to BLM and the Tribes. The report contains confidential information and is therefore not included in this appendix.
- Additional Archaeological and Historical Survey at Moabi Regional Park
  - The field survey was completed in June 2015 and was noted in the 100% BOD (CH2M HILL 2015a).
  - In December 2015, PG&E submitted a report titled *Additional Archaeological and Historical Survey at Moabi Regional Park, San Bernardino County, California* (AE 2015b) to BLM and DTSC. The report contains confidential information and is therefore not included in this appendix.

Applied EARTHWORKS Inc

3292 E. Florida Ave., Suite A
Hemet, CA 92544-4941
O: (951) 766-2000 | F: (951) 766-0020

5 August 2016

Pacific Gas and Electric Company
Attn: Jennifer Darcangelo, Remediation Resource Specialist
2730 Gateway Oaks
Sacramento, CA 95833

RE: Topock Compressor Station Groundwater Remediation Project
Archaeological and Historical Resource Assessment of Proposed Monitoring Well MW-U

Dear Ms. Darcangelo:

To support the in-situ remedy to address chromium in groundwater resulting from historical operation and maintenance of the Topock Compressor Station, Pacific Gas and Electric Company (PG&E) proposes to install a monitoring well within the median of Interstate 40 (I-40) in San Bernardino County, California, approximately 12 miles south of Needles and 0.75 miles west of Topock, Arizona. At your request, Applied EarthWorks, Inc. (Æ) has completed an archaeological and historical resource assessment of the proposed well. This letter reports the results of our assessment.

PROJECT DESCRIPTION

PG&E proposes to install monitoring well MW-U within the I-40 median approximately 3,700 feet east of the Park Moabi Road overpass (Figure 1). The footprint of the drilling rig is approximately 10 feet wide by 50 feet long; including the needed support equipment, staging areas, and related construction requirements, the total area that may be affected covers approximately 150 by 60 feet (Figure 2). The work area will be entirely within the highway median and will be accessed from the highway. The same general work areas, activities, and access routes will be utilized during well operation, maintenance, and decommissioning.

The proposed monitoring well is within the California Department of Transportation (Caltrans) easement across federal property, and PG&E has applied to Caltrans for an encroachment permit to build, operate, and maintain the well. To satisfy Caltrans requirements, Æ completed a cultural resource desktop analysis of the project area. We reviewed prior studies and previously recorded archaeological and historical sites in the vicinity and assessed the potential for previously unidentified resources to be encountered. No fieldwork was conducted because the proposed work area is within a deep (20 to 30 feet) road cut, and any archaeological or historical deposits would have been removed during highway construction. Additionally, safety considerations precluded accessing the highway median at this location.

CULTURAL RESOURCE ASSESSMENT

Since 2004, Æ has conducted numerous records searches, archaeological and historical surveys, and site evaluations in the Area of Potential Effects (APE) of the Topock Remediation Project to locate and record previously unidentified sites and confirm the location and condition of known sites. In this capacity Æ has inventoried more than 1600 acres surrounding the MW-U location, and has the most

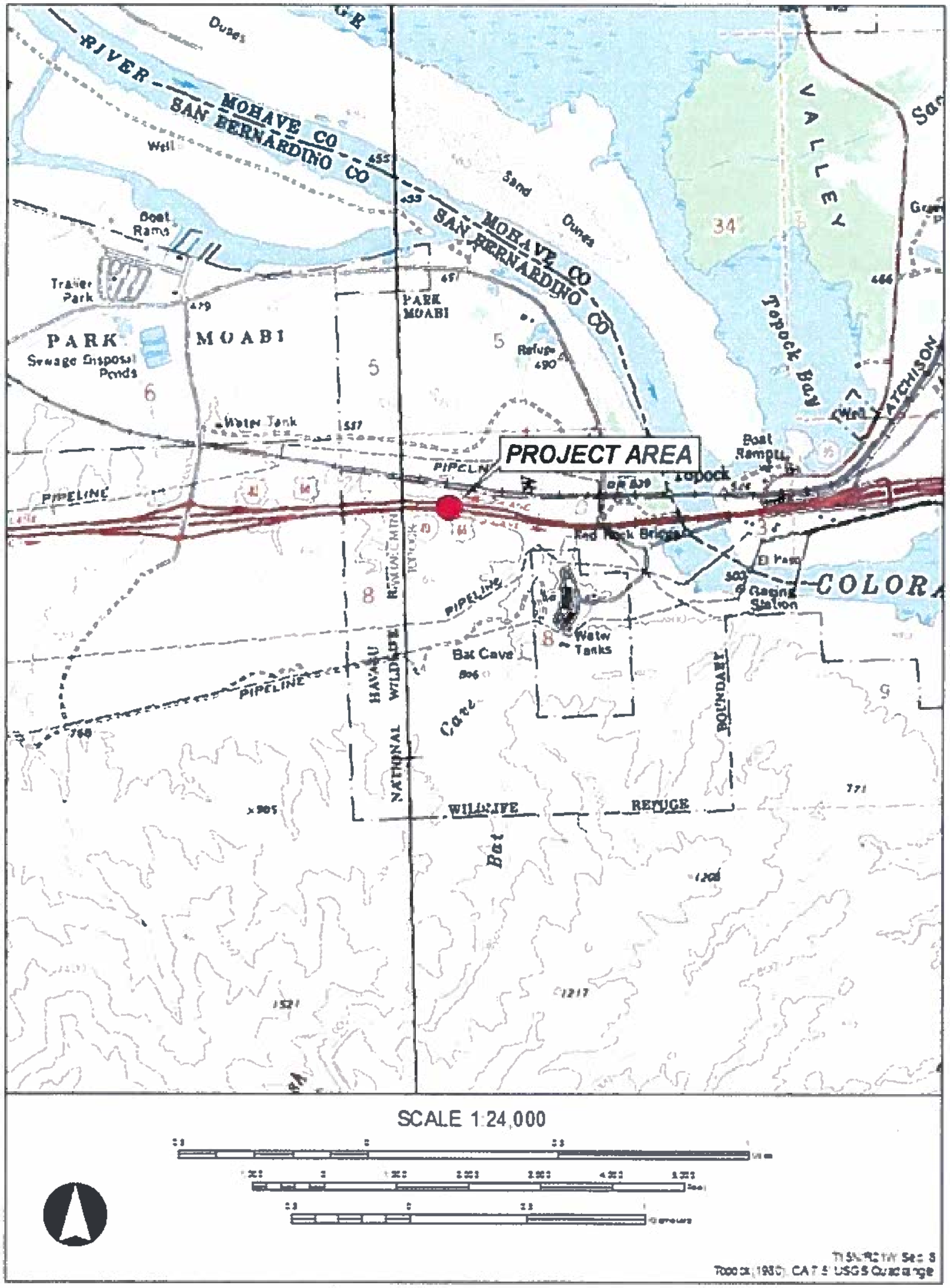

Figure 1 Location of Monitoring Well MW-U.

Figure 1. Detail of MW-U Work Area

up-to-date records for the study area. Although the MW-U installation area is within the APE, it was not surveyed previously for safety reasons and because no project work was anticipated in the highway median.

To date, 10 archaeological and historical sites have been recorded within 1,000 feet of the proposed well (Table 1). Most are small lithic assay/reduction stations where cobbles of naturally occurring toolstone were sampled and reduced. Some of these sites also have undecorated Native ceramics. A portion of Locus A of the Topock Maze (CA-SBR-219A) also falls within 1,000 feet of the well, on the elevated mesa south of I-40. None of these properties are within the I-40 median, but by consensus determination they are all contributing elements of a Native American cultural landscape encompassing the entire APE and considered sacred by several Tribes. This area has been designated by the Bureau of Land Management as a Native American Traditional Cultural Property.

In addition to the Native American cultural resources, several segments of the former National Old Trails Highway/U.S. Route 66 pass within 1,000 feet of MW-U. One of these segments, in use from 1926-1931, may have aligned with the I-40 right-of-way where the well is proposed, but evidence of the old roadway was obliterated by highway construction.

Although there is federal land off the interstate highway that may be suitable for the proposed monitoring well, these areas would require significant grading in preparation for well installation. Many natural, historical, and archaeological resources could be impacted by such grading. Installation of MW-U within the highway median will avoid all such potential impacts.

Table 1.
Summary of Archaeological and Historical Sites within 1,000 Feet

Site Number (CA-SBR-___)	Site Description
219A	Locus A of the Topock Maze
2910H	Segments of the National Old Trails Highway/U.S. Route 66
11905	Lithic assay station
11937	Lithic scatter/assay stations
11938	Lithic scatter/faint lineations
11939	Lithic/ceramic scatter
11959	Lithic scatter/assay stations
11979	Lithic scatter/assay stations
11985	Lithic assay station
13797	Lithic/ceramic scatter

SUMMARY OF PROTOCOLS AND REGULATORY REQUIREMENTS

No archaeological or historical resources have been identified with the I-40 median, and no further studies are recommended. If any such resources are identified during project development, the following protocols and procedures should be followed.

Unanticipated Cultural Resource Discovery Protocols

PG&E Best Management Practice 25 should be implemented if any previously unidentified resources are discovered. Work should cease immediately within an area extending no less than 5 meters and no more than 50 meters from the potential find (to be determined in the field based on the circumstances and nature of the discovery). The PG&E Cultural Resource Specialist should be notified immediately. The specialist will then notify the BLM, Caltrans, and Tribal representatives (if the resource is Native American in nature). No further work will be undertaken until Caltrans and the BLM, in consultation with Tribes and PG&E as appropriate, have determined the nature of the discovery and developed appropriate measures for its evaluation and/or treatment.

In addition, PG&E would implement the measures in Section 2.2.1 of the Cultural Impact Mitigation Program (CIMP) required by Mitigation Measure CUL-1a-8 in the *Topock Compressor Station Groundwater Remediation Project Environmental Impact Report* (the EIR). The requirements in Section 2.2.1 are similar to those in Best Management Practice 25, except that notice of a discovery also would be given to the Department of Toxic Substances Control (DTSC). In addition, PG&E's Cultural Resource Specialist, in coordination with the Tribal Monitor, would perform the initial inspection of the find to ascertain its nature, extent, cultural ascription, and whether or not human remains are present. PG&E also would recommend to the Agencies, including DTSC, whether avoidance of the discovery is feasible, but the Agencies would make final determination regarding the feasibility of avoidance.

PG&E also would comply with EIR Mitigation Measure CUL-1b/c-4, which has similar requirements to Best Management Practice 25 and CIMP Section 2.2.1. The primary difference between Mitigation Measure CUL-1b/c-4 and Best Management Practice 25 is that on Caltrans land, the Qualified Cultural Resources Consultant (also called the Cultural Resource Specialist) must notify DTSC and PG&E. Mitigation Measure CUL-1b/c-4 also states that the Qualified Cultural Resources Consultant, in consultation with DTSC and tribal monitors, would evaluate the resource before construction activities would be allowed to resume.

Human Remains Protocol

In accordance with Section 7050 of the California Health and Safety Code and the Cultural and Historic Properties Management Plan (CHPMP) for the Topock Remediation Project and EIR Mitigation Measure CUL-4, in the event that human remains are discovered all work in the vicinity should cease immediately and steps should be taken to ensure that the remains are secured and are not disturbed further pending implementation of treatment measures. The PG&E Cultural Resource Specialist should be notified immediately to evaluate the circumstances and the Cultural Resource Specialist, archaeologist, or construction site supervisor would provide notification to Caltrans, BLM, DTSC, PG&E, and the County Coroner. The San Bernardino County Coroner will determine if the remains are of recent origin and if an investigation of the cause of death is required (California Health and Safety Code Section 7050.5). If the coroner determines that the human remains are not Native American and not evidence of a crime, project personnel shall coordinate with the Qualified Cultural Resources Consultant (s) to develop an appropriate treatment plan. In the event that the San Bernardino County Coroner determines that the human remains are Native American and not evidence of a crime, project personnel shall contact the NAHC so that a most likely descendent (MLD) can be identified as required under California Public Resources Code Section 5097.98.

SUMMARY

Applied EarthWorks has completed a cultural resources assessment for installation of monitoring well MW-U in the median of I-40 near the Topock Compressor Station in San Bernardino County, California. No archaeological or historical sites are present at the project location and, barring unanticipated discoveries, the project can proceed with no foreseeable impact.

Respectfully submitted,

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Principal Archaeologist
Applied EarthWorks, Inc.

BOD Appendix A16
Biological Assessment of the Northern Mexican Gartersnake (*Thamnophis eques megalops*) for the PG&E Topock Compressor Station Final Groundwater Remedy

TECHNICAL MEMORANDUM

Biological Assessment of the northern Mexican gartersnake (*Thamnophis eques megalops*) for the Pacific Gas & Electric Topock Compressor Station Final Groundwater Remedy

PREPARED FOR:	Virginia Strohl/PG&E
COPY TO:	Marjorie Eisert/CH2M HILL (CH2M)
PREPARED BY:	Steve Long/CH2M
DATE:	November 16, 2016

Overview of the Proposed Action

Details of the Final Groundwater Remedy were previously described in Section 3.3 and Table 2 and are shown in Figures 6 and 7 of the 2014 PBA (CH2MHILL 2014). Proposed activities associated with the Topock Groundwater Remedy near the Topock Marsh in Arizona include the construction of pumping facilities in proximity to the freshwater supply well; the installation of freshwater conveyance pipeline to carry water from existing wells along the Oatman-Topock Highway; the installation of two new groundwater monitoring wells; the temporary use of a construction laydown area to the south of the Topock Marina; the use of existing access roadways during the remedy operation; sampling and maintenance of proposed and existing monitoring wells; conducting remedy operation and maintenance activities; as well as decommissioning, removal, and final restoration of disturbed areas.

Figure 1 depicts the Final Groundwater Remedy features within Arizona and shows their proximity to potentially suitable northern Mexican gartersnake habitat. The inset map of this figure also shows the nearest location where northern Mexican gartersnake habitat has been identified.

Pre-project surveys will be conducted by qualified biologist prior to construction to identify the presence of northern Mexican gartersnake and to adapt operations to minimize any potential for effects. Detecting this rare, secretive, and elusive gartersnake in moderately to heavily complex habitat is extremely difficult using visual encounter methods. Therefore, to increase the odds of detection, surveys will specifically focus on identifying potential microhabitat sites (artificial or natural cover such as debris, wood, or rock piles, wildcat dump sites, high rodent burrow densities, etc.) favorable to gartersnakes in the disturbance area to better gauge the likelihood of species presence during project implementation. Further, it is expected that project activities (especially those involving heavy equipment for the construction of the freshwater pipeline in proximity to potentially suitable northern Mexican gartersnake sheltering/foraging habitat) will occur during February 1st to November 30th, where possible, to coincide with the active period for gartersnake. However, northern Mexican gartersnakes may still be active and above-ground any day of the year where the previous night was above freezing.

The following conservation measures, in addition to the general project management measures discussed in Section 3.4 of the 2014 PBA, will be applied to all actions associated with the Final Groundwater Remedy that will occur in or near potential northern Mexican gartersnake habitat near the southern end of Topock Marsh.

1. Workers shall exercise caution when traveling near potential gartersnake habitat along the southern margin of Topock Marsh. During the most-active season for northern Mexican gartersnakes (February 1st to November 30th), workers will not exceed 10 mph when traveling off-road to maximize the likelihood that gartersnakes would be seen and avoided by drivers. During the inactive season (December 1st to January 31st) workers will not exceed 25 mph when traveling off-road. Construction personnel will abide by the posted speed limit while traveling on the Oatman-Topock Highway.

2. Work will stop if a gartersnake is found within the immediate area to be disturbed and the gartersnake will be allowed to leave the site on its own volition.

3. A qualified biologist shall perform preconstruction surveys prior to ground disturbing activities with the intention of identifying potential microhabitat sites (artificial or natural cover such as debris, wood, or rock piles, wildcat dump sites, high rodent burrow densities, etc.) favorable to gartersnakes in the disturbance area to focus search effort for potential gartersnakes.

4. When possible, ground disturbing activities should be avoided when snakes may be inactive and underground, in order to avoid injury to snakes. Construction will be completed when the northern Mexican gartersnake is active (February1st through November 30th).

5. Northern Mexican gartersnakes are known to utilize talus/rock piles, rip/rap, or any organic or inorganic debris pile. These features are not currently present in the Action Area near the southern margin of Topock Marsh; however, temporary material stockpiles (such as pipe) may be required during construction. If material stockpiles are located near the southern margin of Topock Marsh, they will be limited to designated storage areas that are well away from potentially suitable northern Mexican gartersnake habitat or on the opposite side of the Oatman-Topock Highway.

6. All open holes and trenches shall be inspected for trapped gartersnakes at the beginning, middle, and end of the work day, at a minimum. During excavation of trenches and to the extent possible, earthen ramps or wooden planks shall be provided to facilitate the escape of any wildlife species that may inadvertently become entrapped and to leave the site on its own volition (adapted from 2014 PBA, Section 3.4, General Project Management Measure Number 17; CH2MHILL 2014).

Future project activities will be conducted in accordance with established mitigation measures presented in Section 3 of the 2014 PBA and other relevant documents (e.g., CH2M HILL, 2005), which will help to avoid, reduce, and mitigate operational and construction impacts to the biological environment within the Action Area. It is expected that no emergent marsh habitats will be lost, removed, or manipulated to conduct planned activities, especially those within the Topock Marsh on the HNWR.

Northern Mexican gartersnake (*Thamnophis eques megalops)*

Note the following information concerning status, natural history, abundance, habitat, and status of the species in the Topock Groundwater Remedy Action Area is derived primarily from the Threatened Status for the northern Mexican Gartersnake and Narrow-Headed Gartersnake; Final Rule (USFWS 2014b); the Designation of Critical Habitat for the northern Mexican Gartersnake and Narrow-Headed Gartersnake: Proposed Rule (USFWS 2013a); and the recent Final Biological Opinion for the Maintenance Activities within the Beal Lake Conservation Area, Mohave County, Arizona (USFWS 2015).

Status

The northern Mexican gartersnake was listed as a federally threatened species on July 8, 2014 (USFWS 2014b), under the Endangered Species Act. Critical habitat was proposed on July 10, 2013 (USFWS 2013a) but has not yet been designated for this species.

The need to include this species in the Programmatic Biological Assessment for Pacific Gas and Electric Topock Compressor Station Final Groundwater Remedy (CH2M HILL 2014) arises because of its 2015 discovery in Beal Lake. Beal Lake is within the Havasu National Wildlife Refuge and Topock Marsh in Arizona and is approximately 4.2 miles northwest of the Topock Compressor station. The species was not included in the original PBA because the previous northernmost detection had been on the Bill Williams River near Parker, Arizona in 2012, approximately 35 miles southeast of the Topock Compressor Station. Even with this detection in 2012, the northern Mexican gartersnake was still considered extirpated from the mainstem of the lower Colorado River due to presence of nonnative fish, bullfrogs, and crayfish as well as significant habitat alteration, which is why it was not added by the USFWS to the PBA in 2014 (Innis, P. email communication, 2016).

Natural History, Distribution and Abundance, and Habitat

The northern Mexican gartersnake may reach up to 44 inches in length. It ranges in color from olive to olive-brown or olive-gray with three lighter-colored stripes that run the length of the body, the middle of which darkens toward the tail. It may occur with other native gartersnake species and, because of its similarities, may be difficult to distinguish from them without specific expertise. Throughout its rangewide distribution, the northern Mexican gartersnake occurs at elevations from 130 to 8,497 feet (Rossman et al. 1996) and is primarily found within riparian and moist habitats such as source-area wetlands [e.g., cienegas, stock tanks (small earthen impoundment), etc.], large river riparian woodlands and forests, and streamside gallery forests with limited, if any, herbaceous ground cover or dense grass (USFWS 2016). In the northernmost part of its range, the northern Mexican gartersnake appears to be most active during July and August, with lesser activity in June and September.

The northern Mexican gartersnake is an active predator that depends on smaller animals for its prey base. It forages along vegetated banklines or along the edges of open water and thick stands of vegetation such as cattails. Generally, its diet consists of native amphibians and fishes, such as adult and larval (tadpoles) of select native frog species (e.g., leopard frogs (*Lithobates* sp.), as well as juvenile and adult native fish species (e.g., Gila topminnow (*Poeciliopsis occidentalis occidentalis*), desert pupfish (*Cyprinodon macularius*), and Gila chub (*Gila intermedia*), and roundtail chub (*Gila robusta*) (Rosen and Schwalbe 1988). Other prey items can include earthworms, leeches, and small mammals. The gartersnake may congregate at ephemeral amphibian breeding ponds to exploit high-density prey populations (USFWS 2014b).

Where native prey species are rare or absent, gartersnakes have been known to prey on nonnative species such as bullfrog (*Lithobates catesbeianus*), mosquitofish (*Gambusia affinis*), green sunfish, bluegill, or largemouth bass.

The presence of harmful non-native species is considered the most significant reason for the decline of northern Mexican gartersnake in nearly all localities within the United States (USFWS 2014b). These harmful non-native species are known to compete for similar prey as the gartersnakes and so, can contribute to starvation. These harmful species may also reduce recruitment of young gartersnakes through predation.

The northern Mexican gartersnake was historically widespread in Arizona but had a more limited distribution in New Mexico with scattered populations in the Upper Gila River watershed in Grant and western Hildalgo Counties. Approximately 85 percent of the total rangewide distribution of this subspecies occurs within the Sierra Madre Occidental and the Mexican Plateau in Mexico (USFWS 2015).

All viable populations in the United States, where the northern Mexican gartersnake subspecies may be reliably detected, are in Arizona. The nearest of these viable populations to the Topock Project Area is approximately 35 miles to the southeast in the Bill Williams River near Parker, Arizona. In New Mexico and elsewhere in Arizona, the northern Mexican gartersnake is expected to occur in extremely low population densities within its historical distribution. Especially on tribal lands or within Mexico, survey efforts are mostly insufficient to conclude extirpation of this secretive species (USFWS 2015).

Status of the Species in the Area

The following presents a summary of known detections of northern Mexican gartersnake around the Topock Action Area (USFWS 2015):

- ***Lower Colorado River***--Three records from the late 1800s-early 1900s and a fourth from 2015 document northern Mexican gartersnakes from the Colorado River where they were likely broadly distributed along its course prior to area settlement. Northern Mexican gartersnakes may potentially immigrate to the lower Colorado River from occupied habitat in the Bill Williams River. However, the reestablishment of a viable gartersnake population in the lower Colorado River is likely prohibited by fisheries management policies in the main stem, the abundance of predators, and the significant alteration of habitat along the lower Colorado River.
- ***Bill Williams River***- Prior to 2012, there were no records of northern Mexican gartersnakes from the Bill Williams River. In 2012, a total of ten individuals were observed. The USFWS considers that the northern Mexican gartersnake population is likely viable in the Bill Williams River (USFWS 2015).
- ***Beal Lake Conservation Area*** - Two sightings of northern Mexican gartersnake at BLCA occurred in the spring of 2015. The LCR MSCP was first notified of a possible northern Mexican gartersnake sighting at BLCA in the spring of 2015 by Great Basin Bird Observatory (GBBO) personnel that were conducting riparian bird monitoring on the Havasu National Wildlife Refuge in Arizona. At that time, the Arizona Game and Fish Department (AGFD), the USFWS, and the U.S. Geological Survey were notified and five photographs were provided for identification (USFWS 2015).

  Following this initial sighting, a gartersnake was observed on May 4, 2015 in the same area and two additional photographs were taken for identification. The USFWS notified the LCR MSCP on June 1, 2015 that the species was confirmed as a northern Mexican gartersnake by Jeff Servoss of the USFWS and by Taylor Cotten and Tom Jones of AGFD (USFWS 2015).

  At this time, the distribution and abundance of northern Mexican gartersnake within the BLCA, as well as its distribution on other portions of the Havasu National Wildlife Refuge is not well known. One of the snakes observed in 2015 may have come from the Topock Marsh as it was found on a road about 275 meters from Topock Marsh to the north of the locality and well over 800 meters from open water of the backwater to the south of the locality (USFWS 2015).

Within the Topock Action Area in Arizona, potential sheltering habitat exists at the water's edge and along the shoreline of Topock Marsh where dense vegetation may provide suitable cover. Additional potential sheltering habitat may be found away from the Topock Marsh itself, in the form of any small crack, crevice, hole, wood debris piles or isolated patches of dense vegetation. The southern tip of the Topock Marsh is the location where potentially suitable northern Mexican gartersnake sheltering habitat is closest to proposed construction activities for the freshwater supply pipeline. In this area, the Oatman-Topock Highway has a narrow shoulder with a rocky fill slope that abuts directly into the marsh. It is within this roadway shoulder that the pipeline will be constructed. The roadway shoulder itself may serve the gartersnake for short-term dispersal purposes but would not provide suitable sheltering habitat due to lack of vegetation or other refugia (such as small mammal burrows, wood debris piles, or rock piles).

Northern Mexican gartersnake prey species at BLCA include native amphibians as well as non-native American bullfrog metamorphosed juveniles and tadpoles *(Lithobates catesbeianus)* and juvenile non-native fish. In addition, the northern Mexican gartersnake is known to prey upon invertebrates, lizards, and small mammals.

While specific surveys that would confirm the presence of these prey items have not been conducted, some of these prey species are also likely to occur in portions of the southern Topock Marsh. These species would be primarily associated with the aquatic and adjacent vegetated terrestrial habitats along the margin of Topock Marsh. As many as six different lizard species, including sagebrush lizard (*Sceloporus graciosus*) and one small mammal species, desert woodrat (*Neotoma lepida*), have been identified as part of incidental wildlife observations during other focused surveys in the Topock Action Area.

Breeding season and habitat in the Topock Action Area are expected to be similar to those that were reported in the nearby BLCA (USFWS 2015). Nowak et al. (2011) suggested that open shallow water adjacent to dense emergent and/or submergent vegetation may be important for breeding activities. Mating has been documented in April and May followed by the live birth of between 7 and 38 newborns (average of 13.6) in June, July and August (Rosen and Schwalbe 1988). The breeding season was estimated to occur between March and July (March-May mating; May-August live birth). It was also noted that mild winter temperatures had the potential to increase gartersnake activity in the winter months (USFWS 2015).

Critical Habitat

Critical habitat for the northern Mexican gartersnake has been proposed in 14 units in portions of Arizona and New Mexico totaling 421,423 acres (USFWS 2013a). The nearest of these designated critical habitats is the Bill Williams River, near Parker, Arizona approximately 35 miles southeast of the Topock Compressor Station. Within the proposed critical habitat areas, the primary constituent elements (PCEs) of the physical and biological features essential to northern Mexican gartersnake conservation include 1) aquatic or riparian habitats; 2) adequate terrestrial space adjacent to aquatic features; 3) adequate prey base of native amphibian and native fish species; and 4) an absence or low levels of harmful nonnative fish species, bullfrogs, or crayfish. Suitable aquatic or riparian habitats are those associated with perennial or spatially intermittent streams; ponded freshwater wetlands such as livestock tanks, springs, and cienegas; shoreline habitat with adequate organic and inorganic structural complexity to allow for thermoregulation, gestation, shelter, protection from predators, and foraging opportunities. These suitable aquatic habitats must support an adequate native amphibian prey base; have low salinity (less than 5 parts per thousand; pH greater than or equal to 5.6; and minimal amount or absence of pollutants that could affect survival in any age class of gartersnake. The Final Groundwater Remedy will not impact critical habitat for the northern Mexican gartersnake as the nearest existing proposed critical habitat is 35 miles southeast of the Topock Compressor Station.

Effects of the Action

The potential for impacts to the northern Mexican gartersnake associated with the Topock Groundwater Remedy pertains only to activities that will occur in Arizona and, particularly those activities that are near the Topock Marsh. Based upon the PCEs listed above and because no work is being proposed that will directly affect the Topock Marsh, the most significant of the above-listed activities are those that will occur within 600 feet of the Topock Marsh where adequate vegetative cover is available to shelter foraging gartersnakes.

Of the activities, the proposed pipe installation, decommissioning (removal of pipe), and restoration between the southern end of Topock Marsh and the Oatman-Topock Highway and the two monitoring wells with undetermined locations, represent the activities and locations with the highest potential to affect northern Mexican gartersnakes because of the proximity of the work to occur near suitable habitat. The other activities associated with operations and maintenance are expected to have far less potential effect on the northern Mexican gartersnake because they will cause less ground disturbance that will occur over smaller areas and shorter duration and because they will be subject to the mitigation measures outlined in this technical memorandum.

Direct Effects

Direct effects are those that are caused by the proposed action and occur at the same time and place. Details of the Final Groundwater Remedy were previously described in Section 3.3 and Table 2 and are shown in Figures 6 and 7 of the 2014 PBA (CH2MHILL 2014). The Final Groundwater Remedy actions are summarized here as only they relate to potential direct effects to northern Mexican gartersnake.

Beginning in the eastern portion of the Action Area in Arizona, the Groundwater Remedy has the potential to have a direct effect on northern Mexican gartersnake due to anticipated activities near the southern margin of the Topock Marsh. The planned activities associated with the Topock Groundwater Remedy near the Topock Marsh in Arizona include the construction of pumping facilities in proximity to the freshwater supply well, trenching for the installation of conveyance pipeline along existing roadways to carry fresh water from wells along the Oatman-Topock Highway; the installation of two new groundwater monitoring wells; the temporary use of a construction laydown area to the south of the Topock Marina; use of existing access roadways during the remedy operation; conduct remedy operation and maintenance activities, as well as decommissioning, removal, and final restoration of disturbed areas. With respect to the northern Mexican gartersnake, the activities related to the conveyance pipeline and possibly the two monitoring wells; construction, maintenance, decommissioning, and restoration are most relevant because they occur closest to the suitable northern Mexican gartersnake along the southern margin of the Topock Marsh. There is an existing monitoring well in the Topock 66 Resort parking lot near the boat ramp that will continue to be sampled, maintained and eventually decommissioned. Sampling and maintenance activities associated with this existing monitoring well are not anticipated to impact the gartersnake due to a lack of habitat in the parking lot.

The water supply pipeline will be installed within the previously disturbed areas on the shoulder of the Oatman-Topock Highway. This segment of the pipeline would be installed by direct burial using construction equipment, such as a backhoe, to excavate the trench. After the pipeline segment is connected and tested, the trench will be backfilled so that only shortest active working section of the trench will be left open (estimated to be 100 feet or less in the southern Topock Marsh Area). Given the narrow roadway shoulder access between Oatman-Topock Highway, it is expected that the trench itself will be approximately 4 feet deep and about 4 feet wide, although it could be slightly wider if sloping is required for the trench walls. The underground conveyance pipeline will connect the chosen supply well to the Final Groundwater Remedy facilities in California. The conveyance pipeline alignment will not directly impact suitable emergent marsh habitat but will occur close enough to represent potential disturbance to adjacent, foraging habitat when the pipeline passes along the southern portion of Topock Marsh. For this reason, when possible, ground disturbing activities in this area should be avoided when snakes are least likely to be active on the surface and more likely to be in underground hibernacula in order to avoid injury to snakes in torpor during the winter months (December 1 through January 31). Work in the southern Topock Marsh area that is conducted during this period will be completed in the shortest timeframe possible. Currently, it is anticipated that ground disturbing activities associated with the pipeline installation in this area can be completed with 3 to 4 weeks of activity, so that that the effect on northern Mexican gartersnake should be negligible and discountable. Recent fires in this area have significantly reduced the amount of vegetative cover that was present along the southern margins of Topock Marsh.

The Final Groundwater Remedy activities proposed by PG&E will involve the use of heavy equipment including, but not limited to, drill rigs, backhoes, and other mechanical equipment that may be used to remove vegetation, grade the ground surface, and install wells or pipelines within the floodplain.

The Colorado River mainstem may function as occupied habitat for the northern Mexican gartersnake; however, population densities are expected to be low due to the presence of harmful nonnative fish species and lack of suitable cover along the shoreline along many reaches. Because northern Mexican gartersnake may potentially use the habitat in the Action Area for sheltering and foraging during the year, it is possible that construction and operational activities could alter the behavior of resident gartersnakes , but as discussed, the potential for impact is considered low because of expectedly low population densities and the fact that actions within the most suitable habitat are not planned and activities adjacent to suitable habitats have limited effects (noise, duration, etc.).

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 movements among and between marsh areas in and adjacent to the Action Area. Movement of gartersnakes between shelter habitats may also occur through other adjacent habitats that lack the above-listed characteristics. The regular disturbances by recreational boating and ORV traffic also lower the potential suitability of these areas for northern Mexican gartersnake use.

Activities related to the Final Groundwater Remedy will occur in upland areas that do not support the marsh vegetation and other characteristics commonly associated with northern Mexican gartersnake habitat. For this reason, these activities are not expected to have an effect to this species due to unsuitable habitat at the specific project location. Based on the application of pre-activity surveys and construction monitoring and lack of evidence of suitable refuge sites, any direct effects to northern Mexican gartersnake are expected to be negligible or avoidable.

Indirect Effects

Indirect effects are those that are caused by the proposed action, are later in time, and are reasonably certain to occur. The possible actions that may occur are related to the long-term operation and maintenance of the Final Groundwater Remedy facilities after construction and the decommissioning and restoration the Final Groundwater Remedy.

The possible actions that may occur within the Arizona portion of the Action Area will include the maintenance of freshwater conveyance facilities (i.e., supply well, pump, electrical controls, and pipeline) after construction; sampling, maintenance, and testing of monitoring wells, the decommissioning of those facilities once the remedial objectives have been met; and eventual restoration of the areas once the facilities have been removed or suitably abandoned in place.

However, the low population density expected for northern Mexican gartersnakes within this portion of the Action Area suggests that the probability of negatively altering northern Mexican gartersnake behavior during remedy maintenance activities would be relatively low. Further, the magnitude of project effects may be difficult to discern from other potentially impacting recreational activities (e.g., watercraft) that occur with regularity within the Action Area. Activities associated with well maintenance, pipeline repair, certain road repair; decommissioning and removal of facilities; and restoration activities may require the use of heavy equipment, trucks, materials, and crews to implement.

However, the potential effects of these activities would be reduced by the application of general project management measures discussed in Section 3.4 of the 2014 PBA and species-specific conservation measures discussed above, so that the potential for indirect effects on northern Mexican gartersnake are considered to be low, and therefore are considered insignificant.

Cumulative Effects

Cumulative effects include future state and private activities, excluding federal activities that are reasonably certain to occur within the Action Area. Continued operation of the Topock Compressor Station (TCS) will occur. It is reasonably certain that soil remedial activities could occur within the Action Area but none of these activities will occur in Arizona. The final soil remedy, if required, will include heavy equipment and personnel with minor activities in the ‘floodplain’ portion of the Action Area.

There will be no loss of emergent marsh habitat that would reduce the habitat value and thereby, alter northern Mexican gartersnake use and behavior.

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 and the HNWR, such as boating, fishing, and ORV use of the floodplain and surrounding areas.

Within the Action Area in Arizona, ongoing and future actions include renovations at the Topock Marina (including current rental lodging, and a proposed hotel and new restaurant), continued HNWR restoration efforts associated with the 2008 Sacramento Wash Fire, and HNWR restoration efforts associated with the 2015 Topock Fire, and Mohave County's Sacramento Wash Crossing at Oatman-Topock Highway project. The fire restoration efforts are expected to have an overall positive effect on northern Mexican gartersnake habitat in the Action Area by improving foraging opportunities as the native plantings mature through an increase in sheltering habitat; however, the restoration plantings will not create additional northern Mexican gartersnake habitat.

Effect Determination

Northern Mexican gartersnake have been documented in the nearby BLCA to the north of the Topock Action Area in Arizona. Potentially suitable habitat for the northern Mexican gartersnake occurs along the western and southern edge of the Topock Marsh on the HNWR near the eastern boundary of the Action Area in Arizona. Suitable emergent wetland habitats are approximately 530 feet west of the water supply well HNWR-1 and approximately 2,300 feet west of the Site B supply well. Installation and testing activities for those wells were covered under the 2007 PBA (as re-initiated in 2012).

Potential disturbances to northern Mexican gartersnake habitats could occur during the water conveyance pipeline installation along the Oatman-Topock Highway near the southern portion of the Topock Marsh. As described in the Construction/Remedial Action Work Plan (CRAWP; CH2MHILL 2015), the trenches will be excavated primarily with construction equipment such as a backhoe. Soil removed from the trench, known as spoils, will be placed alongside the trench (on the ground and/or in bins) and/or loaded directly into haul vehicles. When placed next to the trench the spoil will be far enough away from the edge so as not to cause cave-in of the excavation. Where space is limited and/or spoil requires processing, spoil will be loaded into haul vehicles and transported to nearby staging areas. If applicable and where required, topsoil will be segregated from other soil and saved. Excavated soil that can be reused as backfill material will be segregated and stored/stockpiled onsite until backfilling. Methods such as sloping, benching, and/or shoring may be required to prevent the trench walls from caving in and allow construction to proceed in a safe manner and to comply with governmental regulations.

The presence of an open trench near potential gartersnake habitat increases the potential for entrapment and inadvertent burial of gartersnakes. This increase hazard to gartersnakes will be minimized when working in the southern portion of Topock Marsh by limiting the size of the open trench in this area and by following the mitigation measures outlined in this letter including mandatory trench inspections for the presence of snakes at the beginning, middle and end of each day (at a minimum) and directly before backfilling.

Any new monitoring wells would be located outside the habitat for northern Mexican gartersnake to the extent technically feasible but may need to be located near or within habitat. However, adverse effects for work being conducted in this area can be avoided by implementing conservation measures, as described in Section 3.4 of the 2014 PBA, and by implementing mitigation measures listed below to avoid inadvertent impacts to the northern Mexican gartersnake. Furthermore, the regular disturbances from recreational boating at Topock Marina and from traffic along the Oatman-Topock Highway make the potential for negative effects to northern Mexican gartersnake very low. Based on the location of project activities and the fragmented distribution, composition and structure of habitat conditions in or adjacent to the Action Area; and the continued implementation of conservation measures identified in Section 3.4 of the 2014 PBA (CH2MHILL 2014) and as listed above, any potential direct or indirect effects from project activities are likely to be either negligible or avoidable. Therefore, the proposed action may affect, but is not likely to adversely affect the northern Mexican gartersnake.

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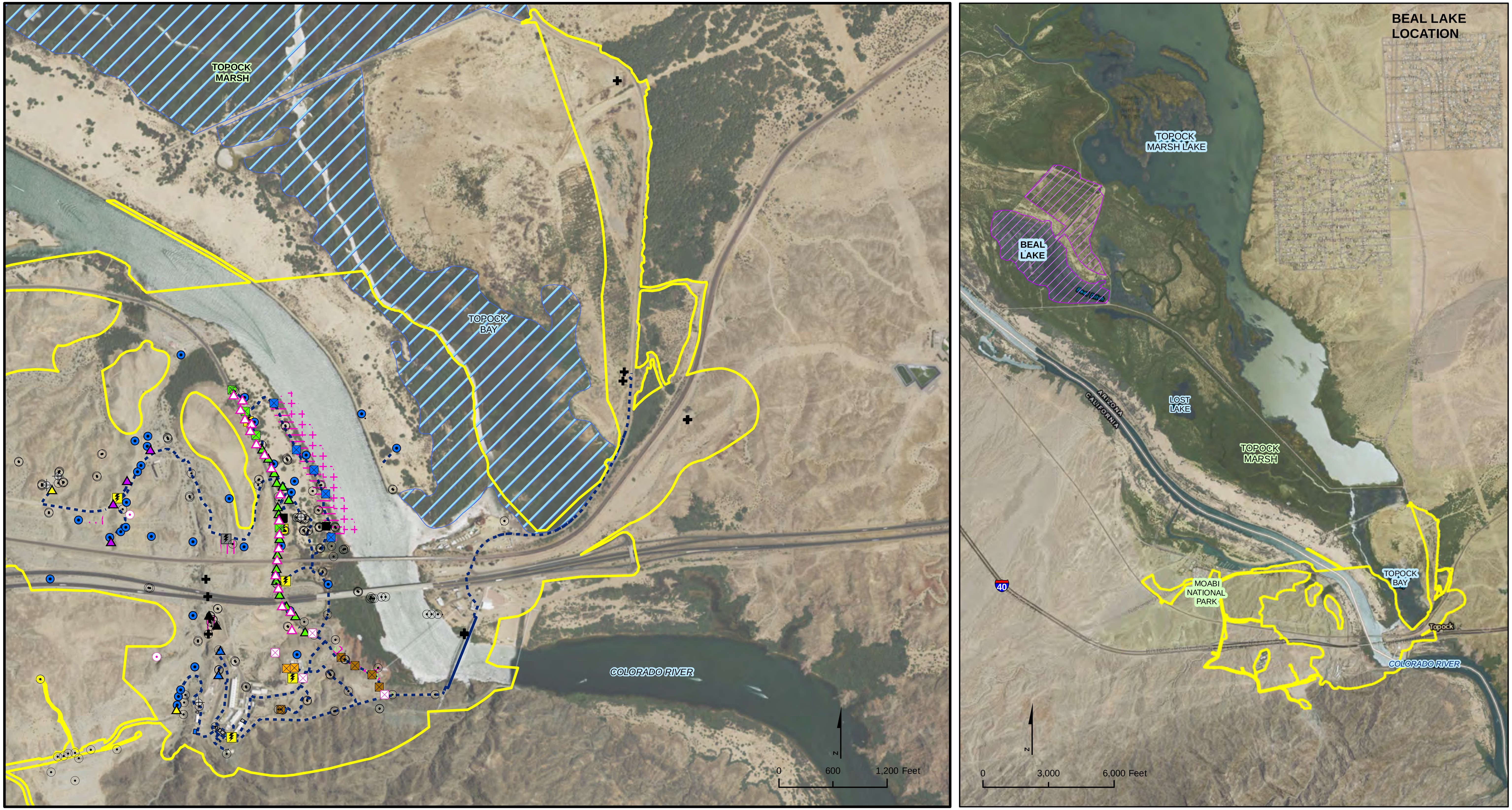

LEGEND

Potential Northern Mexican Gartersnake Habitat
Beal Lake Conservation Area
Action Area

Existing Wells:
- Extraction Well
- Injection Well
- Monitoring Well
- Water Supply Well

(Items in Pink are Provisional)
- Extraction Well
- Injection Well
- Monitoring Well

Planned Wells:
- Extraction, East Ravine
- Extraction, National Trails Highway (NTH) In-situ Reactive Zone (IRZ)
- Extraction, Riverbank
- Extraction, Transwestern Bench
- Injection, Freshwater
- Injection, Inner Recirculation Loop
- Injection, NTH IRZ
- Injection, Topock Compressor Station
- Remedy Monitoring Well
- Recirculation Well

Well Areas

Planned
- Area for Monitoring Well MW-T

Provisional
- Area for East Ravine (ER) Wells and Piezometer
- Area for Potential Slant Well Screens
- Area for Inner Recirculation Loop (IRL) Wells
- Area for River Bank Extraction Wells

Remedy Facilities
- Planned Transformer
- Future Provisional Transformer
- Proposed Remedy Structure
- Contingent Freshwater Pre-injection Treatment System
- New Compressor Station buildings (not part of Remedy)

Pipeline Corridor for Remedy
- Aboveground Pipe
- Underground Pipe/Conduit

FIGURE 1
ACTION AREA WITH FACILITIES NEAR TOPOCK MARSH

PG&E TOPOCK GROUNDWATER REMEDY
PG&E TOPOCK COMPRESSOR STATION,
NEEDLES, CALIFORNIA

CH2MHILL

Path: \\Brookside\GIS_SHARE\ENBG\00_Proj\P\PGE\Topock\MapFiles\2016\EIR\Figure1_DesignatedPotentialCriticalHabitat_v2.mxd

BOD Appendix B
Development of Groundwater Flow and Solute Transport Models

- New report added: *Development of Groundwater Flow and Solute Transport Models* (ARCADIS 2016)

Pacific Gas & Electric

DEVELOPMENT OF GROUNDWATER FLOW AND SOLUTE TRANSPORT MODELS

Pacific Gas & Electric

Topock Compressor Station

Needles, California

February 2016

,

DEVELOPMENT OF GROUNDWATER FLOW AND SOLUTE TRANSPORT MODELS

TOPOCK COMPRESSOR STATION

NEEDLES, CALIFORNIA

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Date:

February 29, 2016

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ACRONYMS AND ABBREVIATIONS

bgs	below ground surface
CMS/FS	Corrective Measures Study/Feasibility Study
Cr(IIII)	trivalent chromium
Cr(VI)	hexavalent chromium
CSM	conceptual site model
ft^2	square feet
ft^3	cubic feet
ft/ft	foot per foot
Floodplain ISPT Final Completion Report	Floodplain Reductive Zone In-Situ Pilot Test Final Completion Report
gpm	gallons per minute
IM	interim measure
IRL	Inner Recirculation Loop
IRZ	in-site reactive zone
ISPT	in-situ pilot test
kg/day	kilograms per day
L/kg	liters per kilogram
m^2/g	square meters per gram
mg	milligram
mg/kg	milligrams per kilogram
mg/L	milligrams per liter
msl	mean sea level
MTC	mass transfer coefficient
mV	millivolt
ng/L	nanograms per liter
NTH	National Trails Highway
ORP	oxidation-reduction potential
PG&E	Pacific Gas and Electric Company
redox	oxidation-reduction

SCM	surface complexation model
TCS	Topock Compressor Station
TDS	total dissolved solid
TOC	total organic carbon
µg/L	micrograms per liter
USEPA	United States Environmental Protection Agency

EXECUTIVE SUMMARY

Pacific Gas and Electric Company (PG&E) is implementing the selected groundwater remedy for chromium in groundwater at the PG&E Topock Compressor Station (TCS, or the Compressor Station) in San Bernardino County, California. Remedial activities at the Topock site are being performed in conformance with the requirements of the Resource Conservation and Recovery Act (RCRA) Corrective Action pursuant to a Corrective Action Consent Agreement (CACA) entered into by PG&E and the California Department of Toxic Substances Control (DTSC) in 1996. In addition, PG&E and the United States executed a Remedial Design/Remedial Action Consent Decree (CD), on behalf of the Department of the Interior (DOI), under the Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA) in 2012, which was approved by the U.S. District Court for the Central District of California in November 2013. The TCS is approximately 1,500 feet west of the Colorado River and ½ mile west of Topock, Arizona. This document, Development of Groundwater Flow and Solute Transport documents the updates made to the groundwater flow and solute transport models that were constructed for the Site as documented in Appendix B of the 100% Basis of Design (Arcadis, 2015). These updates were conducted in compliance with the DOI and DTSC Final Design Directives dated October 19, 2016. The groundwater flow and solute transport model were developed to evaluate the subsurface flow conditions; including the fate and transport of Cr(VI), manganese, and arsenic.

The major components of the updated groundwater flow and solute transport model are presented in this document. Updates to the regional groundwater flow model include lithologic and hydraulic data that had become available since the original calibration (as described in the 30%, 60%, 90%, and 100% basis of design documents), expansion of the regional flow model domain, and conversion of the regional flow model from MicroFEM to MODFLOW in order to directly conduct solute transport analyses without having to extract a submodel. Geochemical modeling (batch and one-dimensional transport simulations) conducted for the 100% basis of design document were utilized to evaluate the anticipated behavior of reactive species during remedy implementation, including TOC, Cr(VI), and byproducts as a function of groundwater geochemistry and aquifer properties. These focused geochemical evaluations were conducted to characterize known geochemical reactions that will occur and to aid in the estimation of parameters used in the site-wide solute transport model. The geochemical modeling was also conducted to test the validity of the site-wide solute transport model in describing Cr(VI) reduction and byproduct dynamics. Solute transport modeling was performed to evaluate the migration and fate of Cr(VI) detected in the groundwater, the fate and transport of select potential IRZ byproducts (manganese and arsenic), and the fate and transport of arsenic associated with the freshwater source injected into the uplands. The solute transport model used the flow results from the calibrated groundwater flow model to simulate solute transport under average flow conditions. Finally, a detailed sensitivity analysis was conducted to evaluate the effects of varying hydraulic parameters on the calibration of the groundwater flow model.

Based on this update of the groundwater flow model and associated solute transport modeling, the solute transport model results indicates that the planned remedy will be effective in remediating the current Cr(VI) plume distribution while minimizing the potential adverse impacts from byproduct generation. This solute transport model can be utilized as a tool to evaluate potential remedial options and supplements monitoring of the implemented remedial system to measure its effectiveness. During installation and implementation of the remedial system, the additional hydrogeologic and groundwater quality data

generated can be utilized to update the groundwater flow and transport models to improve their effectiveness as tools for further understanding site conditions and optimizing the remedy performance.

1 INTRODUCTION AND OBJECTIVES

1.1 General

This report has been prepared for Pacific Gas and Electric Company (PG&E) to present a conceptual Site model (CSM), a calibrated groundwater flow model, sensitivity analyses, and a solute transport model for the PG&E Topock Compressor Station (TCS, or the Compressor Station) in San Bernardino County, California (Figure 1-1).

1.2 Site Location and Description

Remedial activities at the Topock Site are being performed in conformance with the requirements of the Resource Conservation and Recovery Act (RCRA) Corrective Action pursuant to a Corrective Action Consent Agreement (CACA) entered into by PG&E and the California Department of Toxic Substances Control (DTSC) in 1996. In addition, PG&E and the United States executed a Remedial Design/Remedial Action Consent Decree (CD), on behalf of the Department of the Interior (DOI), under the Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA) in 2012, which was approved by the U.S. District Court for the Central District of California in November 2013. The TCS is approximately 1,500 feet west of the Colorado River and ½ mile west of Topock, Arizona.

1.3 Report Objectives and Organization

The objectives of this modeling study were to develop a groundwater flow and solute transport model for use as follows:

- Expand the domain of the regional groundwater flow model and convert the regional groundwater flow model from MicroFEM to MODFLOW;
- Restructure the groundwater flow model to more accurately simulate the interaction between the alluvial aquifer and bedrock with respect to solute transport;
- Identify the major hydrostratigraphic units and represent these units with distinct hydraulic conductivity zones;
- Conduct detailed steady state and transient groundwater flow model calibrations to refine hydraulic parameter values;
- Conduct a sensitivity analysis to evaluate the hydraulic parameters utilized in the groundwater flow model; and
- Evaluate the remedial design from the 100% basis of design with the updated groundwater flow and solute transport model with respect to transport of hexavalent chromium, byproduct manganese, byproduct arsenic, and arsenic associated with freshwater injection in the uplands.

This document describes the results of four major components of the modeling study at the Site:

- updates to and the development of the groundwater flow model
- calibration of the groundwater flow model

- development of the solute transport model
- remediation system analysis

The above components are presented in the following sections of the report:

- Section 2 – Conceptual Site Model (CSM)
- Section 3 – Groundwater Flow Model Development
- Section 4 – Solute Transport Model Development
- Section 5 – Solute Transport Model Results
- Section 6 – Model Uncertainty
- Section 7 – Model Update Procedure

2 CONCEPTUAL SITE MODEL

A CSM is a description of the key components and processes underlying a physical system and provides a framework for the Site. In the case of the Topock Site, the CSM describes the hydrogeology and associated geochemistry and utilizes a basic framework of Source-Pathway-Receptor to describe how contaminants enter an environmental system (source), migrate within it (pathway), and eventually reach their ultimate receptors (receptor). The CSM serves as the basis for quantitative modeling of groundwater flow and contaminant fate and transport that simulates the operation of the remediation system; and it provides the foundational framework for the design and operation of the remediation system

2.1 Site Geology and Hydrogeology

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The conceptual model for groundwater flow herein is a narrative description of the principal components of the groundwater flow system developed from regional, local, and Site-specific data. The primary components of the groundwater flow system include: (1) areal extent, configuration, and types of aquifers and aquitards; (2) hydraulic properties of aquifers and aquitards; (3) natural groundwater recharge and discharge zones; (4) anthropogenic influence on groundwater (sources and sinks); and (5) areal and vertical distribution of groundwater hydraulic head potential. These aquifer system components serve as the framework for the construction of the numerical groundwater flow model (described in Section 3). Sections 2.2 and 2.3, below, describe the regional and Site hydrogeology, respectively.

2.2 Geology

The Site is situated in a basin-and-range geologic environment in the Mohave Valley. The Colorado River is the main source of water to this groundwater basin, but at the southern end where the Site is located, groundwater is also fed by a relatively modest amount of local recharge from mountain runoff. The most prominent geologic structural feature in the area of the Site is a Miocene-age, low-angle normal fault (referred to as a detachment fault) that forms the northern boundary of the Chemehuevi Mountains that are located to the southeast of the Site. The surface expression of the Chemehuevi detachment fault is evident as a pronounced northeast-southwest linear feature that can be traced along the northern boundary of the Chemehuevi Mountains, terminating at the abrupt bend in the Colorado River east of the TCS. The exposed Chemehuevi Mountains are Precambrian- and Mesozoic-age metamorphic and igneous rocks formed by tectonic uplift along the present-day trace of the Chemehuevi detachment fault.

Sedimentary deposits in the area are comprised of Pliocene lacustrine deposits, Tertiary- and Quaternary-age to recent alluvial fan deposits, and fluvial deposits of the Colorado River. The younger Colorado River fluvial deposits occur at the Site within the saturated zone underlying the floodplain, the present river channel, and the associated marsh area (Metzger and Loeltz 1973; Howard et al. 1997).

2.2.1 Hydrostratigraphic Units

There are ten characteristic hydrostratigraphic units (HSUs) in the region (Table 2.2-1) (CH2M Hill, 2006b).

Table 2.2--1 Hydrostratigraphic Units

Index	Stratigraphic Age	Site HSU	Deposit	Description	Characteristics
1	Holocene	Qr3	Fluvial	Upper Fluvial Sand and Silt	Unconsolidated sand and silty sand (no gravel), massive bedded, very well sorted; contains fine grained organic matter
2		Qr2	Fluvial	Middle Fluvial Deposits	Interbedded unconsolidated sand, clay, and minor gravelly sand; clay/silt lenses exhibit both brown and gray (reduced) appearance
3		Qr1	Fluvial	Lower Fluvial Deposits	Unconsolidated sandy gravel and gravelly sand with minor silty gravel (gravel content greater than 15%); subrounded to very well-rounded pebbles and cobbles from distant sources and fluvial deposits
4		Qr0	Fluvial	Colorado River Channel Fill	Fluvial channel fill sediments that occur below elevation 360 ft msl (deepest river deposits encountered in floodplain borings). Per Caltrans I-40 bridge borings includes moderately consolidated to dense, fine to coarse sand and sandy gravel
5	Pleistocene	Qoa	Alluvium	Older Quaternary Alluvium	Unconsolidated sandy gravel and silty/clayey gravel (alluvial fan deposits). Comprises moderately-dissected alluvial terraces' terrace/wash slopes are moderate angle (i.e., 45 degrees)
6	Pliocene	Tb	Alluvium	Bouse Formation	Pre-Colorado River lacustrine and deltaic deposits (well bedded, moderately indurated, green clay, siliceous claystone, sandstone, and basal marl)
7	Pliocene to Late Miocene	Toa2	Alluvium	Tertiary Alluvium - Upper	Moderately consolidated sandy gravel, gravelly sand, and silty/clayey gravel (oldest alluvial fan deposits). Comprises deeply-dissected alluvial terraces; terrace canyon walls are vertical/steep (Subdivision of Toa2 and Toa1 based on contrasts in hydraulic conductivity observed in TW-1, TW-2D, and IW-1).
8		Toa1	Alluvium	Tertiary Alluvium - Lower	

9	Late Miocene	Toa0	Alluvium	Basal Alluvium	Moderately consolidated silty sand, clayey/silty gravel, and minor gravelly sand. Consists of 100% reddish detritus of Miocene conglomerate in floodplain area. In other areas, Toa0 is well-consolidated alluvium, lacks reddish-color, and exhibits high-induction geophysical log response
10	Middle Miocene Pre-tertiary	Bedrock	Bedrock	Miocene Conglomerate Metamorphic/ Igneous Bedrock	Consolidated conglomerate, sandstone, metadiorite, gneiss, and granitic bedrock

2.2.1.1 Fluvial (River) Deposits

The Colorado River deposits (or fluvial deposits) lie from the Topock floodplain eastward to the edge of Topock Bay and Topock Marsh. The thickness of the fluvial deposits ranges from near zero to approximately 250 feet observed in the river seismic survey conducted by the USGS (Peter Martin, Technical Work Group meeting communications 2004). Four HSUs comprise the fluvial deposits: Qr3, Qr2, Qr1, and Qr0 (from the youngest to the oldest).

2.2.1.2 Quaternary Alluvium (Qoa)

The quaternary alluvial deposits overlie the Bouse Formation, where the Bouse Formation is present. Where the Bouse Formation is not present, the Quaternary and Tertiary Alluvial deposits are virtually indistinguishable in site borings. However, in outcrops, the difference between the Quaternary and Tertiary Alluvial deposits is the Quaternary Alluvium has a moderate angle (around 45 degrees).

2.2.1.3 Bouse Formation

The Bouse Formation is located in the western portion of the model domain and consists of interbedded clay, claystone, and sandstone. This formation represents a lacustrine deposit left by a large portion of the Mohave Valley (Howard et al, 1997). However, much of the Bouse Formation was eroded away during the Pleistocene and Holocene Epochs. In Site boring logs, no saturated portion of the Bouse Formation has been encountered.

2.2.1.4 Tertiary Alluvium

The tertiary alluvium consists of sandy gravel and silty/clayey gravel. The tertiary alluvium was divided into lower and upper units based on hydraulic permeability contrasts observed in well testing and variations in geophysical log responses.

2.2.1.5 Basal Alluvium

The basal alluvium has previously been described as either the “Basal Saline Unit” or “reworked Miocene Conglomerate” (CH2M Hill, 2006b). Geophysical induction logging indicates that there is much higher salinity and finer grained material in the basal alluvium than in most of the tertiary alluvium.

2.2.1.6 Bedrock

The bedrock at the Site consists of Pre-Tertiary igneous and metamorphic rock and the Miocene conglomerate. In general, both bedrock units are considered to produce very little water and to be locally fractured (CH2M Hill, 2006b). There is an upward hydraulic gradient between the bedrock units and the alluvial units.

2.3 Hydrogeology

The Site is located at the southern (downstream) end of the Mohave Valley groundwater basin. On a regional scale, groundwater in the northern and central area of the valley is recharged primarily by the Colorado River, while under natural conditions net groundwater discharges occur in the southern area, above where the alluvial aquifer thins near the entrance to Topock Gorge. Regional groundwater flow occurs from north to south, following the direction of flow in the Colorado River. The groundwater directly beneath the Site is derived mostly from the relatively small recharge from the nearby mountains. Under natural conditions, groundwater flows from west/southwest to east/northeast across the Site.

The Colorado River is 1,500 feet east of the TCS with a mean elevation of approximately 450 feet above mean sea level (msl). The TCS is at an elevation of approximately 600 feet above msl on an extensive alluvial terrace that is locally incised by erosional channels formed by surface runoff. Thus, the surface slope is generally toward the river from areas west of the river. Bat Cave Wash, a large north-south erosional channel adjacent to the TCS, only has surface-water flow after large precipitation events. The stretch of the Colorado River east of the Site is 600 to 700 feet wide. Flow in the river fluctuates daily and seasonally due to upstream-regulated water releases by the Bureau of Reclamation at Davis Dam on Lake Mohave. Measured flows range from 4,000 to 25,000 cubic feet per second, and river levels fluctuate between 2 and 3 feet within a single day, depending on the time of year.

Groundwater occurs in the Tertiary-age and younger alluvial fan and fluvial deposits. These deposits are unconsolidated alluvial and fluvial deposits and are underlain by the Miocene-age conglomerate, which is consolidated, and pre-Tertiary-age metamorphic and igneous rocks. Both the conglomerate and igneous/metamorphic units are considered to be bedrock at the Site. The bedrock typically has lower permeability; therefore groundwater movement occurs primarily in the overlying unconsolidated deposits. There is no evidence to indicate any sizable potential for development of groundwater in the bedrock, although locally, small yields may be developed from fractures (Metzger and Loeltz 1973).

This conceptual framework for the bedrock system is supported by recent investigation work in the East Ravine and TCS areas. Of the 17 boreholes that have been drilled into appreciable depths within the bedrock in the East Ravine and TCS areas, only two boreholes, MW-57-185 and MW-70BR-225 (which are both located in close proximity to the approximate bedrock/alluvial aquifer contact at elevation 455 feet above msl), have yielded enough groundwater to sustain pumping for relatively low-volume hydraulic testing. During the test at MW-57-185 (pumped at approximately 3 gallons per minute [gpm] for 7 hours), approximately 78 feet of drawdown was observed within the pumping well, while drawdown of more than 0.05 foot was observed in only one of the seven observations wells (MW-58BR, 0.07 foot). Drawdown in the other six bedrock observation wells was less than 0.05 foot. During the test at MW-70BR-225 (pumped at approximately 9 gpm for 12 hours), approximately 34 feet of drawdown was observed in the pumping well, while drawdown of more than 0.05 foot was observed in only one of the 10 bedrock observation wells (MW-58BR, 0.18 foot).[1] Drawdown in the other nine bedrock observation wells was less than 0.05 foot. During both tests, the yield from the bedrock was insufficient to induce measurable drawdown in wells screened within the unconsolidated alluvial sediments. All other Site bedrock monitoring wells yield very small quantities of groundwater, with several that have become dewatered during routine sampling. These data are consistent with the regional hydrogeology.

The alluvial aquifer within the groundwater basin and beneath the Site consists of: (1) unconsolidated alluvial sands and gravels shed from local mountain ranges that ring the valley and (2) unconsolidated fluvial material deposited by the Colorado River. Groundwater occurs under unconfined to semi-confined conditions within the alluvial and fluvial sediments beneath most of the Site. The alluvial sediments consist primarily of silty sand and gravel deposits (with a relatively minor amount of clay) interfingered with more permeable sand and gravel deposits. The alluvial deposits exhibit an expected 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 water table in the alluvial aquifer is nearly flat and typically equilibrates to an elevation within 3 feet of the river level. Due to the variable topography, the depth to groundwater ranges from as shallow as 5 feet below ground surface (bgs) in the floodplain near the river to approximately 170 feet bgs in the upland alluvial terrace areas. The saturated thickness of the alluvial aquifer is approximately 100 feet in the floodplain and thins to the south, pinching out along locations where the Miocene Conglomerate and igneous/metamorphic rocks outcrop. In the western and northern portions of the Site, where the depth to bedrock increases, the saturated thickness of the alluvial aquifer is over 200 feet.

Several other important hydrogeologic features of the Site are summarized below:

- Under ambient conditions in the vicinity of the Site, the Colorado River recharges groundwater during the higher-flow stages in the spring and summer months, and discharges groundwater to the river during the months of lower river stages in fall and winter. Since 2004, the Interim Measure (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 (i.e., maintains a situation where the river discharges to groundwater). The hydraulic gradient imposed by IM-3 pumping is measured in three pairs of monitoring wells. Over the period from August 2007 through December 2011, the average landward gradient in these three well pairs was approximately 0.005 foot per foot (ft/ft).
- Under natural conditions, groundwater flow is generally from the west-southwest to east-northeast across the Site. Localized areas of northward flow likely occur along the mountain front to the south of the TCS. Hydraulic gradients are very small due to the limited recharge, with a typical value of 0.0005 ft/ft in the alluvial area. Under average conditions, groundwater velocity in the alluvial aquifer ranges from approximately 25 to 46 feet per year, according to numerical model estimates. The

[1] This excludes drawdown observed in the water-table well adjacent to pumping well (MW-70-105), which showed a dewatering trend during the test.

vertical component of the hydraulic gradient is upward between bedrock and the overlying alluvial aquifer and typically, but not universally, upward within the alluvial aquifer.

Groundwater level monitoring in the East Ravine area indicates 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 very low, based on well tests in this area.

The unconsolidated aquifer consists of alluvial sands and gravels derived primarily from the metadiorite and gneissic rocks from the mountains that ring the groundwater basin, as well as fluvial material deposited by the Colorado River over time. These materials govern the observed groundwater geochemistry at the Site. A detailed description of the general groundwater quality and geochemistry at the Site can be found in the RCRA Facility Investigation/Remedial Investigation Report (CH2M HILL 2009a); a brief summary is provided herein.

2.4 Site Geochemistry

The groundwater at the Site is a sodium chloride-dominated type with highly variable total dissolved solid (TDS), varying from less than 1,000 milligrams per liter (mg/L) to greater than 10,000 mg/L. The most frequent values range between approximately 4,000 (33rd percentile) to 7,000 mg/L (66th percentile) and the median value is approximately 5,000 mg/L based on the most recent Site-wide TDS data collected through December 31, 2013. In general, higher TDS levels are encountered in deeper alluvial wells and a few shallow fluvial wells near the alluvium-bedrock interface. Groundwater TDS generally increases with depth throughout the Site. There are 30 Site well clusters that show this trend, and the average TDS increase between shallow and deep zones in these clusters is approximately 6,600 mg/L, with only seven clusters showing a difference greater than 10,000 mg/L. Groundwater density is proportional to TDS, and significant differences in density over the saturated thickness can cause non-uniform injected flow (Ward et al., 2008). However, the TDS ranges in Topock Site profiles are not expected to be large enough to cause issues in the remedy application.

The groundwater pH generally ranges between 7 and 8.5 and alkalinity is typically between 30 and 300 mg/L as calcium carbonate (although values as high as 800 to 1,000 mg/L have been measured in some areas).

Although the alluvial fan and fluvial deposits are of different origin, groundwater flows from the alluvial fan sediments into the fluvial zone sediments; therefore, the groundwater geochemistry in the fluvial zone is strongly influenced by alluvial groundwater geochemistry. One important difference between alluvial and fluvial zones is the presence of a reducing environment in shallow and mid-depth fluvial zones located within the Colorado River floodplain, caused by organic material deposited with the sediment. This reducing zone is characterized by generally lower levels of oxidation-reduction potential (ORP). Alluvial fan zones at the Site tend to exhibit ORP levels in the 0 to 300 millivolt (mV) range, while groundwater in the floodplain “reducing rind” fluvial aquifer can exhibit values in the -220 to -90 mV range, sufficiently reducing for Cr(VI) reduction. This reducing rind exists in the shallow portion of the fluvial aquifer, extending 200 to 500 feet away from the riverbank, generally getting thicker (i.e., penetrating deeper) with proximity to the river. The reducing rind correlates with decreases in nitrate concentrations, which is detected across the Site at concentrations ranging up to 20 mg/L NO_3-N in the alluvial aquifer, but is non-detect in most areas of the reducing rind. Higher dissolved concentrations of manganese, iron, and organic carbon in the floodplain are also consistent with the more strongly reducing environment resulting from organic deposition (greater than 5 mg/L manganese and greater than 10 mg/L iron in some monitoring wells). These higher concentrations of manganese and iron are due to the reductive dissolution of naturally occurring iron and manganese oxides present within the floodplain. Hexavalent chromium is not stable under these conditions and is reduced to trivalent chromium, which is removed from solution as a stable hydroxide precipitate.

The boundary of this reducing rind is defined herein using multiple geochemical oxidation-reduction (redox) indicators, including nitrate, dissolved iron, organic carbon, and ORP. Generally, ORP is not as reliable an indicator of reducing conditions as the direct measurement of the concentration of other redox indicators, most notably nitrate and dissolved iron. The determination of ORP is based upon field electrode measurements, and these are more likely to be subject to measurement error than measurement of concentrations of redox indicators, such as iron and manganese. A cutoff of -90 mV is used herein as a flag to determine where conditions are likely not sufficient for sustained Cr(VI) reduction. This criterion yields the reducing rind boundaries for model layers 1 and 2 in regions where these model layers pass through the fluvial aquifer, as described in the 100% BOD Report, Section 6.4 (Arcadis, 2015).

In contrast, ORP values below -90 mV were not assumed to be sufficient for delineating the reducing rind outside of the fluvial aquifer. Specifically, although ORP values below -90 mV were observed in alluvial wells lining the riverbank, the reducing rind was assumed to stop at the boundary between fluvial and alluvial aquifers. This is based on the observation that the alluvial aquifer does not exhibit the same levels of organic carbon and dissolved iron as the fluvial aquifer. Details regarding correlation between total organic carbon (TOC) and dissolved iron with ORP can be found in the 100% BOD Report (Arcadis, 2015).

3 GROUNDWATER FLOW MODEL DEVELOPMENT

3.1 Model Code Selection and Description

MODFLOW simulates transient, three-dimensional groundwater flow through porous media described by the following partial differential equation for a constant density fluid (Freeze and Cherry, 1979):

$$\frac{\partial}{\partial x}\left(K_{xx}\frac{\partial h}{\partial x}\right)+\frac{\partial}{\partial y}\left(K_{yy}\frac{\partial h}{\partial y}\right)+\frac{\partial}{\partial z}\left(K_{zz}\frac{\partial h}{\partial z}\right)-W=S_s\frac{\partial h}{\partial t} \quad (1)$$

where:

K_{xx}, $K_{yy,}$ and K_{zz} are values of hydraulic conductivity along the x, y, and z coordinate axes, which are assumed to be parallel to the major axes of hydraulic conductivity [L/T]

h is the potentiometric head [L]

W is a volumetric flux and represents sources and/or sinks of water [1/T]

S_s is the specific storage of the porous material [1/L]

t is time [T]

In Equation 1, the hydraulic parameters (i.e., K_{xx}, K_{yy}, K_{zz}, and S_s) may vary in space but not in time, while the source/sink (W) terms may vary both in space and time. The Preconditioned Conjugate Gradient (PCG) solver (Hill, 1990) was used to solve the groundwater flow equation within MODFLOW.

3.2 Model Domain and Grid

The numerical flow model domain is three-dimensional, consisting of 425 rows, 389 columns, and 10 layers. The model domain and grid is presented in Figure 3.2-1. The model consists of 1,653,250 total cells, covering an area of approximately 30,500 acres (47.7 square miles). The grid cell size varies throughout the model domain, with increased resolution in the Site area, with the grid cell size as small as 25 feet by 25 feet. The grid spacing increases up to 200 feet at the model extents. The model grid axes were rotated 45 degrees counter-clockwise to align the major axes of the model with the major direction of anisotropy.

The model was vertically discretized into 10 layers. The bottom of each layer is flat, except for model layers 9 and 10, which vary in elevation, as detailed in Table 3.2-1. Detailed cross sections showing the model layers, planned remedial wells, and monitoring wells are shown in Figures 3.2-2 to 3.2-8.

Table 3.2-1 Model Vertical Structure

Model Layer	Bottom Elevation (ft msl)	Saturated Thickness (ft)
1	425	~30
2	400	25
3	350	50
4	300	50
5	250	50
6	200	50
7	150	50
8	100	50
9	< -200	300+
10	< -500	300

3.3 Boundary Conditions

Boundary conditions must be imposed to define the spatial boundaries of the top, bottom, and all sides of the model grid. Additionally, boundary conditions can be assigned to represent different types of physical features, depending on the rules that govern groundwater flow related to the features. The groundwater flow model features 5 types of boundary conditions: no-flow boundary cells, constant-head cells, river cells, constant flux, and pumping wells.

The main source of groundwater beneath Mohave Valley is derived from the Colorado River (Metzger and Loeltz 1973). The river naturally loses water in the northern part of the valley, feeding alluvial aquifers to the east and west. In the southern part of the valley, the regional groundwater of the valley returns to the river as discharge as the aquifer thins southward. At Needles, a portion of the Colorado River flow is diverted to Topock Marsh. The water supports wetlands over an 8-mile stretch to the east of the river, and the excess water returns to the river either by direct flow or by infiltration into groundwater. The model domain cuts through the northern portion of the marsh, and a constant head boundary is assigned for the northern boundary. River cells were used to simulate the Colorado River and the Topock Bay and Topock Marsh. The river stages in the Topock Bay and Marsh were held constant and corresponds to the average head maintained by the Havasu National Wildlife Refuge, as reported in Guay (2001). The stage of the Colorado River was determined by average stage values measured at I-3 and interpolated based on gradients determined between Davis Dam and Parker Dam. River bed elevations were based on the river seismic survey data and extending the observed slope into areas where no data were collected (CH2M Hill, 2006b).

On the west side of the river, groundwater enters the model at the northern boundary to simulate regional down-valley flow and exits at the river (natural discharge). The regional down-valley flow is simulated as a constant head boundary condition along the northwestern model boundary. This provides a constant southward flux of water into the model domain. A constant head condition was used because the flow into the northern model area is regionally-derived, providing a relatively large amount of water that is not assumed to be affected by pumping conditions within the model domain. The head value used in the model corresponds to the estimated river level at the model boundary. A constant head boundary condition is also assigned to the narrow section of aquifer that exists directly beneath the river channel on the southern model boundary (CH2M Hill, 2006b). The remainder of the southern boundary is assigned as a no-flow boundary because it is all considered competent bedrock, which is assumed to allow very limited groundwater flow (Metzger and Loeltz 1973).

The majority of the eastern and western boundaries of the model are assigned as no-flow boundaries, since they are essentially parallel to the regional flow direction. One exception is a short section of constant flux boundaries used to simulate underflows associated with washes that enter the model domain from the west in the alluvium. This type of boundary condition is assigned in cases where either the flux is considered to be well-quantified or is assumed to be relatively small (i.e. non-regional). The latter condition determined the constant flux condition in the case of this model (CH2M Hill, 2006b). Another exception is the simulation of constant flux boundaries assigned in the southwestern extent of the model to represent the groundwater flux received from precipitation in the Chemehuevi Mountains located to the south of the Site. Pumping wells simulating the regional extraction wells for Golden Shores, Topock 2, Topock 3, and Park Moabi were also incorporated in the model. Boundary conditions are shown for model layer 1 in Figure 3.3-1.

3.4 Hydraulic Parameters

3.4.1 Hydraulic Conductivity

The interpolated bedrock surface elevation and the thicknesses of the hydrostratigraphic units were utilized to determine where the individual hydrostratigraphic units intercepted the revised model layer structure. The hydrostratigraphic unit extents present in each model layer were used to define the hydraulic conductivity zonation. The hydrostratigraphic units for each model layer are shown in Figures 3.4-1 to Figure 3.4-2. Initial hydraulic conductivity values for the individual hydrostratigraphic units were assigned based on available aquifer test data. These initial values were further refined during the calibration process through manual adjustment and automatic parameter estimation using PEST. Hydraulic conductivity was allowed to vary within the range of recorded aquifer test values and previously modelled values using professional judgment. As there was limited regional hydraulic conductivity data available for the full model domain and the majority of the calibration targets are located in the immediate vicinity of the Site, the regional hydraulic conductivity values were dependent on the available Site data. The initial calibration of the model to single hydraulic conductivity values for each hydrostratigraphic unit was then allowed to vary within each hydrostratigraphic unit by generating a stochastic distribution of hydraulic conductivity. A two-dimensional spatially correlated log normal conductivity field was generated for the model using a Gaussian power spectrum (Robin et al, 1993). The distribution was constrained within the range of potential hydraulic conductivity values and the distribution was varied by layer to represent the vertical heterogeneity between hydrostratoigraphic units that span multiple model layers. While the hydraulic conductivity pattern and values varied within each hydrostratigraphic unit, the average value for each hydrostratigraphic unit was still consistent with calibrated values. The use of these random generated fields allows for potential uncertainties associated with heterogeneities encountered in the aquifer while maintaining a well calibrated model. The hydraulic conductivity distributions per model layer are shown in Figures 3.4-3 to 3.4-4. Vertical hydraulic conductivity was not a sensitive parameter during the calibration and sensitivity analyses, so a horizontal to vertical hydraulic conductivity ratio of 10:1 was utilized throughout the model domain.

3.4.2 Evapotranspiration

Direct evapotranspiration of groundwater is also modeled with a specific outward flux assigned to selected model nodes that varies with depth of the water table from land surface. A maximum evapotranspiration flux is assigned to each node, along with an “extinction depth,” which is the depth beneath the ground surface at which evapotranspiration flux equals zero. This is usually assumed to be the maximum effective root depth for plants in the area. The flux of water actually removed from each nodal area depends on the depth of the water table at that location. The maximum assigned evapotranspiration rate is applied when the water table elevation equals the land surface. Calculated flux decreases linearly from the maximum flux at ground surface to zero at the extinction depth. The water table must be above the extinction depth for any water to be removed by evapotranspiration in the simulations. A nominal maximum evapotranspiration rate has been applied to all model nodes, but only nodes close to the Colorado River have a water table depth shallow enough for evapotranspiration to be active. A greater maximum evapotranspiration rate has been assigned in areas of more dense vegetation, notably the mouth of Bat Cave Wash and the southern part of the floodplain (CH2M Hill, 2006b). The evapotranspiration distribution is show in Figure 3.4-5.

3.4.3 Recharge

Rainfall associated with the Chemehuevi Mountains area was accounted for using constant flux boundaries in the southwest corner of the groundwater flow model. In the mountain areas of the model, all layers are assigned bedrock properties. Recharge in these areas is assumed to infiltrate through fractures and weathered bedrock surfaces and emerge near the mountain front. The model allows flow through the bedrock unit, eventually intersecting the more permeable alluvial HSUs to the north of the recharge area. This recharge mechanism result is a mildly upward gradient into the alluvium, as observed on the site at well cluster MW-24. No rainfall recharge is assigned to other areas of the model because the very small amount of rainfall in the lower elevations (less than 5 inches per year) is assumed to evaporate before infiltrating to groundwater (CH2M Hill, 2006b). The published estimate of rainfall in the mountain areas is around 10 inches per year (Metzger and Loeltz 1973), and 1 to 2 percent of this rainfall is assumed to infiltrate either directly into bedrock or into alluvium as mountain front recharge.

3.5 Groundwater Flow Model Calibration

Calibration of a groundwater flow model refers to the process of adjusting model parameters to obtain a reasonable match between observed and simulated water levels. Model calibration is an iterative procedure that involves adjustment of hydraulic properties and/or boundary conditions to achieve the best match between observed and simulated water levels. During model calibration, model parameters are varied over a narrow range set by Site-specific data using the CSM as a guide. During calibration of a groundwater flow model, use of point data (targets) eliminates the potential for interpretive bias that may result from attempting to match a contoured potentiometric surface (Konikow, 1978; Anderson and Woessner, 1992). The groundwater flow model was calibrated under steady state and transient conditions, presented in the following sections.

3.5.1 Steady State Calibration

The steady-state flow calibration process for the numerical model consisted two different time periods: Pre IM-3 Conditions in 2004 and Active IM-3 Conditions in 2015. The Pre IM-3 Pumping Conditions consisted of pumping conditions described in Section 3.3. The Pre IM-3 Conditions consisted of 26 groundwater elevation targets measured at monitoring wells on-Site in 2004 (Table 3.5-1). The Active IM-3 Pumping conditions represents the average 2015 rates and consisted of the addition of 4 pumping wells: IW-2 (screened in model layers 3 through 6) injecting at a total rate of 66.3 gpm), IW-3 (screened in model layers 3 through 6) injecting at a total rate of 61.6 gpm), PE-1 (screened in model layer 3 extracting at a total rate of 26 gpm), and TW-3D (screened in model layers 3 through 4 extracting at a total rate of 102.7 gpm). The Active IM-3 Conditions consisted of 71 groundwater elevation targets measured at monitoring wells on-Site (Table 3.5-2). The Active IM-3 targets were measured over the course of 2015 and averaged.

Table 3.5-1 Pre IM-3 Water Level Targets and Residuals

Name	X	Y	Layer	Observed Water Level (ft msl)	Computed Water Level (ft msl)	Residual (ft)
MW-09	7614780.27	2100673.29	1	456.46	456.05	0.41
MW-10	7614886.60	2100984.20	1	455.35	455.99	-0.64
MW-11	7614865.33	2101557.09	1	455.75	455.91	-0.16
MW-12	7615923.61	2101429.49	1	455.71	455.74	-0.03
MW-13	7614848.07	2103135.17	1	456.15	455.70	0.45
MW-14	7614081.09	2102738.09	1	455.86	455.90	-0.04
MW-15	7613164.94	2100844.08	1	456.08	456.31	-0.23
MW-20-070	7615893.48	2102493.39	1	455.35	455.48	-0.13
MW-21	7616099.26	2101486.75	1	455.48	455.66	-0.18
MW-22	7616359.75	2101566.69	1	454.58	455.33	-0.75
MW-23	7616448.53	2101286.15	1	455.21	456.15	-0.94
MW-24A	7615114.47	2101451.00	1	455.50	455.89	-0.39
MW-27-020	7616557.66	2102294.73	1	455.75	455.22	0.53
MW-30-030	7616141.26	2102499.58	1	455.35	455.38	-0.03
MW-16	7610980.32	2100697.20	1	456.47	456.73	-0.26
MW-17	7610243.29	2103135.56	1	455.73	456.48	-0.75
MW-18	7612598.61	2102894.59	1	455.70	456.13	-0.43
MW-20-100	7615881.03	2102506.33	2	455.22	455.48	-0.26
MW-30-050	7616150.98	2102503.83	2	455.12	455.38	-0.26
MW-34-055	7616444.49	2102542.45	2	455.23	455.28	-0.05
PGE-06	7615050.86	2101525.07	2	455.76	455.89	-0.13
MW-20-130	7615881.52	2102493.68	3	455.53	455.48	0.05
MW-24B	7615069.38	2101436.41	3	455.98	455.90	0.08
MW-34-080	7616444.98	2102535.25	3	455.47	455.28	0.19
IW-03	7613237.80	2103007.18	4	455.17	456.02	-0.85
PGE-07	7615034.78	2101350.19	4	456.50	457.13	-0.63

Residual Statistics	
Residual Mean (ft)	-0.209
Residual Std. Deviation (ft)	0.383
Sum of Squares (ft^2)	4.940
Number of Observations	26
Range in Observations (ft)	1.920
Scaled Residual Std. Deviation	0.199

Table 3.5-2 Active IM-3 Water Level Targets and Residuals

Name	X	Y	Layer	Observed Water Level (ft msl)	Computed Water Level (ft msl)	Residual (ft)
MW-10	7614886.60	2100984.20	1	455.45	455.99	-0.54
MW-11	7614865.33	2101557.09	1	455.90	455.89	0.01
MW-12	7615923.61	2101429.49	1	455.51	455.52	0.00
MW-20-070	7615893.48	2102493.39	1	454.02	454.51	-0.49
MW-21	7616099.26	2101486.75	1	455.24	455.41	-0.17
MW-22	7616359.75	2101566.69	1	454.96	455.13	-0.17
MW-23-060	7616448.25	2101286.36	1	455.24	456.03	-0.79
MW-23-080	7616448.50	2101286.33	1	455.32	456.04	-0.71
MW-25	7615303.59	2102351.22	1	455.45	455.34	0.11
MW-26	7615787.70	2101911.86	1	455.15	455.24	-0.09
MW-27-020	7616557.66	2102294.73	1	455.21	455.01	0.20
MW-28-025	7616280.73	2103003.90	1	455.16	455.06	0.10
MW-30-030	7616141.26	2102499.58	1	454.80	454.62	0.18
MW-32-035	7616306.62	2102034.68	1	454.93	454.96	-0.03
MW-33-040	7615916.42	2103280.79	1	455.02	455.15	-0.13
MW-35-060	7615317.50	2104058.80	1	455.56	455.53	0.03
MW-36-020	7616267.10	2102542.57	1	454.92	454.68	0.23
MW-36-040	7616267.58	2102537.20	1	454.88	454.68	0.19
MW-38S	7614918.75	2101279.65	1	454.95	455.93	-0.98
MW-39-040	7616091.44	2102506.22	1	454.71	454.59	0.13
MW-42-030	7616282.09	2102309.31	1	454.84	454.77	0.07
MW-43-025	7616702.79	2101817.51	1	455.13	455.08	0.05
MW-47-055	7615629.48	2103450.05	1	455.43	455.36	0.07
OW-01S	7613419.20	2103040.48	1	456.55	456.87	-0.32
OW-02S	7613373.76	2103153.89	1	456.57	456.86	-0.28
OW-05S	7613186.80	2103017.60	1	456.61	456.91	-0.31
MW-20-100	7615881.03	2102506.33	2	453.53	454.35	-0.81
MW-27-060	7616534.75	2102288.27	2	455.09	454.97	0.13
MW-30-050	7616150.98	2102503.83	2	454.86	454.59	0.27
MW-33-090	7615914.59	2103287.43	2	455.29	455.17	0.12
MW-34-055	7616444.49	2102542.45	2	455.09	454.83	0.26
MW-36-050	7616267.47	2102532.17	2	454.81	454.63	0.19
MW-36-070	7616267.18	2102542.67	2	454.84	454.62	0.21
MW-37S	7614827.87	2102869.45	2	455.17	455.71	-0.54
MW-39-050	7616095.96	2102498.75	2	454.57	454.55	0.02

MW-39-060	7616099.45	2102495.05	2	454.40	454.56	-0.16
MW-39-070	7616091.38	2102506.30	2	454.09	454.54	-0.45
MW-44-070	7616255.62	2102728.31	2	454.97	454.76	0.21
MW-50-095	7615599.84	2103069.27	2	455.22	455.15	0.07
MW-55-045	7618326.30	2102605.89	2	456.09	455.26	0.83
MW-20-130	7615881.52	2102493.68	3	453.37	454.18	-0.80
MW-27-085	7616540.34	2102290.53	3	455.07	454.95	0.12
MW-28-090	7616289.73	2103005.68	3	455.15	455.03	0.12
MW-31-135	7615819.13	2102835.29	3	454.21	454.48	-0.26
MW-34-080	7616444.98	2102535.25	3	455.16	454.71	0.45
MW-34-100	7616452.41	2102530.60	3	454.86	454.74	0.12
MW-35-135	7615329.76	2104045.82	3	455.76	455.54	0.22
MW-36-090	7616267.63	2102537.34	3	453.97	454.45	-0.48
MW-36-100	7616267.51	2102532.37	3	454.23	454.46	-0.23
MW-39-080	7616095.86	2102498.83	3	454.08	454.48	-0.40
MW-39-100	7616099.30	2102494.96	3	454.56	454.49	0.07
MW-42-065	7616274.98	2102296.96	3	454.76	454.70	0.06
MW-43-090	7616693.22	2101824.65	3	455.48	455.08	0.40
MW-44-115	7616262.10	2102723.85	3	454.55	454.72	-0.17
MW-44-125	7616255.55	2102728.48	3	455.03	454.72	0.31
MW-45-095a	7616358.12	2102559.75	3	453.85	453.84	0.01
MW-45-095B	7616358.12	2102559.75	3	453.86	453.84	0.01
MW-47-115	7615629.75	2103450.10	3	455.46	455.36	0.10
MW-49-135	7615889.63	2103667.52	3	455.40	455.34	0.06
MW-51	7615807.51	2101900.11	3	455.04	455.23	-0.19
MW-54-085	7617082.61	2102958.94	3	455.52	455.21	0.31
MW-55-120	7618326.13	2102606.18	3	456.07	455.26	0.81
PT2D	7616017.74	2102646.24	3	453.90	454.26	-0.36
PT5D	7616112.09	2102629.47	3	454.33	454.48	-0.14
PT6D	7616074.62	2102672.77	3	454.30	454.43	-0.13
MW-33-150	7615906.05	2103302.57	4	455.21	455.22	-0.01
MW-46-175	7616196.86	2102940.02	4	455.11	454.95	0.15
MW-54-140	7617082.16	2102959.12	4	455.90	455.21	0.69
OW-05M	7613185.86	2103008.06	4	457.46	457.24	0.22
MW-54-195	7617089.25	2102951.90	5	455.92	455.22	0.70
OW-05D	7613185.55	2102998.32	6	457.16	457.20	-0.04

Residual Statistics	
Residual Mean (ft)	-0.023

Residual Std. Deviation (ft)	0.358
Sum of Squares (ft^2)	9.118
Number of Observations	71.000
Range in Observations (ft)	4.086
Scaled Residual Std. Deviation	0.088

3.5.1.1 Pre IM-3 Conditions

The quality of the model calibration can be determined by a statistical analysis of the residuals, as shown in Table 3.5-1. Residuals are defined as the difference between the model-simulated heads and the observed values. Positive residual values indicate that the model-simulated values are lower than the measured values, and negative residual values indicate that the model-simulated values are higher than the measured values. Residual statistics (Table 3.5-1) for the calibrated groundwater flow model indicate an acceptable agreement between simulated and measured groundwater elevations. The residual mean, residual standard deviation, and sum of squared residuals were calculated to be -0.209 feet, 0.383 feet, and 4.940 square feet (ft^2), respectively. The residual standard deviation is less than 20% of the range in observed water levels. These statistics indicate a good agreement between the observed and simulated water levels. A plot of observed versus simulated groundwater elevations for the 26 calibration targets is presented on Figure 3.5-1. The Pre IM-3 Conditions were considered a validation of the model calibration rather than the primary target set since Site 2004 data was fairly limited. The simulated layer-wise and full model water budget is shown in table 3.5-3

Table 3.5-3 Pre IM-3 Conditions Water Balance

Description	Model Layer 1		Model Layer 2		Model Layer 3		Model Layer 4		Model Layer 5	
	Inflow (ft^3/day)	Outflow (ft^3/day)	Inflow (ft^3/day)	Outflow (ft^3/day)	Inflow (ft^3/day)	Outflow (ft^3/day)	Inflow (ft^3/day)	Outflow (ft^3/day)	Inflow (ft^3/day)	Outflow (ft^3/day)
Constant Flux	1,326	0	14,924	0	5,543	0	0	0	0	0
ET	0	97,335	0	0	0	0	0	0	0	0
Constant Head	2,969	2,075	2,074	1,417	3,766	2,573	4,330	2,361	4,254	2,159
River	376,923	310,063	0	0	0	0	0	0	0	0
Well	0	11,849	0	9,461	0	418	0	256	0	2,887
Storage	0	0	0	0	0	0	0	0	0	0
TOTAL	683,095	682,785	576,407	576,407	484,205	484,205	400,268	400,268	328,602	328,602
ERROR	**4.55E-02**		**3.69E-06**		**-6.71E-07**		**1.49E-06**		**2.86E-06**	
Description	**Model Layer 6**		**Model Layer 7**		**Model Layer 8**		**Model Layer 9**		**Model Layer 10**	
	Inflow (ft^3/day)	Outflow (ft^3/day)	Inflow (ft^3/day)	Outflow (ft^3/day)	Inflow (ft^3/day)	Outflow (ft^3/day)	Inflow (ft^3/day)	Outflow (ft^3/day)	Inflow (ft^3/day)	Outflow (ft^3/day)

Constant Flux	0	0	0	0	0	0	0	0	0	0
ET	0	0	0	0	0	0	0	0	0	0
Constant Head	2,729	762	3,359	853	3,260	990	97,779	44,439	1	36
River	0	0	0	0	0	0	0	0	0	0
Well	0	3,764	0	1,046	0	871	0	49	0	0
Storage	0	0	0	0	0	0	0	0	0	0
TOTAL	275,314	275,314	241,653	241,653	204,124	204,124	160,701	160,701	96	96
ERROR	**4.74E-07**		**1.83E-06**		**3.06E-06**		**3.21E-05**		**2.07E-01**	

Description	**FULL MODEL**	
	Inflow (ft^3/day)	**Outflow (ft^3/day)**
Constant Flux	21,794	0
ET	0	97,368
Constant Head	124,522	57,663
River	342,967	303,340
Well	0	30,601
Storage	0	0
TOTAL	489,283	488,972
ERROR	**6.36E-02**	

3.5.1.2 Active IM-3 Conditions

To simulate active IM-3 conditions, the observed water levels Residual statistics (Table 3.5-2) for the calibrated groundwater flow model indicate an acceptable agreement between simulated and measured groundwater elevations. The residual mean, residual standard deviation, and sum of squared residuals were calculated to be -0.023 feet, 0.358 feet, and 9.121ft^2, respectively. The residual standard deviation is less than 9% of the range in observed water levels. These statistics indicate a good agreement between the observed and simulated water levels. A plot of observed versus simulated groundwater elevations for the 72 calibration targets is presented on Figure 3.5-2. The simulated layerwise and full model water budget is shown in Table 3.5-4. The model calibration process focused more on the active IM-3 conditions (2015) rather than pre-IM-3 conditions (2004) because substantially more data was available in 2015 and water levels were more reflective of annual average levels.

Table 3.5-4 Active IM-3 Conditions Water Balance

Description	**Model Layer 1**		**Model Layer 2**		**Model Layer 3**		**Model Layer 4**		**Model Layer 5**	
	Inflow (ft^3/day)	**Outflow (ft^3/day)**	**Inflow (ft^3/day)**	**Outflow (ft^3/day)**	**Inflow (ft^3/day)**	**Outflow (ft^3/day)**	**Inflow (ft^3/day)**	**Outflow (ft^3/day)**	**Inflow (ft^3/day)**	**Outflow (ft^3/day)**

Constant Flux	1,326	0	14,924	0	5,543	0	0	0	0	0
ET	0	97,366	0	0	0	0	0	0	0	0
Constant Head	2,962	2,075	2,069	1,417	3,758	2,573	4,322	2,361	4,246	2,160
River	348,722	308,620	0	0	0	0	0	0	0	0
Well	0	11,862	0	9,448	3,955	19,801	8,221	5,658	7,816	2,895
Storage	0	0	0	0	0	0	0	0	0	0
TOTAL	698,101	697,790	597,132	597,132	514,602	514,602	421,841	421,841	345,259	345,259
ERROR	**4.45E-02**		**2.85E-06**		**-1.19E-07**		**9.31E-07**		**2.52E-06**	

Description	**Model Layer 6**		**Model Layer 7**		**Model Layer 8**		**Model Layer 9**		**Model Layer 10**	
	Inflow (ft^3/day)	**Outflow (ft^3/day)**	**Inflow (ft^3/day)**	**Outflow (ft^3/day)**	**Inflow (ft^3/day)**	**Outflow (ft^3/day)**	**Inflow (ft^3/day)**	**Outflow (ft^3/day)**	**Inflow (ft^3/day)**	**Outflow (ft^3/day)**
Constant Flux	0	0	0	0	0	0	0	0	0	0
ET	0	0	0	0	0	0	0	0	0	0
Constant Head	2,722	762	3,351	853	3,252	990	97,573	44,495	1	36
River	0	0	0	0	0	0	0	0	0	0
Well	4,640	3,775	0	1,049	0	873	0	25	0	0
Storage	0	0	0	0	0	0	0	0	0	0
TOTAL	286,025	286,025	245,695	245,695	204,911	204,911	160,278	160,278	97	96
ERROR	**1.30E-06**		**1.95E-06**		**3.52E-06**		**2.75E-05**		**1.98E-01**	

Description	**FULL MODEL**	
	Inflow (ft^3/day)	**Outflow (ft^3/day)**
Constant Flux	21,794	0
ET	0	97,366
Constant Head	124,257	57,723
River	348,722	308,620
Well	24,632	55,385
Storage	0	0
TOTAL	519,405	519,094
ERROR	**5.99E-02**	

3.5.2 Transient Calibration

The transient calibration was conducted with 827 water level targets from November 2014 to October 2015. Average variations in the Colorado River stage and pumping were computed on a monthly basis. As the transient calibration model is a time dependent simulation, storativity (storage) needed to be incorporated into the model. Storage values were varied per hydrostratigraphic unit. The calibrated storativity values for the individual hydrostratigraphic units are shown in Table 3.5-5. In general, storativity was not a sensitive parameter in matching the transient calibration period, so the values in Table 3.5-5 should be considered approximations. As the solute transport modelling is conducted as a long term steady state run, the storage values are not used in the solute transport model.

Table 3.5-5 Hydrostratigraphic Unit Storativity Values

Hydrostratigraphic Unit	Description	Average Storativity Value
Qr3	Upper Fluvial Sand and Silt	6.5E-02
Qr2	Middle Fluvial Deposits	1.9E-02
Qr1	Lower Fluvial Deposits	1.4E-02
Qr0	Colorado River Channel Fill	1.5E-02
Qoa	Older Quarternary Alluvium	5.1E-2
Tb	Bouse Formation	6.0E-2
Toa2	Upper Tertiary Alluvium	1.9E-02
Toa1	Lower Tertiary Alluvium	8.1E-05
Toa0	Basal Alluvium	2.8E-05
Tmc	Miocene Conglomerate	2.2E-04

Residual statistics (Appendix A) for the calibrated groundwater flow model indicate an acceptable agreement between simulated and measured groundwater elevations. The residual mean, residual standard deviation, and sum of squared residuals were calculated to be 0.16 feet, 0.42 feet, and 169.0ft^2, respectively. The residual standard deviation is 6% of the range in observed water levels. These statistics indicate a good agreement between the observed and simulated water levels. A plot of observed versus simulated groundwater elevations for the 827 calibration targets is presented on Figure 3.5-3.Example hydrographs for the floodplain and upland areas are shown in Figures 3.5-4 and 3.5-5, respectively. Each hydrograph shows good fit between observed and simulated conditions as the river stage and IM-3 pumping rates varied over time.

3.6 Simulated Groundwater Flow

The simulated water levels under the Active IM-3 Conditions were mapped both regionally and for the Site and are presented in Figures 3.6-1 and 3.6-2, respectively. Regionally, groundwater flow is from north to south. Due to the contrast in permeabilities between the alluvium and the bedrock, the gradient steepens in the bedrock located to the south of the Site. At the Site, mounding and drawdown is evident due to local IM-3 pumping at the injection and extraction wells (IW-2, IW-3, PE-1, and TW-3D). In the vicinity of the Site, groundwater flow is predominantly to the east towards the Colorado River. In the bedrock, groundwater travels from south to north out of the bedrock and into the alluvium.

3.7 Sensitivity Analyses

Sensitivity analyses were conducted on the following parameters: hydraulic conductivity, riverbed conductance, leakance, and evapotranspiration. The 2015 steady state calibration model was utilized to conduct this sensitivity analysis. The sensitivity of the model to global changes in parameters is presented graphically in Figure 3.7-1. The layerwise sensitivity analysis of leakance is presented graphically in Figure 3.7-2. Additional details on the sensitivity analysis are discussed in the sections below.

3.7.1 Hydraulic Conductivity

Hydraulic conductivity values were varied globally by applying a range of multipliers between 0.5 and 1.75 and the resultant statistics are presented in Table 3.7-1. The majority of the targets are located in the immediate vicinity of the Site, but the parameters were varied across the full model domain to gauge the overall impact. Based on the calibration statistics, the hydraulic conductivity value is a relatively sensitive parameter. Within a 5% increase and decrease in hydraulic conductivity the calibration had minimal changes. As the multiplier was increased and decreased further, the deviation from the base calibration statistics increased significantly. Due to the heterogeneous nature of the stochastic distribution of simulated hydraulic conductivity values, further discrete sensitivity analyses were not conducted on hydraulic conductivity.

Table 3.7-1 Hydraulic Conductivity Sensitivity Analysis

Residual Statistics	Hydraulic Conductivity										
Multiplier	0.50	0.75	0.85	0.90	0.95	1.00	1.05	1.15	1.25	1.50	1.75
Residual Mean (ft)	0.227	0.067	0.026	0.008	-0.008	-0.023	-0.037	-0.061	-0.083	-0.128	-0.163
Residual Std. Deviation (ft)	0.665	0.405	0.372	0.364	0.359	0.358	0.358	0.364	0.374	0.402	0.430
Sum of Squares (ft^2)	35.07	11.98	9.881	9.397	9.164	9.118	9.212	9.690	10.41	12.65	15.00
Scaled Residual Std. Deviation	0.163	0.099	0.091	0.089	0.088	0.088	0.088	0.089	0.091	0.098	0.105

3.7.2 Riverbed Conductance

Riverbed conductance values were varied globally in all river cells by applying a range of multipliers between 0.1 and 10 and the resultant statistics are presented in Table 3.7-2. Riverbed conductance values had a relatively low degree of sensitivity with only a slight increase in residual statistics when riverbed conductance values were reduced beyond a 0.75 multiplier. Increasing the riverbed conductance did not result in a significant improvement of calibration statistics. The asymptotic nature of this sensitivity curve supports the baseline riverbed conductance value utilized for the model calibration.

Table 3.7-2 Riverbed Conductance Sensitivity Analysis

Residual Statistics	Riverbed Conductance							
Multiplier	0.10	0.50	0.75	1.00	1.25	1.50	1.75	10.00
Residual Mean (ft)	-0.014	-0.016	-0.020	-0.023	-0.025	-0.026	-0.028	-0.037
Residual Std. Deviation (ft)	0.377	0.360	0.358	0.358	0.357	0.357	0.356	0.355
Sum of Squares (ft^2)	10.092	9.232	9.152	9.118	9.093	9.080	9.070	9.041
Scaled Residual Std. Deviation	0.092	0.088	0.088	0.088	0.087	0.087	0.087	0.087

3.7.3 Evapotranspiration

Evapotranspiration rates were varied uniformly across the full model domain by applying multipliers from 0.1 to 10 and resultant statistics are presented in Table 3.7-3. Although evapotranspiration zones were defined throughout the model domain, due to the relatively large depth to water and limited vegetation in the uplands, this parameter was really only active in the Colorado River floodplain and Topock Marsh areas as this is where the groundwater is relatively shallow and vegetation exists. This sensitivity analysis indicates that evapotranspiration is a relatively insensitive parameter. Decreasing the evapotranspiration rate had little to no impact of the residual calibration statistics. Only by increasing the evapotranspiration rate by an order of magnitude resulted in a larger increase in calibration statistics.

Table 3.7-3 Evapotranspiration Sensitivity Analysis

Residual Statistics	Evapotranspiration							
Multiplier	0.10	0.50	0.75	1.00	1.25	1.50	1.75	10.00
Residual Mean (ft)	-0.031	-0.027	-0.025	-0.023	-0.021	-0.019	-0.017	0.047
Residual Std. Deviation (ft)	0.362	0.360	0.359	0.358	0.356	0.355	0.354	0.333
Sum of Squares (ft^2)	9.389	9.263	9.189	9.118	9.050	8.985	8.923	8.031
Scaled Residual Std. Deviation	0.089	0.088	0.088	0.088	0.087	0.087	0.087	0.081

3.7.4 Leakance

Leakance rates were first varied uniformly across the full model domain in all model layers by applying multipliers from 0.1 to 10 and resultant statistics are presented in Table 3.7-4. In general leakance was fairly insensitive until the leakance values were increased or decreased by an order of magnitude. The base leakance value had the lowest residual sum of squares and scaled residual standard deviation supporting the calibration values suggested.

Table 3.7-4 Leakance Sensitivity Analysis

Residual Statistics	Leakance							
Multiplier	0.10	0.50	0.75	1.00	1.25	1.50	1.75	10.00
Residual Mean (ft)	-0.006	-0.021	-0.022	-0.023	-0.024	-0.025	-0.026	-0.040
Residual Std. Deviation (ft)	0.422	0.360	0.358	0.358	0.358	0.358	0.359	0.365
Sum of Squares (ft^2)	12.642	9.243	9.131	9.118	9.132	9.155	9.181	9.600
Scaled Residual Std. Deviation	0.103	0.088	0.088	0.088	0.088	0.088	0.088	0.089

To further evaluate the leakance rates in the model, the individual leakance values between model layers 1 through 3 were varied independently to gauge the relative sensitivity by layer. Layers 1 through 3 were selected as these were the layers containing the majority of the calibration targets. Leakance in each layer was varied between 0.1 and 10 times the baseline leakance value and the resultant calibration statistics are shown in Table 3.7-5 and are depicted graphically in Figure 3.7-2. The overall conclusions between the global leakance variations and layerwise leakance variations are similar indicating that leakance is a relatively insensitive parameter.

Table 3.7-5 Layerwise Leakance Sensitivity Analysis

Residual Statistics	Leakance Model layer 1							
Multiplier	0.10	0.50	0.75	1.00	1.25	1.50	1.75	10.00
Residual Mean (ft)	-0.020	-0.017	-0.020	-0.023	-0.025	-0.027	-0.026	-0.039
Residual Std. Deviation (ft)	0.362	0.357	0.357	0.358	0.358	0.358	0.359	0.363
Sum of Squares (ft^2)	9.340	9.081	9.094	9.118	9.144	9.169	9.181	9.472
Scaled Residual Std. Deviation	0.089	0.087	0.087	0.088	0.088	0.088	0.088	0.089
Residual Statistics	**Leakance Model layer 2**							
Multiplier	0.10	0.50	0.75	1.00	1.25	1.50	1.75	10.00
Residual Mean (ft)	-0.052	-0.025	-0.024	-0.023	-0.023	-0.023	-0.023	-0.026
Residual Std. Deviation (ft)	0.399	0.357	0.357	0.358	0.358	0.359	0.359	0.365
Sum of Squares (ft2)	11.498	9.110	9.091	9.118	9.150	9.181	9.208	9.501
Scaled Residual Std. Deviation	0.098	0.087	0.087	0.088	0.088	0.088	0.088	0.089
Residual Statistics	**Leakance Model layer 3**							
Multiplier	0.10	0.50	0.75	1.00	1.25	1.50	1.75	10.00

Residual Mean (ft)	-0.045	-0.025	-0.023	-0.023	-0.023	-0.023	-0.023	-0.026
Residual Std. Deviation (ft)	0.362	0.359	0.358	0.358	0.357	0.357	0.357	0.357
Sum of Squares (ft2)	9.465	9.175	9.137	9.118	9.107	9.099	9.095	9.092
Scaled Residual Std. Deviation	0.089	0.088	0.088	0.088	0.087	0.087	0.087	0.087

4 SOLUTE TRANSPORT MODEL DEVELOPMENT

Solute transport modeling was performed to evaluate the migration and fate of Cr(VI) detected in the groundwater, as well as the fate and transport of potential IRZ byproducts (i.e., manganese and arsenic). The solute transport model used the results from the calibrated groundwater flow model to simulate solute transport under average flow conditions. The solute transport model was used to evaluate the fate and transport of Cr(VI), as well as select byproducts (manganese and arsenic) to evaluate various potential remedial systems.

4.1 Code Selection

The solute transport modeling was performed using the modular three-dimensional transport model referred to as MT3D. MT3D was originally developed by Zheng (1990) at S.S. Papadopulos & Associates, Inc. for the Robert S. Kerr Environmental Research Laboratory of the U.S. Environmental Protection Agency (USEPA). The MT3D code uses the flows computed by MODFLOW in its transport calculations. MT3D also uses the same finite-difference grid structure and boundary conditions as MODFLOW, simplifying the effort to construct the solute transport model. MT3D is regularly updated (Zheng and Wang 1999), and the most recent version is referred to in the literature as MT3DMS, where MS denotes the Multi-Species structure for accommodating add-on reaction packages. MT3DMS has a comprehensive set of options and capabilities for simulating advection, dispersion/diffusion, and chemical reactions of contaminants in groundwater flow systems under a range of hydrogeologic conditions. Recent updates to MT3DMS have included the dual-domain formulation and the ability to incorporate Site-specific processes.

The major inputs to MT3DMS for the modeling assessment are as follows:

- Mobile and Immobile Porosity: affecting the groundwater flow velocity and solute storage
- Mass Transfer Coefficient: affecting the exchange of mass between mobile and immobile portions of the aquifer
- Partition Coefficient: affecting the adsorption of Cr(VI) and byproducts to soil particles
- Carbon Degradation Rate: affecting the rate of Cr(VI) reduction/precipitation
- Initial Groundwater Concentrations: affecting the overall distribution and concentration of Cr(VI), manganese, and arsenic

- Byproduct Generation Coefficient: affecting the generation of manganese and arsenic from the introduction of carbon to aquifer

4.2 Solute Transport Parameters

4.2.1 Porosity

The first phase of calibration was to accurately represent the groundwater velocity in the impacted portion of the aquifer. The groundwater velocity is computed within MT3DMS by dividing the groundwater flux term from MODFLOW by the mobile porosity. The mobile porosity is that fraction of the aquifer through which the majority of groundwater is moving. While often conceptualized as solely a pore-scale concept, it also represents aquifer-scale behavior driven by hydraulic conductivity contrasts in different portions of the aquifer matrix. The immobile porosity is the remaining portion of the void space, where groundwater flows much slower or not at all, and the void space is primarily a storage reservoir for dissolved mass. Solute mass is exchanged between mobile and immobile portions of the aquifer by diffusion. This conceptualization of solute transport is the dual-domain formulation, and is often referred to as advection-diffusion. There is extensive literature on the dual-domain model (Gillham et al. 1984; Molz et al. 2006; Flach et al. 2004; Harvey and Gorelick 2000; Feehley et al. 2000; Julian et al. 2001; Zheng and Bennet 2002) and it is generally considered the most accurate approach for simulating solute transport.

The total (combination of mobile and immobile) porosity of the aquifer is controlled by grain sizes, sorting, and post-depositional consolidation processes. Attachment A of CH2M Hill 2010 - Methods of Estimating Pore Volume Flushing Efficiency Used in Calculating Mass Removal Rates for CMS/FS Alternative indicated a range in immobile porosities of 22% to 28%, and a range in total porosities of 29% to 40%. The total porosity range is supported by porosity measurements made on 20 Site samples as part of the original draft RFI (E&E, 2004), which ranged between 26.8% and 42.7%, with an average of 35.5%. A mobile porosity of 12% was determined through Site ISPT tracer studies (Arcadis, 2008) (see Section 3.4.4), including the breakthrough of IM-3 injection water. Based on this 12% mobile porosity, an immobile porosity of 23% and a total porosity of 35% were selected as average values for the solute transport modeling exercise to be consistent with the calculated ranges in observed immobile and total porosities. The total porosity of 35% is also consistent with porosity values recorded for similar alluvial and fluvial aquifer materials (Fetter, 2001; Payne et al., 2008). Local variability will not have an impact on overall results, and 35% is a reliable estimate for the total porosity of the alluvium simulated in modeled layers 1 through 9.

With respect to the bedrock porosity, there is very low to negligible primary (intergranular) porosity but secondary porosity (bedrock fractures) is the main porosity associated with the bedrock. A dual domain model can be utilized to simulate flow through fractured bedrock. The basis for this approach is the fact that at large enough scale, fractured rock flow systems can be effectively simulated as porous media with low mobile porosity. As a general rule of thumb, the size of the block of fractured rock that may be treated as a porous media is often considered to be about 100 times the average fracture spacing (Gerber, Bither, and Muff, 1991). An analysis of the rock core logs from the Phase 1 and 2 ER-TCS area boreholes shows an average fracture spacing in the saturated zone to be about 0.29 feet. The transport model grid cell dimensions over the extent of the plume are 25 ft x 25 ft. The current model grid spacing is therefore close to the 100 times the fracture spacing, suggesting that it is reasonable to use the existing model to simulate the fractured rock at Topock. The simulated total porosity to represent bedrock fracture flow (secondary porosity) was reduced to 2%, of which 1.9% simulated as mobile porosity and 0.1% as the immobile porosity.

4.2.2 Mass Transfer Coefficient

An estimated mass transfer coefficient (MTC) value of 1.0 x 10^{-3}/day was utilized for all model layers in the solute transport model. This MTC was developed based on a range of literature values and models of similar dimensions and aquifer properties (Gillham et al. 1984; Molz et al. 2006; Flach et al. 2004; Harvey and Gorelick, 2000; Feehley et al. 2000; Julian et al. 2001). The solute transport model was then run with initialized current plumes to determine if the selected MTC produced reasonable results with the constituent distribution currently observed. It was recognized that variations in historic plume interpretations were not just a function of plume movement, but also improved delineation of the plume that developed over time as the monitoring well network density evolved. The current plume interpretation is based on a much more advanced monitoring well network, which improved the resolution of the plume delineation. The MTC value for the solute transport model was systematically adjusted between 1.0 x 10^{-05} (1/day) and 1.0 (1/day), and small-scale and short-term plume movements were evaluated until the solute transport model produced reasonable plume movement.

4.2.3 Chromium Adsorption

The retardation factor (R_f) is used by the solute transport model to represent the amount of adsorption of a constituent from the dissolved or solute phase. The retardation factor used for Cr(VI) is based on the linear sorption isotherm and is calculated in MT3D using the bulk density (ρ_b), the porosity (n) of the aquifer material, and a distribution coefficient (K_d), according to the following equation:

$$R_f = 1 + \frac{\rho_b K_d}{n} \qquad (4\text{-}1)$$

The presence of background Cr(VI) concentrations associated with the naturally occurring mineralogy suggests nominal adsorption (low K_d value) is representative of the aquifer. This assessment is consistent with the literature, which identifies a wide range of K_d values (USEPA 1999) for naturally occurring Cr(VI) in aquifer soils with a normal pH range. The calibration of the regional groundwater flow model to the growth of the Cr(VI) plume (CH2M Hill, 2005b) supports the limited retardation of Cr(VI) transport, and thereby low K_d values at the Site. If K_d values for Cr(VI) were larger, the extent of the Cr(VI) plume would be more limited than the current extents of the Cr(VI) plume footprint. Additionally, a laboratory study on aerobic core samples from the Site (CH2M Hill, 2005a) indicated the range in K_d values from two aerobic core samples collected from the flood plain varied between 0.01 and 0.09 L/kg. The model includes a small amount of adsorption for Cr(VI), incorporating a distribution coefficient (K_d) of 0.05 liter per kilogram (L/kg) in the aquifer, which falls within the range of reported K_d values. A K_d value of 0.05 L/kg in the aquifer results in a retardation factor of approximately 1.25 for the Cr(VI) plume in the solute transport model. This indicates the plume will migrate about 25% slower than the ambient groundwater flow velocity. Given the limits of the current plume and the understanding of groundwater flow through the region, the K_d value of 0.05 L/kg in the aquifer is a reasonable estimate of natural chromium adsorption rates at the Site. The Cr(VI) K_d value was further adjusted in the bedrock to better simulate the movement of Cr(VI) in the fractured bedrock. The bedrock was simulated with a total porosity of 2% so the K_d value in bedrock was reduced to 0.0029 L/kg to yield an equivalent R_f as calculated in the aquifer to establish a uniform R_f value of 1.25 throughout the entire model domain.

4.2.4 Chromium Reduction

The reduction and precipitation of Cr(VI) in the aquifer was simulated by accounting for the reduction/precipitation of chromium in the presence of injected carbon (as part of an in-situ remediation approach). To account for this, the model utilized a Cr(VI) reduction/precipitation whenever the injected carbon exceeds a concentration of 0.1 mg/L. At the same time, a carbon half-life of 20 days was assigned to account for the degradation of the injected carbon over time. By simulating both Cr(VI) and carbon simultaneously, the interactions between the plume and the active IRZ were accounted for in the solute transport model.

4.2.5 Initial Hexavalent Chromium Distribution

The initial hexavalent chromium plume concentration distribution was based on all hexavalent chromium data collected through December 31, 2013. In the upper five model layers, the plume delineation varied to reflect the differing Cr(VI) concentrations encountered with depth. Cr(VI) was not initialized in model layers 6 through 10. The initialized Cr(VI) distributions are the same in both the mobile and immobile portions of the aquifer. The distribution of the Cr(VI) for model layers 1 through 5 are shown on Figure 4.2-1. Hexavalent chromium was also initialized for December 2015. The distribution of Cr(VI) for December 2015 for model layers 1 through 5 are shown on Figure 4.2-2.

4.2.6 Byproduct Generation

As discussed previously, the introduction of dissolved organic carbon into the aquifer will facilitate treatment of Cr(VI) in groundwater through precipitation of stable, low-solubility Cr(III) minerals. This precipitation reaction results from the formation of geochemical conditions that are similar to those currently present in the fluvial aquifer that comprises the rind adjacent to the river. Naturally occurring minerals in the rind are currently dissolved due to the presence of natural organic carbon, at the same time that Cr(VI) is undergoing precipitation in this rind. The goals of the in-situ groundwater treatment are to promote these geochemical conditions in order to facilitate treatment. Once geochemical conditions form in the alluvial aquifer that are similar to the fluvial aquifer, there will be natural minerals that dissolve (specifically natural iron minerals), and naturally occurring manganese and arsenic associated with these natural minerals may become soluble. These byproducts of the introduction of organic carbon will be generated only in the presence of organic carbon, and their migration will be limited in distance outside of the reactive zone where Cr(VI) is treated. These secondary water quality effects are discussed in detail in Appendix G of the CMS/FS (CH2M HILL, 2009b). Byproducts will be generated due to dissolution of naturally occurring iron minerals in the aquifer, and the distance over which they travel will be controlled by attenuation mechanisms, principally sorption. The solute transport model was used to evaluate the generation of byproducts and their fate and transport.

Byproduct generation is simulated in the fate and transport model by linking the concentration of organic carbon to a corresponding concentration of dissolved manganese and arsenic. Based on the floodplain and upland ISPT results (Arcadis 2008, 2009), the generation coefficients for manganese and arsenic were determined to be 0.016 mg of manganese per mg of organic carbon and 0.000108 mg of arsenic per mg of organic carbon, respectively. A range of generation coefficients for manganese and arsenic were selected based upon this base case, as detailed in Table 4.2-1.

Table 4.2-1

Byproduct Generation Terms Used in Fate and Transport Model

Byproduct	Generation Term (mg of Byproduct per mg Organic Carbon per Liter)		
	Low	Base Case	High
Manganese	0.005	0.016	0.05
Arsenic	0.00005	0.000108	0.00018

4.2.7 Byproduct Adsorption and Precipitation

The dissolution of iron, manganese, and arsenic in the IRZs is temporary and these elements will then return to baseline concentrations. Iron, manganese, and arsenic that have dissolved and moved out of the reactive zone under the influence of groundwater flow will undergo reactions that will transition these dissolved, naturally occurring elements to sorbed or precipitated forms, thereby removing them from groundwater. Dissolved iron will react by sorbing to solid-phase iron minerals outside of the reactive zone, and it will also precipitate through reaction with dissolved oxygen in the aquifer. Manganese concentrations will attenuate via sorption, reoxidation, and precipitation reactions; and arsenic concentrations will attenuate via coprecipitation and sorption as described in Appendix B of the 100% Basis of Design (Arcadis, 2015). Oxygen will be introduced through the natural flux of dissolved oxygen in groundwater flowing from areas outside of the IRZ and from the river. In more oxic portions of the aquifer, Fe(II) uptake will occur both through reaction with dissolved oxygen and by adsorption to/oxidation by Fe(III) minerals, forming mixed Fe(II)/ (III)-oxides. Dissolved oxygen and iron minerals in the deeper aquifer will mix and come into contact with groundwater coming in from upgradient. As iron minerals accumulate downgradient of the IRZ, this will continue to provide additional sorption capacity for manganese and arsenic. This process of attenuation of iron by sorption, rather than re-oxidation, is similar to the attenuation mechanism that is anticipated and that was modeled for manganese as described in Appendix B of the 100% Basis of Design (Arcadis, 2015). Concentrations of these analytes will be monitored downgradient of the IRZ, and program modifications will be made as necessary if analyte concentrations exceed anticipated levels, as described in the Operations and Maintenance Manual Volume 2: Sampling and Analysis Plan (Appendix L of the 100% Basis of Design).

Changes in pH and production of dissolved gases are not anticipated to be a concern based on the in-situ pilot test (ISPT) results as well as results observed at Hinkley and other Sites. During pilot testing, no significant changes in pH were observed in monitoring wells, indicating that any pH changes caused by carbon consumption and subsequent redox/precipitation/dissolution reactions were adequately buffered by the aquifer solids.

Dissolved gas concentrations generated within the IRZ are anticipated to be sufficiently low as to minimize formation of a gas phase within the aquifer. Given the relatively low carbon concentration used in pilot testing and specified in the design, any CO_2 generated will be at a low enough concentration that it will remain dissolved and be flushed through the IRZ over time. Further, pH buffering to circumneutral values by the aquifer solids will ensure that most of the inorganic carbon generated will be present as bicarbonate rather than dissolved CO_2. Formation of H_2(g), H_2S, and methane will be limited by controlling TOC concentrations to limit byproduct generation. Formation of these gases (as well as N_2 formation) was not an issue during the pilot testing conducted in the floodplain. Gas generation was higher during the upland ISPT in locations where organic carbon was distributed at concentrations in the 5,000 to 10,000 mg/L TOC range. The upland ISPT results indicate that lower concentrations of organic carbon, which have been proven effective, should be used to prevent excess gas generation; and lower concentrations have been specified in the design. The changes associated with the in-situ system are not expected to affect the reducing rind enveloping the river. Downgradient of the IRZ within the floodplain, manganese attenuation is modeled via adsorption, whereas arsenic attenuation is modeled via rate-limited co-precipitation according to a given half-life. These processes are assumed not to occur within the IRZ itself, instead taking effect within the redox recovery zone downgradient of the IRZ. In the solute transport model, this process is captured by activating the manganese and arsenic attenuation mechanisms outside of the maximum simulated 1 mg/L TOC footprint.

Oxidation of Mn(II) was incorporated into the solute transport model by assuming a half-life of 29 days, and coprecipitation of arsenic was accounted for by assigning a half-life of 30 days (base case) derived from the ISPT data.

A summary of the sorption parameters used in the model is provided in Table 4.2-2, below. Development of these parameters is discussed in the 100% Basis of Design Sections 5.3.2 (for manganese) and 5.4.3 (for arsenic).

Table 4.2-2

Byproduct Sorption Terms Used in Fate and Transport Model

Byproduct	Freundlich Parameters		
	Low	Base Case	High
Manganese	K_F=0.137, N=0.875	K_F=1.37, N=0.875	K_F=6.85, N=0.875
Arsenic	K_F=0.554, N=0.465	K_F=2.77, N=0.465	K_F=13.85, N=0.465

4.3 Parameter Assessment

Future groundwater flow model calibrations during remedy installation and operation will utilize recent data sets along with historical calibration data sets to further calibrate the groundwater flow model. Upon completion of the calibration of the groundwater flow model, the solute transport model will be calibrated against recent concentration data and observed trends, in accordance with the schedule in Section 7.The solute transport model was adopted following the choice of remedy in the CMS, with the approved hydraulic model forming the basis of this model. A predictive sensitivity analysis was conducted in the 100% basis of design using the solute transport model by varying multiple solute transport model parameters and remedy operations, and observing the impact on Cr(VI), TOC, Mn, and As. Various aspects of the Cr(VI) plume and behavior of manganese and arsenic were analyzed in detail with the solute transport model to determine an appropriate range of solute transport parameters to use for the predictive modeling. Utilizing the data collected during installation and implementation of the remedy as described in Section 7 will also allow for further refinement of the model and the predicted performance of the remedy design can be further assessed.

4.4 Remediation Design

There are seven components of the remediation design that are simulated concurrently with the solute transport model to effectively remediate the hexavalent chromium plume while reducing the impact of potential byproducts:

- NTH IRZ (NTH IRZ Injection and Extraction Wells)
- River Bank extraction (River Bank Extraction Wells)
- Uplands injection (Inner Recirculation Loop [IRL] Injection Wells)
- Transwestern Bench extraction (Transwestern Bench Extraction Wells)
- East Ravine extraction (East Ravine Extraction Wells)
- TCS injection (TCS Injection Wells)
- Freshwater injection (Freshwater Injection Wells)

Details of each component is presented in the 100% Basis of Design Report (Arcadis, 2015). The remediation design is shown in Figure 4.4-1.

4.5 Pathline Analysis

Figures 4.5-1 to 4.5-10 show simulated groundwater pathlines under active remedy flow conditions in model layers 1 through 5, respectively. Each model layer has 2 figures to represent the different time periods with the NTH IRZ, active or inactive. These pathlines were delineated using MODPATH (Pollack, 1989). MODPATH is a program that is used in conjunction with MODFLOW to track the advective movement of groundwater and directly utilizes the computed flow information from the MODFLOW model. A ring of particles was initialized at each of the uplands injection, freshwater injection and TCS injection wells in each layer and run with forward particle tracking for a period of 30 years. These figures help to illustrate the movement of the injected water during the remedy operation and should not be used independently from the solute transport model in order to best evaluate remedy performance For evaluation of hexavalent chromium, manganese and arsenic migration, the solute transport model is a more useful tool as it is able to account for mechanisms that would influence the behavior of these species in groundwater (i.e., sorption, reduction, oxidation, precipitation, etc.). For evaluation of TDS, these pathlines can be useful in helping to visualize the anticipated TDS footprint as the particles behave as a tracer without retardation. Focusing on the particles originating at injection wells IRL-1 and IRL-2, which receive River Bank extracted water in the nominal remediation operation scenario, indicates that these pathlines are encapsulated by the upgradient freshwater injection wells (IRL-3, IRL-4, and FW-1) thereby limiting the extent of potential elevated TDS concentrations associated with River Bank extracted water.

5 SOLUTE TRANSPORT MODEL RESULTS

5.1 Hexavalent Chromium

The solute transport model was run for a period of 30 years utilizing the transport parameters and flow conditions described in Section 4 for the simulated Cr(VI). The results are shown for years 0.5, 1.5, 3, 5, 10, 20, and 30 for each of the five model layers in which Cr(VI) was initialized on Figures 5.1-1 through 7.1-5. These figures show the impact the injected carbon concentrations and remediation design flow conditions are predicted to have on the chromium distribution over time. Carbon is actively injected into the NTH IRZ during the first 6 months of the simulation, followed by an 18-month period where the NTH IRZ is turned off. This 6-month on/18-month off NTH IRZ cycle period is repeated for the full duration of the transport run. This solute transport run indicates the NTH IRZ successfully creates a remediation barrier along the majority of the NTH IRZ line in all four model layers. The sections of the plume that are initialized on the east side of the NTH IRZ and the low Cr(VI) concentrations in the vicinity of the NTH IRZ wells that are not treated by the NTH IRZ (e.g., the low concentration finger of the plume that migrates past the northern NTH IRZ in model layers 3 and 4; see Figures 5.1-3 and 5.1-4, during the 18-month rest cycle when active pumping is suspended) are hydraulically controlled by the River Bank Extraction Wells. Most of the Cr(VI) remaining after 30 years of simulation is located in the bedrock in model layers 1 and 2 where the plume was initialized and persists due to the simulated low permeability of the bedrock. Due to the simulated low permeability of the bedrock, the sustainable yield in the bedrock is limited, so the East Ravine Extraction well rates were kept low. Based on the Cr(VI) transport results, minor modifications were made to operational rates in the NTH IRZ. NTH IRZ extraction well IRZ-5 was reduced by 20 gpm, and extraction well IRZ-9 was increased by 20 gpm in efforts to provide more control of the northern plume extents. As there is currently a limited monitoring well network in the northern portion of the plume, there is uncertainty with the exact Cr(VI) plume distribution, but the plume was conservatively drawn to account for historic concentrations slightly greater than 32 ppb in the vicinity of IRZ-1. These adjusted rates fall within the range of remediation well design rates presented in Table 3.2-1 of the 100% Basis of Design (Arcadis, 2015).

The solute transport model was rerun with the 2015 Cr(VI) plumes initialized in model layers 1 through 5. The results are shown on Figures 5.1-6 through 5.1-10, respectively. There was no simulated hexavalent chromium present in model layers 6 through 10, so these layers were not presented. As there were only minor changes to the Cr(VI) plume distribution between 2013 and 2015, the 2015 Cr (VI) simulation results are similar to those with the 2013 initialized plume.

5.2 Manganese

Figure 5.2-1 shows the maximum manganese in all layers generated as a byproduct from the injection of carbon-amended groundwater for the 30-year simulation period. The manganese transport run indicates that portions of the naturally occurring manganese rind and generated manganese byproduct will be extracted by the River Bank Extraction Wells and injected into IRL-1 and IRL-2, located in the upland area. This potential manganese impact in the uplands needs to be monitored over time to avoid elevated manganese concentrations. A potential method to mitigate this upland manganese impact would be to reduce or terminate flow from the River Bank and/or blend the River Bank extracted water with the freshwater injection over the course of the remedial program. The simulated magnitude and extent of byproduct manganese using the revised groundwater flow model are generally consistent with simulated manganese in the 100% basis of design report.

5.3 Arsenic

Figure 5.3-1 shows the maximum simulated arsenic transport in all layers for the 30-year simulation period. The arsenic runs take into account both the simulated naturally occurring arsenic associated with the freshwater injection as well as potential arsenic generated as a byproduct from carbon amended injection wells. The solute transport run indicates that arsenic concentrations associated with carbon-amended injection never exceed 10 μg/L in the 30-year simulation period. The only arsenic concentrations that exceed 10 μg/L are associated with the naturally occurring arsenic concentrations that are injected into the 4 wells receiving freshwater injection at a concentration of 15 μg/L. Despite constant injection rates and arsenic concentrations at these locations, the expansion of the arsenic footprint is relatively slow. This is due to the fact that the simulated arsenic sorption regulates the extent of the injected arsenic distribution. The simulated magnitude and extent of freshwater arsenic and byproduct arsenic using the revised groundwater flow model are generally consistent with simulated manganese in the 100% basis of design report.

6 UNCERTAINTY

As with all mathematical models of natural systems, the groundwater flow and solute transport model is limited by factors, such as scale, accuracy of the estimated hydraulic properties and/or boundary conditions, and the underlying simplifications and assumptions incorporated into the model. These factors result in limitations to the model's appropriate uses and to the interpretations that may be made of the simulation results. The remedy design and range of operation were based on the conceptual Site model, calibrated groundwater flow model, the predictive solute transport modeling and sensitivity analysis, and professional judgment.

Several strategies were employed to address the uncertainties inherent to the predictive model. As discussed in Section 3, the flow model was calibrated against: (a) pre-IM-3 steady state conditions, (b) active IM-3 operating steady state conditions (2015), and (c) average monthly site conditions responding to fluctuating river levels and pumping during 2015. This calibration procedure utilized a stochastic approach that resulted in a highly heterogeneous distribution of hydraulic conductivity to represent the identified hydrostratigraphic units. Note that density-dependent flows (resulting from potential deviations in temperature and salinity) were not simulated because these will have a negligible impact on system flows and the remedy design when compared to the natural heterogeneity of the aquifer.

A dual domain mass-transfer approach was used to model solute transport in the heterogeneous aquifer system as the small-scale preferential flow pathways cannot be fully and explicitly represented by the spatial discretization in a numerical model for practical reasons. Uncertainty was further addressed by conducting a detailed sensitivity analysis on various hydraulic parameters. This sensitivity analysis can be utilized to identify the degree of sensitivity associated with each parameter.

With respect to TDS and density variations, while it is acknowledged that effects of density-driven flow may be possible, they are not expected to be significant. Given the aquifer heterogeneity and vertical anisotropy, and the relatively high expected flow velocities within the system in the vicinity to the freshwater injection wells, advection-driven flows are expected to allow adequate horizontal flows to develop and be maintained at all depths between freshwater injection wells and River Bank extraction wells. If however, effects of density are observed during remedy implementation (i.e. slower, or 'short-circuiting' of flushing within the deeper, more saline portions of the aquifer in areas some distance away from the injection wells with respect to monitored average hydraulic gradients), steps can be taken to mitigate these impacts. Potential steps include varying well flow rates over the entire screened zone, or packing off sections of upper screened intervals to increase flushing in deeper zones, effectively countering buoyant effects caused by density contrasts between injected freshwater and in-situ denser water.

7 MODEL UPDATE PROCEDURE

During remedy well installation and testing, after system start-up, and during remedy operation, data will be collected and analyzed to identify whether the groundwater flow, geochemical, and solute transport models differ from the conceptual Site model with respect to the hydrogeologic characterization or remedy performance. The groundwater flow model, geochemical model, and/or the solute transport model will be updated and recalibrated at the intervals defined in the sections below. This will allow the models to be used as predictive tools to evaluate remedy performance and assist in providing recommended optimizations for operation of the remedial system (i.e., injection/extraction rates and frequency, carbon dosing frequency and concentration, and need for provisional wells). The model can also be further utilized to support capture zone analyses by simulating the capture zones of extraction wells under operational conditions to supplement the other lines of evidence for hydraulic capture based on field data. This is critical where a limited monitoring network is present for the riverbank extraction wells due to their proximity to the Colorado River. The updated model will also be used to re-evaluate remediation timeframe estimates by integrating anticipated remedy component operational rates and carbon dosing frequency and concentration. The updates made to the model will be noted in the corresponding quarterly report and presented in detail in the annual report.

During each defined model update the following steps will be included:

- Hydraulic property distributions will be refined based on updates to the spatial distribution of aquifer test data and lithologic descriptions.
- Actual operational data will be integrated into the groundwater flow model (i.e. pumping rates, pumping schedule, and vertical flow distribution)
- The groundwater flow model will be recalibrated to average observed water levels during each model update interval.
- The groundwater flow model will be recalibrated to observed transient water levels to gauge hydraulic responses to pumping and/or river fluctuations where applicable.
- Geochemical modeling parameters will be refined based on observed water quality data and field parameters.
- Solute transport modeling parameters will be refined based on observed water quality data and field parameters as well as geochemical modeling.
- Actual remedy operation parameters will be integrated into the solute transport model (i.e. TOC concentration, TOC injection frequency, etc.).
- Solute transport model will be calibrated against observed movement of Cr(VI), Mn, and As during the previous time interval.
- After model calibration, predictive modeling runs will be conducted to evaluate the simulated remedy performance in the future.
- Potential design and operations updates will be considered to further optimize remedy operation (i.e. pumping rates, TOC dosing concentration, dosing and operational frequency)
- Assessment of hydraulic capture zones based on simulated capture delineation and hydraulic gradients.

7.1 Well Installation and Testing

During the remedy well construction and testing period, the geochemical, groundwater flow and solute transport models will be updated annually to evaluate potential impacts of data collected during construction on the planned remedy performance. This model update schedule will allow for data from multiple wells to be considered and integrated into the groundwater flow and solute transport model on a wider areal basis rather than on a well-by-well basis. Examples of how data collected during the well installation period will focus on specific hydrogeologic data and Cr(VI) data are described below:

- Lithologic Descriptions: Lithologic descriptions that are logged from each borehole based on the visual inspection of the retrieved core or the drill cuttings will be collected. Additional soil samples at select wells will be collected for analysis of physical properties. By comparing multiple borehole lithologic descriptions and available physical property data, local stratigraphy will be assessed to better identify any potential key continuous hydrogeologic features that can be incorporated into the groundwater flow model during the update and recalibration process.
- Saturated Aquifer Thickness: During well installation, the saturated aquifer thickness at each well will be determined by observing where both the water table and bedrock contact are encountered. This data can be utilized to refine the structure of the regional groundwater flow model and then be transferred into the model. The current model structure was interpolated from available monitoring well points and boring logs, and can be refined with additional data points to better represent the geologic structure. The new borehole/well information will be incorporated by first verifying the model structure in the area (alluvial aquifer and bedrock contact) and then aquifer properties gained from well testing will be assessed.
- Hydraulic Conductivity/Transmissivity: Constant rate and step rate aquifer tests will be conducted at select locations and the recorded data can be utilized to calculate approximate hydraulic conductivity / transmissivity data. The vertical and lateral distributions of hydraulic conductivity values will be used to guide hydraulic conductivity values during the calibration process. Depending on the distribution, hydraulic conductivity values may be averaged or used directly. The approximate spatial distribution of this data can be incorporated into the groundwater flow model during the model update and recalibration process. Any potential changes will be carried through in the model for future transport run simulations.
- Hexavalent chromium distribution: Groundwater samples will be collected and analyzed from the existing monitoring well network, as well as newly installed wells, during the well installation period. Cr(VI) data will be utilized to update the Cr(VI) plume distribution in the solute transport model for subsequent transport simulations to evaluate the remedy design. The vertical aquifer sampling (VAS) Cr(VI) data collected during well installation and testing will not be utilized to update the Cr(VI) plume distribution as this data is qualitative screening level data.

The data will be utilized to update and recalibrate the regional groundwater flow model. The groundwater flow model recalibration will involve adjustments to model parameters, structure, and boundary conditions as necessary to reduce the difference between the average observed and simulated water levels and hydraulic gradients. Groundwater flow model updates could include updates to the simulated geologic structure, hydraulic conductivity, and vertical hydraulic conductivity. The geochemical modeling parameters will be refined based on observed water quality data and field parameters. The solute transport model will be updated with the available hexavalent chromium data to reflect updated initial plume conditions and refined geochemical parameters will be integrated. The groundwater flow and solute transport model will then be utilized to rerun the initial baseline remedy to determine if there are changes in the simulated hexavalent chromium transport projections.

7.2 Remedy Start-up and Operation

Data collected during remedy start-up and operation will focus on injection and extraction rates, observed hydraulic responses (water levels, hydraulic gradients, and potentiometric surfaces), Cr(VI) concentrations, arsenic concentrations, manganese concentrations, and TOC distribution. Based on these data, the model will be updated to reflect the actual pumping rates attained during remedy start-up and the observed response in groundwater flow and solute transport. To evaluate remedy performance, the groundwater flow and solute transport model simulations will be compared against observed hydraulic and analytical data annually during the start-up period, as well as after each five years of remedy operation. The models will be updated according to this schedule so that the model can be further utilized as a predictive tool to evaluate remedy timeframes. By collecting the aforementioned data, the following are example parameters that can potentially be refined in the groundwater flow and solute transport models:

- Operational Data: Actual operational data will be integrated into the groundwater flow model (i.e., pumping rates, pumping schedule, and vertical flow distribution).
- Hydraulic Conductivity / Transmissivity: By evaluating the observed hydraulic responses during remedy operation the hydraulic conductivity / transmissivity parameters can potentially be refined. Comparing the simulated point water levels, potentiometric surfaces and hydraulic gradients to the observed field values, the regional groundwater flow model will be recalibrated under active remedy conditions. Upon completion of the groundwater flow model update, the solute transport model will be rerun to evaluate longer term remedy performance to evaluate the remedy timeframe.
- Riverbed Conductance: Although the riverbed conductance is not directly measured during remedy operation, this parameter will be evaluated during the calibration of the regional groundwater flow model. By monitoring the average groundwater level elevations under active remedy conditions, adjustments can potentially be made to the riverbed conductance to further improve the flow model calibration statistics.
- Hexavalent Chromium Sorption: The observed migration of hexavalent chromium based on the observed point data can be utilized to further determine if the simulated sorption parameters are still reasonable. This refinement will assist in assessing the overall plume velocity and associated remediation timeframe.
- Hexavalent Chromium Distribution: Based on the observed point hexavalent chromium concentrations, the hexavalent chromium plume distribution can be updated in each of the four model layers. This will assist in evaluating the performance of the remedy design and conduct long term model simulations to evaluate the predicted remedial timeframes.
- TOC Degradation Rate: The TOC concentrations will be observed to determine if the simulated degradation rate is appropriate or needs to be adjusted to reflect the developed reducing conditions downgradient from the NTH IRZ and the TCS injection wells. Adjusting this parameter will allow for refinement of the simulation of the extent, duration, and magnitude of the TOC in the simulated IRZ footprint.
- Byproduct Generation: The manganese and arsenic concentrations will be monitored downgradient of the active in-situ reactive wells to assess whether observed magnitudes and extents match

modeled distributions. Adjustments can be made to the relationship between simulated TOC degradation and the mobilization of manganese and arsenic if observed data suggests modifications are needed.

- Byproduct Sorption: The byproduct manganese and arsenic Freundlich isotherm sorption parameters can be evaluated to compare field parameters to modeled parameters. These parameters will first be evaluated with the geochemical model and then transferred into the solute transport model. Predictive modeling can then be conducted.

The groundwater flow model will be recalibrated to average and transient observed water levels during each model update interval. Following groundwater flow model calibration, the assessment of hydraulic capture zones based on simulated capture delineation and hydraulic gradients will be conducted. Geochemical modeling parameters will be refined based on observed water quality data and field parameters. Solute transport modeling parameters will be refined based on observed water quality data and field parameters as well as geochemical modeling. The solute transport model will be calibrated against observed movement of Cr(VI), Mn, and As during previous time intervals. After model calibration, predictive modeling runs will be conducted to evaluate the simulated remedy performance in the future. Potential design updates and operations will be considered to further optimize remedy operation (i.e., pumping rates, TOC dosing concentration, dosing and operational frequency). The model will be used to predict future performance in conjunction with empirical data. The model will not be used for all changes associated with system operation where current empirical data is a more accurate reflection of system performance and the need for operational changes; such as flow rate changes, TOC feed adjustments, and maintenance needs.

8 SUMMARY AND CONCLUSIONS

The regional groundwater flow model was converted from MicroFEM to MODFLOW to develop a single tool to evaluate remedial design through both groundwater flow and solute transport. The model layer structure was revised to better account of the potential mass transfer between the groundwater in alluvium and bedrock. The major hydrostratigraphic units were defined using hydraulic conductivity zones throughout the revised model structure. The hydraulic conductivity zones were further manipulated by assigning a stochastic distribution to account for potential heterogeneities encountered in the aquifer. The model was calibrated to steady state conditions for both pre-IM-3 and active IM-3 operations, as well as a transient period for 1 year that simulated average monthly changes in river stage and pumping rates. Calibration results indicated the model was well calibrated. The calibrated groundwater flow model then underwent a series of sensitivity analyses to further evaluate the simulated hydraulic parameters.

The updated groundwater flow model was then utilized to examine the remedial design and solute transport modeling presented in the 100% basis of design report. Overall, the solute transport modeling conducted with the updated groundwater flow model results were similar to those of the 100% basis of design report. Hexavalent chromium footprints were similar over the simulated 30 year transport period with the exception of more persistent hexavalent chromium concentrations initialized in the bedrock due to the enhanced simulation of the alluvium/bedrock contact. Byproduct manganese and arsenic results were similar in extent and magnitude in the floodplain and downgradient of the TCS injection wells as those presented in the 100% basis of design. The simulated arsenic footprints associated with the freshwater injection into the upland wells also were similar in extent and magnitude as presented in the 100% basis of design report.

Based on this update of the groundwater flow model and associated solute transport modeling, the solute transport model results indicates that the planned remedy will be effective in remediating the current Cr(VI) plume distribution while minimizing the potential adverse impacts from byproduct generation. This updated groundwater flow model and solute transport model can be utilized as a tool to evaluate potential remedial options and supplements monitoring of the implemented remedial system to measure its effectiveness. During installation and implementation of the remedial system, the additional hydrogeologic and groundwater quality data generated can be utilized to update the groundwater flow and transport models to improve their effectiveness as tools for further understanding site conditions and optimizing the remedy performance.

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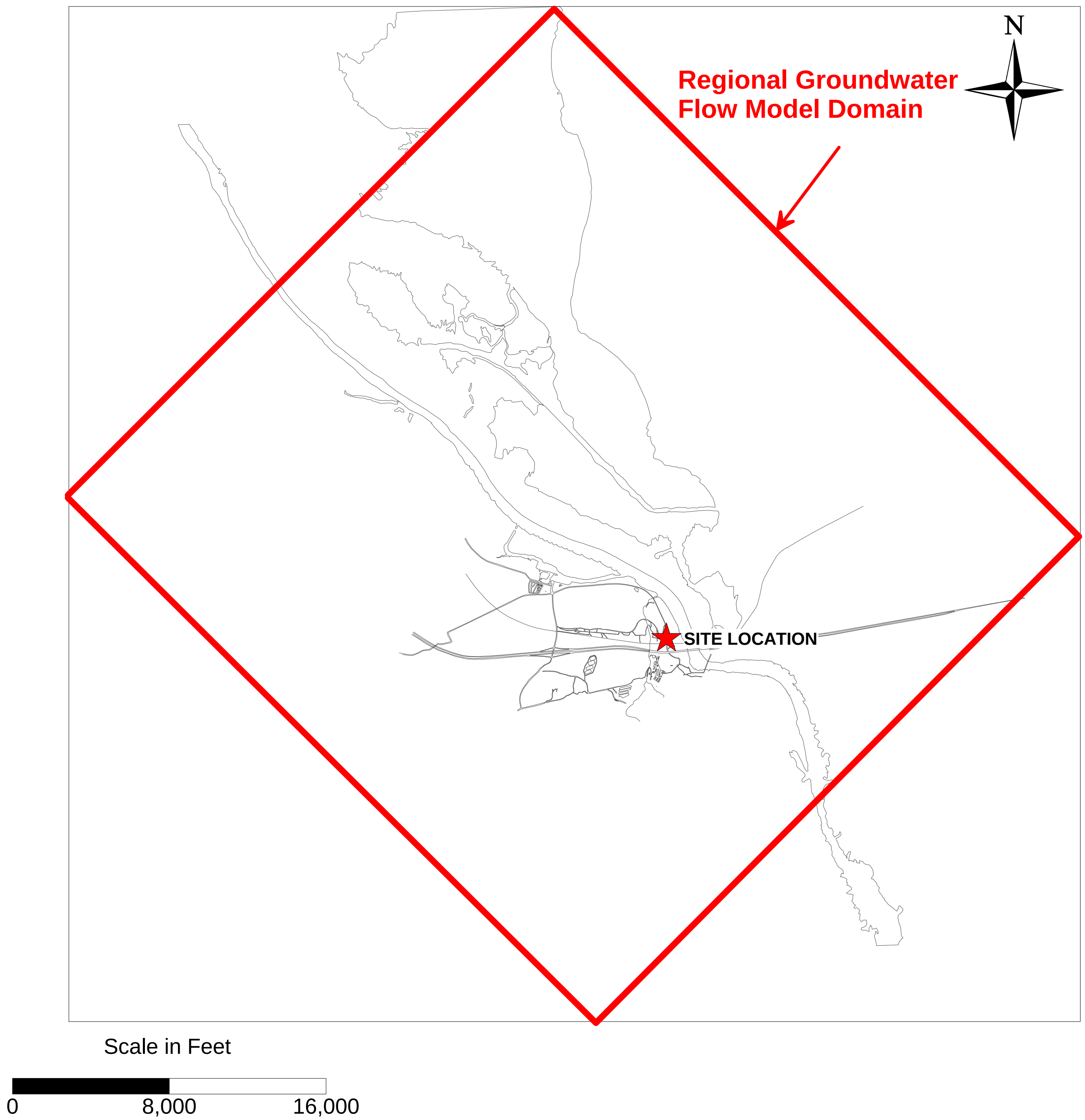
FIGURES

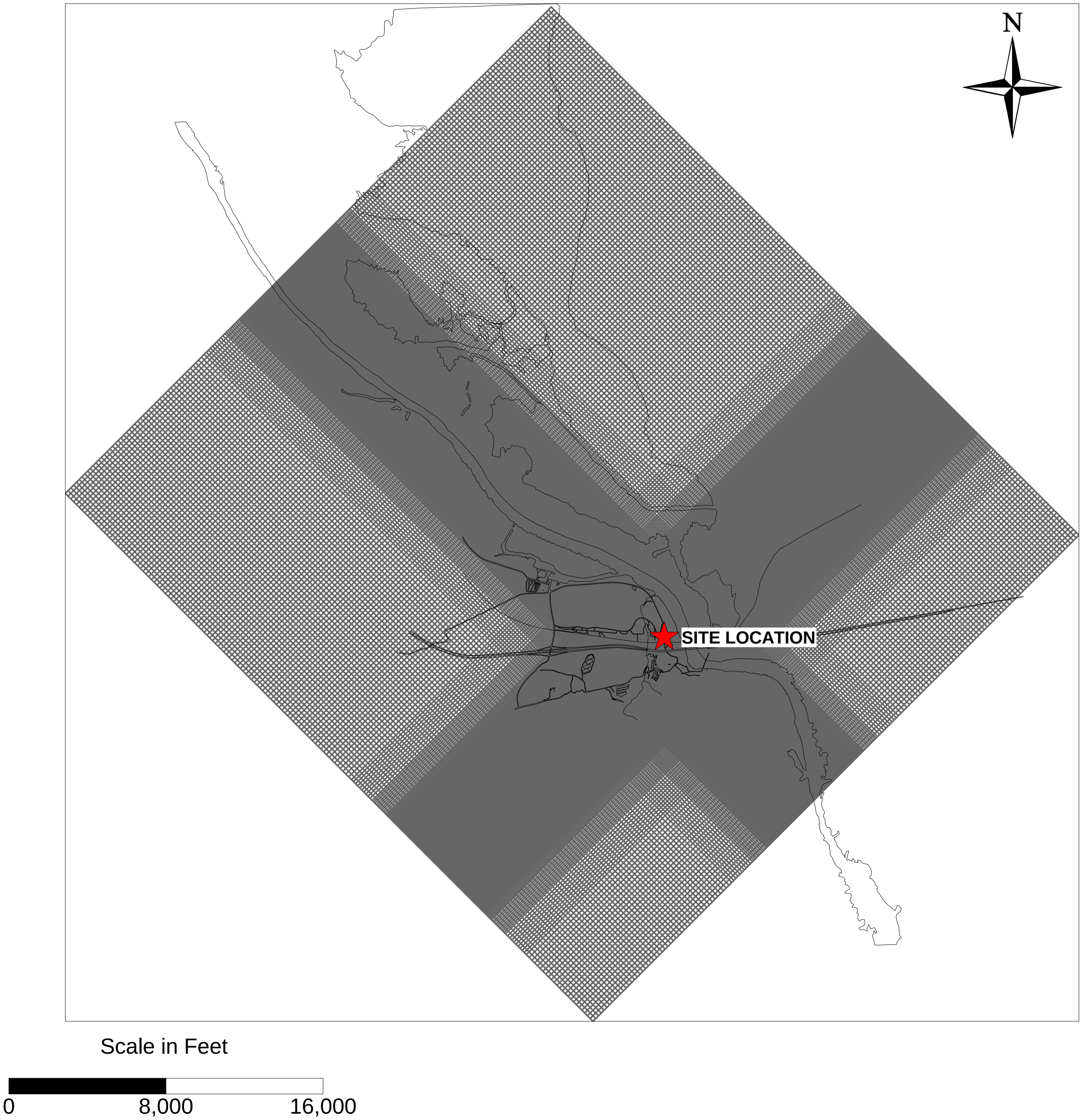


PG&E
TOPOCK COMPRESSOR STATION
NEEDLES, CALIFORNIA
DEVELOPMENT OF GROUNDWATER FLOW AND SOLUTE TRANSPORT MODELS

REGIONAL MODEL DOMAIN EXTENTS

ARCADIS Design & Consultancy for natural and built assets

FIGURE
1-1



LEGEND

Finite Difference Grid Cell

*Grid cells gradually expand from 25 ft x 25 ft in the vicinity of the Site, to 200 ft x 200 ft near the extents of the model domain.

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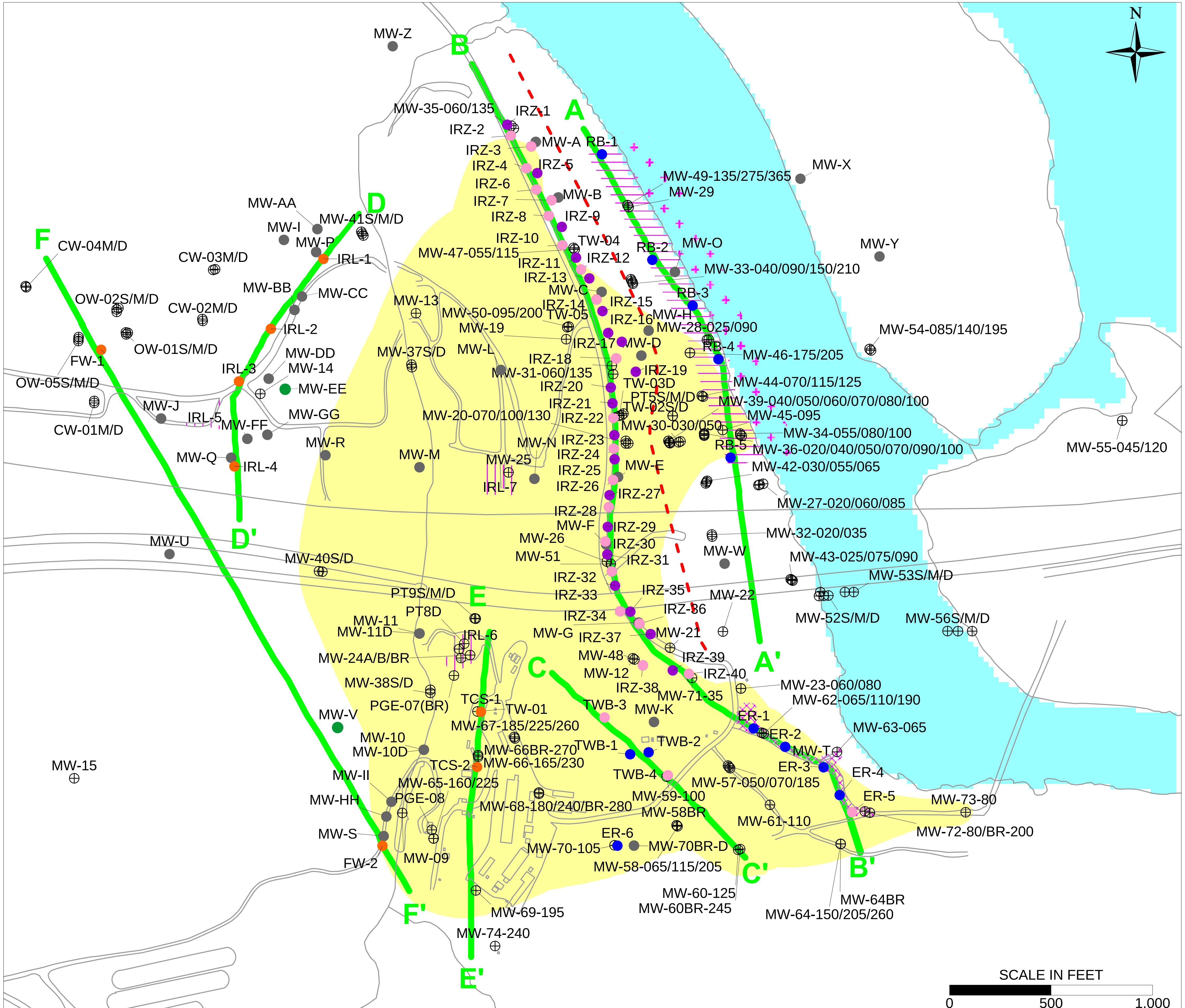
NEEDLES, CALIFORNIA
DEVELOPMENT OF GROUNDWATER FLOW AND SOLUTE TRANSPORT MODELS

FINITE DIFFERENCE GRID

ARCADIS Design & Consultancy for natural and built assets

FIGURE 3.2-1



LEGEND

- AREA FOR FUTURE PROVISIONAL IRL INJECTION WELL
- AREA FOR FUTURE PROVISIONAL EAST RAVINE EXTRACTION WELLS AND WELL MW-T
- AREA FOR FUTURE PROVISIONAL RIVERBANK EXTRACTION WELLS
- AREA FOR POTENTIAL SLANT WELL SCREENS
- CUMULATIVE HEXAVALENT CHROMIUM PLUME FOOTPRINT >32 ppb (12/31/2013)
- CROSS-SECTION LOCATIONS
- EXISTING MONITORING WELL LOCATIONS
- PROPOSED MONITORING WELL LOCATIONS
- FUTURE PROVISIONAL MONITORING WELL LOCATIONS

PROPOSED REMEDIATION WELLS

- NTH IRZ WELL LOCATIONS
- FUTURE PROVISIONAL WELL LOCATIONS
- RIVERBANK, TRANSWESTERN BENCH, AND EAST RAVINE EXTRACTION WELLS
- FRESHWATER, IRL, AND TCS INJECTION WELLS
- APPROXIMATE EXTENT OF REDUCING RIND

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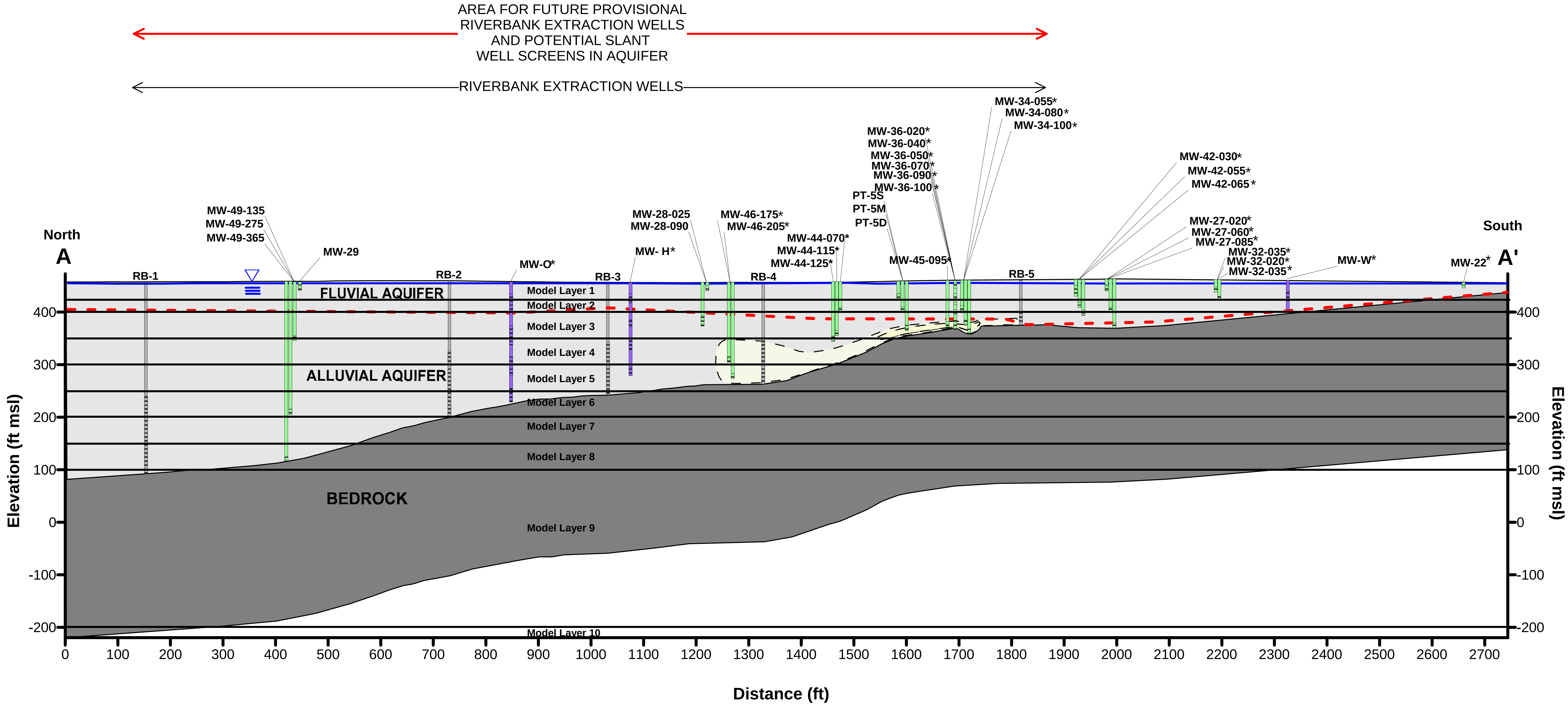
TOPOCK COMPRESSOR STATION
NEEDLES, CALIFORNIA
DEVELOPMENT OF GROUNDWATER FLOW AND SOLUTE TRANSPORT MODELS

CONCEPTUAL FINAL GROUNDWATER REMEDY CROSS-SECTION LOCATIONS

ARCADIS Design & Consultancy for natural and built assets

FIGURE 3.2-2



*Well is projected onto cross-section. Actual well screen elevations are honored in all wells. Model layer boundaries are adjusted to correlate to the projected wells.

Proposed Remediation Well

Existing Monitoring Well

Proposed Monitoring Well

Hexavalent Chromium Concentration (ppb)

32 | 100 | 500 | 1,000 | 5,000 | 10,000 | 15,000

Approximate extent of reducing rind

Number of wells, total screen intervals, and screen length and depth placement at each well location ID are for purposes of final (100%) design submittal and may be modified during installation. River Bank Extraction Wells (RB-1 to RB-5) will be installed with a second shallow screen interval for potential future use which will be isolated from the deeper screen interval with a pneumatic packer.

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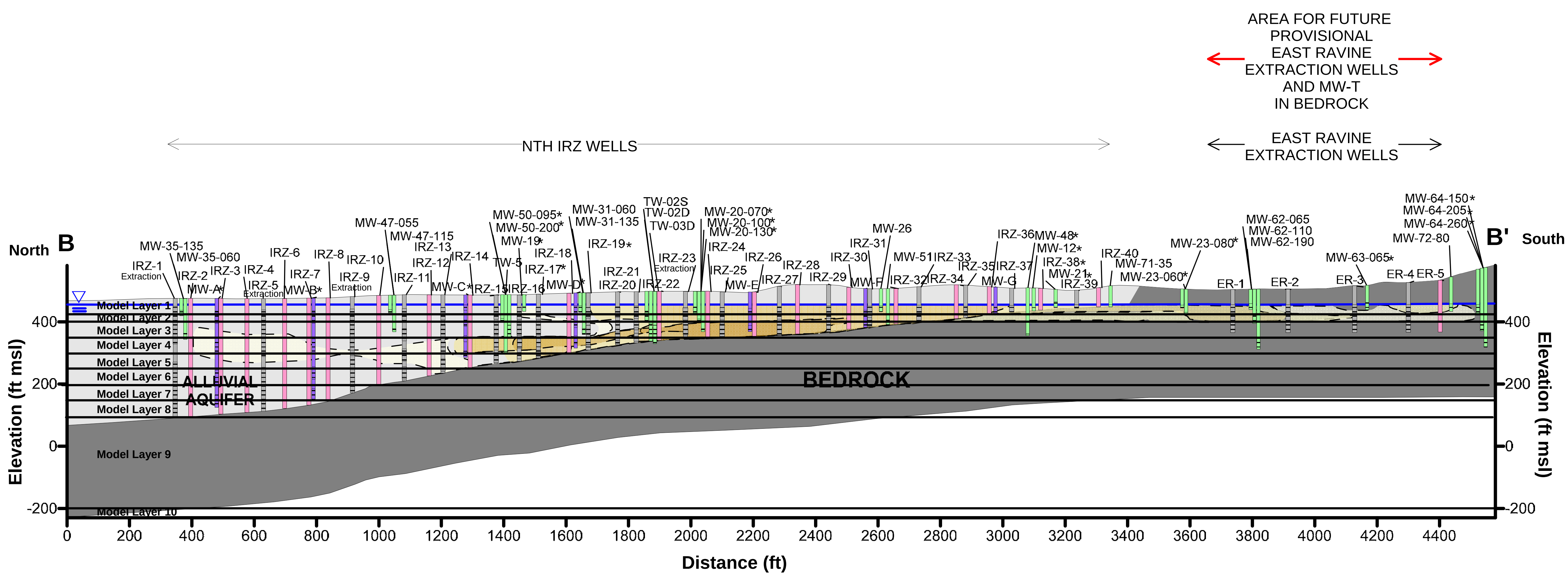
NEEDLES, CALIFORNIA
DEVELOPMENT OF GROUNDWATER FLOW AND SOLUTE TRANSPORT MODELS

CONCEPTUAL FINAL GROUNDWATER REMEDY
CROSS-SECTION A-A'

ARCADIS Design & Consultancy for natural and built assets

FIGURE
3.2-3



Number of wells, total screen intervals, and screen length and depth placement at each well location ID are for purposes of final (100%) design submittal and may be modified during installation. One well location ID may consist of multiple wells or screens, and one well screen interval may include more than one model layer. A maximum of two discrete screen intervals will be included per individual remediation well. Dual screen wells will consist of one well with two discrete screen intervals separated by a packer. Some well location IDs include two dual screen wells which will be installed in separate boreholes. Wells IRZ-1, 5, and 9 are constructed with a dedicated pump for each well screen with the intervals separated using a pneumatic packer. IRZ-23 well design and operation will target extraction of groundwater from all four model layers without being screened across all layers. East Ravine extraction wells (ER-1 to ER-4) are not expected to produce significant water and automated pump cycling could be required.

Hexavalent Chromium Concentration (ppb)

32, 100, 500, 1,000, 5,000, 10,000, 15,000

*Well is projected onto cross-section. Actual well screen elevations are honored in all wells. Model layer boudaries are adjusted to correlate to the projected wells.

Proposed Remediation Well | Future Provisional Remediation Well | Existing Monitoring Well | Proposed Monitoring Well

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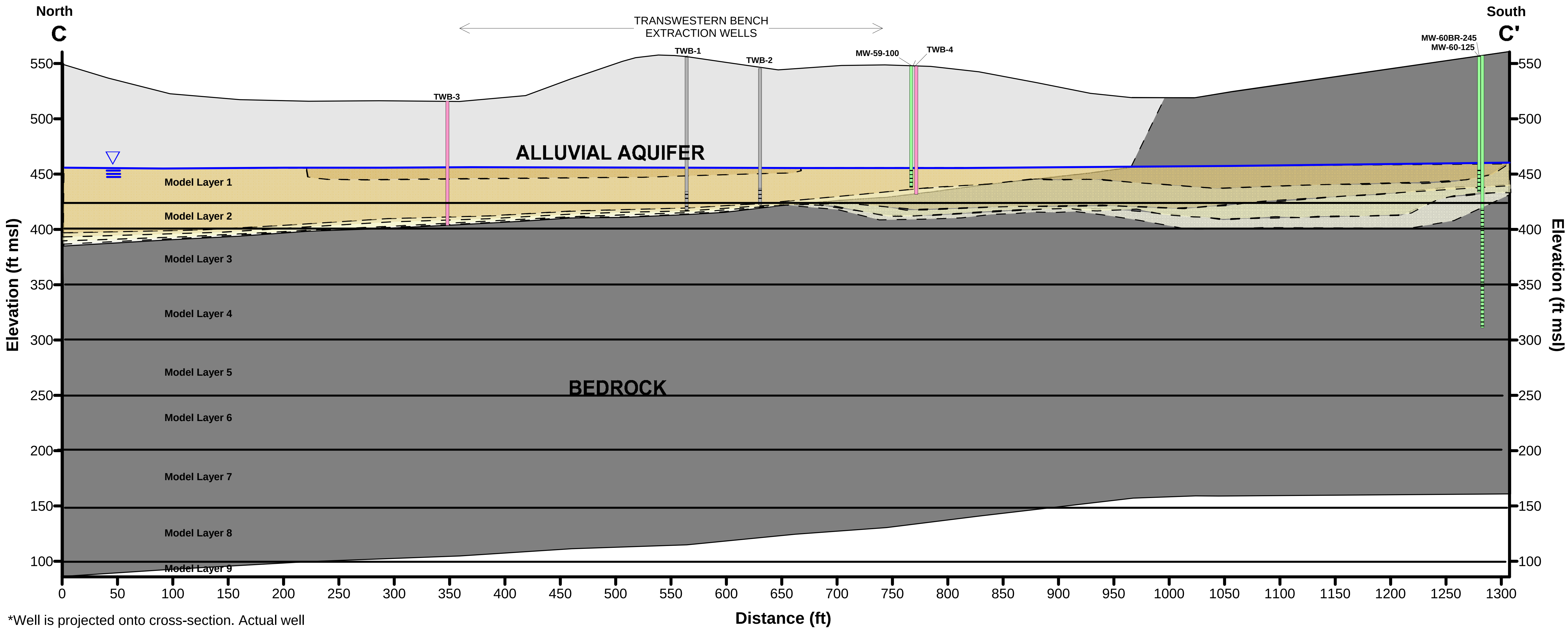
TOPOCK COMPRESSOR STATION
NEEDLES, CALIFORNIA
DEVELOPMENT OF GROUNDWATER FLOW AND SOLUTE TRANSPORT MODELS

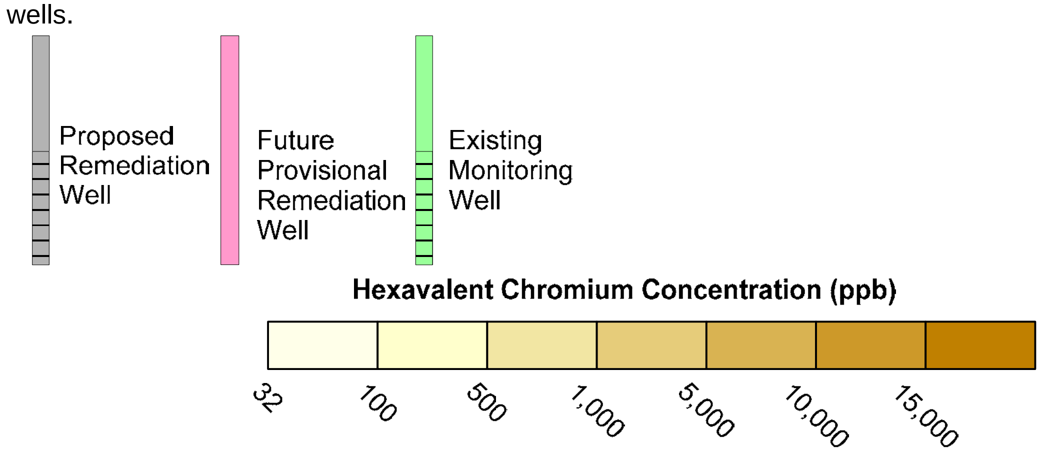
CONCEPTUAL FINAL GROUNDWATER REMEDY CROSS-SECTION B-B'

ARCADIS Design & Consultancy for natural and built assets

FIGURE 3.2-4



*Well is projected onto cross-section. Actual well screen elevations are honored in all wells. Model layer boudaries are adjusted to correlate to the projected wells.



Number of wells, total screen intervals, and screen length and depth placement at each well location ID are for purposes of final (100%) design submittal and may be modified during installation. One well location ID may consist of multiple screens, and one well screen interval may include more than one model layer. A maximum of two discrete screen intervals will be included per individual remediation well. Dual screen wells will consist of one well with two discrete screen intervals separated by a packer. Extraction well design and operation will target extraction of groundwater from all four model layers without being screened across all layers.

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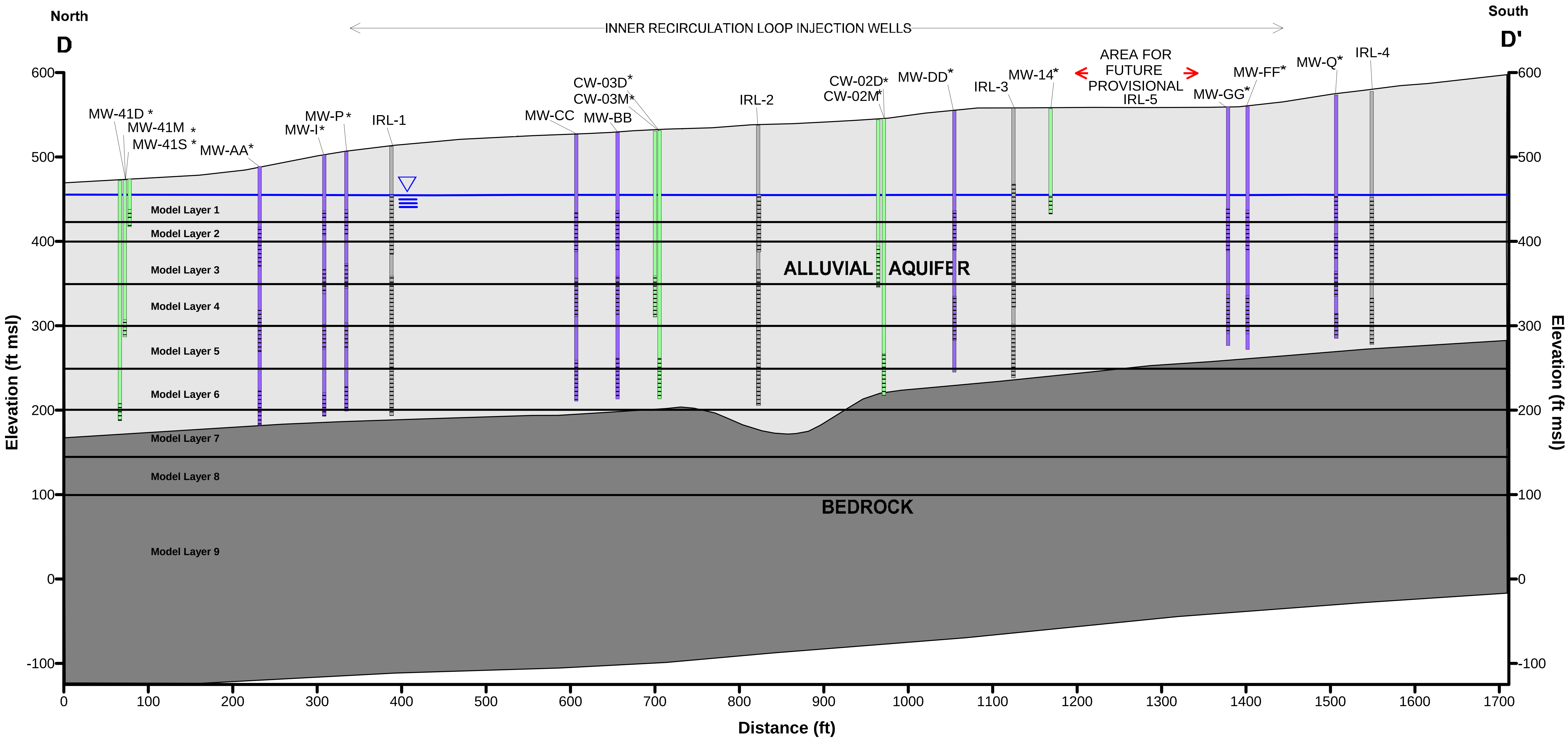
NEEDLES, CALIFORNIA
DEVELOPMENT OF GROUNDWATER FLOW AND SOLUTE TRANSPORT MODELS

CONCEPTUAL FINAL GROUNDWATER REMEDY
CROSS-SECTION C-C'

ARCADIS Design & Consultancy for natural and built assets

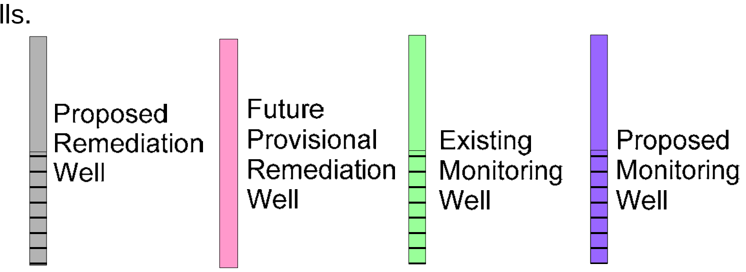
FIGURE
3.2-5



Number of wells, total screen intervals, and screen length and depth placement at each well location ID are for purposes of final (100%) design submittal and may be modified during installation.

One well location ID may consist of multiple screens, and one well screen interval may include more than one model layer. A maximum of two discrete screen intervals will be included per individual remediation well. Dual screen wells will consist of one well with two discrete screen intervals separated by a packer (as appropriate).

*Well is projected onto cross-section. Actual well screen elevations are honored in all wells. Model layer boundaries are adjusted to correlate to the projected wells.



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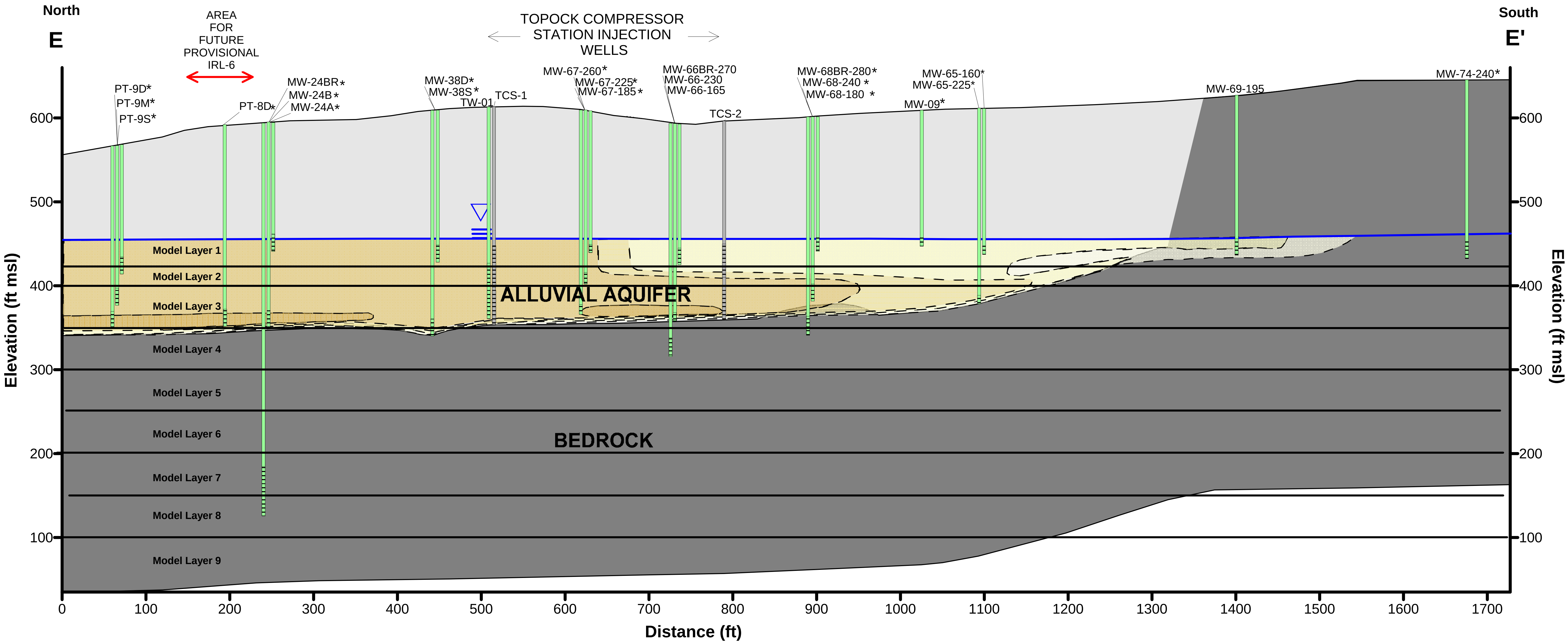
TOPOCK COMPRESSOR STATION
NEEDLES, CALIFORNIA
DEVELOPMENT OF GROUNDWATER FLOW AND SOLUTE TRANSPORT MODELS

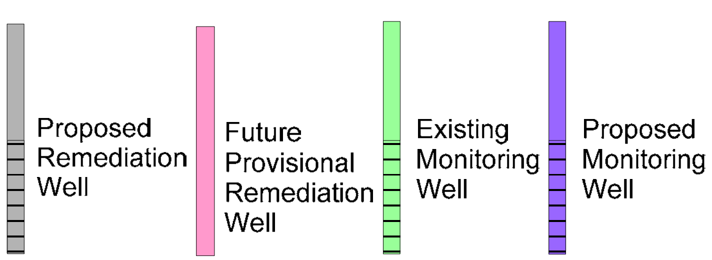
CONCEPTUAL FINAL GROUNDWATER REMEDY
CROSS-SECTION D-D'

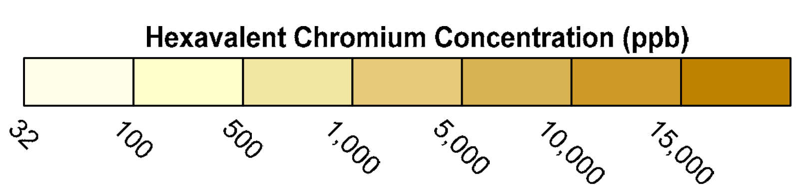
ARCADIS Design & Consultancy for natural and built assets

FIGURE
3.2-6



*Well is projected onto cross-section. Actual well screen elevations are honored in all wells. Model layer boundaries are adjusted to correlate to the projected wells.





Number of wells, total screen intervals, and screen length and depth placement at each well location ID are for purposes of final (100%) design submittal and may be modified during installation. One well location ID may consist of multiple screens, and one well screen interval may include more than one model layer. A maximum of two discrete screen intervals will be included per individual remediation well. Dual screen wells will consist of one well with two discrete screen intervals separated by a packer.

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TOPOCK COMPRESSOR STATION
NEEDLES, CALIFORNIA
DEVELOPMENT OF GROUNDWATER FLOW AND SOLUTE TRANSPORT MODELS

CONCEPTUAL FINAL GROUNDWATER REMEDY CROSS-SECTION E-E'

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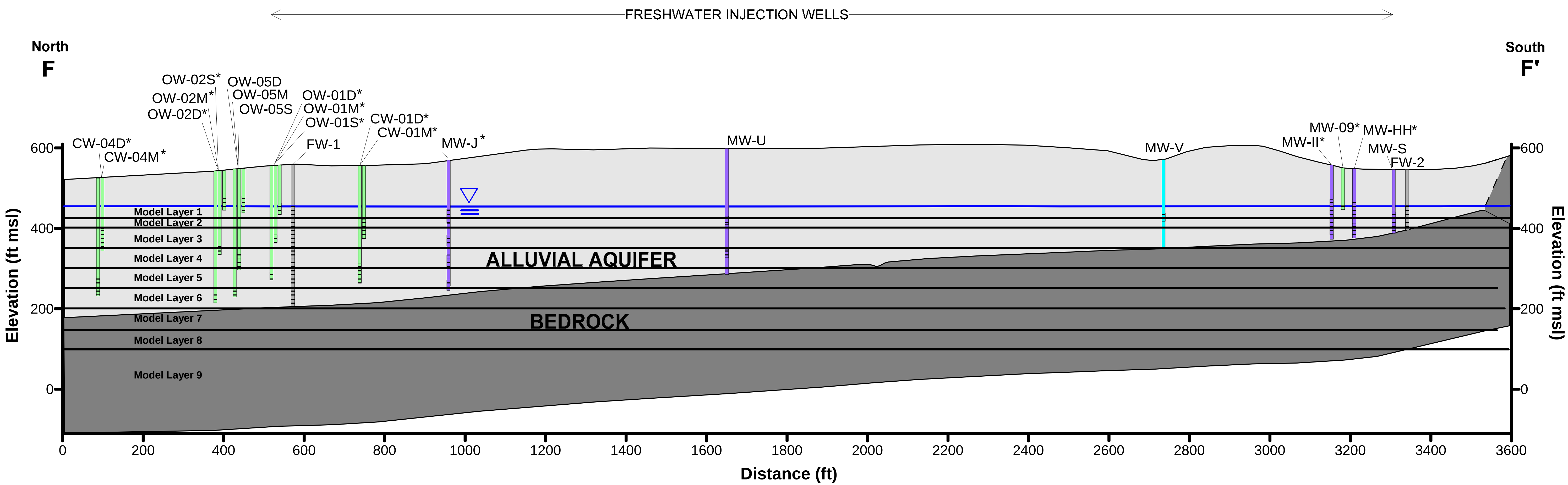
FIGURE
3.2-7



*Well is projected onto cross-section. Actual well screen elevations are honored in all wells. Model layer boudaries are adjusted to correlate to the projected wells.

Proposed Remediation Well

Existing Monitoring Well

Proposed Monitoring Well

Future Provisional Monitoring Well

Number of wells, total screen intervals, and screen length and depth placement at each well location ID are for purposes of final (100%) design submittal and may be modified during installation.

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TOPOCK COMPRESSOR STATION
NEEDLES, CALIFORNIA
DEVELOPMENT OF GROUNDWATER FLOW AND SOLUTE TRANSPORT MODELS

CONCEPTUAL FINAL GROUNDWATER REMEDY
CROSS-SECTION F-F'

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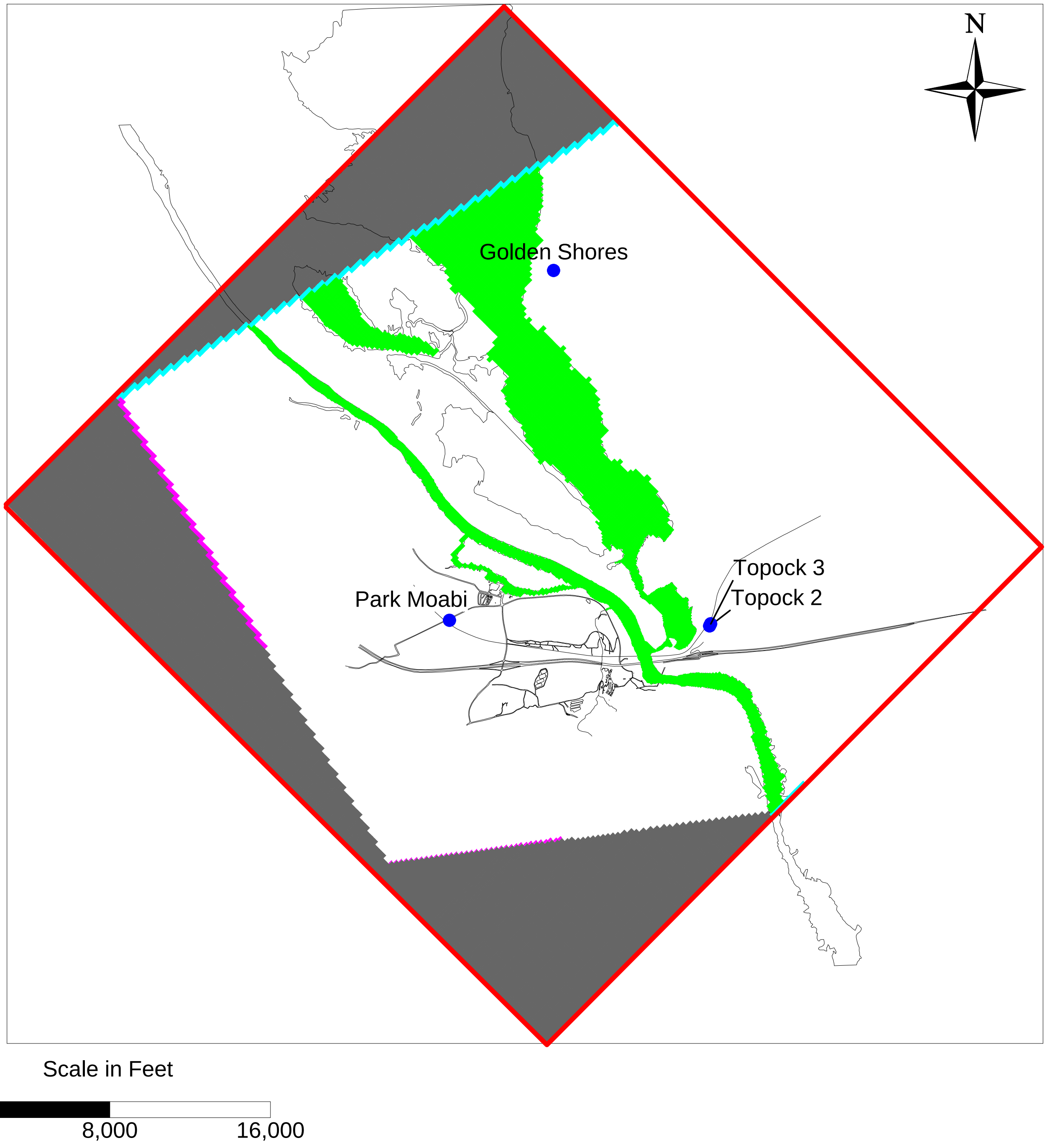
FIGURE
3.2-8



LEGEND

- Constant Flux Boundary Cell
- Constant Head Boundary Cell
- River Boundary Cell
- No Flow Boundary Cell
- Pumping Wells
- Model Extents

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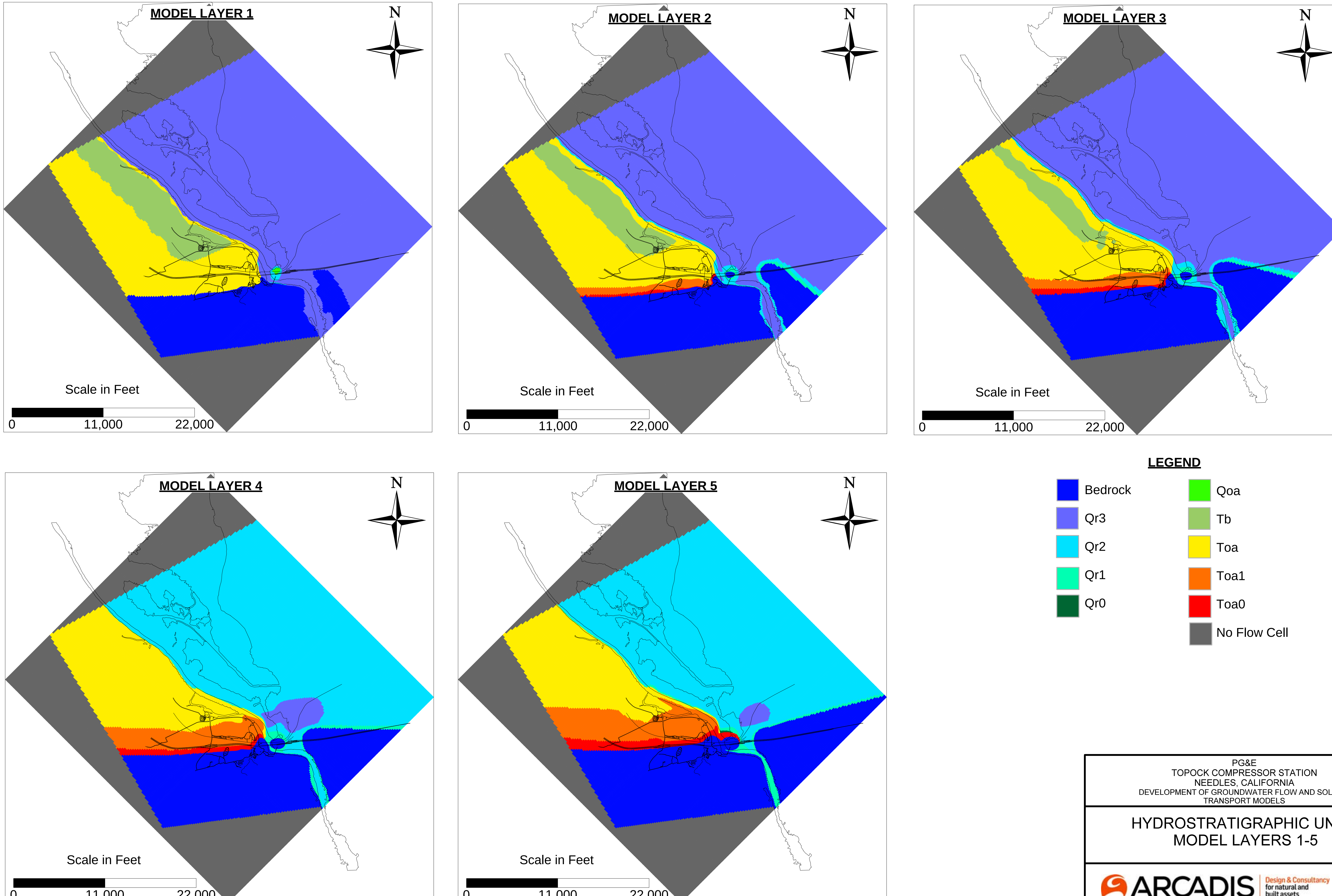
TOPOCK COMPRESSOR STATION
NEEDLES, CALIFORNIA
DEVELOPMENT OF GROUNDWATER FLOW AND SOLUTE TRANSPORT MODELS

BOUNDARY CONDITIONS

ARCADIS Design & Consultancy for natural and built assets

FIGURE
3.3-1



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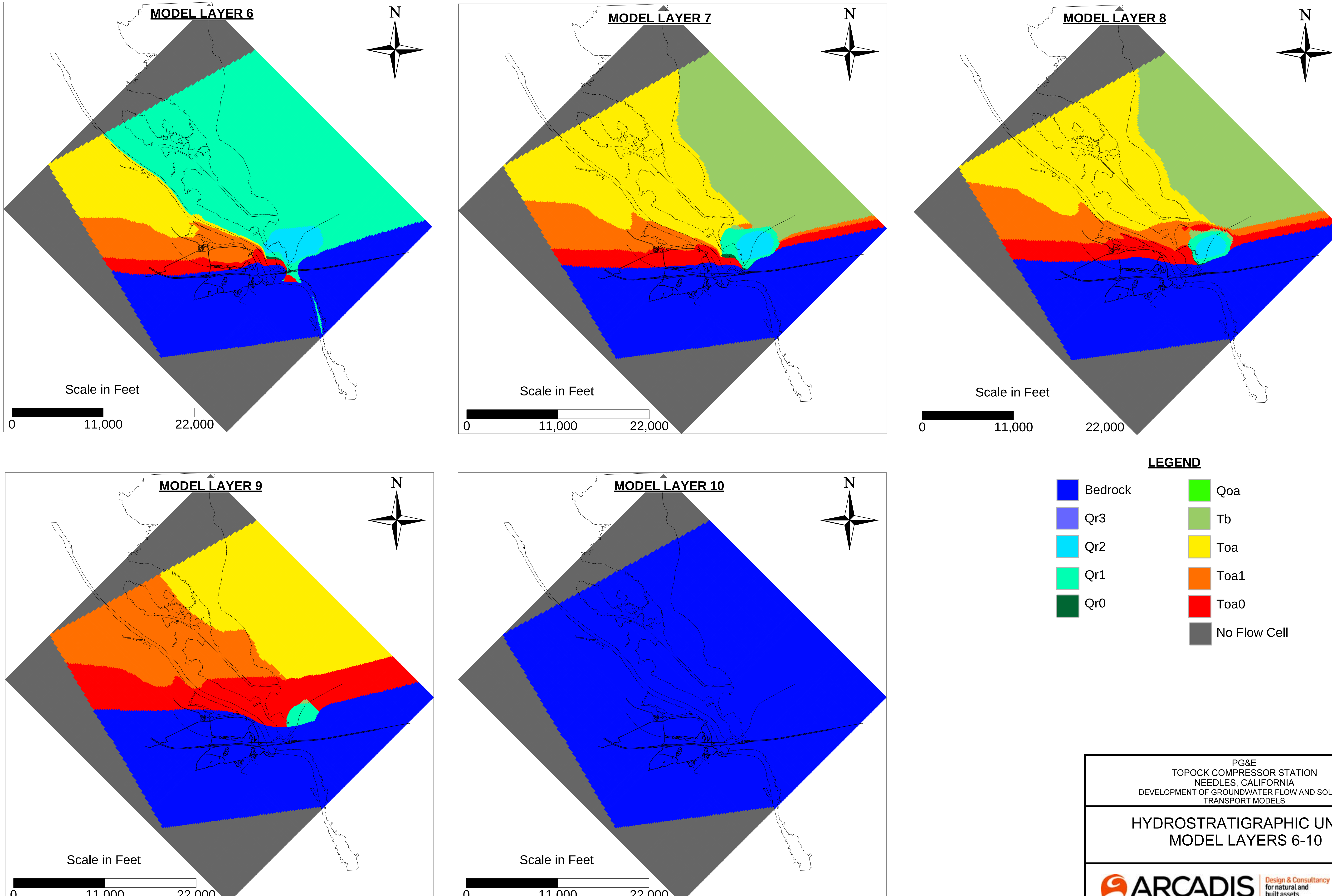
TOPOCK COMPRESSOR STATION
NEEDLES, CALIFORNIA
DEVELOPMENT OF GROUNDWATER FLOW AND SOLUTE TRANSPORT MODELS

HYDROSTRATIGRAPHIC UNITS
MODEL LAYERS 1-5

ARCADIS Design & Consultancy for natural and built assets

FIGURE
3.4-1



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TOPOCK COMPRESSOR STATION
NEEDLES, CALIFORNIA
DEVELOPMENT OF GROUNDWATER FLOW AND SOLUTE TRANSPORT MODELS

HYDROSTRATIGRAPHIC UNITS
MODEL LAYERS 6-10

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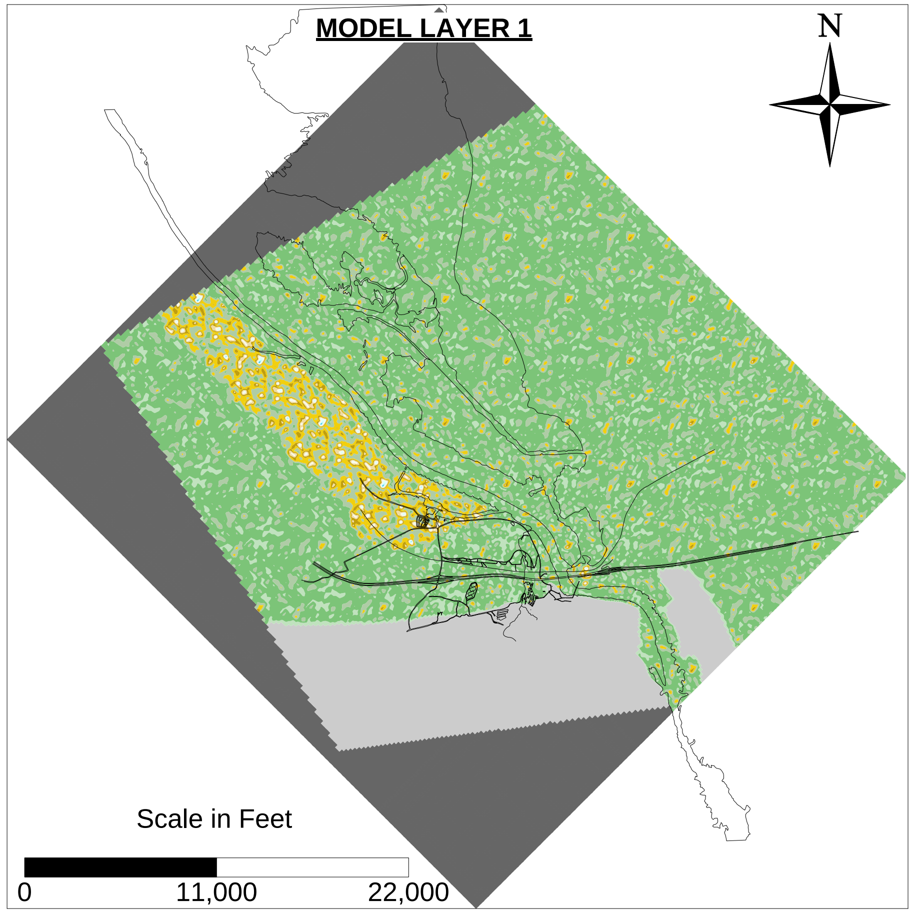
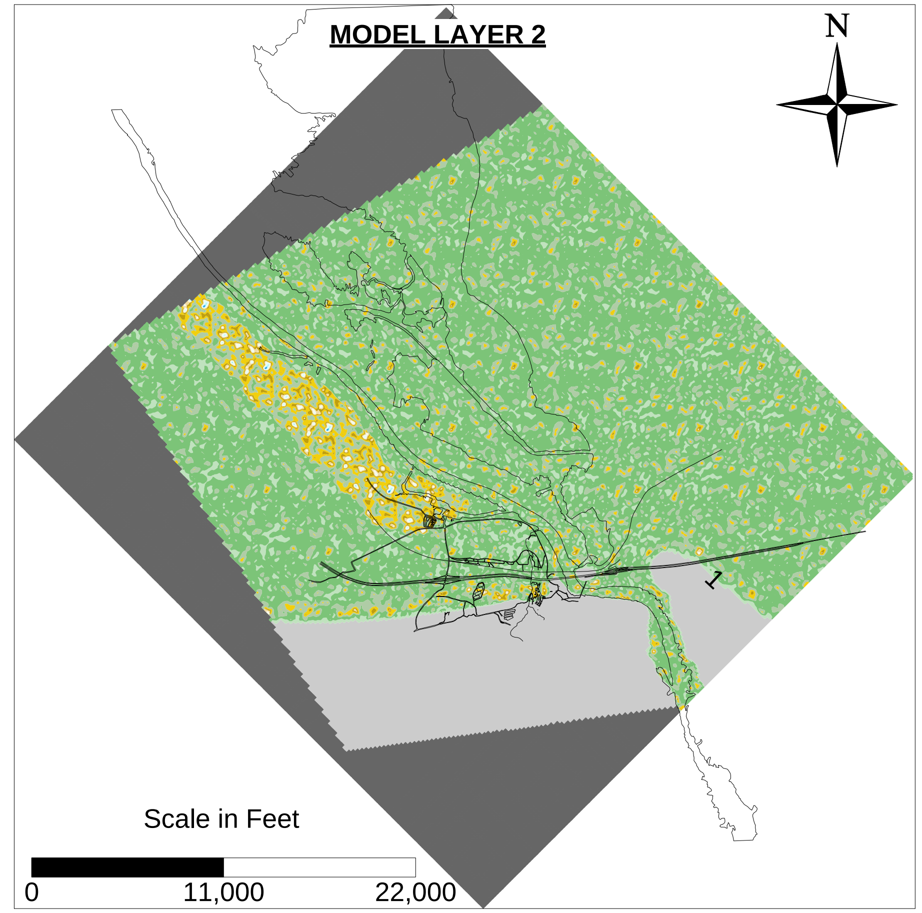
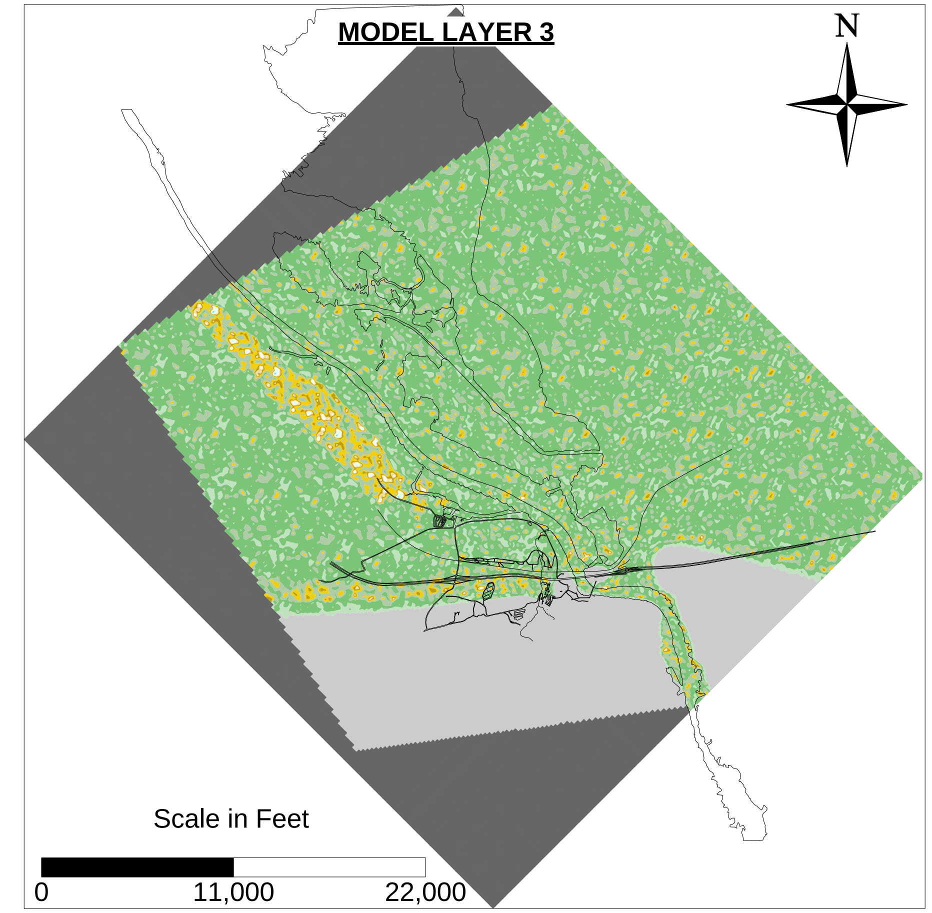
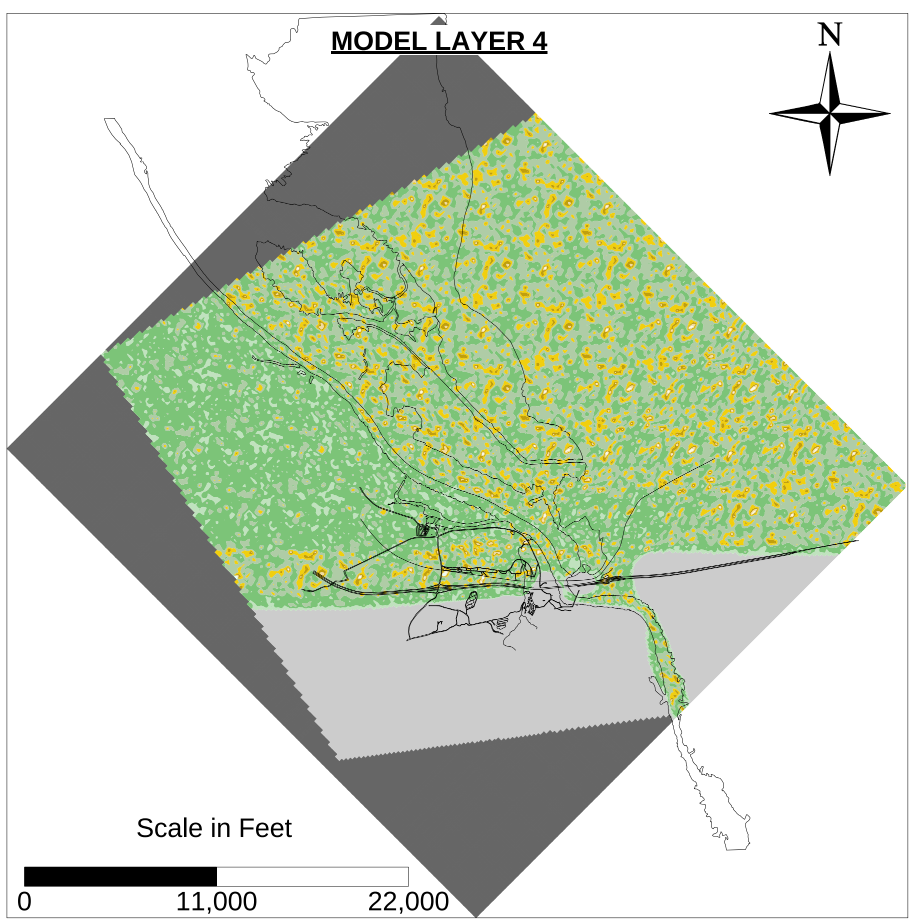
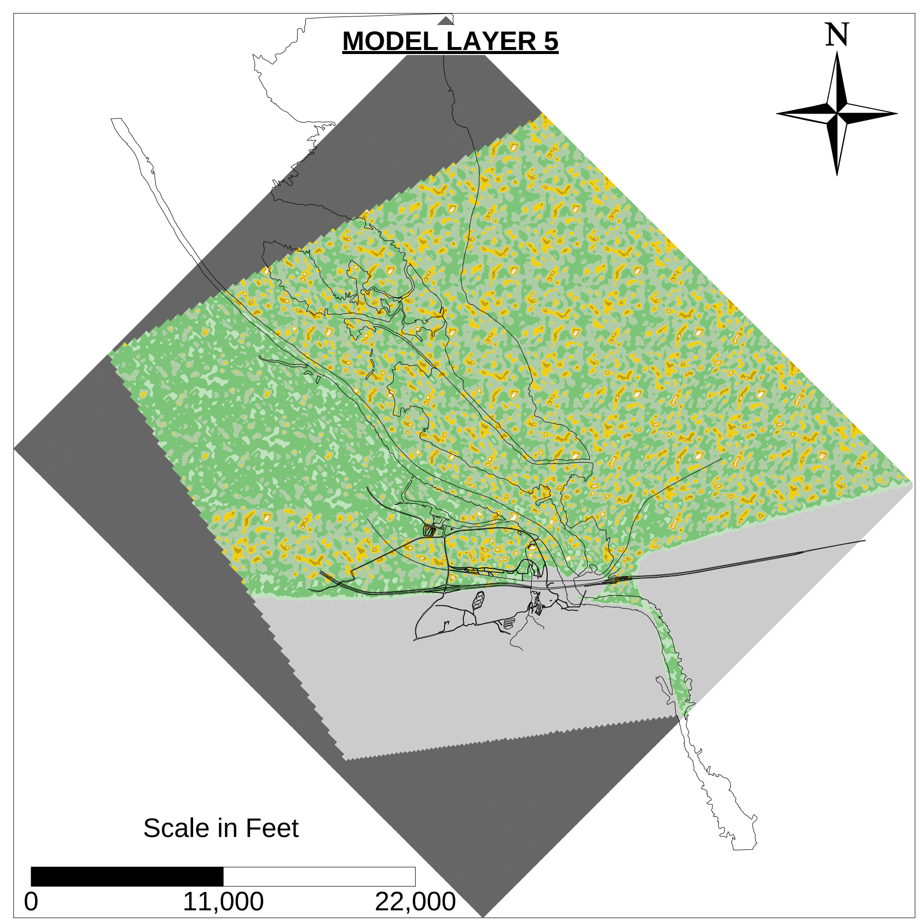
FIGURE
3.4-2











LEGEND

Horizontal Hydraulic Conductivity (ft/day)

0 1 25 50 75 100 125 150 175 200 225 250

No Flow Boundary Cell

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TOPOCK COMPRESSOR STATION
NEEDLES, CALIFORNIA
DEVELOPMENT OF GROUNDWATER FLOW AND SOLUTE TRANSPORT MODELS

HYDRAULIC CONDUCTIVITY
MODEL LAYERS 1-5

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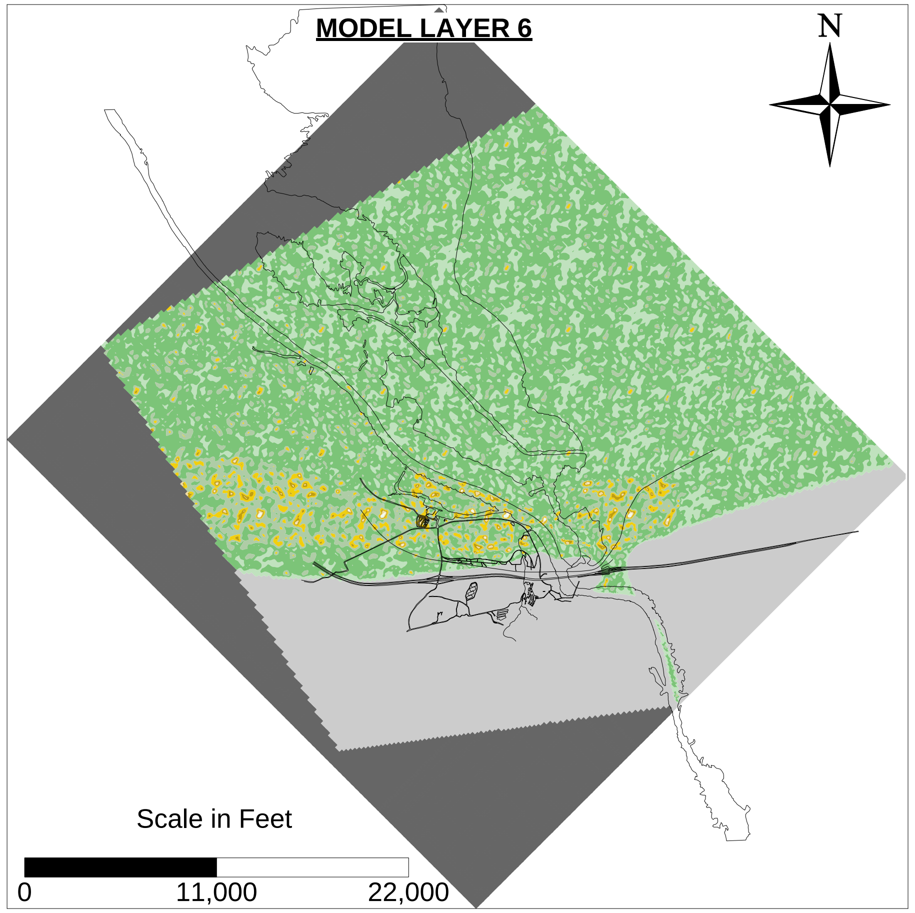
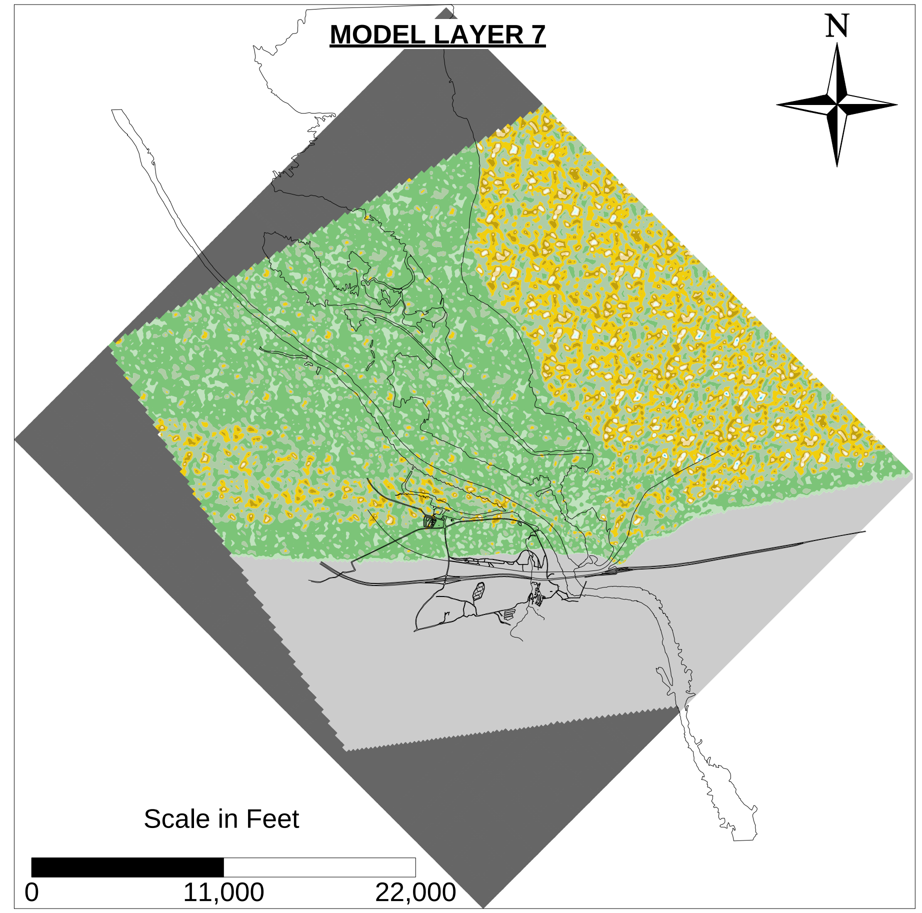
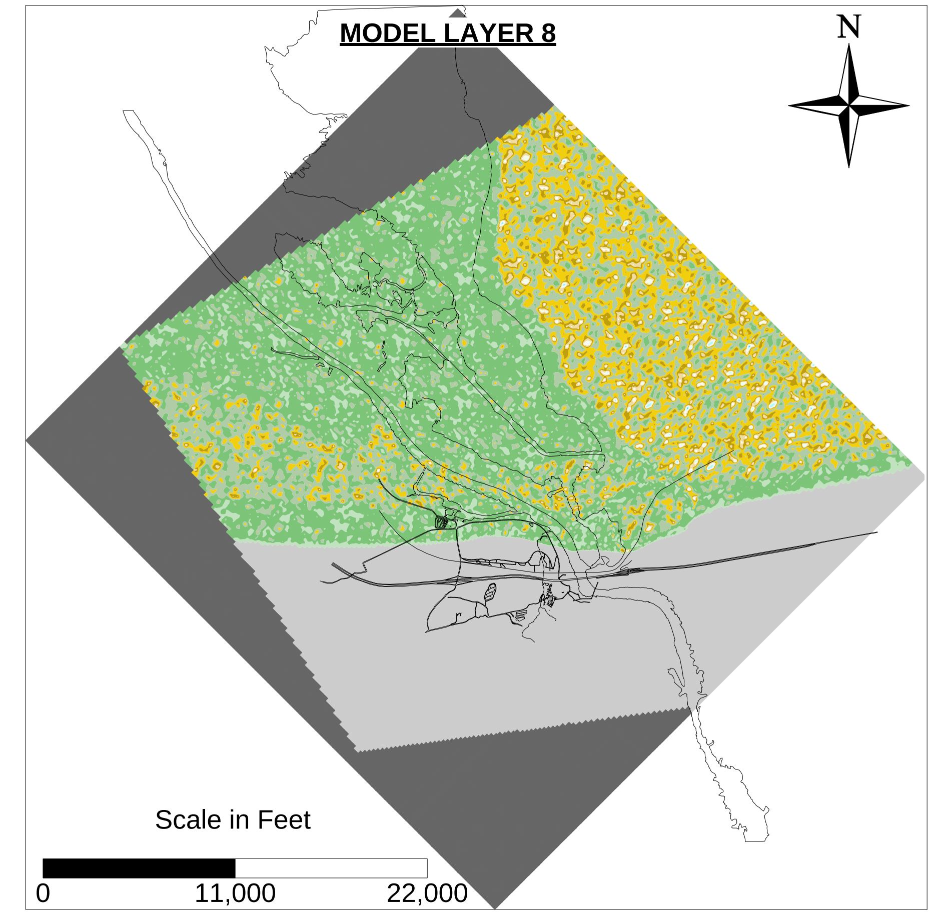
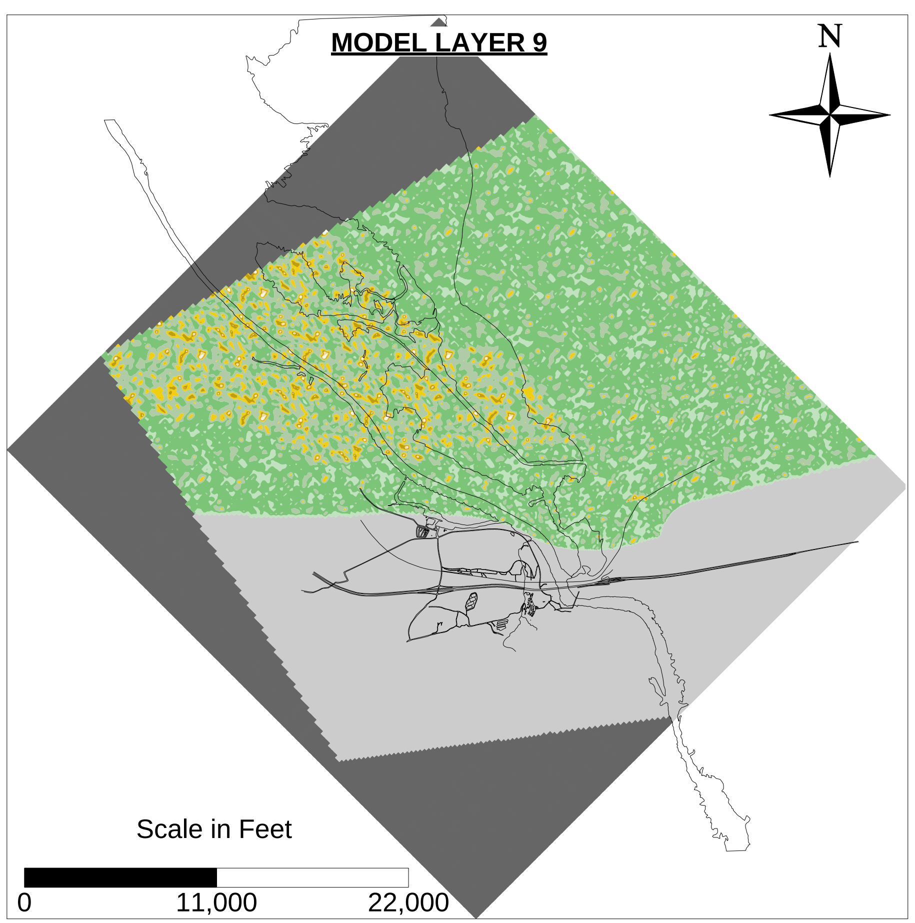
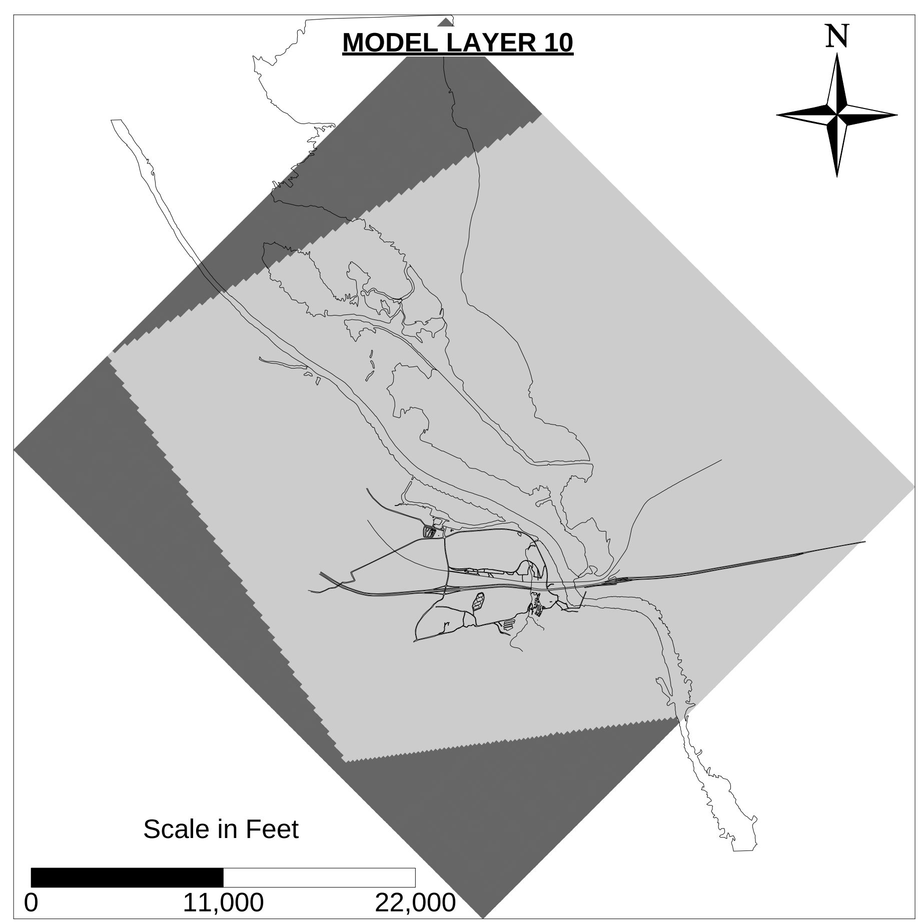
FIGURE
3.4-3

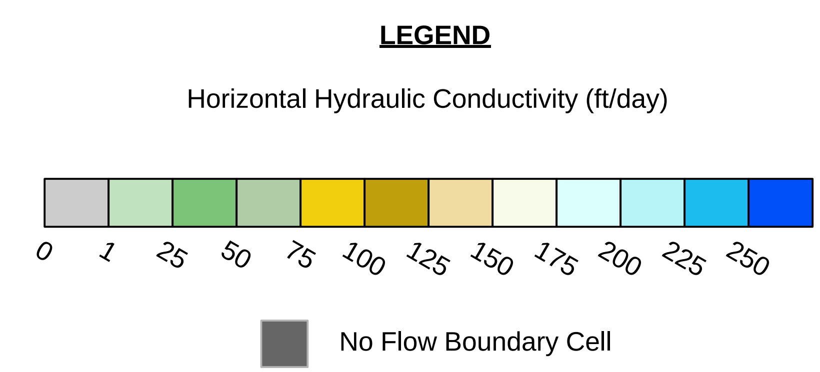












PG&E
TOPOCK COMPRESSOR STATION
NEEDLES, CALIFORNIA
DEVELOPMENT OF GROUNDWATER FLOW AND SOLUTE TRANSPORT MODELS

HYDRAULIC CONDUCTIVITY
MODEL LAYERS 6-10

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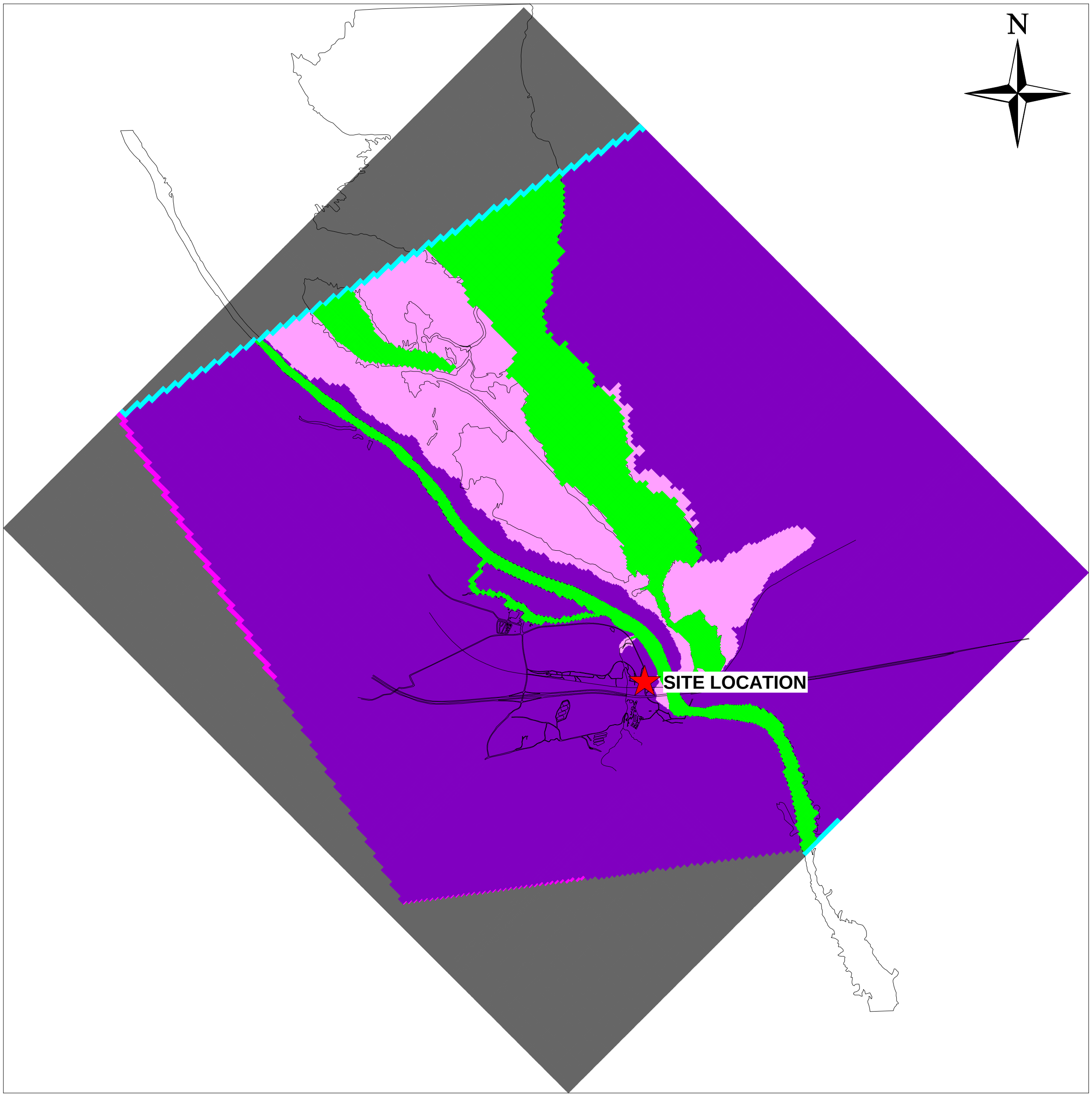
FIGURE
3.4-4



Scale in Feet

0 8,000 16,000

LEGEND

- Constant Flux Boundary Cell
- Constant Head Boundary Cell
- River Boundary Cell
- No Flow Boundary Cell
- ET = 0.42 in/yr
- ET = 4.2 in/yr

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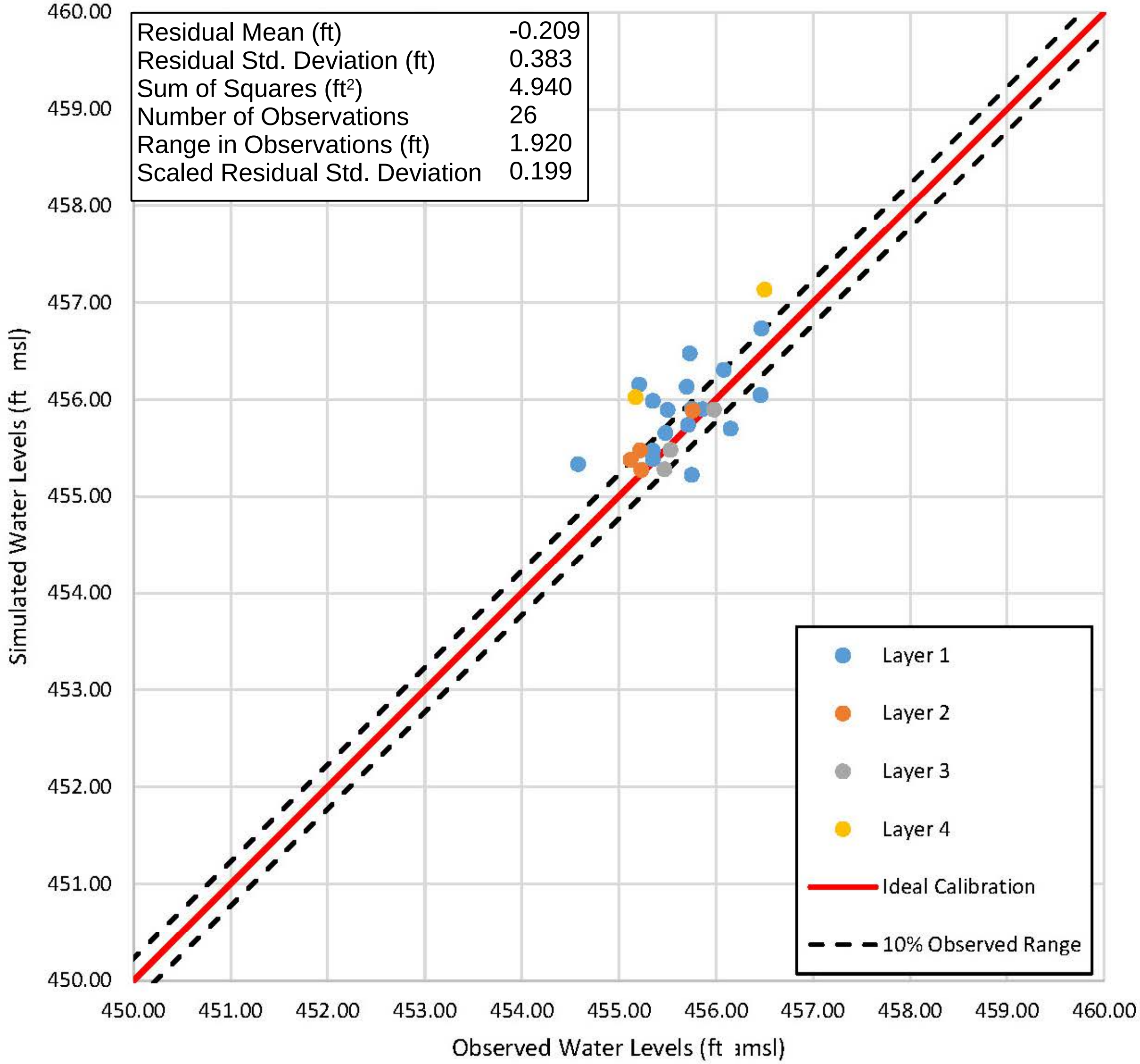
TOPOCK COMPRESSOR STATION
NEEDLES, CALIFORNIA
DEVELOPMENT OF GROUNDWATER FLOW AND SOLUTE TRANSPORT MODELS

EVAPOTRANSPIRATION ZONES

ARCADIS Design & Consultancy for natural and built assets

FIGURE
3.4-5



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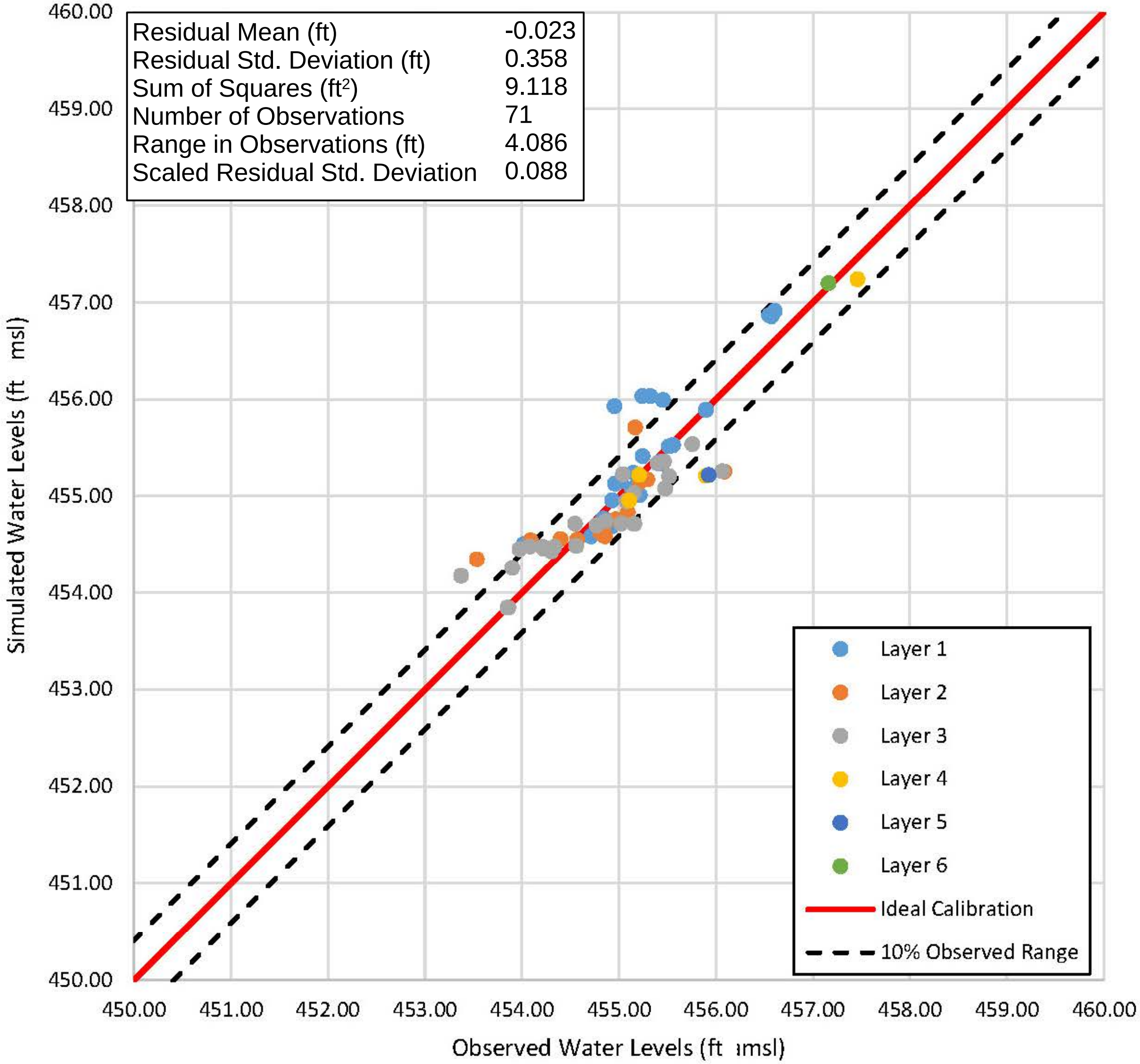
TOPOCK COMPRESSOR STATION
NEEDLES, CALIFORNIA
DEVELOPMENT OF GROUNDWATER FLOW AND SOLUTE TRANSPORT MODELS

SIMULATED VS. OBSERVED WATER LEVELS PRE IM-3 CONDITIONS

ARCADIS Design & Consultancy for natural and built assets

FIGURE
3.5-1

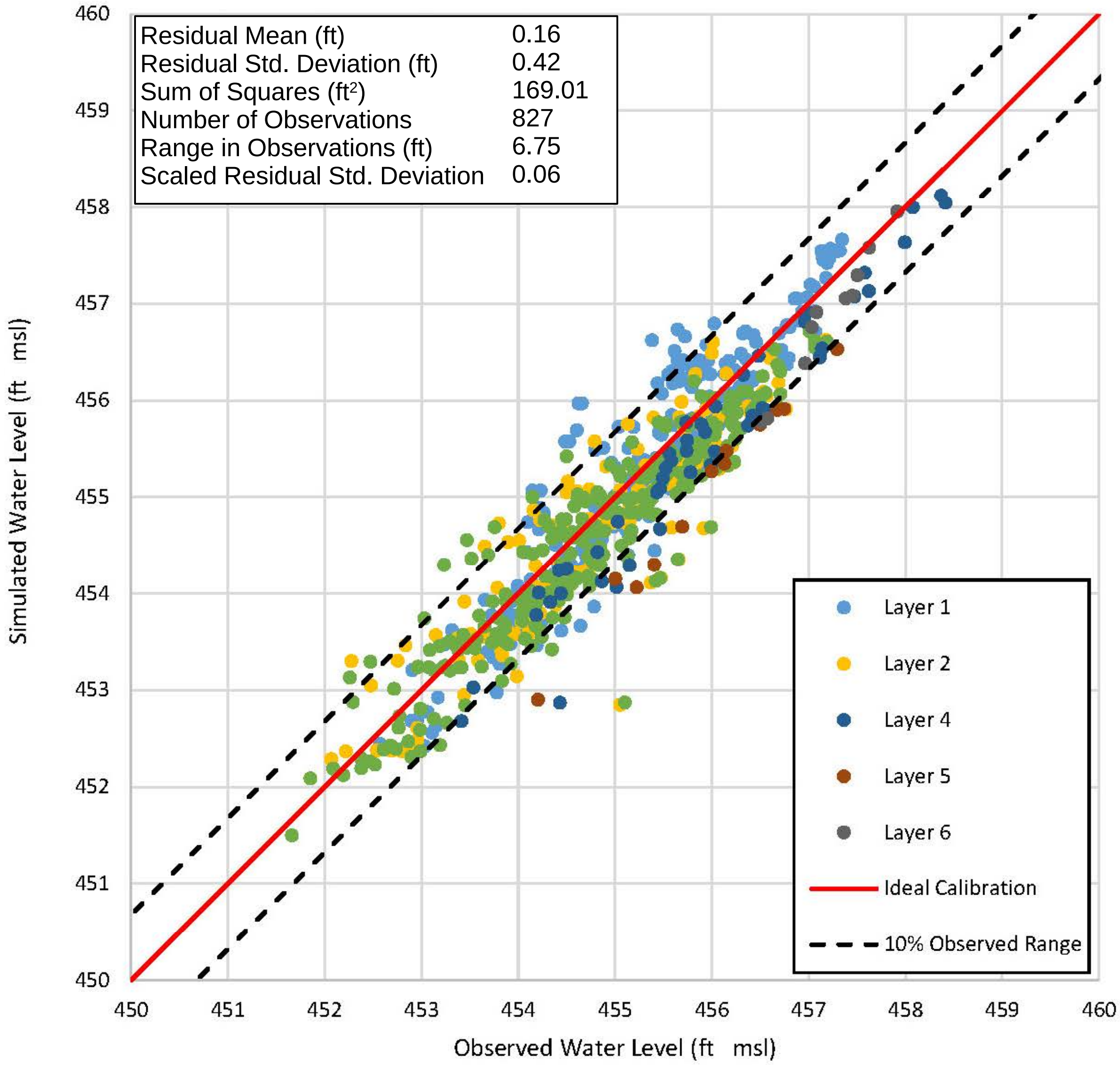


PG&E
TOPOCK COMPRESSOR STATION
NEEDLES, CALIFORNIA
DEVELOPMENT OF GROUNDWATER FLOW AND SOLUTE TRANSPORT MODELS

SIMULATED VS. OBSERVED WATER LEVELS ACTIVE IM-3 CONDITIONS

ARCADIS Design & Consultancy for natural and built assets

FIGURE
3.5-2



PG&E
TOPOCK COMPRESSOR STATION
NEEDLES, CALIFORNIA
DEVELOPMENT OF GROUNDWATER FLOW AND SOLUTE TRANSPORT MODELS

SIMULATED VS. OBSERVED WATER LEVELS TRANSIENT CALIBRATION

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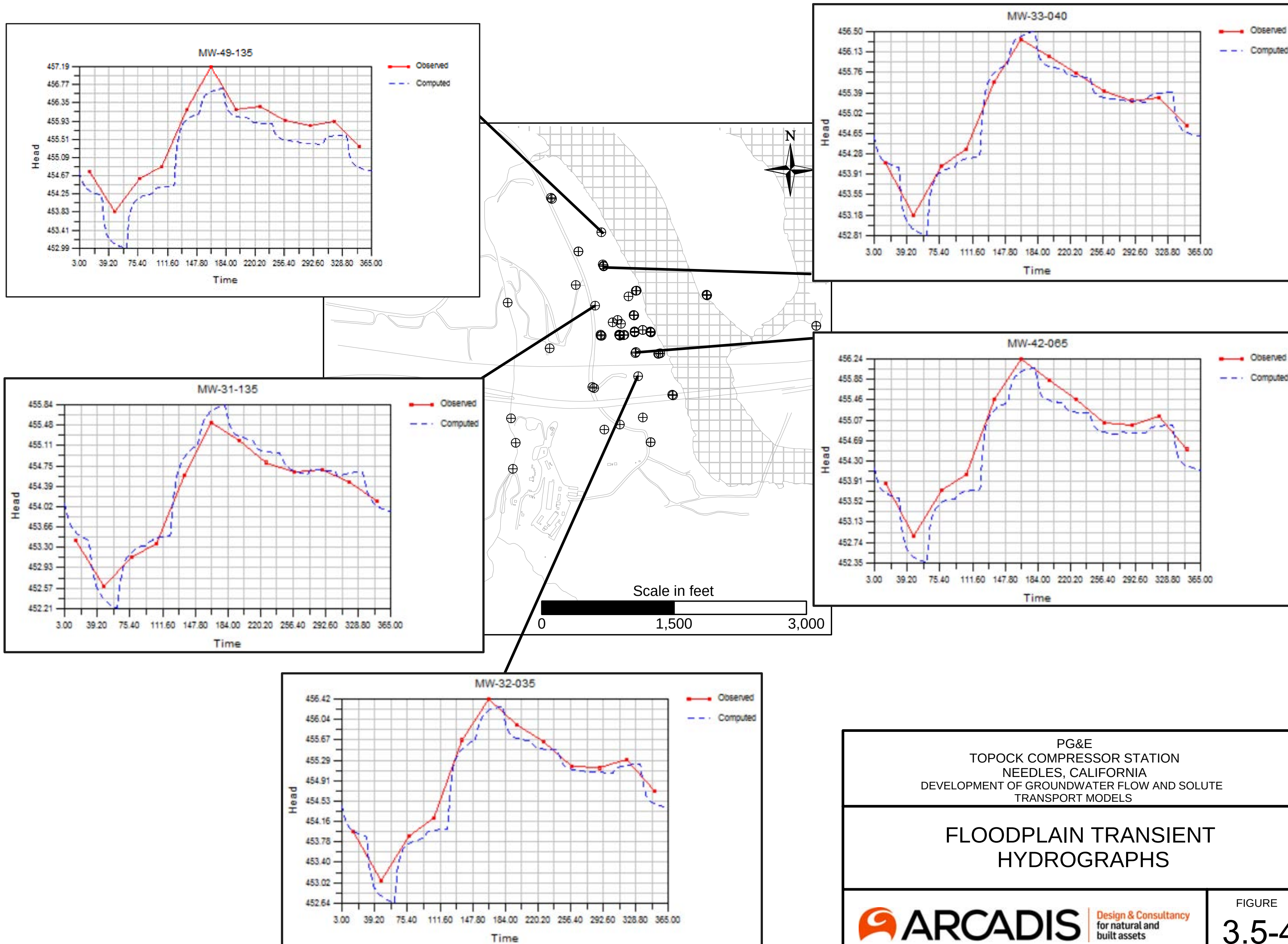
FIGURE
3.5-3

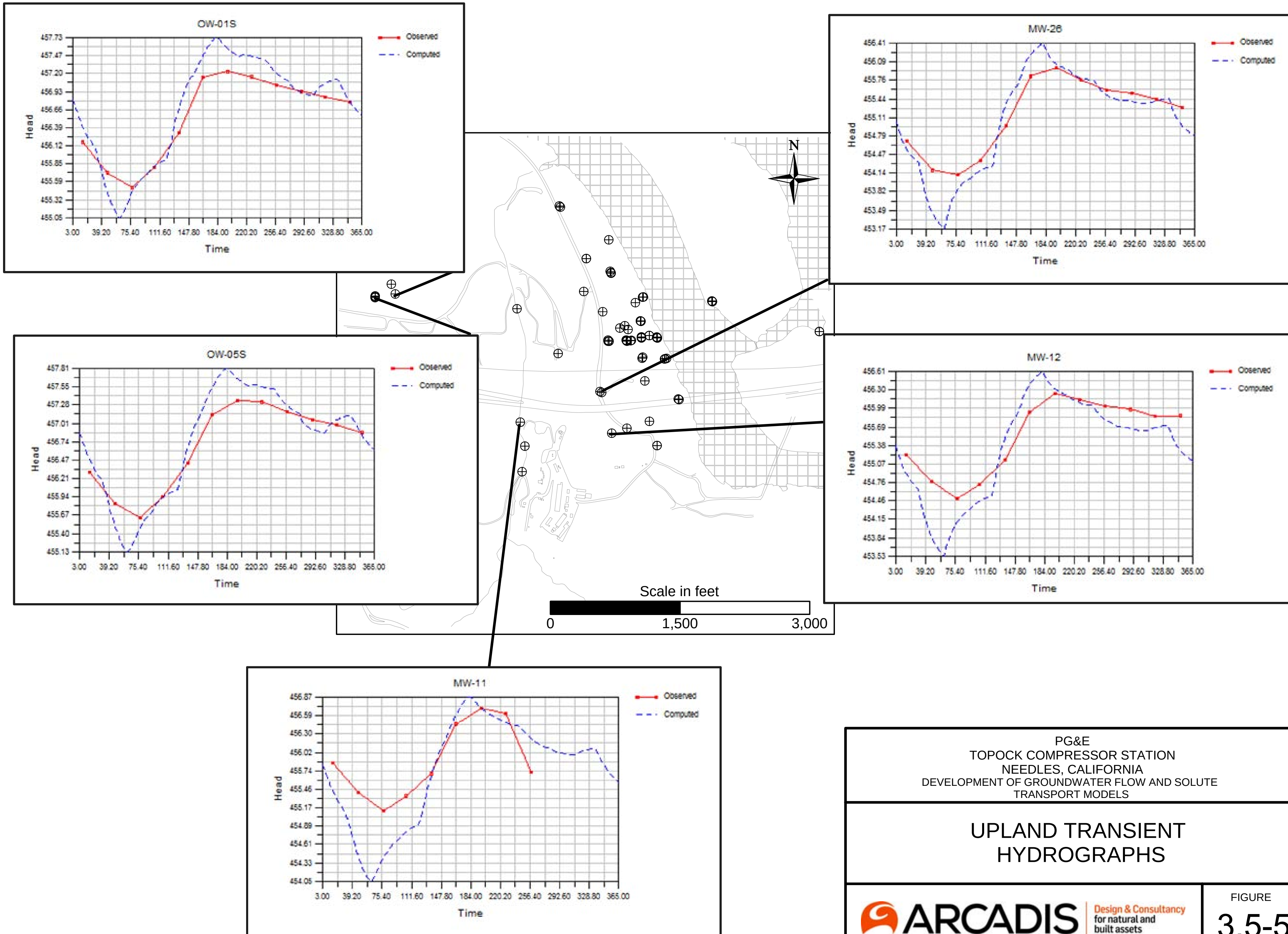


PG&E
TOPOCK COMPRESSOR STATION
NEEDLES, CALIFORNIA
DEVELOPMENT OF GROUNDWATER FLOW AND SOLUTE TRANSPORT MODELS

FLOODPLAIN TRANSIENT HYDROGRAPHS

ARCADIS Design & Consultancy for natural and built assets

FIGURE
3.5-4

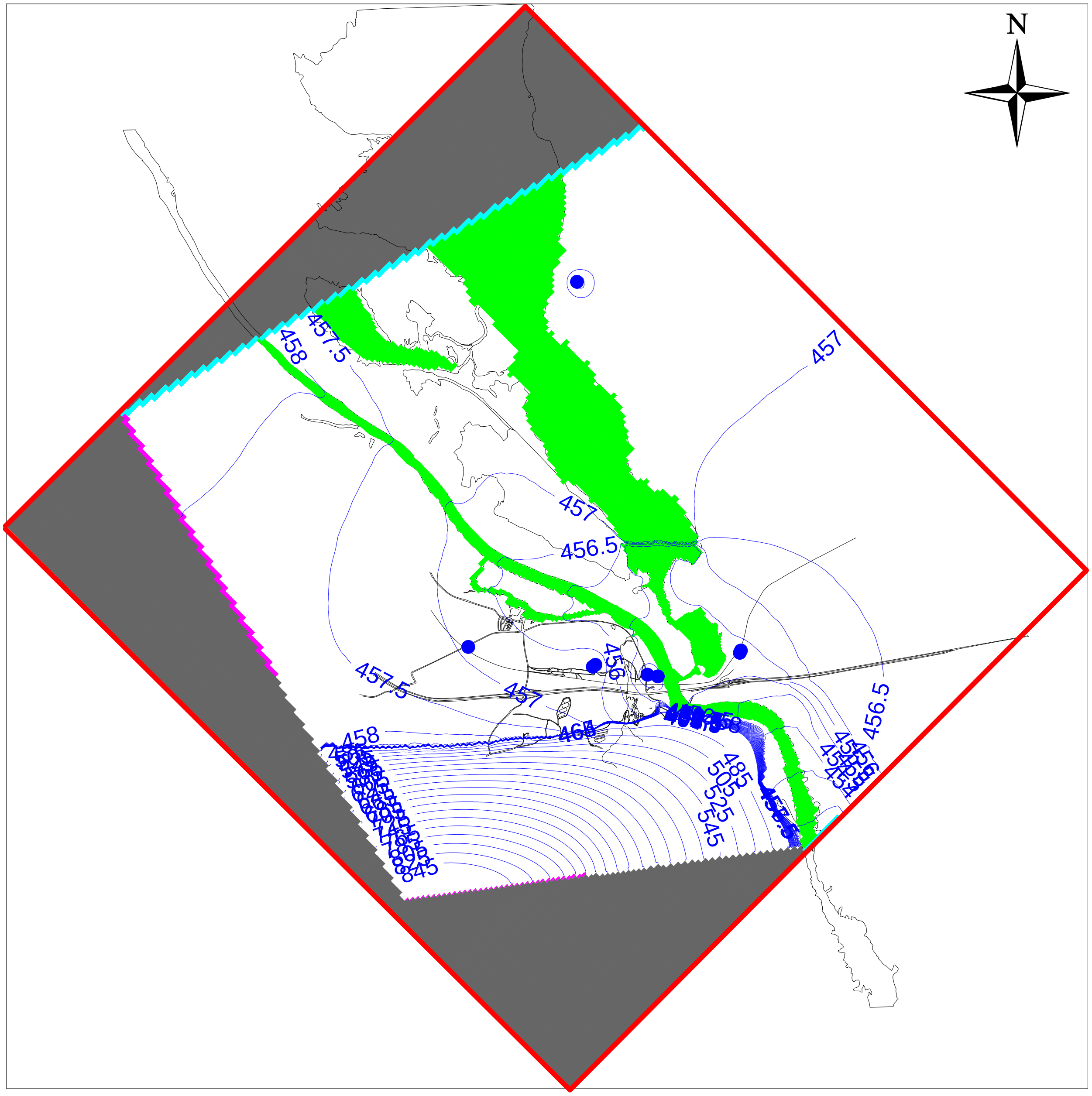


PG&E
TOPOCK COMPRESSOR STATION
NEEDLES, CALIFORNIA
DEVELOPMENT OF GROUNDWATER FLOW AND SOLUTE TRANSPORT MODELS

UPLAND TRANSIENT HYDROGRAPHS

ARCADIS Design & Consultancy for natural and built assets

FIGURE
3.5-5



Scale in Feet

0 8,000 16,000

LEGEND

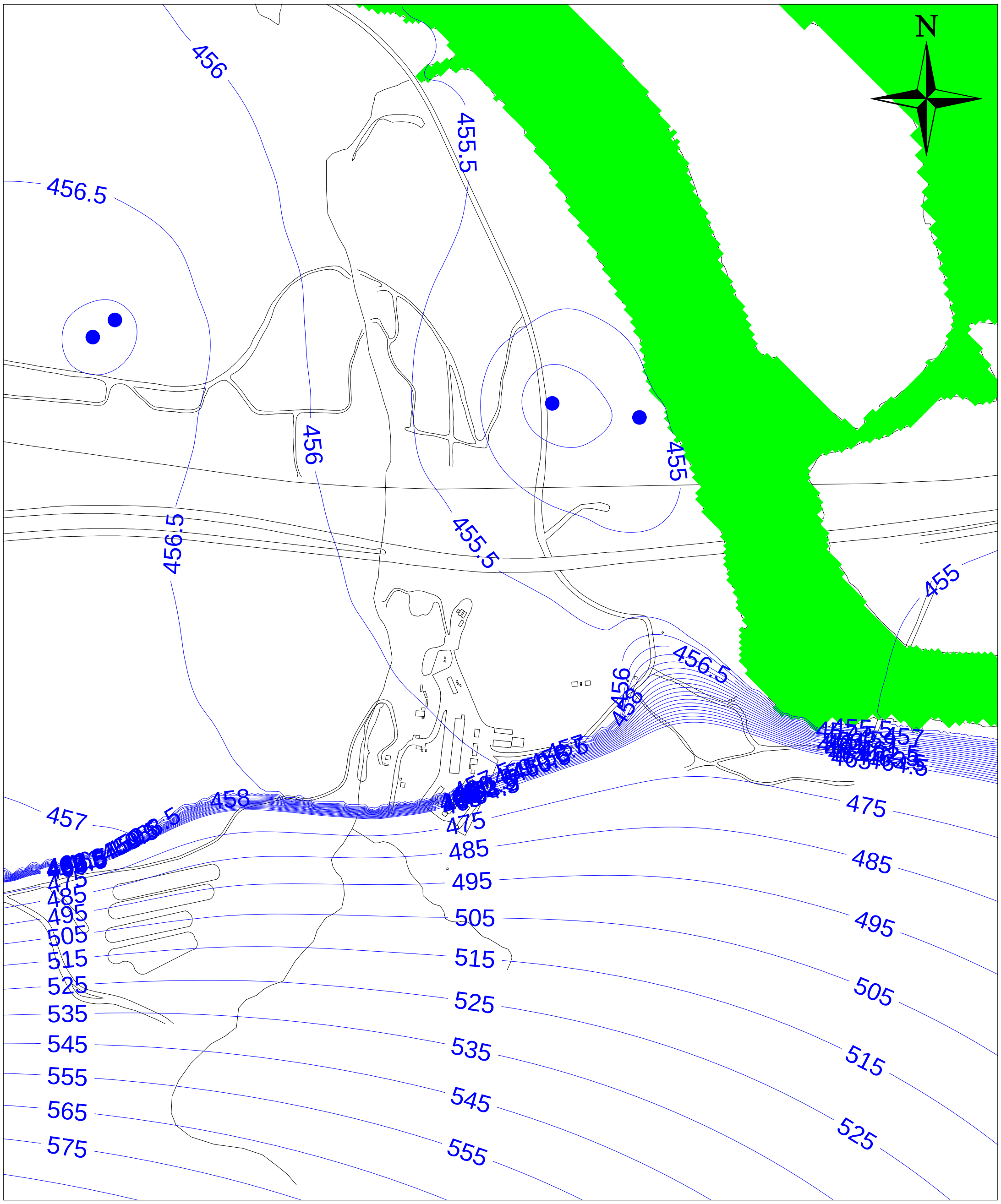
- Constant Flux Boundary Cell
- Constant Head Boundary Cell
- River Boundary Cell
- No Flow Boundary Cell
- Pumping Wells
- 457 Simulated Groundwater Levels (ft msl)
- Model Extents

PG&E
TOPOCK COMPRESSOR STATION
NEEDLES, CALIFORNIA
DEVELOPMENT OF GROUNDWATER FLOW AND SOLUTE TRANSPORT MODELS

REGIONAL SIMULATED WATER LEVEL
MODEL LAYER 1

ARCADIS Design & Consultancy for natural and built assets

FIGURE
3.6-1



Scale in Feet

0 1,000 2,000

LEGEND

River Boundary Cell

Extraction Wells

457 Simulated Groundwater Levels (ft msl)

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TOPOCK COMPRESSOR STATION
NEEDLES, CALIFORNIA
DEVELOPMENT OF GROUNDWATER FLOW AND SOLUTE TRANSPORT MODELS

SITE SIMULATED WATER LEVEL
MODEL LAYER 1

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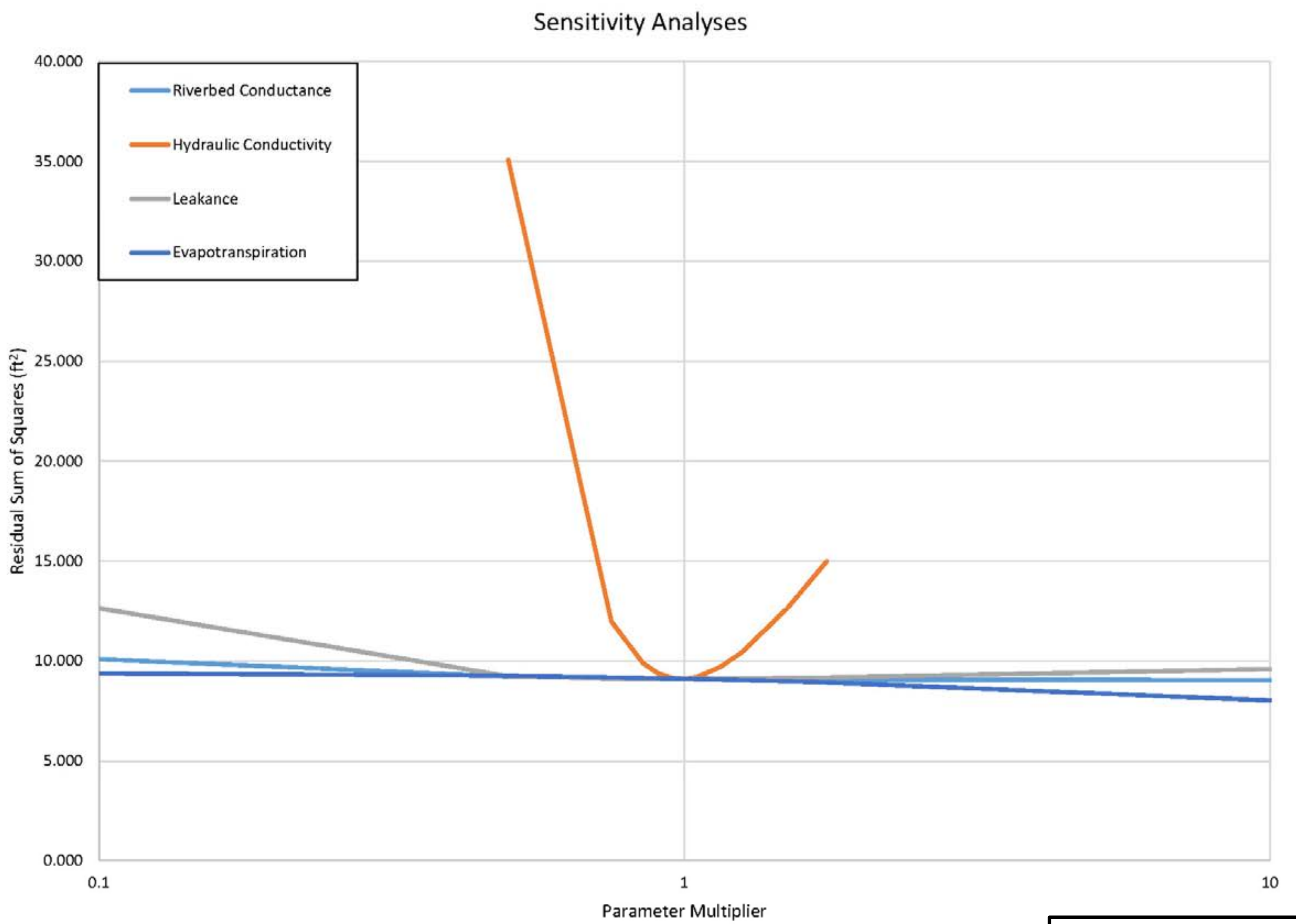
FIGURE
3.6-2



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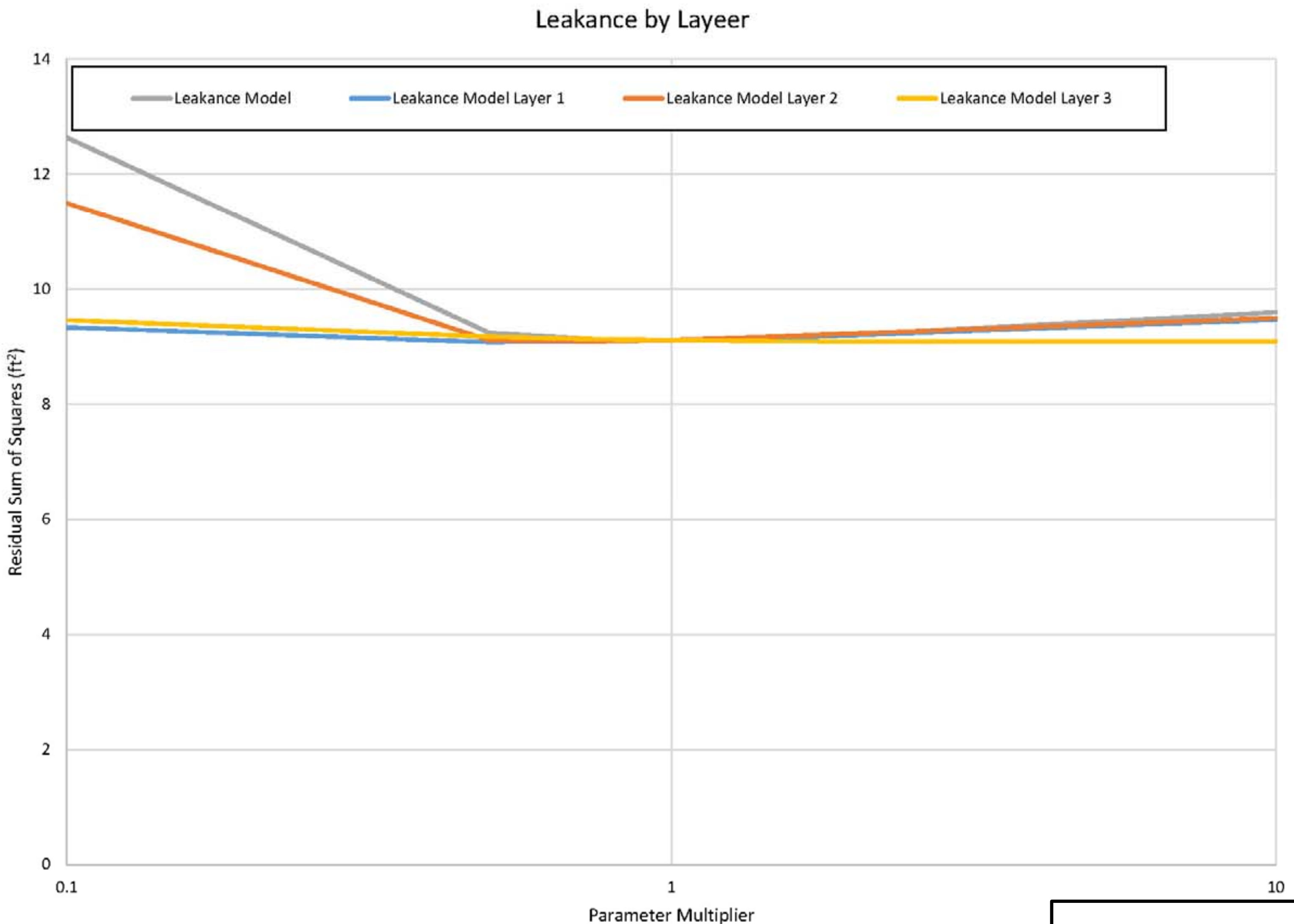
TOPOCK COMPRESSOR STATION
NEEDLES, CALIFORNIA
DEVELOPMENT OF GROUNDWATER FLOW AND SOLUTE TRANSPORT MODELS

SENSITIVITY ANALYSES

ARCADIS Design & Consultancy for natural and built assets

FIGURE 3.7-1



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DEVELOPMENT OF GROUNDWATER FLOW AND SOLUTE TRANSPORT MODELS

SENSITIVITY ANALYSES
LEAKANCE BY LAYER

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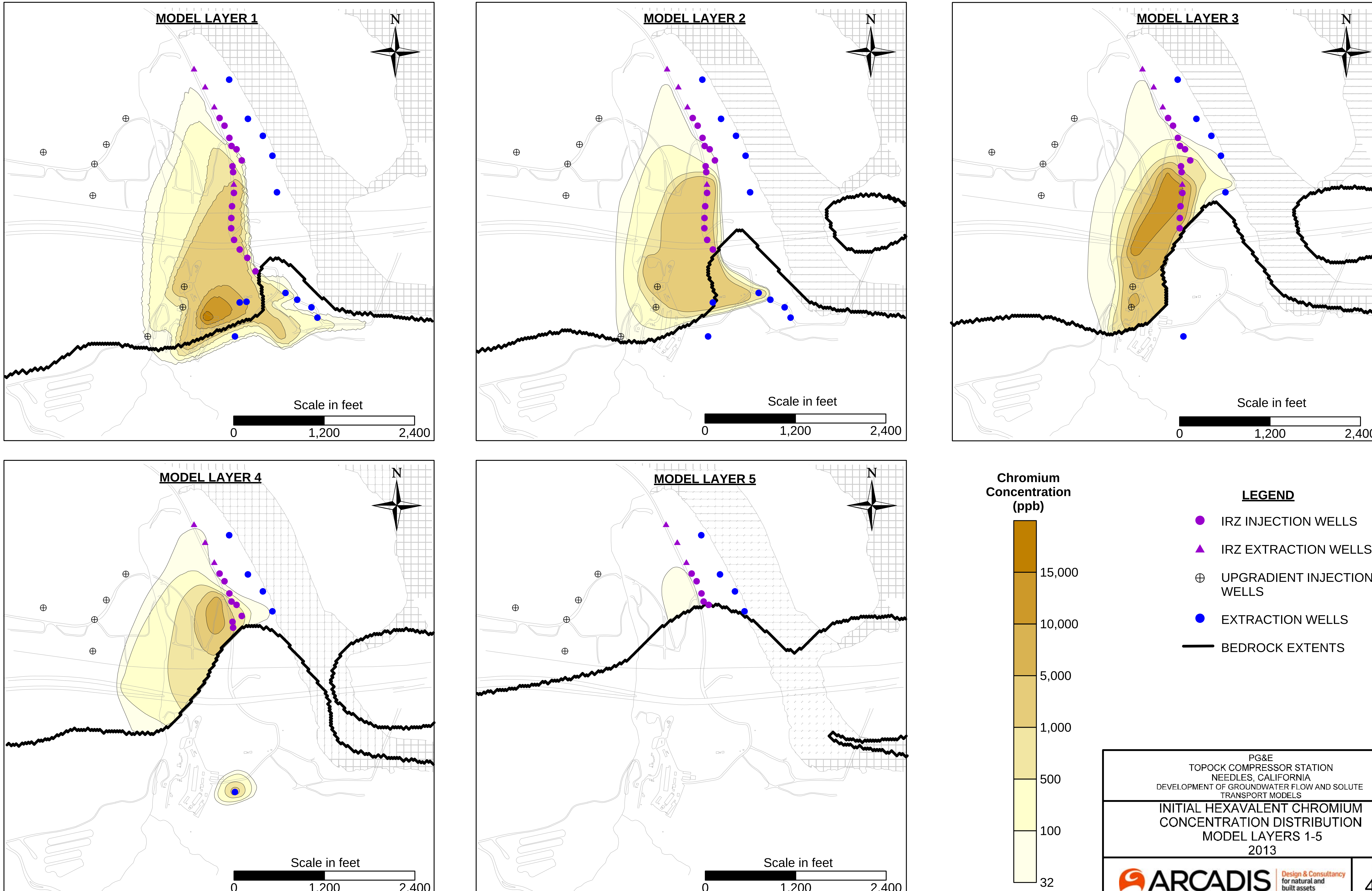
FIGURE
3.7-2



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DEVELOPMENT OF GROUNDWATER FLOW AND SOLUTE TRANSPORT MODELS

INITIAL HEXAVALENT CHROMIUM CONCENTRATION DISTRIBUTION
MODEL LAYERS 1-5
2013

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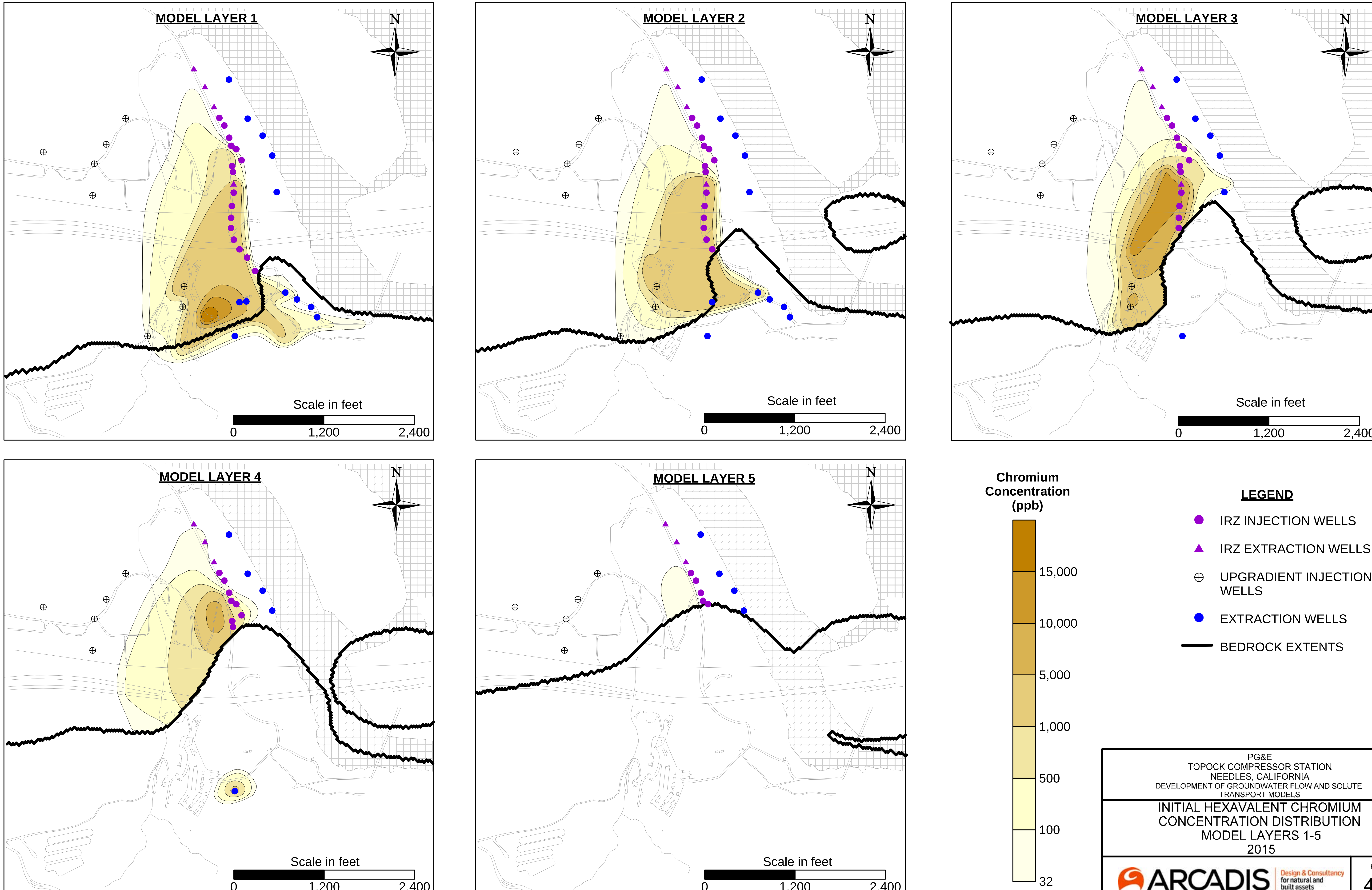
FIGURE
4.2-1



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DEVELOPMENT OF GROUNDWATER FLOW AND SOLUTE TRANSPORT MODELS

INITIAL HEXAVALENT CHROMIUM CONCENTRATION DISTRIBUTION
MODEL LAYERS 1-5
2015

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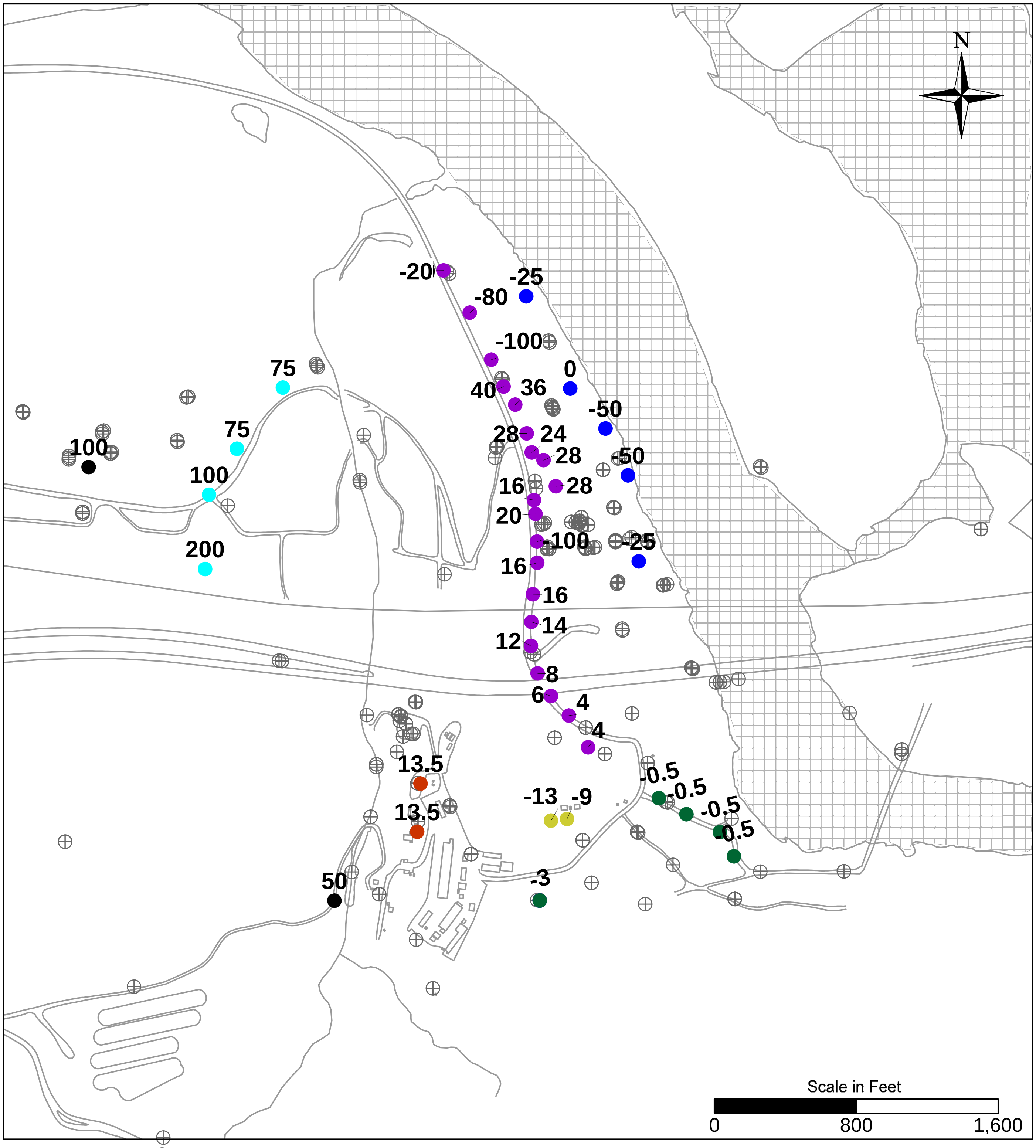
FIGURE
4.2-2



LEGEND

- NTH IRZ WELL LOCATIONS
- COMPRESSOR STATION INJECTION
- IRL INJECTION WELLS
- FRESHWATER INJECTION
- EAST RAVINE EXTRACTION WELLS
- RIVERBANK EXTRACTION WELLS
- TRANSWESTERN BENCH EXTRACTION WELLS
- MONITORING WELLS

Active Rates in GPM

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NEEDLES, CALIFORNIA
DEVELOPMENT OF GROUNDWATER FLOW AND SOLUTE TRANSPORT MODELS

REMEDIATION DESIGN WELL LOCATIONS

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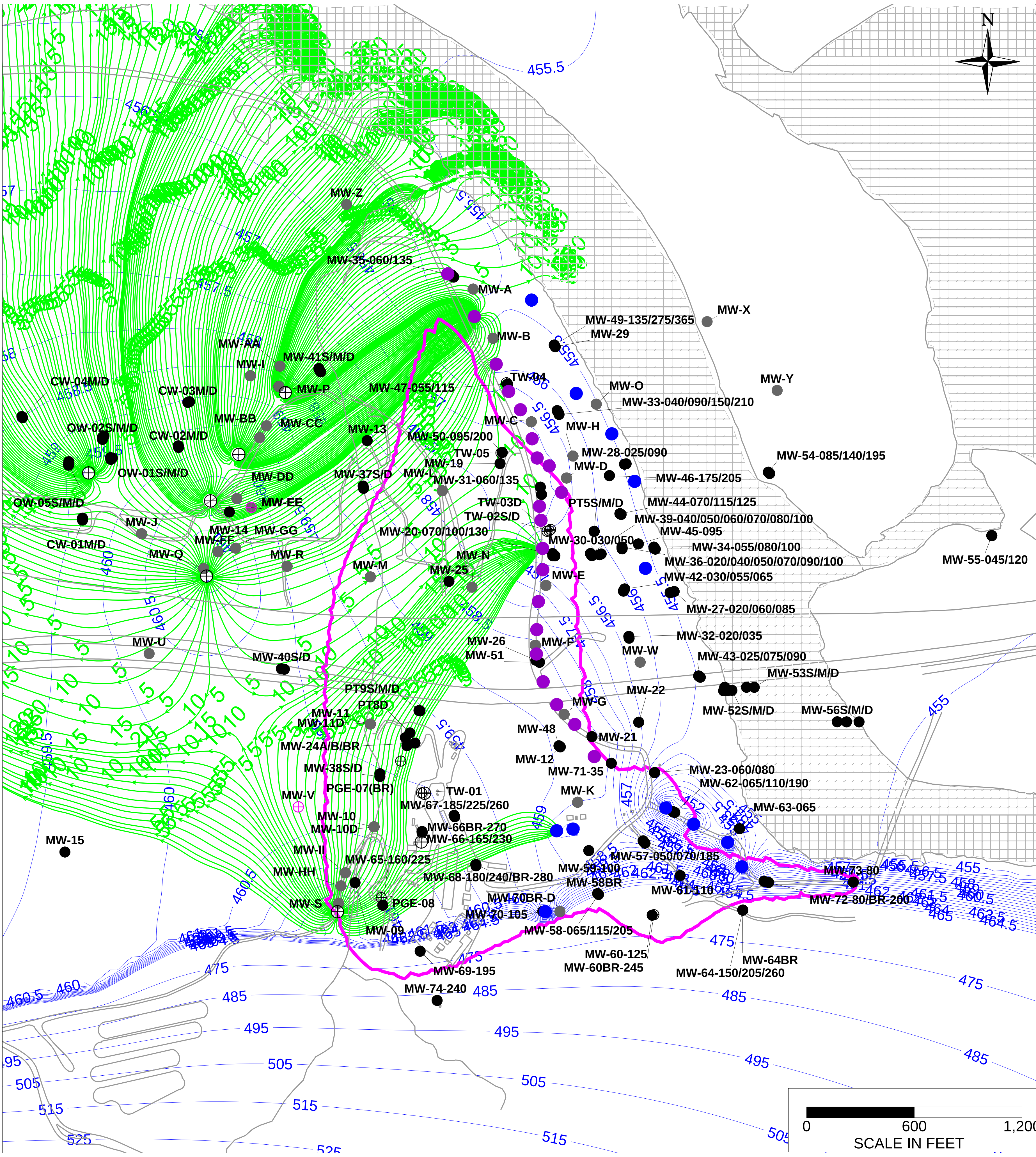
FIGURE 4.4-1



LEGEND

- IRZ WELLS
- UPGRADIENT INJECTION WELLS
- EXTRACTION WELLS
- EXISTING MONITORING WELLS
- PROPOSED MONITORING WELLS
- FUTURE PROVISIONAL MONITORING WELLS

- 460 SIMULATED GROUNDWATER LEVELS (FT MSL)
- ESTIMATED HEXAVALENT CHROMIUM 32 ug/L CONTOUR
- 5 SIMULATED GROUNDWATER PARTICLE PATHLINE* (5 YEAR POSTINGS)

*Simulated particle pathlines depict simulated groundwater flow and are not representative of solute transport as they do not take into account mechanisms such as sorption, reduction, oxidation, degradation, etc.

SIMULATED PUMPING RATES

NTH IRZ (300 gpm)

EXTRACTION	INJECTION
NTH IRZ = 300 gpm	NTH IRZ = 300 gpm

TCS LOOP (27 gpm)

EXTRACTION	INJECTION
ER-1 = 0.5 gpm	TCS-1 = 13.5 gpm
ER-2 = 0.5 gpm	TCS-2 = 13.5 gpm
ER-3 = 0.5 gpm	
ER-4 = 0.5 gpm	
ER-6 = 3.0 gpm	
TWB-1 = 13 gpm	
TWB-2 = 9 gpm	

IRL LOOP (150 gpm)

EXTRACTION	INJECTION
RB-1 = 25 gpm	IRL-1 = 75 gpm
RB-2 = OFF	IRL-2 = 75 gpm
RB-3 = 50 gpm	
RB-4 = 50 gpm	
RB-5 = 25 gpm	

FRESHWATER (450 gpm)

EXTRACTION	INJECTION
HNWR-1A = 450 gpm	FW-1 = 100 gpm
	FW-2 = 50 gpm
	IRL-3 = 100 gpm
	IRL-4 = 200 gpm

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DEVELOPMENT OF GROUNDWATER FLOW AND SOLUTE TRANSPORT MODELS

SIMULATED SUBSURFACE GROUNDWATER FLOW AND PATHLINES MODEL LAYER 1 - NTH IRZ ON

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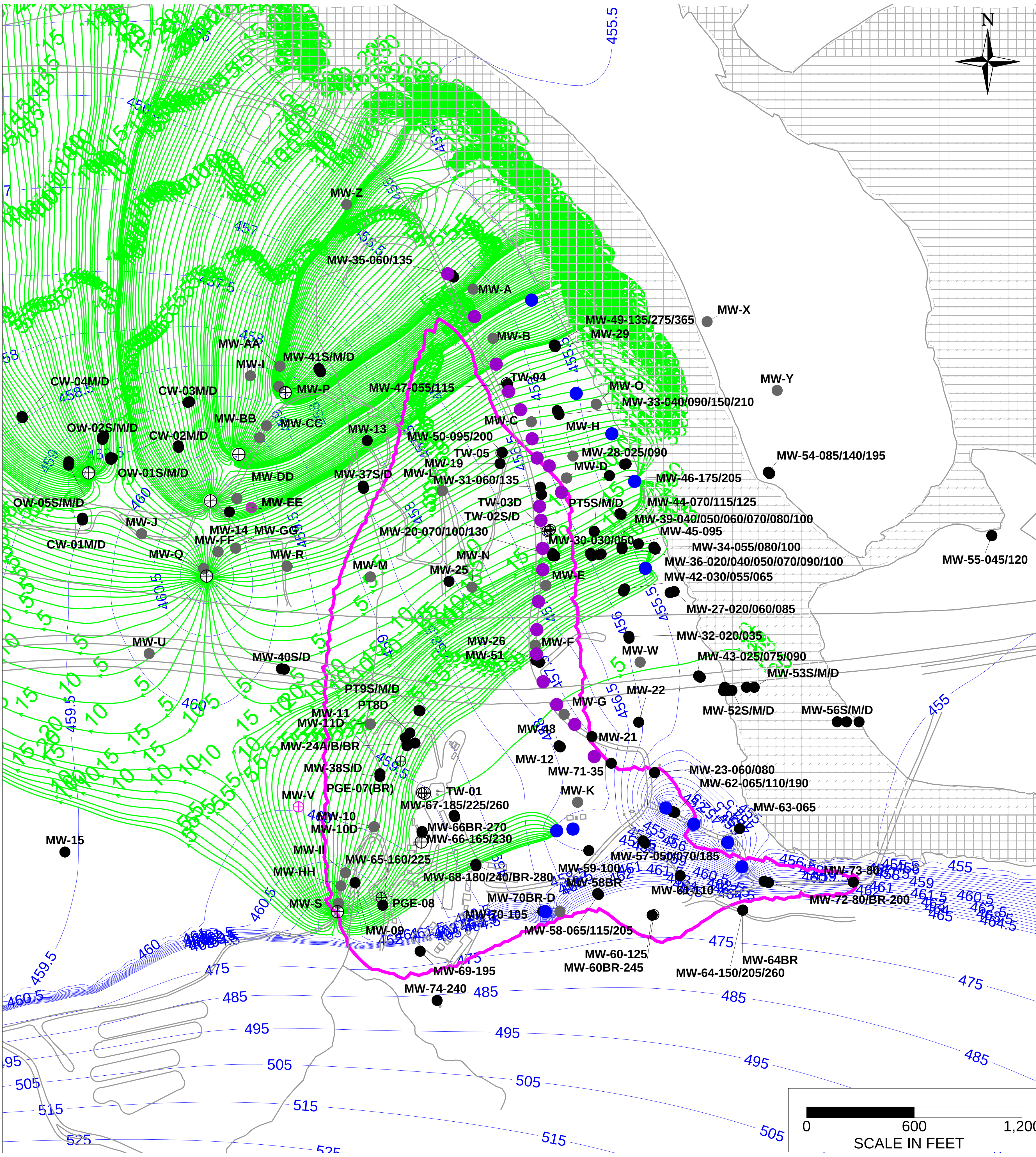
FIGURE 4.5-1



LEGEND

- IRZ WELLS
- UPGRADIENT INJECTION WELLS
- EXTRACTION WELLS
- EXISTING MONITORING WELLS
- PROPOSED MONITORING WELLS
- FUTURE PROVISIONAL MONITORING WELLS
- 460 SIMULATED GROUNDWATER LEVELS (FT MSL)
- ESTIMATED HEXAVALENT CHROMIUM 32 ug/L CONTOUR
- 5 SIMULATED GROUNDWATER PARTICLE PATHLINE* (5 YEAR POSTINGS)

SIMULATED PUMPING RATES

NTH IRZ (OFF)

EXTRACTION	INJECTION
NTH IRZ = OFF	NTH IRZ = OFF

TCS LOOP (27 gpm)

EXTRACTION	INJECTION
ER-1 = 0.5 gpm	TCS-1 = 13.5 gpm
ER-2 = 0.5 gpm	TCS-2 = 13.5 gpm
ER-3 = 0.5 gpm	
ER-4 = 0.5 gpm	
ER-6 = 3.0 gpm	
TWB-1 = 13 gpm	
TWB-2 = 9 gpm	

IRL LOOP (150 gpm)

EXTRACTION	INJECTION
RB-1 = 25 gpm	IRL-1 = 75 gpm
RB-2 = OFF	IRL-2 = 75 gpm
RB-3 = 50 gpm	
RB-4 = 50 gpm	
RB-5 = 25 gpm	

FRESHWATER (450 gpm)

EXTRACTION	INJECTION
HNWR-1A = 450 gpm	FW-1 = 100 gpm
	FW-2 = 50 gpm
	IRL-3 = 100 gpm
	IRL-4 = 200 gpm

*Simulated particle pathlines depict simulated groundwater flow and are not representative of solute transport as they do not take into account mechanisms such as sorption, reduction, oxidation, degradation, etc.

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DEVELOPMENT OF GROUNDWATER FLOW AND SOLUTE TRANSPORT MODELS

SIMULATED SUBSURFACE GROUNDWATER FLOW AND PATHLINES
MODEL LAYER 1 - NTH IRZ OFF

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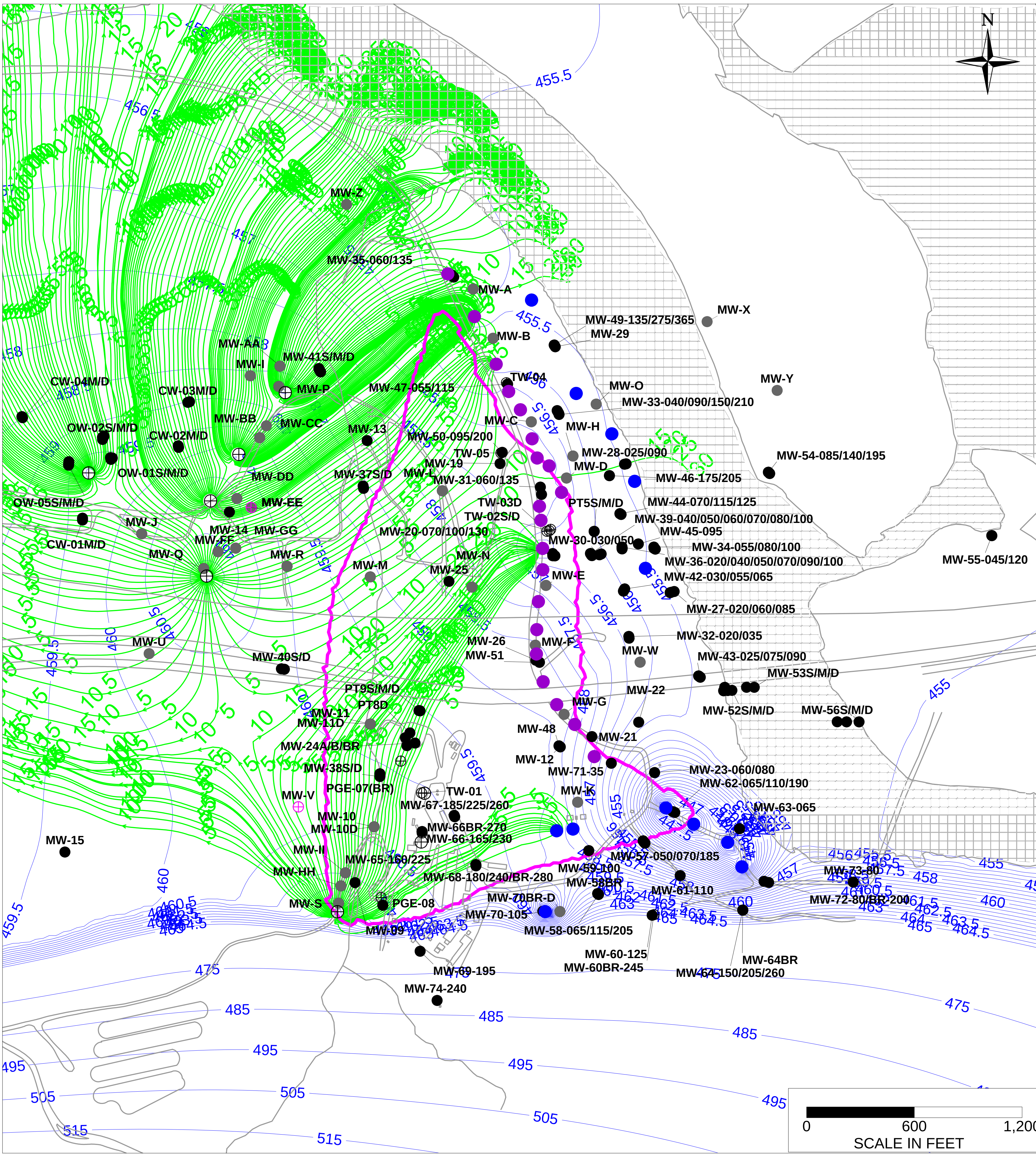
FIGURE
4.5-2



LEGEND

- IRZ WELLS
- UPGRADIENT INJECTION WELLS
- EXTRACTION WELLS
- EXISTING MONITORING WELLS
- PROPOSED MONITORING WELLS
- FUTURE PROVISIONAL MONITORING WELLS

- 460 SIMULATED GROUNDWATER LEVELS (FT MSL)
- ESTIMATED HEXAVALENT CHROMIUM 32 ug/L CONTOUR
- 5 SIMULATED GROUNDWATER PARTICLE PATHLINE* (5 YEAR POSTINGS)

SIMULATED PUMPING RATES

NTH IRZ (300 gpm)

EXTRACTION	INJECTION
NTH IRZ = 300 gpm	NTH IRZ = 300 gpm

TCS LOOP (27 gpm)

EXTRACTION	INJECTION
ER-1 = 0.5 gpm	TCS-1 = 13.5 gpm
ER-2 = 0.5 gpm	TCS-2 = 13.5 gpm
ER-3 = 0.5 gpm	
ER-4 = 0.5 gpm	
ER-6 = 3.0 gpm	
TWB-1 = 13 gpm	
TWB-2 = 9 gpm	

IRL LOOP (150 gpm)

EXTRACTION	INJECTION
RB-1 = 25 gpm	IRL-1 = 75 gpm
RB-2 = OFF	IRL-2 = 75 gpm
RB-3 = 50 gpm	
RB-4 = 50 gpm	
RB-5 = 25 gpm	

FRESHWATER (450 gpm)

EXTRACTION	INJECTION
HNWR-1A = 450 gpm	FW-1 = 100 gpm
	FW-2 = 50 gpm
	IRL-3 = 100 gpm
	IRL-4 = 200 gpm

*Simulated particle pathlines depict simulated groundwater flow and are not representative of solute transport as they do not take into account mechanisms such as sorption, reduction, oxidation, degradation, etc.

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SIMULATED SUBSURFACE GROUNDWATER FLOW AND PATHLINES MODEL LAYER 2 - NTH IRZ ON

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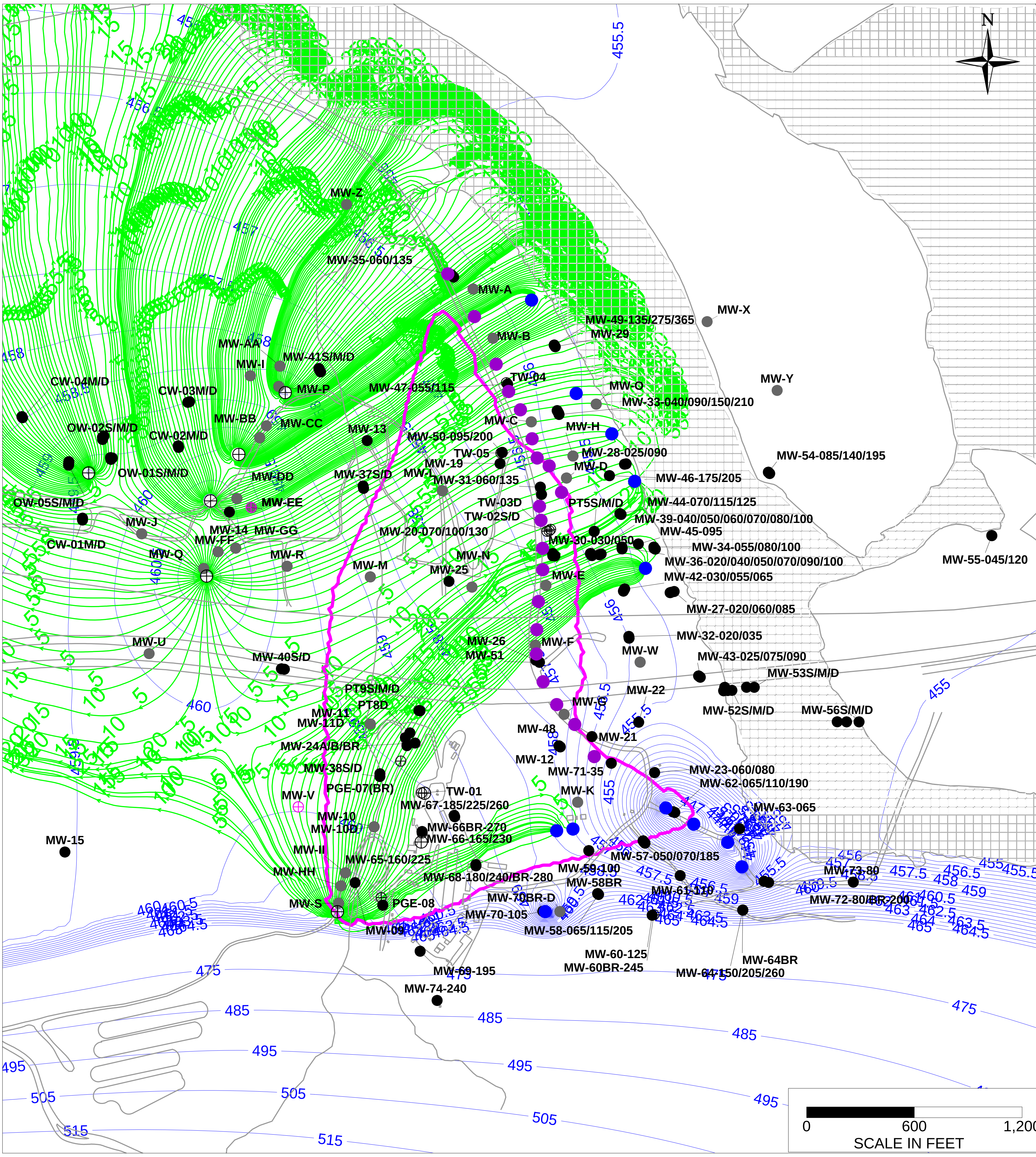
FIGURE
4.5-3



LEGEND

- IRZ WELLS
- UPGRADIENT INJECTION WELLS
- EXTRACTION WELLS
- EXISTING MONITORING WELLS
- PROPOSED MONITORING WELLS
- FUTURE PROVISIONAL MONITORING WELLS
- 460 SIMULATED GROUNDWATER LEVELS (FT MSL)
- ESTIMATED HEXAVALENT CHROMIUM 32 ug/L CONTOUR
- 5 SIMULATED GROUNDWATER PARTICLE PATHLINE* (5 YEAR POSTINGS)

SIMULATED PUMPING RATES

NTH IRZ (OFF)

EXTRACTION	INJECTION
NTH IRZ = OFF	NTH IRZ = OFF

TCS LOOP (27 gpm)

EXTRACTION	INJECTION
ER-1 = 0.5 gpm	TCS-1 = 13.5 gpm
ER-2 = 0.5 gpm	TCS-2 = 13.5 gpm
ER-3 = 0.5 gpm	
ER-4 = 0.5 gpm	
ER-6 = 3.0 gpm	
TWB-1 = 13 gpm	
TWB-2 = 9 gpm	

IRL LOOP (150 gpm)

EXTRACTION	INJECTION
RB-1 = 25 gpm	IRL-1 = 75 gpm
RB-2 = OFF	IRL-2 = 75 gpm
RB-3 = 50 gpm	
RB-4 = 50 gpm	
RB-5 = 25 gpm	

FRESHWATER (450 gpm)

EXTRACTION	INJECTION
HNWR-1A = 450 gpm	FW-1 = 100 gpm
	FW-2 = 50 gpm
	IRL-3 = 100 gpm
	IRL-4 = 200 gpm

*Simulated particle pathlines depict simulated groundwater flow and are not representative of solute transport as they do not take into account mechanisms such as sorption, reduction, oxidation, degradation, etc.

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DEVELOPMENT OF GROUNDWATER FLOW AND SOLUTE TRANSPORT MODELS

SIMULATED SUBSURFACE GROUNDWATER FLOW AND PATHLINES
MODEL LAYER 2 - NTH IRZ OFF

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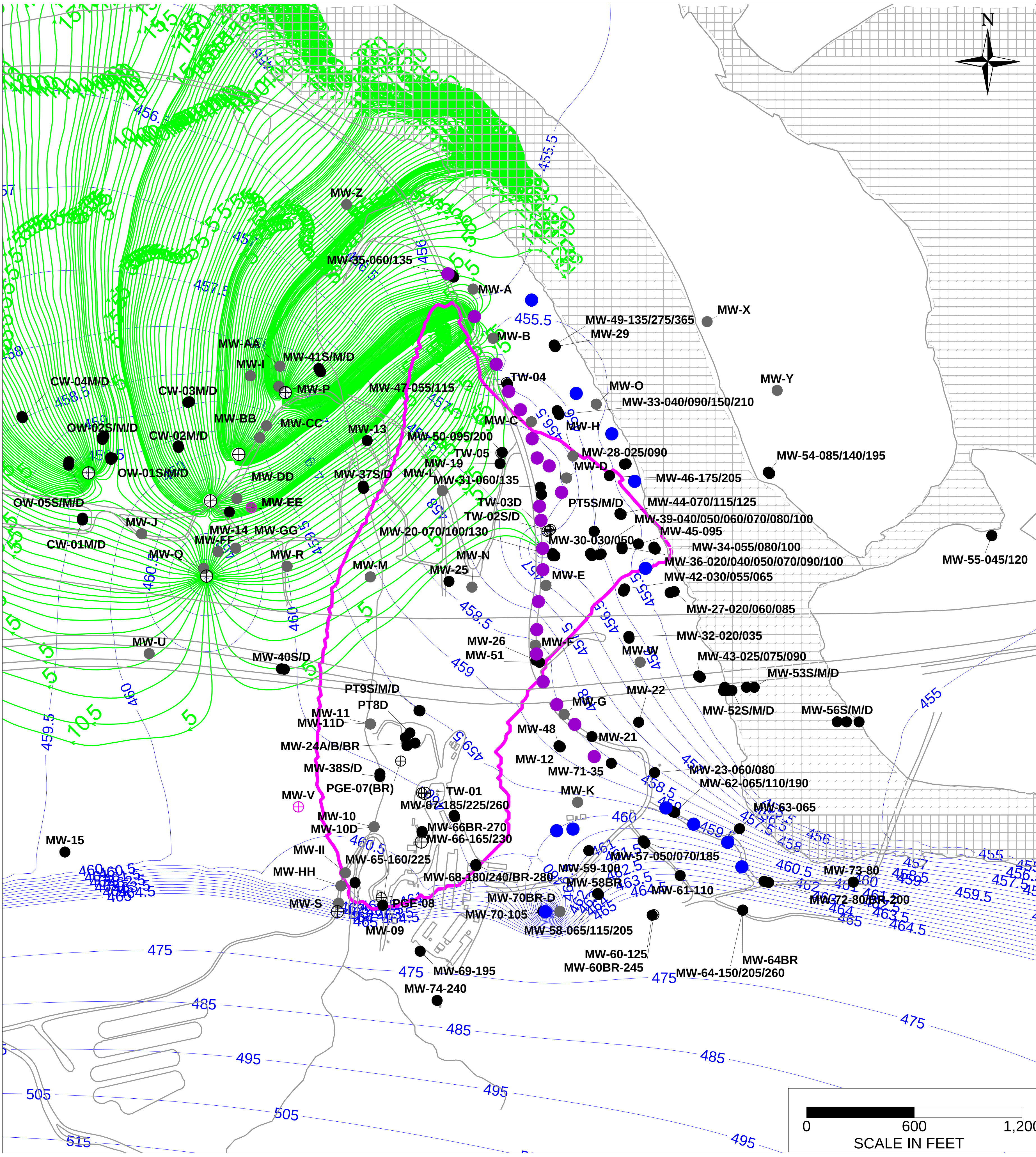
FIGURE
4.5-4



LEGEND

- IRZ WELLS
- UPGRADIENT INJECTION WELLS
- EXTRACTION WELLS
- EXISTING MONITORING WELLS
- PROPOSED MONITORING WELLS
- FUTURE PROVISIONAL MONITORING WELLS

- 460 SIMULATED GROUNDWATER LEVELS (FT MSL)
- ESTIMATED HEXAVALENT CHROMIUM 32 ug/L CONTOUR
- 5 SIMULATED GROUNDWATER PARTICLE PATHLINE* (5 YEAR POSTINGS)

SIMULATED PUMPING RATES

NTH IRZ (300 gpm)

EXTRACTION	INJECTION
NTH IRZ = 300 gpm	NTH IRZ = 300 gpm

TCS LOOP (27 gpm)

EXTRACTION	INJECTION
ER-1 = 0.5 gpm	TCS-1 = 13.5 gpm
ER-2 = 0.5 gpm	TCS-2 = 13.5 gpm
ER-3 = 0.5 gpm	
ER-4 = 0.5 gpm	
ER-6 = 3.0 gpm	
TWB-1 = 13 gpm	
TWB-2 = 9 gpm	

IRL LOOP (150 gpm)

EXTRACTION	INJECTION
RB-1 = 25 gpm	IRL-1 = 75 gpm
RB-2 = OFF	IRL-2 = 75 gpm
RB-3 = 50 gpm	
RB-4 = 50 gpm	
RB-5 = 25 gpm	

FRESHWATER (450 gpm)

EXTRACTION	INJECTION
HNWR-1A = 450 gpm	FW-1 = 100 gpm
	FW-2 = 50 gpm
	IRL-3 = 100 gpm
	IRL-4 = 200 gpm

*Simulated particle pathlines depict simulated groundwater flow and are not representative of solute transport as they do not take into account mechanisms such as sorption, reduction, oxidation, degradation, etc.

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DEVELOPMENT OF GROUNDWATER FLOW AND SOLUTE TRANSPORT MODELS

SIMULATED SUBSURFACE GROUNDWATER FLOW AND PATHLINES
MODEL LAYER 3 - NTH IRZ ON

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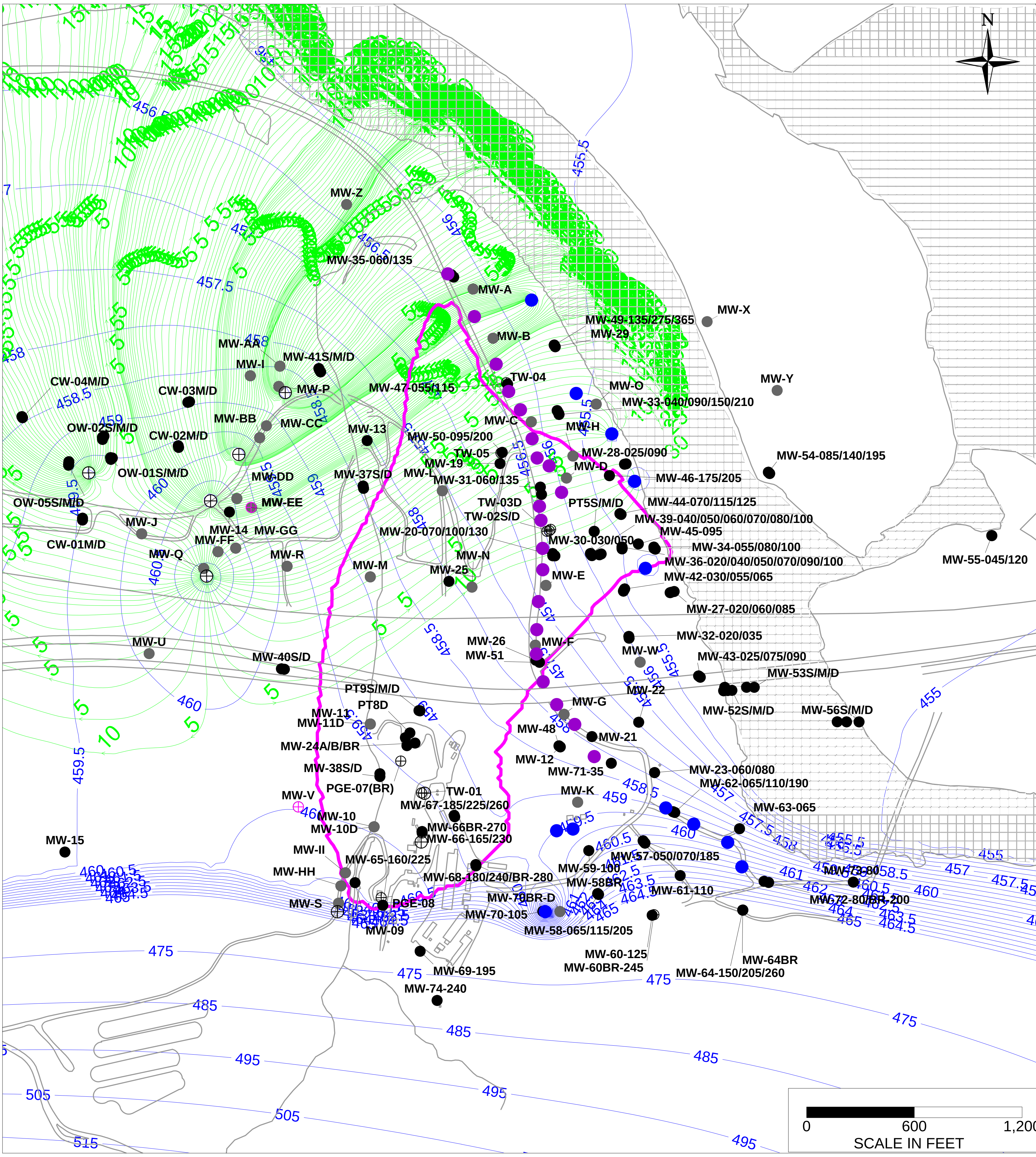
FIGURE
4.5-5



LEGEND

- IRZ WELLS
- UPGRADIENT INJECTION WELLS
- EXTRACTION WELLS
- EXISTING MONITORING WELLS
- PROPOSED MONITORING WELLS
- FUTURE PROVISIONAL MONITORING WELLS

- 460 SIMULATED GROUNDWATER LEVELS (FT MSL)
- ESTIMATED HEXAVALENT CHROMIUM 32 ug/L CONTOUR
- 5 SIMULATED GROUNDWATER PARTICLE PATHLINE* (5 YEAR POSTINGS)

SIMULATED PUMPING RATES

NTH IRZ (OFF)

EXTRACTION	INJECTION
NTH IRZ = OFF	NTH IRZ = OFF

TCS LOOP (27 gpm)

EXTRACTION	INJECTION
ER-1 = 0.5 gpm	TCS-1 = 13.5 gpm
ER-2 = 0.5 gpm	TCS-2 = 13.5 gpm
ER-3 = 0.5 gpm	
ER-4 = 0.5 gpm	
ER-6 = 3.0 gpm	
TWB-1 = 13 gpm	
TWB-2 = 9 gpm	

IRL LOOP (150 gpm)

EXTRACTION	INJECTION
RB-1 = 25 gpm	IRL-1 = 75 gpm
RB-2 = OFF	IRL-2 = 75 gpm
RB-3 = 50 gpm	
RB-4 = 50 gpm	
RB-5 = 25 gpm	

FRESHWATER (450 gpm)

EXTRACTION	INJECTION
HNWR-1A = 450 gpm	FW-1 = 100 gpm
	FW-2 = 50 gpm
	IRL-3 = 100 gpm
	IRL-4 = 200 gpm

*Simulated particle pathlines depict simulated groundwater flow and are not representative of solute transport as they do not take into account mechanisms such as sorption, reduction, oxidation, degradation, etc.

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SIMULATED SUBSURFACE GROUNDWATER FLOW AND PATHLINES MODEL LAYER 3 - NTH IRZ OFF

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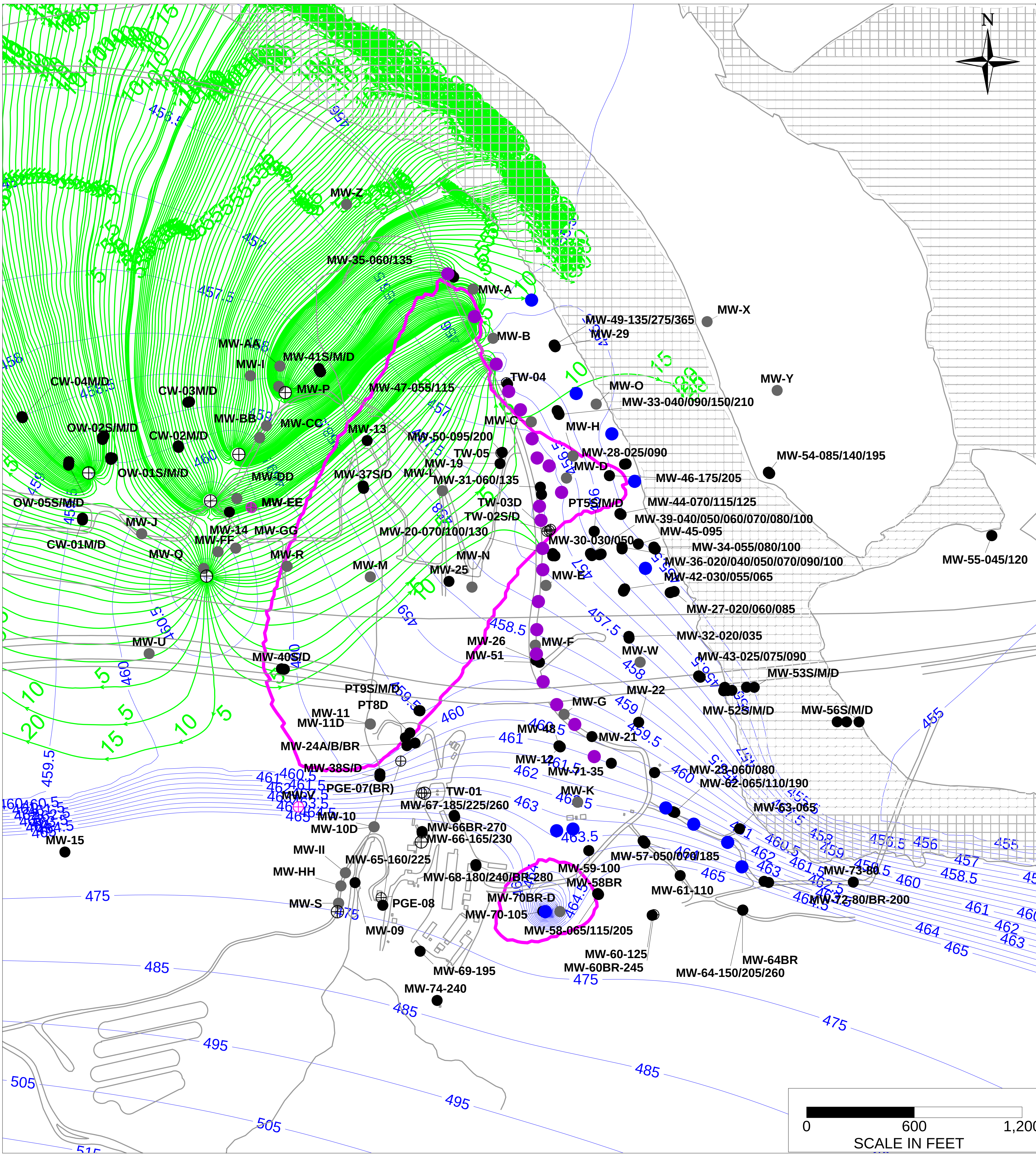
FIGURE 4.5-6



LEGEND

- IRZ WELLS
- UPGRADIENT INJECTION WELLS
- EXTRACTION WELLS
- EXISTING MONITORING WELLS
- PROPOSED MONITORING WELLS
- FUTURE PROVISIONAL MONITORING WELLS
- 460 SIMULATED GROUNDWATER LEVELS (FT MSL)
- ESTIMATED HEXAVALENT CHROMIUM 32 ug/L CONTOUR
- 5 SIMULATED GROUNDWATER PARTICLE PATHLINE* (5 YEAR POSTINGS)

SIMULATED PUMPING RATES

NTH IRZ (300 gpm)

EXTRACTION	INJECTION
NTH IRZ = 300 gpm	NTH IRZ = 300 gpm

IRL LOOP (150 gpm)

EXTRACTION	INJECTION
RB-1 = 25 gpm	IRL-1 = 75 gpm
RB-2 = OFF	IRL-2 = 75 gpm
RB-3 = 50 gpm	
RB-4 = 50 gpm	
RB-5 = 25 gpm	

TCS LOOP (27 gpm)

EXTRACTION	INJECTION
ER-1 = 0.5 gpm	TCS-1 = 13.5 gpm
ER-2 = 0.5 gpm	TCS-2 = 13.5 gpm
ER-3 = 0.5 gpm	
ER-4 = 0.5 gpm	
ER-6 = 3.0 gpm	
TWB-1 = 13 gpm	
TWB-2 = 9 gpm	

FRESHWATER (450 gpm)

EXTRACTION	INJECTION
HNWR-1A = 450 gpm	FW-1 = 100 gpm
	FW-2 = 50 gpm
	IRL-3 = 100 gpm
	IRL-4 = 200 gpm

*Simulated particle pathlines depict simulated groundwater flow and are not representative of solute transport as they do not take into account mechanisms such as sorption, reduction, oxidation, degradation, etc.

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SIMULATED SUBSURFACE GROUNDWATER FLOW AND PATHLINES
MODEL LAYER 4 - NTH IRZ ON

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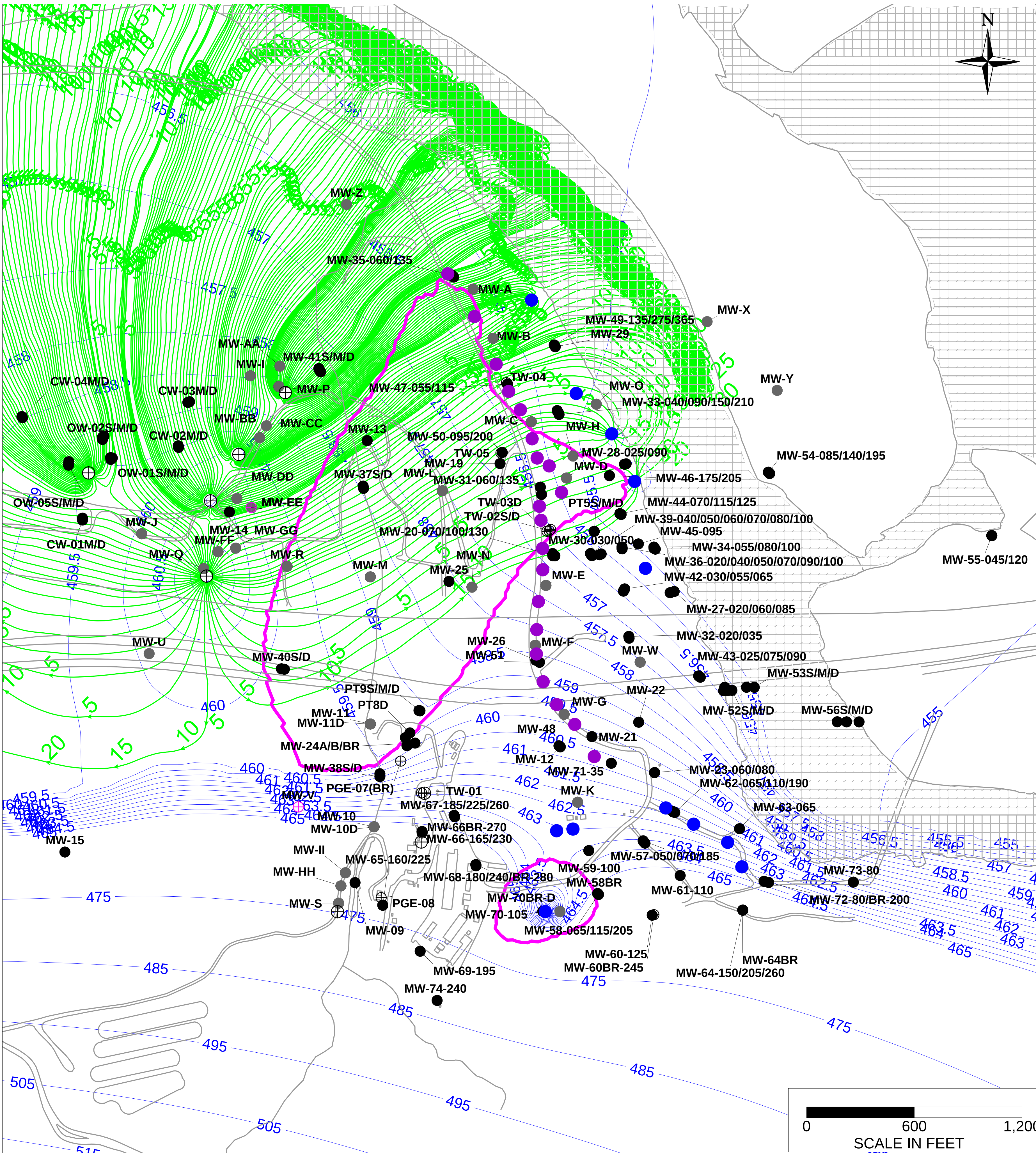
FIGURE
4.5-7



LEGEND

- IRZ WELLS
- UPGRADIENT INJECTION WELLS
- EXTRACTION WELLS
- EXISTING MONITORING WELLS
- PROPOSED MONITORING WELLS
- FUTURE PROVISIONAL MONITORING WELLS

- 460 SIMULATED GROUNDWATER LEVELS (FT MSL)
- ESTIMATED HEXAVALENT CHROMIUM 32 ug/L CONTOUR
- 5 SIMULATED GROUNDWATER PARTICLE PATHLINE* (5 YEAR POSTINGS)

SIMULATED PUMPING RATES

NTH IRZ (OFF)

EXTRACTION	INJECTION
NTH IRZ = OFF	NTH IRZ = OFF

TCS LOOP (27 gpm)

EXTRACTION	INJECTION
ER-1 = 0.5 gpm	TCS-1 = 13.5 gpm
ER-2 = 0.5 gpm	TCS-2 = 13.5 gpm
ER-3 = 0.5 gpm	
ER-4 = 0.5 gpm	
ER-6 = 3.0 gpm	
TWB-1 = 13 gpm	
TWB-2 = 9 gpm	

IRL LOOP (150 gpm)

EXTRACTION	INJECTION
RB-1 = 25 gpm	IRL-1 = 75 gpm
RB-2 = OFF	IRL-2 = 75 gpm
RB-3 = 50 gpm	
RB-4 = 50 gpm	
RB-5 = 25 gpm	

FRESHWATER (450 gpm)

EXTRACTION	INJECTION
HNWR-1A = 450 gpm	FW-1 = 100 gpm
	FW-2 = 50 gpm
	IRL-3 = 100 gpm
	IRL-4 = 200 gpm

*Simulated particle pathlines depict simulated groundwater flow and are not representative of solute transport as they do not take into account mechanisms such as sorption, reduction, oxidation, degradation, etc.

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SIMULATED SUBSURFACE GROUNDWATER FLOW AND PATHLINES MODEL LAYER 4 - NTH IRZ OFF

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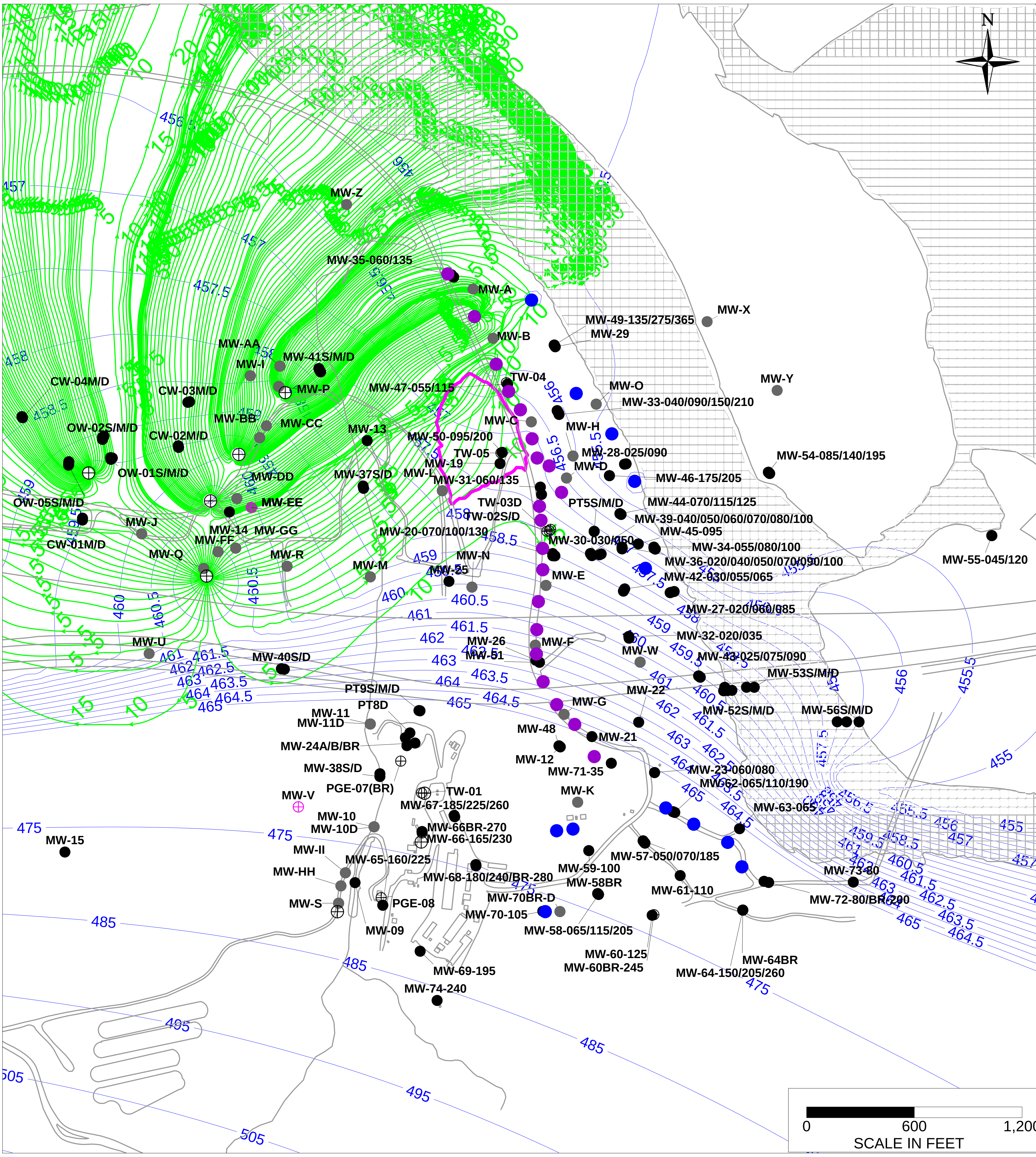
FIGURE 4.5-8



LEGEND

- IRZ WELLS
- UPGRADIENT INJECTION WELLS
- EXTRACTION WELLS
- EXISTING MONITORING WELLS
- PROPOSED MONITORING WELLS
- FUTURE PROVISIONAL MONITORING WELLS

- 460 SIMULATED GROUNDWATER LEVELS (FT MSL)
- ESTIMATED HEXAVALENT CHROMIUM 32 ug/L CONTOUR
- 5 SIMULATED GROUNDWATER PARTICLE PATHLINE* (5 YEAR POSTINGS)

SIMULATED PUMPING RATES

NTH IRZ (300 gpm)

EXTRACTION	INJECTION
NTH IRZ = 300 gpm	NTH IRZ = 300 gpm

TCS LOOP (27 gpm)

EXTRACTION	INJECTION
ER-1 = 0.5 gpm	TCS-1 = 13.5 gpm
ER-2 = 0.5 gpm	TCS-2 = 13.5 gpm
ER-3 = 0.5 gpm	
ER-4 = 0.5 gpm	
ER-6 = 3.0 gpm	
TWB-1 = 13 gpm	
TWB-2 = 9 gpm	

IRL LOOP (150 gpm)

EXTRACTION	INJECTION
RB-1 = 25 gpm	IRL-1 = 75 gpm
RB-2 = OFF	IRL-2 = 75 gpm
RB-3 = 50 gpm	
RB-4 = 50 gpm	
RB-5 = 25 gpm	

FRESHWATER (450 gpm)

EXTRACTION	INJECTION
HNWR-1A = 450 gpm	FW-1 = 100 gpm
	FW-2 = 50 gpm
	IRL-3 = 100 gpm
	IRL-4 = 200 gpm

*Simulated particle pathlines depict simulated groundwater flow and are not representative of solute transport as they do not take into account mechanisms such as sorption, reduction, oxidation, degradation, etc.

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DEVELOPMENT OF GROUNDWATER FLOW AND SOLUTE TRANSPORT MODELS

SIMULATED SUBSURFACE GROUNDWATER FLOW AND PATHLINES MODEL LAYER 5 - NTH IRZ ON

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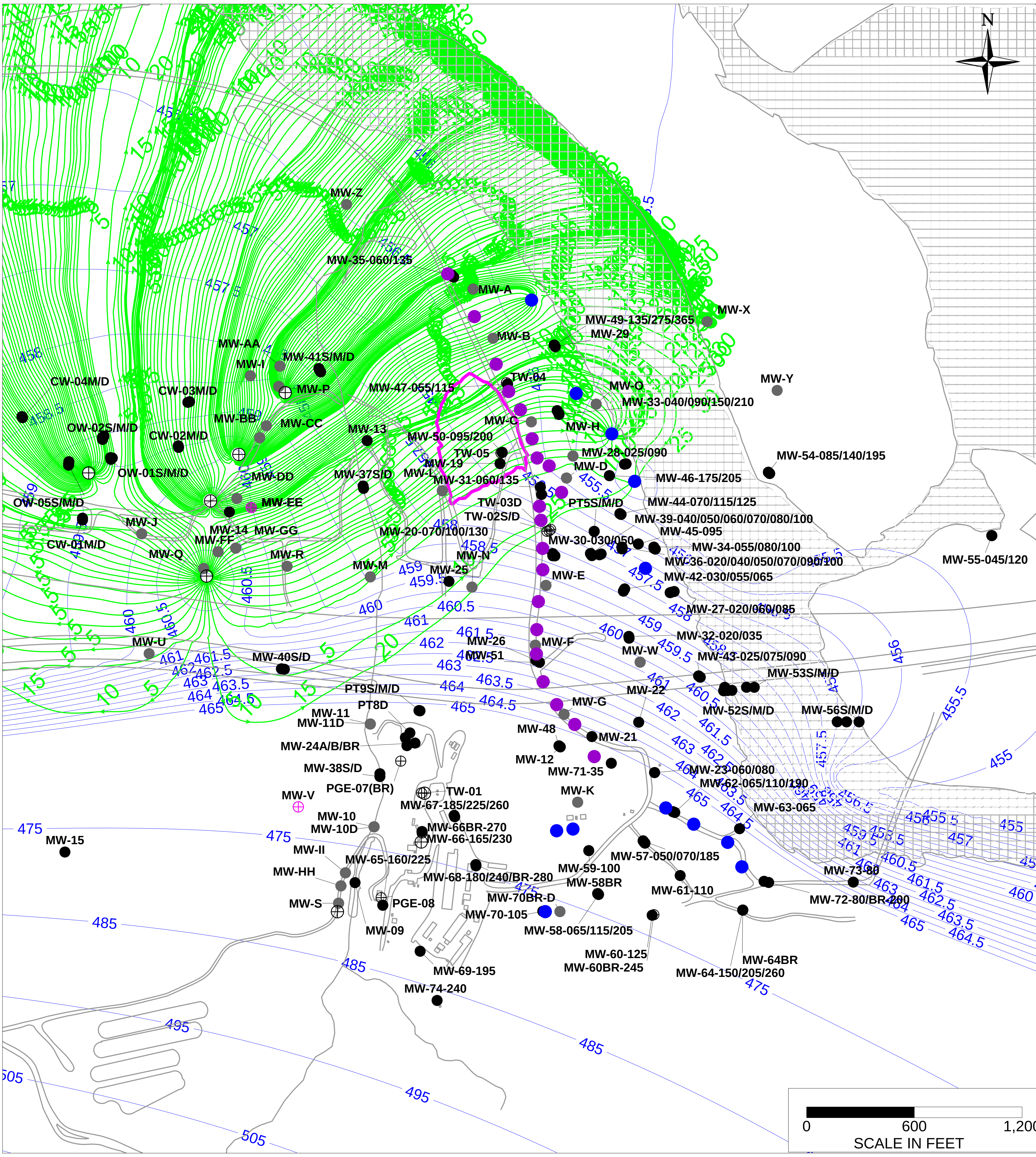
FIGURE 4.5-9



LEGEND

- IRZ WELLS
- UPGRADIENT INJECTION WELLS
- EXTRACTION WELLS
- EXISTING MONITORING WELLS
- PROPOSED MONITORING WELLS
- FUTURE PROVISIONAL MONITORING WELLS
- 460 SIMULATED GROUNDWATER LEVELS (FT MSL)
- ESTIMATED HEXAVALENT CHROMIUM 32 ug/L CONTOUR
- 5 SIMULATED GROUNDWATER PARTICLE PATHLINE* (5 YEAR POSTINGS)

SIMULATED PUMPING RATES

NTH IRZ (OFF)

EXTRACTION	INJECTION
NTH IRZ = OFF	NTH IRZ = OFF

TCS LOOP (27 gpm)

EXTRACTION	INJECTION
ER-1 = 0.5 gpm	TCS-1 = 13.5 gpm
ER-2 = 0.5 gpm	TCS-2 = 13.5 gpm
ER-3 = 0.5 gpm	
ER-4 = 0.5 gpm	
ER-6 = 3.0 gpm	
TWB-1 = 13 gpm	
TWB-2 = 9 gpm	

IRL LOOP (150 gpm)

EXTRACTION	INJECTION
RB-1 = 25 gpm	IRL-1 = 75 gpm
RB-2 = OFF	IRL-2 = 75 gpm
RB-3 = 50 gpm	
RB-4 = 50 gpm	
RB-5 = 25 gpm	

FRESHWATER (450 gpm)

EXTRACTION	INJECTION
HNWR-1A = 450 gpm	FW-1 = 100 gpm
	FW-2 = 50 gpm
	IRL-3 = 100 gpm
	IRL-4 = 200 gpm

*Simulated particle pathlines depict simulated groundwater flow and are not representative of solute transport as they do not take into account mechanisms such as sorption, reduction, oxidation, degradation, etc.

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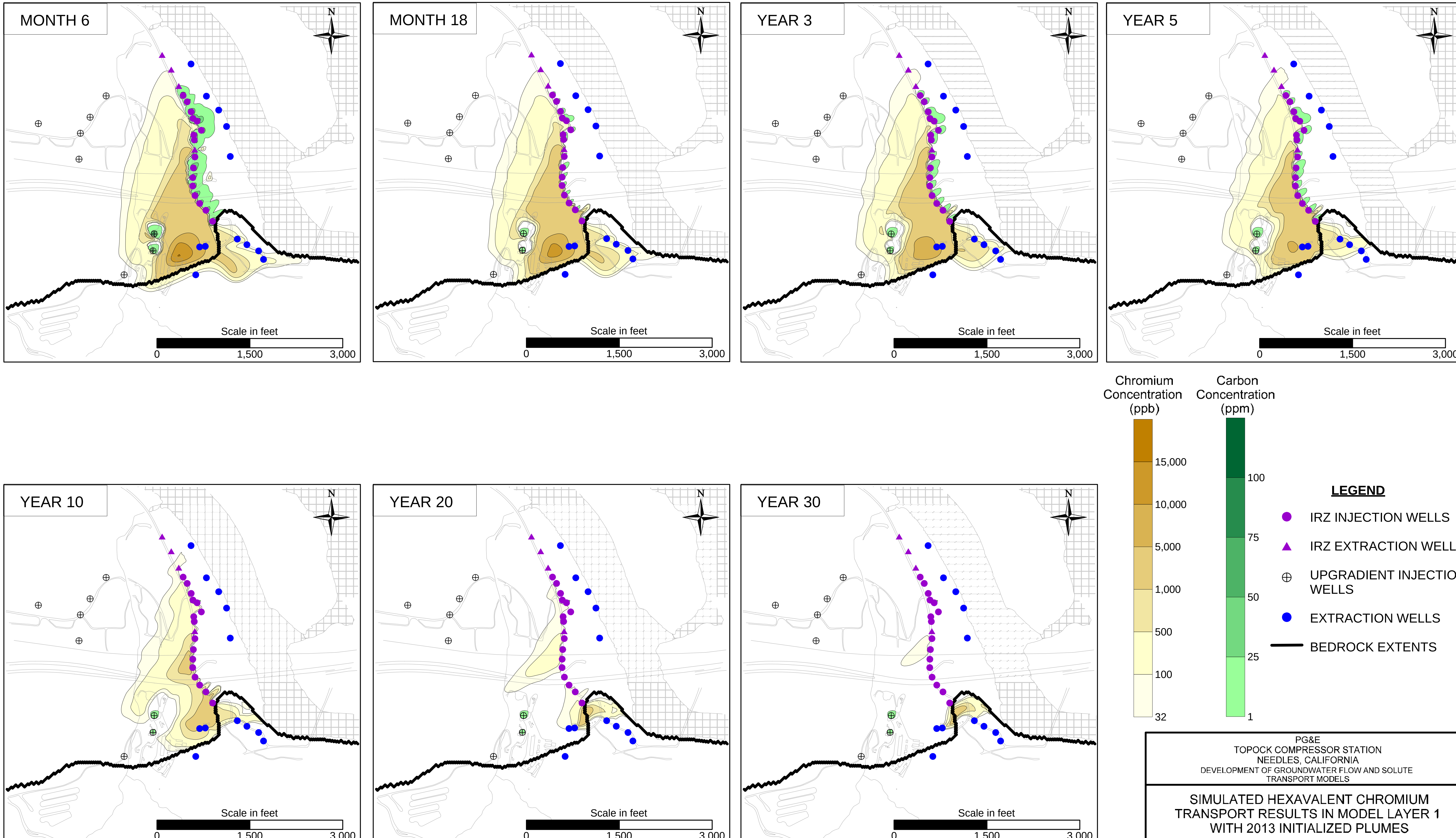
NEEDLES, CALIFORNIA
DEVELOPMENT OF GROUNDWATER FLOW AND SOLUTE TRANSPORT MODELS

SIMULATED SUBSURFACE GROUNDWATER FLOW AND PATHLINES MODEL LAYER 5 - NTH IRZ OFF

ARCADIS Design & Consultancy for natural and built assets

FIGURE
4.5-10

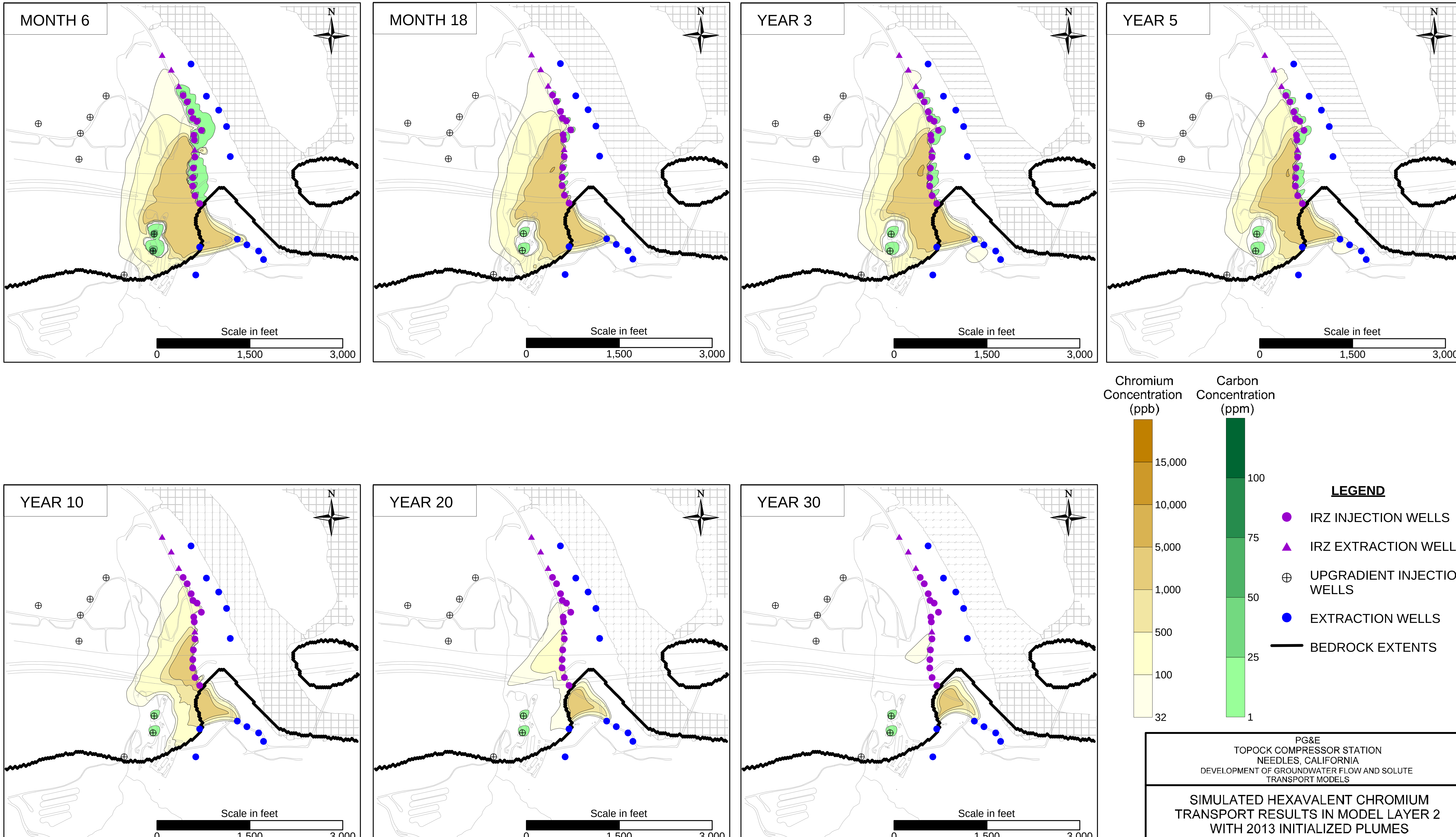


PG&E
TOPOCK COMPRESSOR STATION
NEEDLES, CALIFORNIA
DEVELOPMENT OF GROUNDWATER FLOW AND SOLUTE TRANSPORT MODELS

SIMULATED HEXAVALENT CHROMIUM TRANSPORT RESULTS IN MODEL LAYER 1 WITH 2013 INITIALIZED PLUMES

ARCADIS Design & Consultancy for natural and built assets

FIGURE
5.1-1

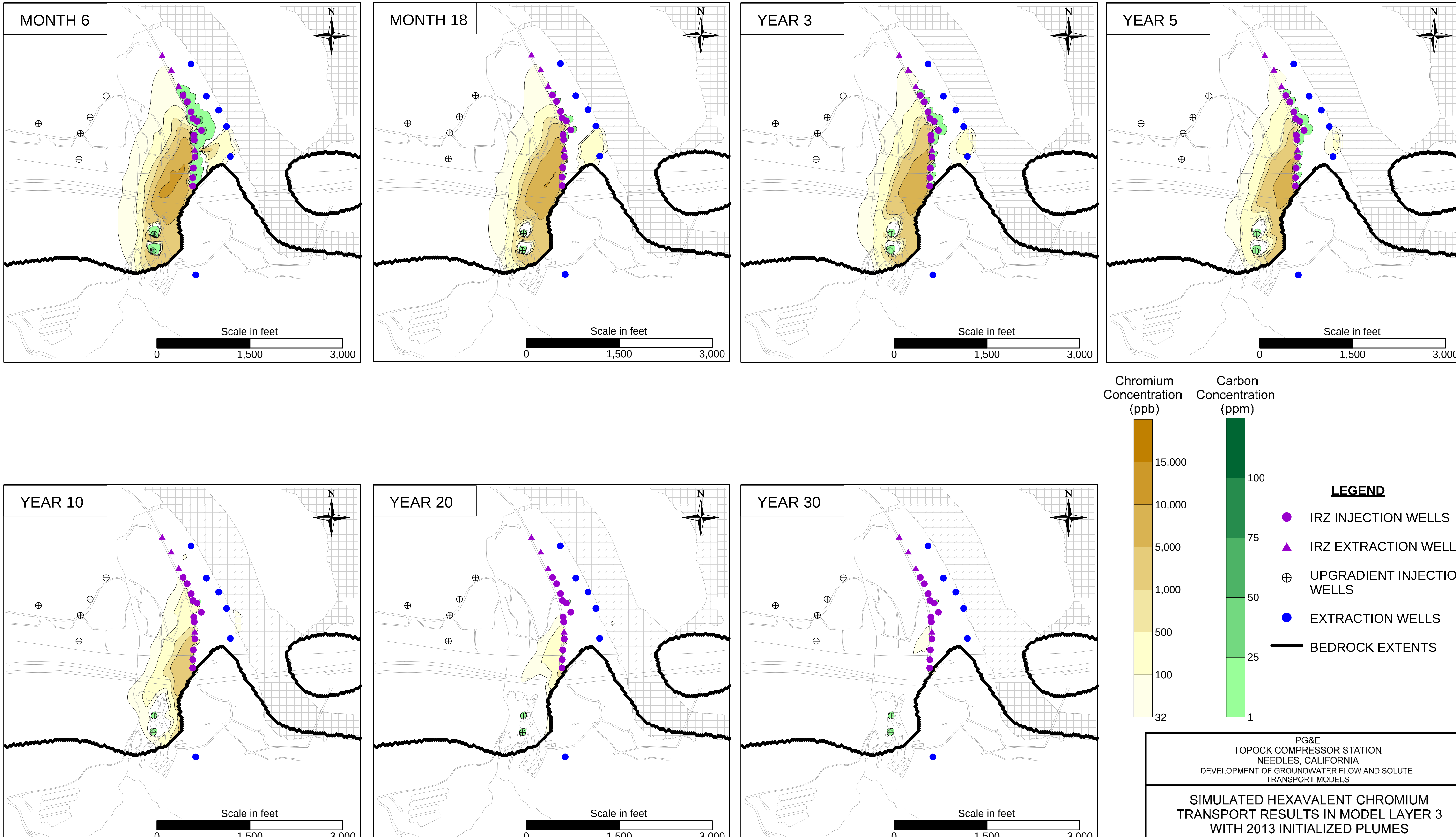


PG&E
TOPOCK COMPRESSOR STATION
NEEDLES, CALIFORNIA
DEVELOPMENT OF GROUNDWATER FLOW AND SOLUTE TRANSPORT MODELS

SIMULATED HEXAVALENT CHROMIUM TRANSPORT RESULTS IN MODEL LAYER 2 WITH 2013 INITIALIZED PLUMES

ARCADIS Design & Consultancy for natural and built assets

FIGURE
5.1-2

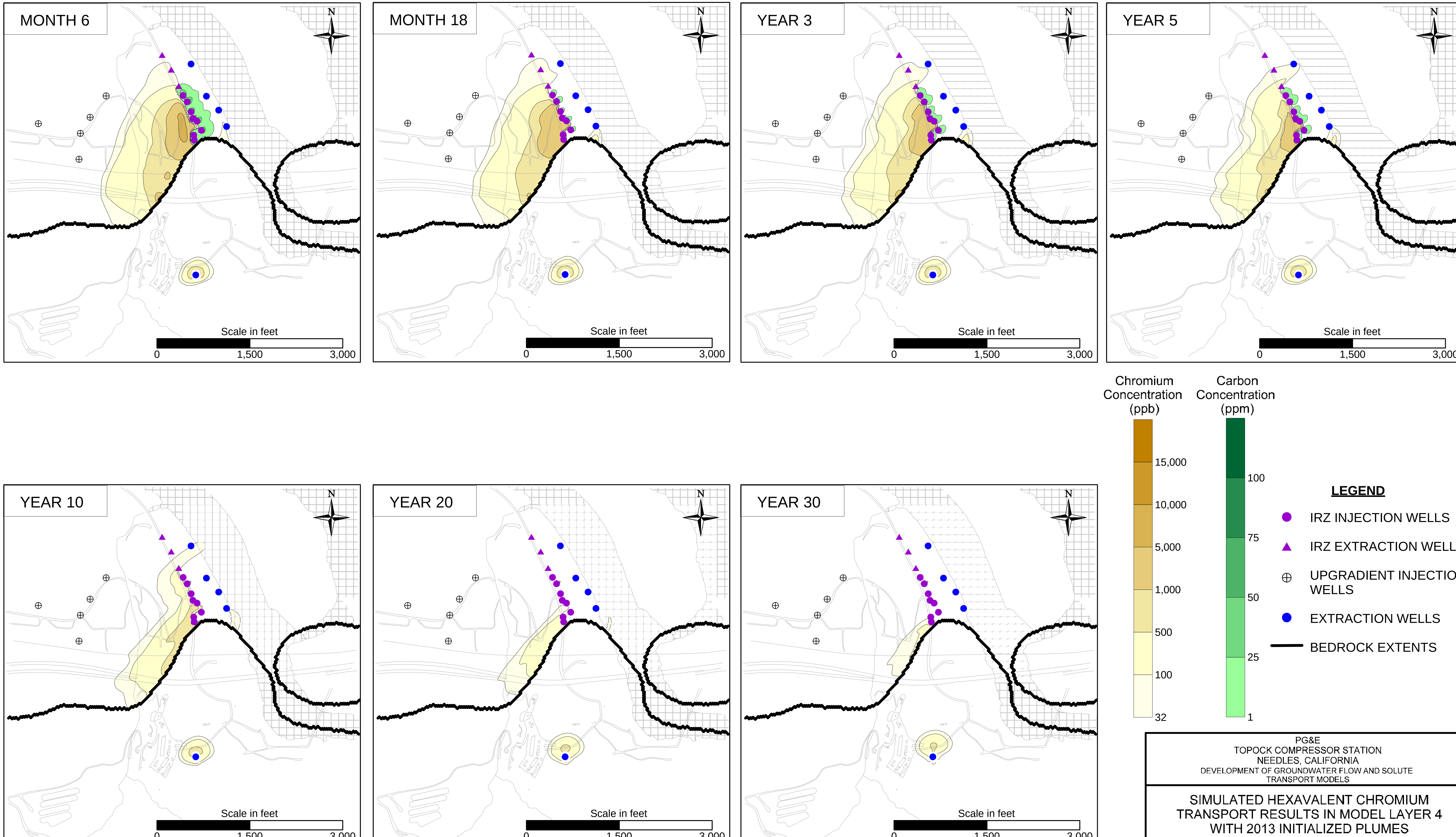


PG&E
TOPOCK COMPRESSOR STATION
NEEDLES, CALIFORNIA
DEVELOPMENT OF GROUNDWATER FLOW AND SOLUTE TRANSPORT MODELS

SIMULATED HEXAVALENT CHROMIUM TRANSPORT RESULTS IN MODEL LAYER 3 WITH 2013 INITIALIZED PLUMES

ARCADIS Design & Consultancy for natural and built assets

FIGURE
5.1-3



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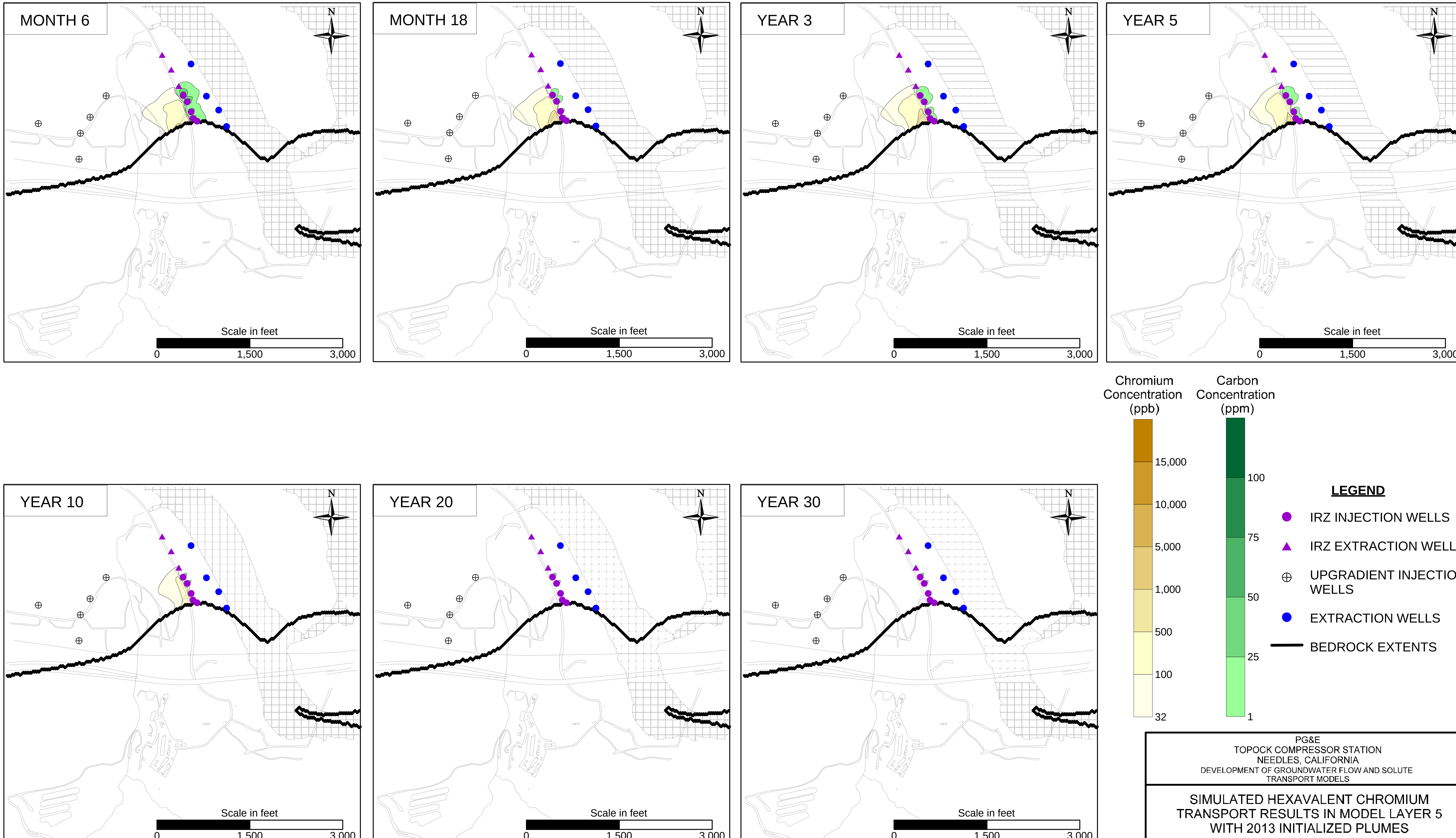
TOPOCK COMPRESSOR STATION
NEEDLES, CALIFORNIA
DEVELOPMENT OF GROUNDWATER FLOW AND SOLUTE TRANSPORT MODELS

SIMULATED HEXAVALENT CHROMIUM TRANSPORT RESULTS IN MODEL LAYER 4 WITH 2013 INITIALIZED PLUMES

ARCADIS Design & Consultancy for natural and built assets

FIGURE
5.1-4

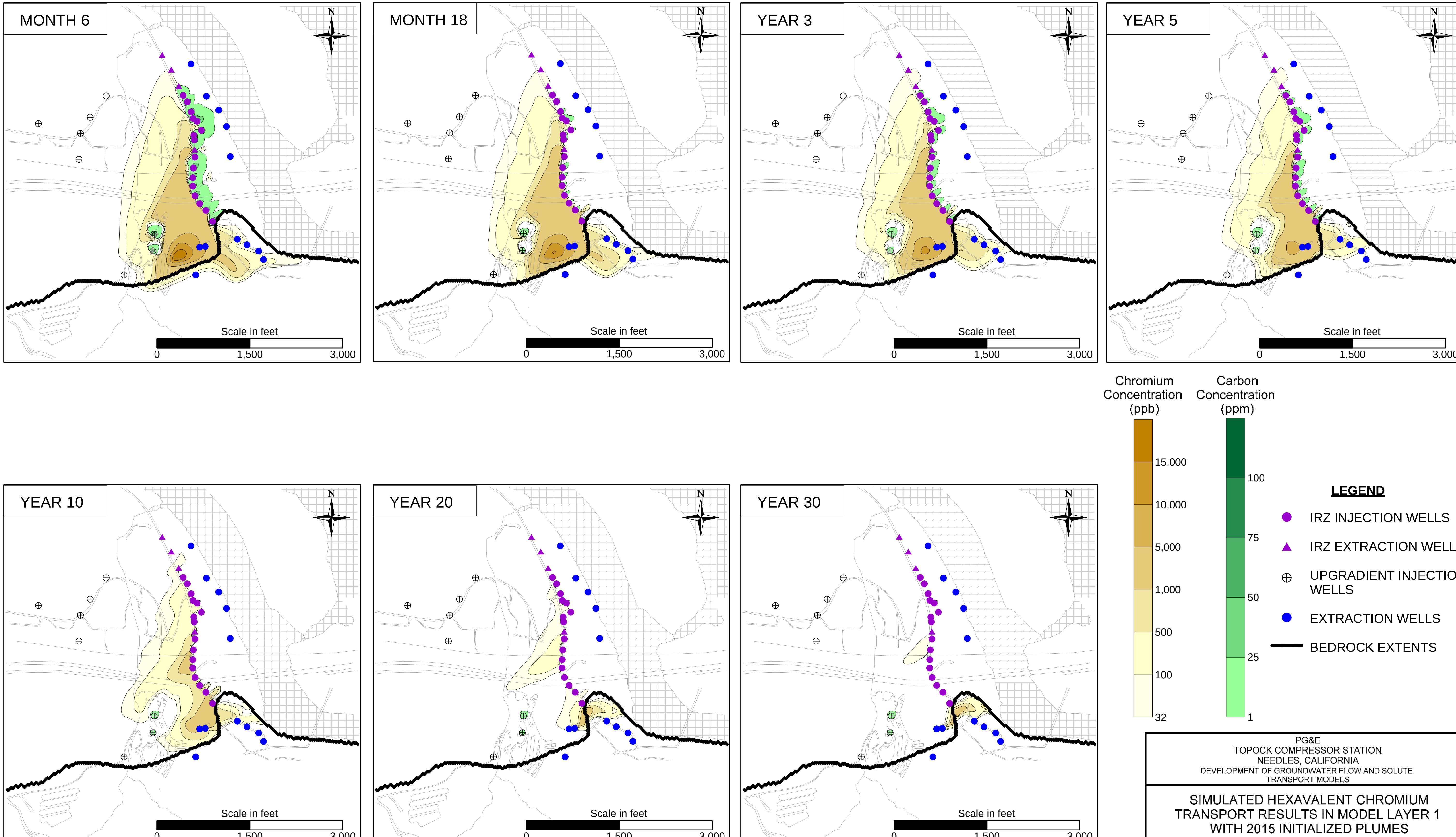


PG&E
TOPOCK COMPRESSOR STATION
NEEDLES, CALIFORNIA
DEVELOPMENT OF GROUNDWATER FLOW AND SOLUTE TRANSPORT MODELS

SIMULATED HEXAVALENT CHROMIUM TRANSPORT RESULTS IN MODEL LAYER 5 WITH 2013 INITIALIZED PLUMES

ARCADIS Design & Consultancy for natural and built assets

FIGURE
5.1-5

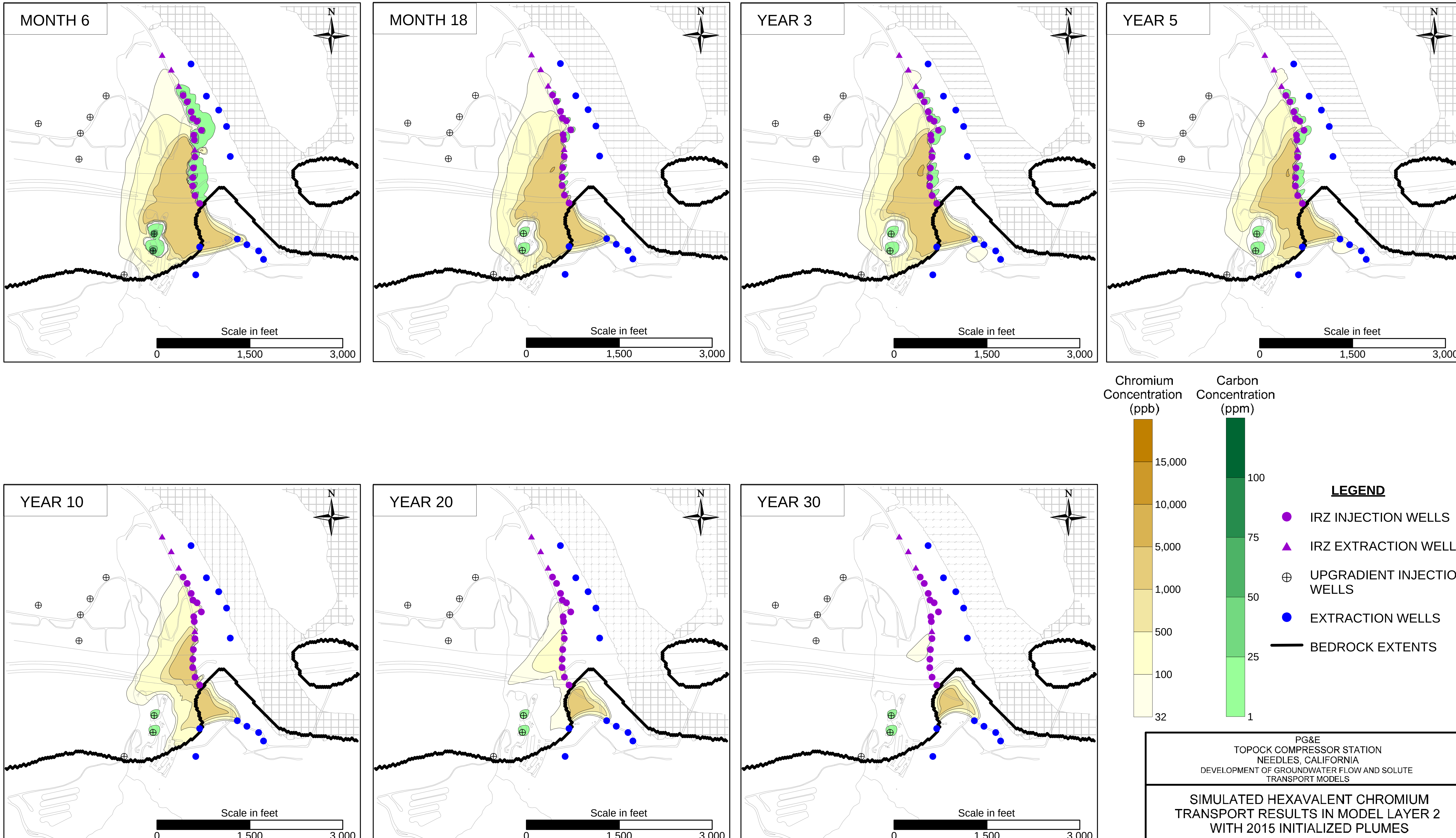


PG&E
TOPOCK COMPRESSOR STATION
NEEDLES, CALIFORNIA
DEVELOPMENT OF GROUNDWATER FLOW AND SOLUTE TRANSPORT MODELS

SIMULATED HEXAVALENT CHROMIUM TRANSPORT RESULTS IN MODEL LAYER 1 WITH 2015 INITIALIZED PLUMES

ARCADIS Design & Consultancy for natural and built assets

FIGURE
5.1-6

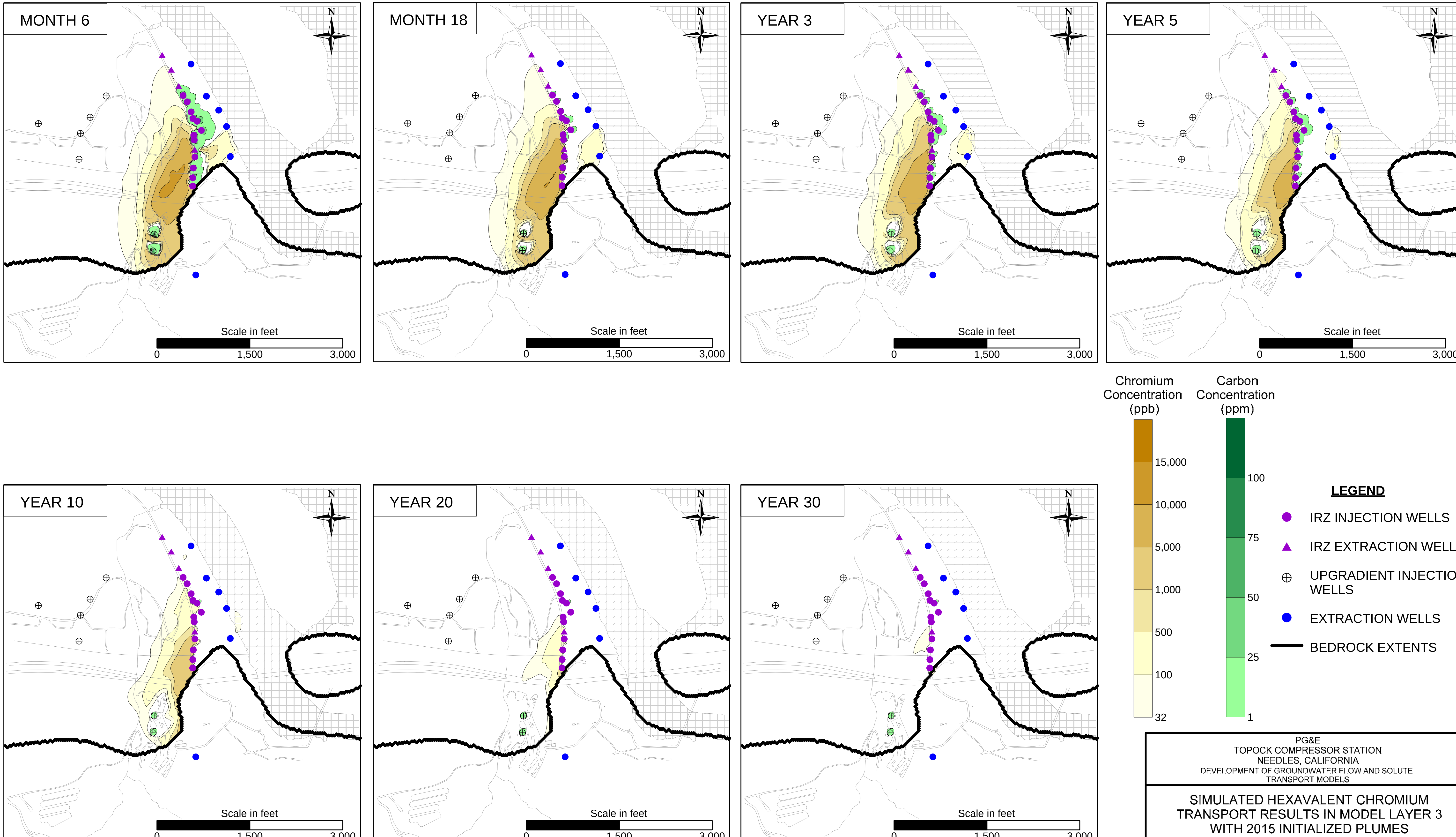


PG&E
TOPOCK COMPRESSOR STATION
NEEDLES, CALIFORNIA
DEVELOPMENT OF GROUNDWATER FLOW AND SOLUTE TRANSPORT MODELS

SIMULATED HEXAVALENT CHROMIUM TRANSPORT RESULTS IN MODEL LAYER 2 WITH 2015 INITIALIZED PLUMES

ARCADIS Design & Consultancy for natural and built assets

FIGURE
5.1-7

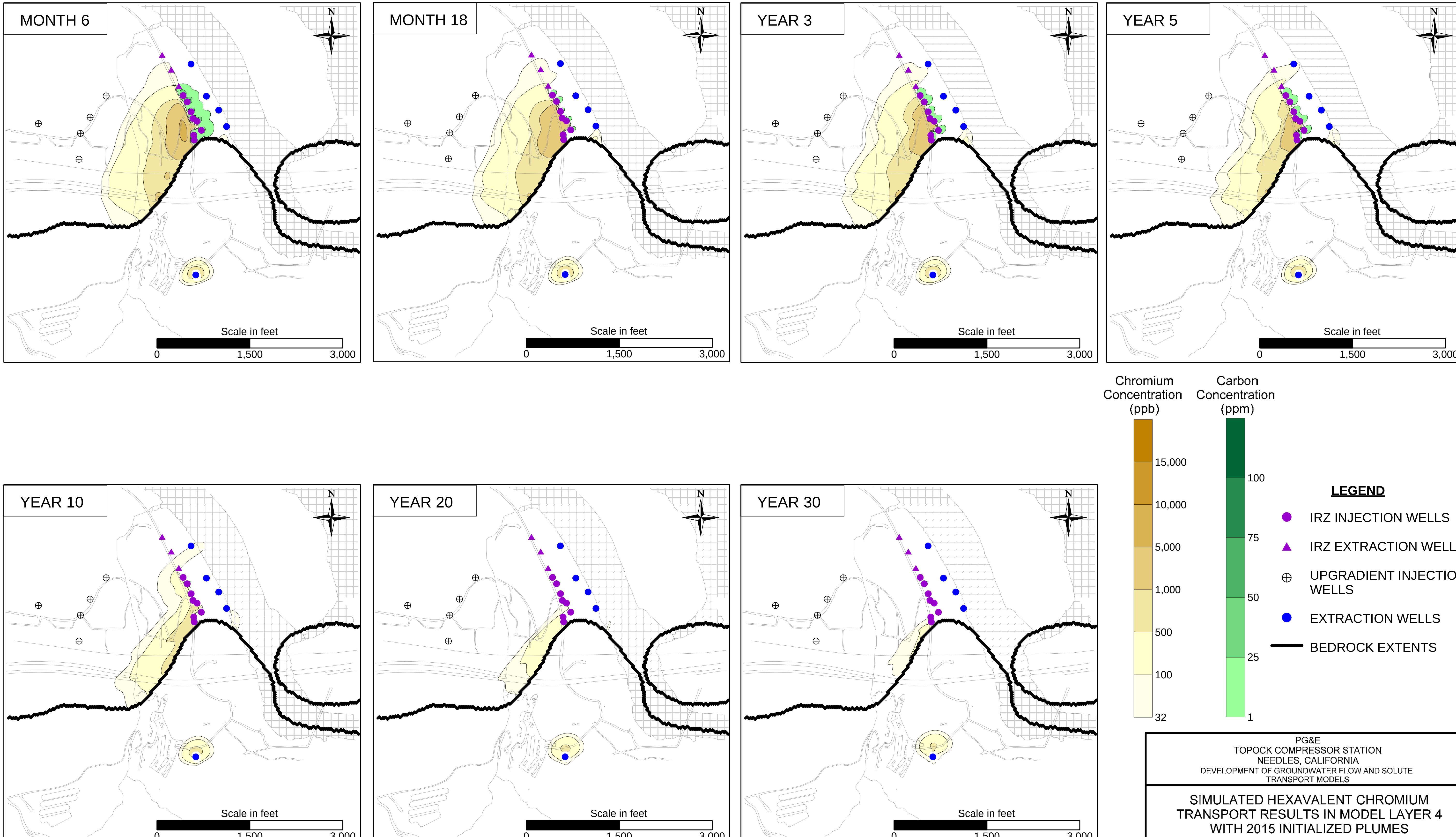


PG&E
TOPOCK COMPRESSOR STATION
NEEDLES, CALIFORNIA
DEVELOPMENT OF GROUNDWATER FLOW AND SOLUTE TRANSPORT MODELS

SIMULATED HEXAVALENT CHROMIUM TRANSPORT RESULTS IN MODEL LAYER 3 WITH 2015 INITIALIZED PLUMES

ARCADIS Design & Consultancy for natural and built assets

FIGURE
5.1-8



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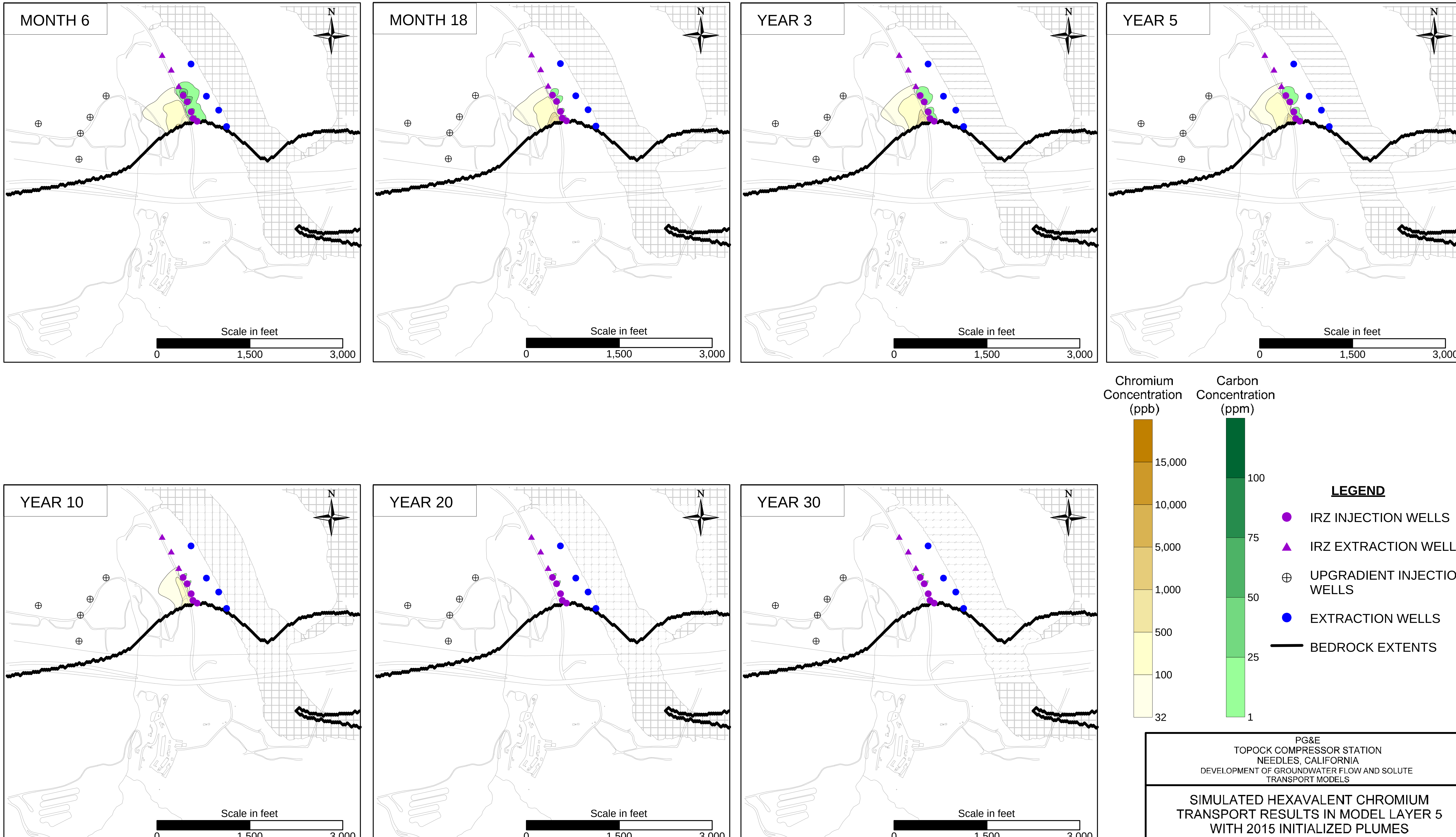
TOPOCK COMPRESSOR STATION
NEEDLES, CALIFORNIA
DEVELOPMENT OF GROUNDWATER FLOW AND SOLUTE TRANSPORT MODELS

SIMULATED HEXAVALENT CHROMIUM TRANSPORT RESULTS IN MODEL LAYER 4 WITH 2015 INITIALIZED PLUMES

ARCADIS Design & Consultancy for natural and built assets

FIGURE
5.1-9



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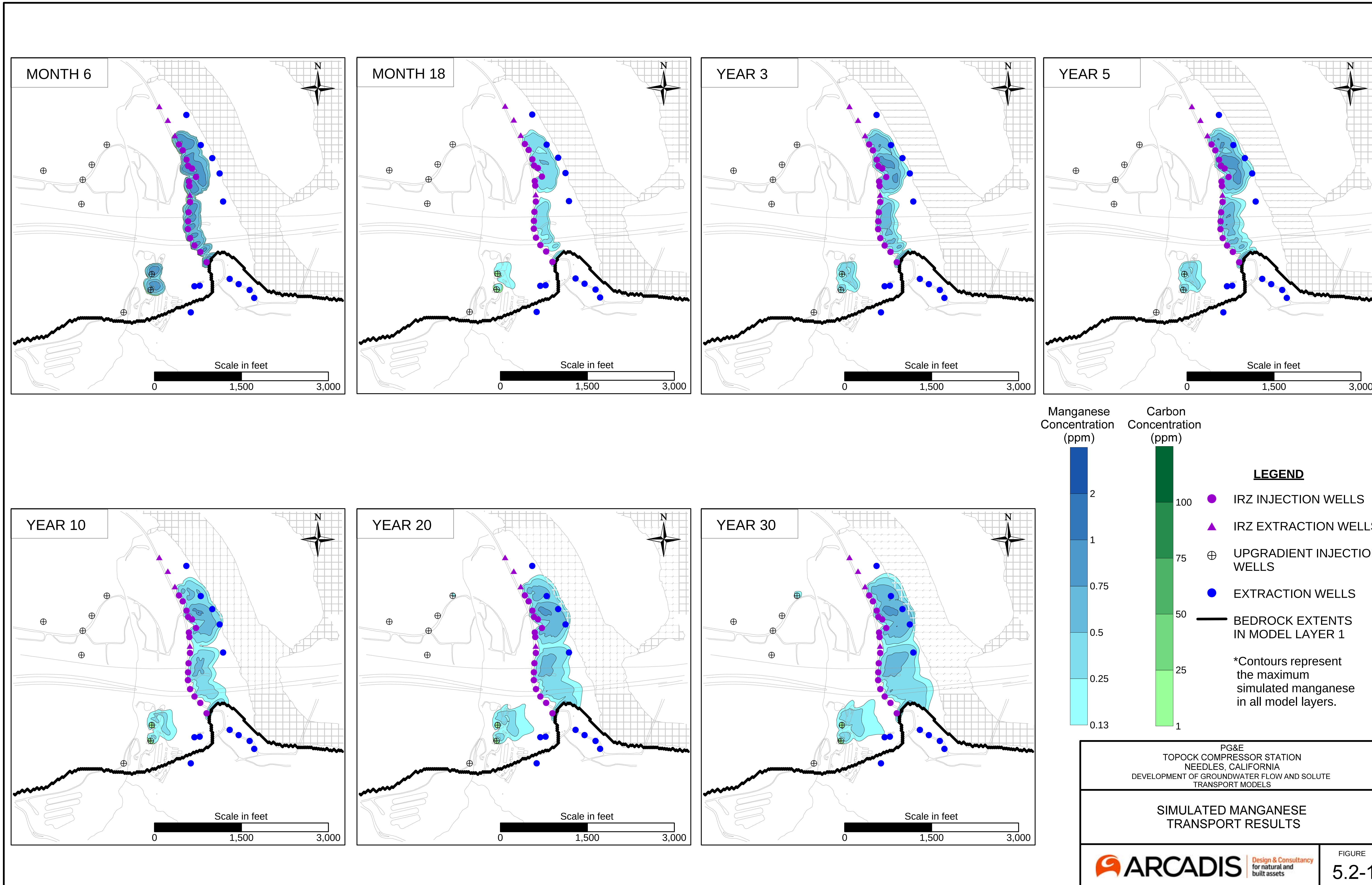
TOPOCK COMPRESSOR STATION
NEEDLES, CALIFORNIA
DEVELOPMENT OF GROUNDWATER FLOW AND SOLUTE TRANSPORT MODELS

SIMULATED HEXAVALENT CHROMIUM TRANSPORT RESULTS IN MODEL LAYER 5 WITH 2015 INITIALIZED PLUMES

ARCADIS Design & Consultancy for natural and built assets

FIGURE
5.1-10


MONTH 6
MONTH 18
YEAR 3
YEAR 5
YEAR 10
YEAR 20
YEAR 30
N
Scale in feet
0
1,500
3,000
Manganese Concentration (ppm)
2
1
0.75
0.5
0.25
0.13
Carbon Concentration (ppm)
100
75
50
25
1
LEGEND
IRZ INJECTION WELLS
IRZ EXTRACTION WELLS
UPGRADIENT INJECTION WELLS
EXTRACTION WELLS
BEDROCK EXTENTS IN MODEL LAYER 1
*Contours represent the maximum simulated manganese in all model layers.
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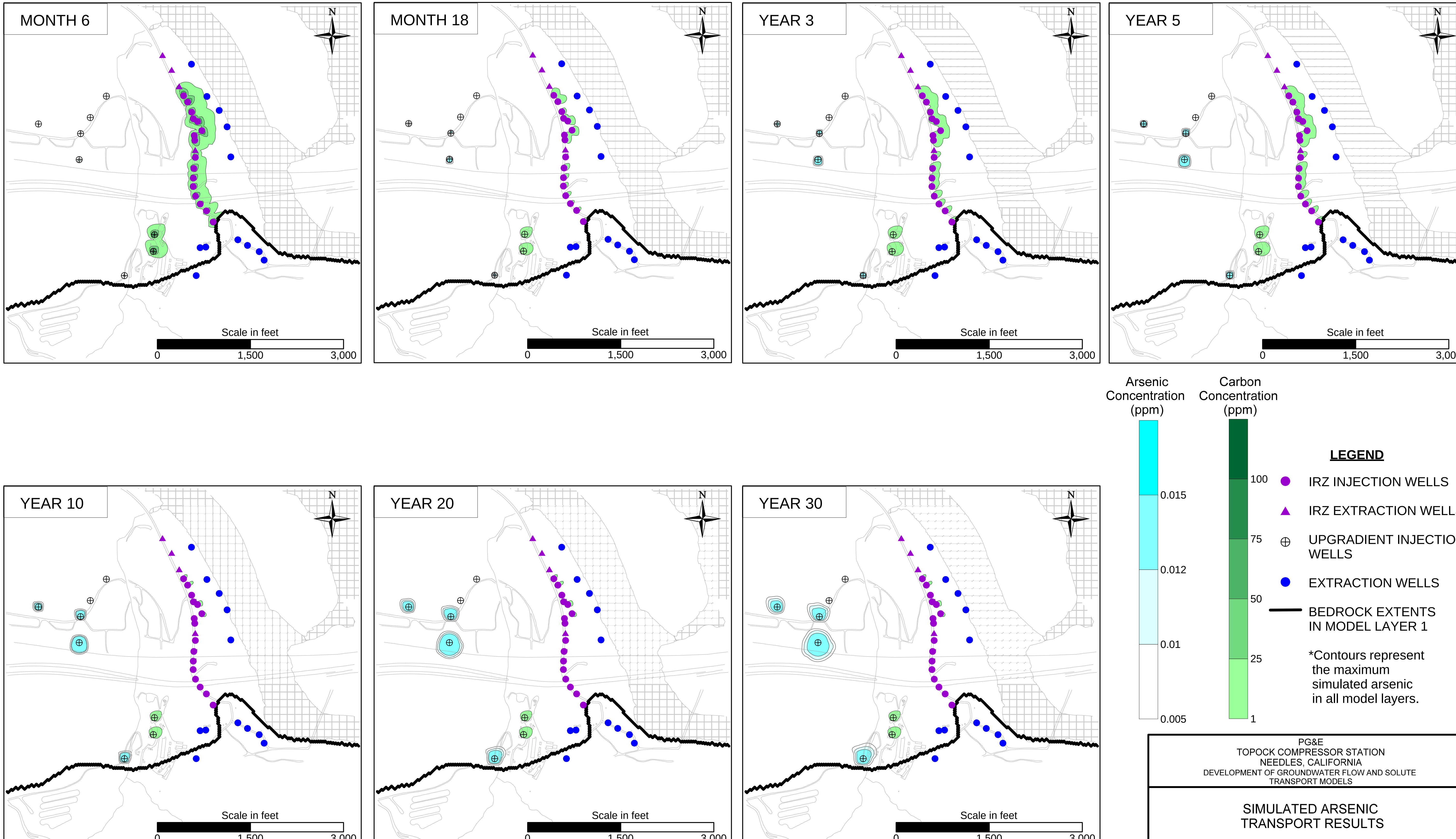
TOPOCK COMPRESSOR STATION
NEEDLES, CALIFORNIA
DEVELOPMENT OF GROUNDWATER FLOW AND SOLUTE TRANSPORT MODELS
SIMULATED MANGANESE TRANSPORT RESULTS
ARCADIS
Design & Consultancy for natural and built assets
FIGURE
5.2-1



PG&E
TOPOCK COMPRESSOR STATION
NEEDLES, CALIFORNIA
DEVELOPMENT OF GROUNDWATER FLOW AND SOLUTE TRANSPORT MODELS

SIMULATED ARSENIC TRANSPORT RESULTS

ARCADIS Design & Consultancy for natural and built assets

FIGURE
5.3-1

APPENDIX A

Transient Calibration Data

DRAFT ARCADIS Design & Consultancy for natural and built assets

Name	Time (day)	X	Y	Layer	Observed Water Level (ft msl)	Computed Water Level (ft	Residual (ft)
MW-10	15.00	7614886.60	2100984.20	1	455.66	455.57	0.09
MW-10	46.00	7614886.60	2100984.20	1	455.14	454.60	0.54
MW-10	77.00	7614886.60	2100984.20	1	454.71	454.49	0.22
MW-10	105.00	7614886.60	2100984.20	1	454.79	454.90	-0.11
MW-10	136.00	7614886.60	2100984.20	1	455.04	455.73	-0.69
MW-10	166.00	7614886.60	2100984.20	1	455.72	456.66	-0.94
MW-10	197.00	7614886.60	2100984.20	1	456.02	456.80	-0.77
MW-10	227.00	7614886.60	2100984.20	1	455.94	456.58	-0.63
MW-10	258.00	7614886.60	2100984.20	1	455.86	456.34	-0.48
MW-10	289.00	7614886.60	2100984.20	1	455.79	456.14	-0.34
MW-11	15.00	7614865.33	2101557.09	1	455.86	455.44	0.42
MW-11	46.00	7614865.33	2101557.09	1	455.41	454.45	0.96
MW-11	77.00	7614865.33	2101557.09	1	455.14	454.40	0.74
MW-11	105.00	7614865.33	2101557.09	1	455.35	454.80	0.55
MW-11	136.00	7614865.33	2101557.09	1	455.70	455.68	0.02
MW-11	166.00	7614865.33	2101557.09	1	456.46	456.60	-0.15
MW-11	197.00	7614865.33	2101557.09	1	456.69	456.70	0.00
MW-11	227.00	7614865.33	2101557.09	1	456.62	456.47	0.14
MW-11	258.00	7614865.33	2101557.09	1	455.72	456.23	-0.51
MW-12	15.00	7615923.61	2101429.49	1	455.22	454.92	0.31
MW-12	46.00	7615923.61	2101429.49	1	454.78	453.87	0.92
MW-12	77.00	7615923.61	2101429.49	1	454.50	454.09	0.41
MW-12	105.00	7615923.61	2101429.49	1	454.73	454.45	0.28
MW-12	136.00	7615923.61	2101429.49	1	455.14	455.51	-0.37
MW-12	166.00	7615923.61	2101429.49	1	455.93	456.39	-0.46
MW-12	197.00	7615923.61	2101429.49	1	456.23	456.31	-0.08
MW-12	227.00	7615923.61	2101429.49	1	456.14	456.08	0.05
MW-12	258.00	7615923.61	2101429.49	1	456.03	455.80	0.23
MW-12	289.00	7615923.61	2101429.49	1	455.97	455.66	0.32
MW-12	319.00	7615923.61	2101429.49	1	455.87	455.67	0.19
MW-12	350.00	7615923.61	2101429.49	1	455.87	455.29	0.58
MW-20-070	15.00	7615893.48	2102493.39	1	453.32	453.62	-0.31
MW-20-070	46.00	7615893.48	2102493.39	1	452.57	452.45	0.12
MW-20-070	77.00	7615893.48	2102493.39	1	452.91	453.21	-0.30
MW-20-070	105.00	7615893.48	2102493.39	1	453.24	453.47	-0.24
MW-20-070	136.00	7615893.48	2102493.39	1	454.22	454.89	-0.67
MW-20-070	166.00	7615893.48	2102493.39	1	455.19	455.73	-0.54
MW-20-070	197.00	7615893.48	2102493.39	1	455.00	455.31	-0.31
MW-20-070	227.00	7615893.48	2102493.39	1	454.64	455.03	-0.40
MW-20-070	258.00	7615893.48	2102493.39	1	454.44	454.70	-0.26
MW-20-070	289.00	7615893.48	2102493.39	1	454.47	454.69	-0.22
MW-20-070	319.00	7615893.48	2102493.39	1	454.21	454.67	-0.46
MW-20-070	350.00	7615893.48	2102493.39	1	453.99	454.08	-0.09

Name	Time (day)	X	Y	Layer	Observed Water Level (ft msl)	Computed Water Level (ft	Residual (ft)
MW-20-100	15.00	7615881.03	2102506.33	2	452.84	453.46	-0.63
MW-20-100	46.00	7615881.03	2102506.33	2	452.07	452.29	-0.22
MW-20-100	77.00	7615881.03	2102506.33	2	452.48	453.05	-0.57
MW-20-100	105.00	7615881.03	2102506.33	2	452.75	453.31	-0.56
MW-20-100	136.00	7615881.03	2102506.33	2	453.80	454.73	-0.93
MW-20-100	166.00	7615881.03	2102506.33	2	454.79	455.58	-0.79
MW-20-100	197.00	7615881.03	2102506.33	2	454.51	455.16	-0.65
MW-20-100	227.00	7615881.03	2102506.33	2	454.16	454.87	-0.71
MW-20-100	258.00	7615881.03	2102506.33	2	453.90	454.53	-0.64
MW-20-100	289.00	7615881.03	2102506.33	2	454.01	454.55	-0.54
MW-20-100	319.00	7615881.03	2102506.33	2	453.65	454.49	-0.84
MW-20-100	350.00	7615881.03	2102506.33	2	453.44	453.92	-0.47
MW-20-130	15.00	7615881.52	2102493.68	3	452.47	453.29	-0.82
MW-20-130	46.00	7615881.52	2102493.68	3	452.19	452.12	0.07
MW-20-130	77.00	7615881.52	2102493.68	3	452.29	452.88	-0.59
MW-20-130	105.00	7615881.52	2102493.68	3	452.26	453.13	-0.87
MW-20-130	136.00	7615881.52	2102493.68	3	453.47	454.56	-1.09
MW-20-130	166.00	7615881.52	2102493.68	3	454.50	455.42	-0.93
MW-20-130	197.00	7615881.52	2102493.68	3	454.15	455.00	-0.86
MW-20-130	227.00	7615881.52	2102493.68	3	453.75	454.69	-0.94
MW-20-130	258.00	7615881.52	2102493.68	3	453.52	454.36	-0.85
MW-20-130	289.00	7615881.52	2102493.68	3	453.69	454.40	-0.71
MW-20-130	319.00	7615881.52	2102493.68	3	453.23	454.30	-1.07
MW-20-130	350.00	7615881.52	2102493.68	3	453.03	453.74	-0.71
MW-21	15.00	7616099.26	2101486.75	1	454.10	454.74	-0.64
MW-21	46.00	7616099.26	2101486.75	1	454.64	453.67	0.98
MW-21	77.00	7616099.26	2101486.75	1	454.28	454.03	0.25
MW-21	105.00	7616099.26	2101486.75	1	454.47	454.37	0.10
MW-21	136.00	7616099.26	2101486.75	1	454.88	455.51	-0.63
MW-21	166.00	7616099.26	2101486.75	1	455.77	456.36	-0.58
MW-21	197.00	7616099.26	2101486.75	1	455.67	456.20	-0.53
MW-21	227.00	7616099.26	2101486.75	1	456.00	455.98	0.02
MW-21	258.00	7616099.26	2101486.75	1	455.86	455.68	0.19
MW-21	289.00	7616099.26	2101486.75	1	455.82	455.55	0.27
MW-21	319.00	7616099.26	2101486.75	1	455.69	455.59	0.11
MW-21	350.00	7616099.26	2101486.75	1	455.66	455.14	0.52
MW-22	15.00	7616359.75	2101566.69	1	454.28	454.17	0.12
MW-22	46.00	7616359.75	2101566.69	1	453.78	452.98	0.80
MW-22	77.00	7616359.75	2101566.69	1	453.93	453.92	0.01
MW-22	105.00	7616359.75	2101566.69	1	454.32	454.16	0.16
MW-22	136.00	7616359.75	2101566.69	1	455.48	455.65	-0.17
MW-22	166.00	7616359.75	2101566.69	1	455.87	456.34	-0.47
MW-22	197.00	7616359.75	2101566.69	1	455.58	455.85	-0.26
MW-22	227.00	7616359.75	2101566.69	1	455.45	455.67	-0.22
MW-22	258.00	7616359.75	2101566.69	1	455.20	455.30	-0.10
MW-22	289.00	7616359.75	2101566.69	1	455.25	455.22	0.03

Appendix A
Transient Calibration Data
PGE
Topock Compressor Station
Needles, California

DRAFT ARCADIS Design & Consultancy for natural and built assets

Name	Time (day)	X	Y	Layer	Observed Water Level (ft msl)	Computed Water Level (ft	Residual (ft)
MW-22	319.00	7616359.75	2101566.69	1	455.26	455.36	-0.11
MW-22	350.00	7616359.75	2101566.69	1	455.11	454.67	0.44
MW-23-060	15.00	7616448.25	2101286.36	1	454.62	455.97	-1.35
MW-23-060	46.00	7616448.25	2101286.36	1	454.48	455.58	-1.09
MW-23-060	77.00	7616448.25	2101286.36	1	454.15	455.07	-0.92
MW-23-060	105.00	7616448.25	2101286.36	1	454.60	455.02	-0.42
MW-23-060	136.00	7616448.25	2101286.36	1	455.12	455.19	-0.07
MW-23-060	166.00	7616448.25	2101286.36	1	455.81	455.74	0.07
MW-23-060	197.00	7616448.25	2101286.36	1	455.89	456.27	-0.38
MW-23-060	227.00	7616448.25	2101286.36	1	455.87	456.42	-0.54
MW-23-060	258.00	7616448.25	2101286.36	1	455.65	456.42	-0.77
MW-23-060	289.00	7616448.25	2101286.36	1	455.59	456.30	-0.72
MW-23-060	319.00	7616448.25	2101286.36	1	455.63	456.23	-0.60
MW-23-060	350.00	7616448.25	2101286.36	1	455.44	456.18	-0.74
MW-23-080	15.00	7616448.50	2101286.33	1	454.66	455.97	-1.31
MW-23-080	46.00	7616448.50	2101286.33	1	454.53	455.58	-1.05
MW-23-080	77.00	7616448.50	2101286.33	1	454.23	455.07	-0.84
MW-23-080	105.00	7616448.50	2101286.33	1	454.67	455.02	-0.35
MW-23-080	136.00	7616448.50	2101286.33	1	455.20	455.19	0.01
MW-23-080	166.00	7616448.50	2101286.33	1	455.91	455.74	0.16
MW-23-080	197.00	7616448.50	2101286.33	1	455.99	456.27	-0.29
MW-23-080	227.00	7616448.50	2101286.33	1	455.96	456.42	-0.45
MW-23-080	258.00	7616448.50	2101286.33	1	455.70	456.42	-0.71
MW-23-080	289.00	7616448.50	2101286.33	1	455.64	456.30	-0.66
MW-23-080	319.00	7616448.50	2101286.33	1	455.69	456.23	-0.53
MW-23-080	350.00	7616448.50	2101286.33	1	455.59	456.18	-0.58
MW-25	15.00	7615303.59	2102351.22	1	454.98	454.70	0.29
MW-25	46.00	7615303.59	2102351.22	1	454.44	453.62	0.83
MW-25	77.00	7615303.59	2102351.22	1	454.34	453.92	0.42
MW-25	105.00	7615303.59	2102351.22	1	454.68	454.28	0.41
MW-25	136.00	7615303.59	2102351.22	1	455.24	455.39	-0.16
MW-25	166.00	7615303.59	2102351.22	1	456.13	456.27	-0.14
MW-25	197.00	7615303.59	2102351.22	1	456.29	456.14	0.14
MW-25	227.00	7615303.59	2102351.22	1	456.18	455.90	0.29
MW-25	258.00	7615303.59	2102351.22	1	455.90	455.61	0.29
MW-25	289.00	7615303.59	2102351.22	1	455.83	455.49	0.34
MW-25	319.00	7615303.59	2102351.22	1	455.74	455.48	0.25
MW-25	350.00	7615303.59	2102351.22	1	455.57	455.09	0.48
MW-26	15.00	7615787.70	2101911.86	1	454.70	454.55	0.15
MW-26	46.00	7615787.70	2101911.86	1	454.19	453.46	0.73
MW-26	77.00	7615787.70	2101911.86	1	454.10	453.85	0.25
MW-26	105.00	7615787.70	2101911.86	1	454.36	454.19	0.17
MW-26	136.00	7615787.70	2101911.86	1	454.96	455.36	-0.40
MW-26	166.00	7615787.70	2101911.86	1	455.83	456.22	-0.39
MW-26	197.00	7615787.70	2101911.86	1	455.97	456.04	-0.07
MW-26	227.00	7615787.70	2101911.86	1	455.77	455.80	-0.03

Name	Time (day)	X	Y	Layer	Observed Water Level (ft msl)	Computed Water Level (ft	Residual (ft)
MW-26	258.00	7615787.70	2101911.86	1	455.59	455.50	0.09
MW-26	289.00	7615787.70	2101911.86	1	455.54	455.39	0.15
MW-26	319.00	7615787.70	2101911.86	1	455.42	455.40	0.02
MW-26	350.00	7615787.70	2101911.86	1	455.28	454.96	0.33
MW-27-020	15.00	7616557.66	2102294.73	1	454.09	453.89	0.20
MW-27-020	46.00	7616557.66	2102294.73	1	453.15	452.63	0.52
MW-27-020	77.00	7616557.66	2102294.73	1	454.18	453.89	0.29
MW-27-020	105.00	7616557.66	2102294.73	1	454.38	454.09	0.29
MW-27-020	136.00	7616557.66	2102294.73	1	456.06	455.76	0.30
MW-27-020	166.00	7616557.66	2102294.73	1	456.78	456.38	0.40
MW-27-020	197.00	7616557.66	2102294.73	1	456.02	455.69	0.33
MW-27-020	227.00	7616557.66	2102294.73	1	455.83	455.54	0.29
MW-27-020	258.00	7616557.66	2102294.73	1	455.39	455.12	0.27
MW-27-020	289.00	7616557.66	2102294.73	1	455.30	455.08	0.23
MW-27-020	319.00	7616557.66	2102294.73	1	455.56	455.29	0.27
MW-27-020	350.00	7616557.66	2102294.73	1	454.83	454.44	0.39
MW-27-060	15.00	7616534.75	2102288.27	2	454.08	453.86	0.22
MW-27-060	46.00	7616534.75	2102288.27	2	452.95	452.61	0.35
MW-27-060	77.00	7616534.75	2102288.27	2	454.17	453.83	0.34
MW-27-060	105.00	7616534.75	2102288.27	2	454.39	454.03	0.36
MW-27-060	136.00	7616534.75	2102288.27	2	456.04	455.69	0.35
MW-27-060	166.00	7616534.75	2102288.27	2	456.69	456.32	0.37
MW-27-060	197.00	7616534.75	2102288.27	2	455.96	455.66	0.30
MW-27-060	227.00	7616534.75	2102288.27	2	455.77	455.49	0.28
MW-27-060	258.00	7616534.75	2102288.27	2	455.40	455.08	0.32
MW-27-060	289.00	7616534.75	2102288.27	2	455.31	455.04	0.27
MW-27-060	319.00	7616534.75	2102288.27	2	455.53	455.24	0.29
MW-27-060	350.00	7616534.75	2102288.27	2	454.76	454.41	0.35
MW-27-085	15.00	7616540.34	2102290.53	3	454.11	453.84	0.27
MW-27-085	46.00	7616540.34	2102290.53	3	452.99	452.59	0.40
MW-27-085	77.00	7616540.34	2102290.53	3	454.04	453.81	0.23
MW-27-085	105.00	7616540.34	2102290.53	3	454.32	454.01	0.31
MW-27-085	136.00	7616540.34	2102290.53	3	455.96	455.67	0.29
MW-27-085	166.00	7616540.34	2102290.53	3	456.71	456.30	0.40
MW-27-085	197.00	7616540.34	2102290.53	3	456.03	455.64	0.38
MW-27-085	227.00	7616540.34	2102290.53	3	455.80	455.47	0.33
MW-27-085	258.00	7616540.34	2102290.53	3	455.39	455.06	0.33
MW-27-085	289.00	7616540.34	2102290.53	3	455.30	455.03	0.27
MW-27-085	319.00	7616540.34	2102290.53	3	455.53	455.23	0.30
MW-27-085	350.00	7616540.34	2102290.53	3	454.72	454.39	0.34
MW-28-025	15.00	7616280.73	2103003.90	1	454.10	453.95	0.15
MW-28-025	46.00	7616280.73	2103003.90	1	452.96	452.70	0.26
MW-28-025	77.00	7616280.73	2103003.90	1	453.65	453.93	-0.28
MW-28-025	105.00	7616280.73	2103003.90	1	454.54	454.13	0.41
MW-28-025	136.00	7616280.73	2103003.90	1	455.98	455.80	0.19
MW-28-025	166.00	7616280.73	2103003.90	1	456.70	456.42	0.28

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Name	Time (day)	X	Y	Layer	Observed Water Level (ft msl)	Computed Water Level (ft	Residual (ft)
MW-28-025	197.00	7616280.73	2103003.90	1	456.00	455.75	0.25
MW-28-025	227.00	7616280.73	2103003.90	1	455.89	455.59	0.30
MW-28-025	258.00	7616280.73	2103003.90	1	455.41	455.18	0.23
MW-28-025	289.00	7616280.73	2103003.90	1	455.32	455.13	0.19
MW-28-025	319.00	7616280.73	2103003.90	1	455.54	455.32	0.21
MW-28-025	350.00	7616280.73	2103003.90	1	454.70	454.50	0.20
MW-28-090	15.00	7616289.73	2103005.68	3	454.23	453.95	0.28
MW-28-090	46.00	7616289.73	2103005.68	3	453.13	452.70	0.42
MW-28-090	77.00	7616289.73	2103005.68	3	454.18	453.88	0.30
MW-28-090	105.00	7616289.73	2103005.68	3	454.40	454.09	0.31
MW-28-090	136.00	7616289.73	2103005.68	3	455.98	455.73	0.26
MW-28-090	166.00	7616289.73	2103005.68	3	456.68	456.37	0.31
MW-28-090	197.00	7616289.73	2103005.68	3	456.05	455.73	0.32
MW-28-090	227.00	7616289.73	2103005.68	3	455.86	455.56	0.30
MW-28-090	258.00	7616289.73	2103005.68	3	455.48	455.16	0.33
MW-28-090	289.00	7616289.73	2103005.68	3	455.44	455.11	0.33
MW-28-090	319.00	7616289.73	2103005.68	3	455.57	455.29	0.28
MW-28-090	350.00	7616289.73	2103005.68	3	454.84	454.49	0.35
MW-30-050	15.00	7616150.98	2102503.83	2	453.86	453.60	0.27
MW-30-050	46.00	7616150.98	2102503.83	2	452.88	452.38	0.49
MW-30-050	77.00	7616150.98	2102503.83	2	453.83	453.36	0.48
MW-30-050	105.00	7616150.98	2102503.83	2	454.11	453.59	0.52
MW-30-050	136.00	7616150.98	2102503.83	2	455.51	455.12	0.38
MW-30-050	166.00	7616150.98	2102503.83	2	456.39	455.88	0.51
MW-30-050	197.00	7616150.98	2102503.83	2	455.78	455.35	0.43
MW-30-050	227.00	7616150.98	2102503.83	2	455.48	455.11	0.37
MW-30-050	258.00	7616150.98	2102503.83	2	455.10	454.74	0.37
MW-30-050	289.00	7616150.98	2102503.83	2	454.99	454.74	0.26
MW-30-050	319.00	7616150.98	2102503.83	2	455.11	454.83	0.28
MW-30-050	350.00	7616150.98	2102503.83	2	454.54	454.09	0.44
MW-31-135	15.00	7615819.13	2102835.29	3	453.43	453.57	-0.14
MW-31-135	46.00	7615819.13	2102835.29	3	452.61	452.39	0.22
MW-31-135	77.00	7615819.13	2102835.29	3	453.13	453.20	-0.08
MW-31-135	105.00	7615819.13	2102835.29	3	453.36	453.46	-0.10
MW-31-135	136.00	7615819.13	2102835.29	3	454.58	454.91	-0.33
MW-31-135	166.00	7615819.13	2102835.29	3	455.52	455.73	-0.20
MW-31-135	197.00	7615819.13	2102835.29	3	455.19	455.27	-0.08
MW-31-135	227.00	7615819.13	2102835.29	3	454.81	455.00	-0.19
MW-31-135	258.00	7615819.13	2102835.29	3	454.65	454.66	-0.01
MW-31-135	289.00	7615819.13	2102835.29	3	454.67	454.66	0.01
MW-31-135	319.00	7615819.13	2102835.29	3	454.47	454.62	-0.16
MW-31-135	350.00	7615819.13	2102835.29	3	454.11	454.04	0.08
MW-32-035	15.00	7616306.62	2102034.68	1	453.97	453.98	-0.01
MW-32-035	46.00	7616306.62	2102034.68	1	453.06	452.78	0.29
MW-32-035	77.00	7616306.62	2102034.68	1	453.88	453.75	0.14
MW-32-035	105.00	7616306.62	2102034.68	1	454.22	453.99	0.24

DRAFT ARCADIS Design & Consultancy for natural and built assets

Name	Time (day)	X	Y	Layer	Observed Water Level (ft msl)	Computed Water Level (ft	Residual (ft)
MW-32-035	136.00	7616306.62	2102034.68	1	455.66	455.50	0.17
MW-32-035	166.00	7616306.62	2102034.68	1	456.42	456.21	0.21
MW-32-035	197.00	7616306.62	2102034.68	1	455.94	455.69	0.25
MW-32-035	227.00	7616306.62	2102034.68	1	455.64	455.49	0.14
MW-32-035	258.00	7616306.62	2102034.68	1	455.18	455.12	0.06
MW-32-035	289.00	7616306.62	2102034.68	1	455.15	455.07	0.08
MW-32-035	319.00	7616306.62	2102034.68	1	455.30	455.20	0.10
MW-32-035	350.00	7616306.62	2102034.68	1	454.72	454.48	0.24
MW-33-040	15.00	7615916.42	2103280.79	1	454.13	454.15	-0.02
MW-33-040	46.00	7615916.42	2103280.79	1	453.17	452.93	0.24
MW-33-040	77.00	7615916.42	2103280.79	1	454.06	453.96	0.10
MW-33-040	105.00	7615916.42	2103280.79	1	454.37	454.20	0.17
MW-33-040	136.00	7615916.42	2103280.79	1	455.59	455.75	-0.16
MW-33-040	166.00	7615916.42	2103280.79	1	456.35	456.42	-0.07
MW-33-040	197.00	7615916.42	2103280.79	1	456.05	455.87	0.18
MW-33-040	227.00	7615916.42	2103280.79	1	455.75	455.68	0.07
MW-33-040	258.00	7615916.42	2103280.79	1	455.43	455.30	0.12
MW-33-040	289.00	7615916.42	2103280.79	1	455.25	455.24	0.01
MW-33-040	319.00	7615916.42	2103280.79	1	455.30	455.39	-0.09
MW-33-040	350.00	7615916.42	2103280.79	1	454.80	454.66	0.14
MW-33-090	15.00	7615914.59	2103287.43	2	454.41	454.17	0.24
MW-33-090	46.00	7615914.59	2103287.43	2	453.44	452.95	0.49
MW-33-090	77.00	7615914.59	2103287.43	2	454.24	453.98	0.26
MW-33-090	105.00	7615914.59	2103287.43	2	454.58	454.22	0.36
MW-33-090	136.00	7615914.59	2103287.43	2	455.87	455.76	0.11
MW-33-090	166.00	7615914.59	2103287.43	2	456.60	456.44	0.16
MW-33-090	197.00	7615914.59	2103287.43	2	456.22	455.89	0.33
MW-33-090	227.00	7615914.59	2103287.43	2	455.97	455.71	0.27
MW-33-090	258.00	7615914.59	2103287.43	2	455.73	455.32	0.40
MW-33-090	289.00	7615914.59	2103287.43	2	455.63	455.26	0.38
MW-33-090	319.00	7615914.59	2103287.43	2	455.80	455.40	0.39
MW-33-090	350.00	7615914.59	2103287.43	2	455.58	454.68	0.90
MW-33-150	15.00	7615906.05	2103302.57	4	454.42	454.24	0.18
MW-33-150	46.00	7615906.05	2103302.57	4	453.53	453.03	0.50
MW-33-150	77.00	7615906.05	2103302.57	4	454.21	454.01	0.20
MW-33-150	105.00	7615906.05	2103302.57	4	454.50	454.26	0.24
MW-33-150	136.00	7615906.05	2103302.57	4	455.73	455.77	-0.04
MW-33-150	166.00	7615906.05	2103302.57	4	456.48	456.46	0.02
MW-33-150	197.00	7615906.05	2103302.57	4	456.04	455.94	0.10
MW-33-150	227.00	7615906.05	2103302.57	4	455.89	455.75	0.13
MW-33-150	258.00	7615906.05	2103302.57	4	455.58	455.38	0.20
MW-33-150	289.00	7615906.05	2103302.57	4	455.52	455.30	0.22
MW-33-150	319.00	7615906.05	2103302.57	4	455.56	455.45	0.11
MW-33-150	350.00	7615906.05	2103302.57	4	455.03	454.75	0.28
MW-34-055	15.00	7616444.49	2102542.45	2	454.13	453.73	0.40
MW-34-055	46.00	7616444.49	2102542.45	2	452.95	452.48	0.47

Name	Time (day)	X	Y	Layer	Observed Water Level (ft msl)	Computed Water Level (ft	Residual (ft)
MW-34-055	77.00	7616444.49	2102542.45	2	454.14	453.68	0.46
MW-34-055	105.00	7616444.49	2102542.45	2	454.39	453.88	0.50
MW-34-055	136.00	7616444.49	2102542.45	2	456.05	455.53	0.52
MW-34-055	166.00	7616444.49	2102542.45	2	456.69	456.19	0.50
MW-34-055	197.00	7616444.49	2102542.45	2	456.04	455.54	0.50
MW-34-055	227.00	7616444.49	2102542.45	2	455.84	455.35	0.49
MW-34-055	258.00	7616444.49	2102542.45	2	455.33	454.94	0.39
MW-34-055	289.00	7616444.49	2102542.45	2	455.30	454.92	0.37
MW-34-055	319.00	7616444.49	2102542.45	2	455.52	455.13	0.39
MW-34-055	350.00	7616444.49	2102542.45	2	454.74	454.27	0.47
MW-34-080	15.00	7616444.98	2102535.25	3	454.23	453.61	0.62
MW-34-080	46.00	7616444.98	2102535.25	3	452.99	452.37	0.62
MW-34-080	77.00	7616444.98	2102535.25	3	454.24	453.55	0.69
MW-34-080	105.00	7616444.98	2102535.25	3	454.48	453.75	0.73
MW-34-080	136.00	7616444.98	2102535.25	3	456.09	455.39	0.70
MW-34-080	166.00	7616444.98	2102535.25	3	456.71	456.07	0.64
MW-34-080	197.00	7616444.98	2102535.25	3	456.06	455.43	0.63
MW-34-080	227.00	7616444.98	2102535.25	3	455.89	455.22	0.67
MW-34-080	258.00	7616444.98	2102535.25	3	455.43	454.82	0.61
MW-34-080	289.00	7616444.98	2102535.25	3	455.41	454.82	0.59
MW-34-080	319.00	7616444.98	2102535.25	3	455.63	455.04	0.59
MW-34-080	350.00	7616444.98	2102535.25	3	454.77	454.15	0.62
MW-34-100	15.00	7616452.41	2102530.60	3	453.86	453.64	0.22
MW-34-100	46.00	7616452.41	2102530.60	3	452.74	452.39	0.34
MW-34-100	77.00	7616452.41	2102530.60	3	453.77	453.58	0.19
MW-34-100	105.00	7616452.41	2102530.60	3	454.04	453.78	0.25
MW-34-100	136.00	7616452.41	2102530.60	3	455.63	455.43	0.21
MW-34-100	166.00	7616452.41	2102530.60	3	456.32	456.10	0.22
MW-34-100	197.00	7616452.41	2102530.60	3	455.87	455.46	0.41
MW-34-100	227.00	7616452.41	2102530.60	3	455.67	455.25	0.42
MW-34-100	258.00	7616452.41	2102530.60	3	455.25	454.85	0.40
MW-34-100	289.00	7616452.41	2102530.60	3	455.21	454.84	0.37
MW-34-100	319.00	7616452.41	2102530.60	3	455.43	455.06	0.36
MW-34-100	350.00	7616452.41	2102530.60	3	454.57	454.18	0.39
MW-35-060	15.00	7615317.50	2104058.80	1	454.67	454.60	0.08
MW-35-060	46.00	7615317.50	2104058.80	1	453.68	453.40	0.28
MW-35-060	77.00	7615317.50	2104058.80	1	454.55	454.29	0.25
MW-35-060	105.00	7615317.50	2104058.80	1	454.86	454.57	0.29
MW-35-060	136.00	7615317.50	2104058.80	1	456.27	456.02	0.24
MW-35-060	166.00	7615317.50	2104058.80	1	457.07	456.71	0.36
MW-35-060	197.00	7615317.50	2104058.80	1	456.43	456.24	0.19
MW-35-060	227.00	7615317.50	2104058.80	1	456.21	456.07	0.14
MW-35-060	258.00	7615317.50	2104058.80	1	455.91	455.70	0.21
MW-35-060	289.00	7615317.50	2104058.80	1	455.84	455.60	0.25
MW-35-060	319.00	7615317.50	2104058.80	1	455.90	455.76	0.14
MW-35-060	350.00	7615317.50	2104058.80	1	455.33	455.09	0.24

Name	Time (day)	X	Y	Layer	Observed Water Level (ft msl)	Computed Water Level (ft	Residual (ft)
MW-35-135	15.00	7615329.76	2104045.82	3	455.16	454.61	0.55
MW-35-135	46.00	7615329.76	2104045.82	3	454.35	453.42	0.92
MW-35-135	77.00	7615329.76	2104045.82	3	454.82	454.30	0.52
MW-35-135	105.00	7615329.76	2104045.82	3	455.15	454.58	0.57
MW-35-135	136.00	7615329.76	2104045.82	3	456.22	456.03	0.20
MW-35-135	166.00	7615329.76	2104045.82	3	457.01	456.72	0.29
MW-35-135	197.00	7615329.76	2104045.82	3	456.52	456.25	0.27
MW-35-135	227.00	7615329.76	2104045.82	3	456.56	456.08	0.47
MW-35-135	258.00	7615329.76	2104045.82	3	456.30	455.72	0.59
MW-35-135	289.00	7615329.76	2104045.82	3	456.24	455.61	0.63
MW-35-135	319.00	7615329.76	2104045.82	3	456.20	455.77	0.42
MW-35-135	350.00	7615329.76	2104045.82	3	455.75	455.11	0.65
MW-36-020	15.00	7616267.10	2102542.57	1	454.04	453.65	0.39
MW-36-020	46.00	7616267.10	2102542.57	1	453.03	452.42	0.61
MW-36-020	77.00	7616267.10	2102542.57	1	453.92	453.48	0.44
MW-36-020	105.00	7616267.10	2102542.57	1	454.23	453.70	0.53
MW-36-020	136.00	7616267.10	2102542.57	1	455.51	455.28	0.23
MW-36-020	166.00	7616267.10	2102542.57	1	456.36	456.00	0.36
MW-36-020	197.00	7616267.10	2102542.57	1	455.86	455.43	0.43
MW-36-020	227.00	7616267.10	2102542.57	1	455.62	455.20	0.42
MW-36-020	258.00	7616267.10	2102542.57	1	455.22	454.82	0.40
MW-36-020	289.00	7616267.10	2102542.57	1	455.14	454.81	0.33
MW-36-020	319.00	7616267.10	2102542.57	1	455.32	454.95	0.38
MW-36-020	350.00	7616267.10	2102542.57	1	454.72	454.16	0.56
MW-36-040	15.00	7616267.58	2102537.20	1	453.93	453.65	0.28
MW-36-040	46.00	7616267.58	2102537.20	1	452.86	452.42	0.44
MW-36-040	77.00	7616267.58	2102537.20	1	453.87	453.48	0.39
MW-36-040	105.00	7616267.58	2102537.20	1	454.15	453.70	0.45
MW-36-040	136.00	7616267.58	2102537.20	1	455.67	455.28	0.39
MW-36-040	166.00	7616267.58	2102537.20	1	456.42	456.00	0.43
MW-36-040	197.00	7616267.58	2102537.20	1	455.88	455.43	0.45
MW-36-040	227.00	7616267.58	2102537.20	1	455.65	455.20	0.45
MW-36-040	258.00	7616267.58	2102537.20	1	455.18	454.82	0.37
MW-36-040	289.00	7616267.58	2102537.20	1	455.10	454.81	0.29
MW-36-040	319.00	7616267.58	2102537.20	1	455.26	454.95	0.32
MW-36-040	350.00	7616267.58	2102537.20	1	454.54	454.16	0.38
MW-36-050	15.00	7616267.47	2102532.17	2	453.86	453.59	0.26
MW-36-050	46.00	7616267.47	2102532.17	2	452.80	452.37	0.43
MW-36-050	77.00	7616267.47	2102532.17	2	453.82	453.42	0.40
MW-36-050	105.00	7616267.47	2102532.17	2	454.11	453.64	0.46
MW-36-050	136.00	7616267.47	2102532.17	2	455.64	455.21	0.43
MW-36-050	166.00	7616267.47	2102532.17	2	456.38	455.94	0.44
MW-36-050	197.00	7616267.47	2102532.17	2	455.73	455.38	0.35
MW-36-050	227.00	7616267.47	2102532.17	2	455.51	455.14	0.37
MW-36-050	258.00	7616267.47	2102532.17	2	455.05	454.76	0.29
MW-36-050	289.00	7616267.47	2102532.17	2	454.97	454.76	0.21

Name	Time (day)	X	Y	Layer	Observed Water Level (ft msl)	Computed Water Level (ft	Residual (ft)
MW-36-050	319.00	7616267.47	2102532.17	2	455.15	454.90	0.24
MW-36-050	350.00	7616267.47	2102532.17	2	454.38	454.10	0.28
MW-36-070	15.00	7616267.18	2102542.67	2	453.93	453.59	0.34
MW-36-070	46.00	7616267.18	2102542.67	2	452.81	452.36	0.45
MW-36-070	77.00	7616267.18	2102542.67	2	453.83	453.42	0.41
MW-36-070	105.00	7616267.18	2102542.67	2	454.11	453.64	0.46
MW-36-070	136.00	7616267.18	2102542.67	2	455.65	455.22	0.43
MW-36-070	166.00	7616267.18	2102542.67	2	456.37	455.94	0.43
MW-36-070	197.00	7616267.18	2102542.67	2	455.86	455.37	0.48
MW-36-070	227.00	7616267.18	2102542.67	2	455.63	455.14	0.49
MW-36-070	258.00	7616267.18	2102542.67	2	455.15	454.76	0.39
MW-36-070	289.00	7616267.18	2102542.67	2	455.06	454.76	0.30
MW-36-070	319.00	7616267.18	2102542.67	2	455.22	454.90	0.32
MW-36-070	350.00	7616267.18	2102542.67	2	454.48	454.10	0.38
MW-36-090	15.00	7616267.63	2102537.34	3	453.09	453.41	-0.33
MW-36-090	46.00	7616267.63	2102537.34	3	452.09	452.19	-0.10
MW-36-090	77.00	7616267.63	2102537.34	3	452.96	453.24	-0.28
MW-36-090	105.00	7616267.63	2102537.34	3	453.19	453.46	-0.27
MW-36-090	136.00	7616267.63	2102537.34	3	454.61	455.03	-0.42
MW-36-090	166.00	7616267.63	2102537.34	3	455.45	455.77	-0.33
MW-36-090	197.00	7616267.63	2102537.34	3	455.06	455.22	-0.16
MW-36-090	227.00	7616267.63	2102537.34	3	454.69	454.96	-0.27
MW-36-090	258.00	7616267.63	2102537.34	3	454.35	454.58	-0.22
MW-36-090	289.00	7616267.63	2102537.34	3	454.46	454.60	-0.14
MW-36-090	319.00	7616267.63	2102537.34	3	454.45	454.77	-0.32
MW-36-090	350.00	7616267.63	2102537.34	3	453.73	453.92	-0.18
MW-36-100	15.00	7616267.51	2102532.37	3	453.38	453.42	-0.04
MW-36-100	46.00	7616267.51	2102532.37	3	452.38	452.19	0.18
MW-36-100	77.00	7616267.51	2102532.37	3	453.22	453.24	-0.02
MW-36-100	105.00	7616267.51	2102532.37	3	453.42	453.46	-0.04
MW-36-100	136.00	7616267.51	2102532.37	3	454.83	455.03	-0.20
MW-36-100	166.00	7616267.51	2102532.37	3	455.68	455.78	-0.10
MW-36-100	197.00	7616267.51	2102532.37	3	455.33	455.22	0.11
MW-36-100	227.00	7616267.51	2102532.37	3	454.85	454.96	-0.11
MW-36-100	258.00	7616267.51	2102532.37	3	454.53	454.58	-0.05
MW-36-100	289.00	7616267.51	2102532.37	3	454.57	454.61	-0.04
MW-36-100	319.00	7616267.51	2102532.37	3	454.66	454.77	-0.12
MW-36-100	350.00	7616267.51	2102532.37	3	453.87	453.92	-0.05
MW-37S	15.00	7614827.87	2102869.45	2	454.74	455.08	-0.35
MW-37S	46.00	7614827.87	2102869.45	2	454.21	454.01	0.20
MW-37S	77.00	7614827.87	2102869.45	2	454.18	454.29	-0.12
MW-37S	105.00	7614827.87	2102869.45	2	454.50	454.66	-0.16
MW-37S	136.00	7614827.87	2102869.45	2	455.13	455.76	-0.63
MW-37S	166.00	7614827.87	2102869.45	2	456.01	456.60	-0.59
MW-37S	197.00	7614827.87	2102869.45	2	456.00	456.49	-0.49
MW-37S	227.00	7614827.87	2102869.45	2	455.83	456.27	-0.44

Name	Time (day)	X	Y	Layer	Observed Water Level (ft msl)	Computed Water Level (ft	Residual (ft)
MW-37S	258.00	7614827.87	2102869.45	2	455.69	455.99	-0.30
MW-37S	289.00	7614827.87	2102869.45	2	455.66	455.83	-0.17
MW-38S	15.00	7614918.75	2101279.65	1	454.79	455.49	-0.70
MW-38S	46.00	7614918.75	2101279.65	1	454.39	454.51	-0.12
MW-38S	77.00	7614918.75	2101279.65	1	454.09	454.43	-0.34
MW-38S	105.00	7614918.75	2101279.65	1	454.26	454.84	-0.58
MW-38S	136.00	7614918.75	2101279.65	1	454.60	455.69	-1.09
MW-38S	166.00	7614918.75	2101279.65	1	455.38	456.62	-1.24
MW-38S	197.00	7614918.75	2101279.65	1	455.64	456.73	-1.09
MW-38S	227.00	7614918.75	2101279.65	1	455.61	456.51	-0.90
MW-38S	258.00	7614918.75	2101279.65	1	455.55	456.27	-0.73
MW-38S	289.00	7614918.75	2101279.65	1	455.48	456.07	-0.59
MW-39-040	15.00	7616091.44	2102506.22	1	453.85	453.62	0.23
MW-39-040	46.00	7616091.44	2102506.22	1	452.84	452.41	0.42
MW-39-040	77.00	7616091.44	2102506.22	1	453.74	453.34	0.40
MW-39-040	105.00	7616091.44	2102506.22	1	454.02	453.58	0.44
MW-39-040	136.00	7616091.44	2102506.22	1	455.45	455.09	0.36
MW-39-040	166.00	7616091.44	2102506.22	1	456.23	455.86	0.37
MW-39-040	197.00	7616091.44	2102506.22	1	455.64	455.36	0.28
MW-39-040	227.00	7616091.44	2102506.22	1	455.38	455.11	0.27
MW-39-040	258.00	7616091.44	2102506.22	1	455.03	454.75	0.28
MW-39-040	289.00	7616091.44	2102506.22	1	454.94	454.74	0.20
MW-39-040	319.00	7616091.44	2102506.22	1	455.02	454.80	0.21
MW-39-040	350.00	7616091.44	2102506.22	1	454.44	454.11	0.33
MW-39-050	15.00	7616095.96	2102498.75	2	453.68	453.58	0.10
MW-39-050	46.00	7616095.96	2102498.75	2	452.69	452.37	0.32
MW-39-050	77.00	7616095.96	2102498.75	2	453.58	453.31	0.27
MW-39-050	105.00	7616095.96	2102498.75	2	453.86	453.55	0.31
MW-39-050	136.00	7616095.96	2102498.75	2	455.28	455.06	0.22
MW-39-050	166.00	7616095.96	2102498.75	2	456.07	455.83	0.24
MW-39-050	197.00	7616095.96	2102498.75	2	455.50	455.33	0.17
MW-39-050	227.00	7616095.96	2102498.75	2	455.23	455.07	0.16
MW-39-050	258.00	7616095.96	2102498.75	2	454.88	454.71	0.17
MW-39-050	289.00	7616095.96	2102498.75	2	454.86	454.71	0.15
MW-39-050	319.00	7616095.96	2102498.75	2	454.90	454.77	0.13
MW-39-050	350.00	7616095.96	2102498.75	2	454.32	454.07	0.25
MW-39-060	15.00	7616099.45	2102495.05	2	453.51	453.58	-0.08
MW-39-060	46.00	7616099.45	2102495.05	2	452.54	452.38	0.16
MW-39-060	77.00	7616099.45	2102495.05	2	453.39	453.31	0.07
MW-39-060	105.00	7616099.45	2102495.05	2	453.66	453.55	0.11
MW-39-060	136.00	7616099.45	2102495.05	2	455.05	455.06	-0.02
MW-39-060	166.00	7616099.45	2102495.05	2	455.87	455.84	0.03
MW-39-060	197.00	7616099.45	2102495.05	2	455.31	455.33	-0.02
MW-39-060	227.00	7616099.45	2102495.05	2	455.06	455.08	-0.02
MW-39-060	258.00	7616099.45	2102495.05	2	454.74	454.71	0.03
MW-39-060	289.00	7616099.45	2102495.05	2	454.73	454.71	0.02

Name	Time (day)	X	Y	Layer	Observed Water Level (ft msl)	Computed Water Level (ft	Residual (ft)
MW-39-060	319.00	7616099.45	2102495.05	2	454.73	454.78	-0.05
MW-39-060	350.00	7616099.45	2102495.05	2	454.18	454.07	0.11
MW-39-070	15.00	7616091.38	2102506.30	2	453.15	453.57	-0.43
MW-39-070	46.00	7616091.38	2102506.30	2	452.22	452.37	-0.15
MW-39-070	77.00	7616091.38	2102506.30	2	452.27	453.30	-1.03
MW-39-070	105.00	7616091.38	2102506.30	2	453.38	453.54	-0.16
MW-39-070	136.00	7616091.38	2102506.30	2	454.50	455.05	-0.55
MW-39-070	166.00	7616091.38	2102506.30	2	455.40	455.82	-0.43
MW-39-070	197.00	7616091.38	2102506.30	2	454.91	455.32	-0.41
MW-39-070	227.00	7616091.38	2102506.30	2	454.60	455.06	-0.46
MW-39-070	258.00	7616091.38	2102506.30	2	454.32	454.70	-0.38
MW-39-070	289.00	7616091.38	2102506.30	2	454.36	454.70	-0.34
MW-39-070	319.00	7616091.38	2102506.30	2	454.23	454.76	-0.54
MW-39-070	350.00	7616091.38	2102506.30	2	453.78	454.06	-0.28
MW-39-080	15.00	7616095.86	2102498.83	3	453.29	453.51	-0.22
MW-39-080	46.00	7616095.86	2102498.83	3	452.37	452.31	0.06
MW-39-080	77.00	7616095.86	2102498.83	3	453.07	453.24	-0.16
MW-39-080	105.00	7616095.86	2102498.83	3	453.34	453.47	-0.13
MW-39-080	136.00	7616095.86	2102498.83	3	454.63	454.99	-0.36
MW-39-080	166.00	7616095.86	2102498.83	3	455.52	455.76	-0.25
MW-39-080	197.00	7616095.86	2102498.83	3	455.04	455.26	-0.22
MW-39-080	227.00	7616095.86	2102498.83	3	454.67	455.00	-0.33
MW-39-080	258.00	7616095.86	2102498.83	3	454.38	454.63	-0.26
MW-39-080	289.00	7616095.86	2102498.83	3	454.45	454.65	-0.20
MW-39-080	319.00	7616095.86	2102498.83	3	454.31	454.70	-0.39
MW-39-080	350.00	7616095.86	2102498.83	3	453.87	454.00	-0.13
MW-39-100	15.00	7616099.30	2102494.96	3	453.84	453.51	0.32
MW-39-100	46.00	7616099.30	2102494.96	3	452.90	452.31	0.59
MW-39-100	77.00	7616099.30	2102494.96	3	453.62	453.24	0.38
MW-39-100	105.00	7616099.30	2102494.96	3	453.89	453.48	0.41
MW-39-100	136.00	7616099.30	2102494.96	3	455.19	454.99	0.20
MW-39-100	166.00	7616099.30	2102494.96	3	456.00	455.77	0.23
MW-39-100	197.00	7616099.30	2102494.96	3	455.39	455.26	0.12
MW-39-100	227.00	7616099.30	2102494.96	3	455.05	455.00	0.05
MW-39-100	258.00	7616099.30	2102494.96	3	454.80	454.64	0.16
MW-39-100	289.00	7616099.30	2102494.96	3	454.89	454.65	0.24
MW-39-100	319.00	7616099.30	2102494.96	3	454.80	454.71	0.09
MW-39-100	350.00	7616099.30	2102494.96	3	454.34	454.00	0.34
MW-42-030	15.00	7616282.09	2102309.31	1	453.72	453.77	-0.05
MW-42-030	46.00	7616282.09	2102309.31	1	453.11	452.56	0.55
MW-42-030	77.00	7616282.09	2102309.31	1	453.88	453.55	0.33
MW-42-030	105.00	7616282.09	2102309.31	1	453.92	453.79	0.13
MW-42-030	136.00	7616282.09	2102309.31	1	455.32	455.32	0.00
MW-42-030	166.00	7616282.09	2102309.31	1	456.11	456.05	0.06
MW-42-030	197.00	7616282.09	2102309.31	1	455.69	455.52	0.17
MW-42-030	227.00	7616282.09	2102309.31	1	455.34	455.30	0.05

DRAFT ARCADIS Design & Consultancy for natural and built assets

Name	Time (day)	X	Y	Layer	Observed Water Level (ft msl)	Computed Water Level (ft	Residual (ft)
MW-42-030	258.00	7616282.09	2102309.31	1	454.96	454.92	0.04
MW-42-030	289.00	7616282.09	2102309.31	1	454.86	454.90	-0.04
MW-42-030	319.00	7616282.09	2102309.31	1	454.99	455.01	-0.02
MW-42-030	350.00	7616282.09	2102309.31	1	454.41	454.28	0.14
MW-42-065	15.00	7616274.98	2102296.96	3	453.86	453.69	0.17
MW-42-065	46.00	7616274.98	2102296.96	3	452.86	452.47	0.39
MW-42-065	77.00	7616274.98	2102296.96	3	453.73	453.49	0.24
MW-42-065	105.00	7616274.98	2102296.96	3	454.04	453.72	0.32
MW-42-065	136.00	7616274.98	2102296.96	3	455.47	455.27	0.20
MW-42-065	166.00	7616274.98	2102296.96	3	456.24	456.00	0.25
MW-42-065	197.00	7616274.98	2102296.96	3	455.83	455.45	0.38
MW-42-065	227.00	7616274.98	2102296.96	3	455.48	455.22	0.26
MW-42-065	258.00	7616274.98	2102296.96	3	455.03	454.84	0.18
MW-42-065	289.00	7616274.98	2102296.96	3	454.98	454.83	0.15
MW-42-065	319.00	7616274.98	2102296.96	3	455.15	454.96	0.19
MW-42-065	350.00	7616274.98	2102296.96	3	454.52	454.19	0.32
MW-43-025	15.00	7616702.79	2101817.51	1	454.04	453.94	0.10
MW-43-025	46.00	7616702.79	2101817.51	1	452.90	452.68	0.21
MW-43-025	77.00	7616702.79	2101817.51	1	454.18	453.97	0.21
MW-43-025	105.00	7616702.79	2101817.51	1	454.39	454.16	0.23
MW-43-025	136.00	7616702.79	2101817.51	1	456.12	455.85	0.27
MW-43-025	166.00	7616702.79	2101817.51	1	456.79	456.44	0.35
MW-43-025	197.00	7616702.79	2101817.51	1	456.07	455.74	0.32
MW-43-025	227.00	7616702.79	2101817.51	1	455.93	455.61	0.33
MW-43-025	258.00	7616702.79	2101817.51	1	455.42	455.19	0.23
MW-43-025	289.00	7616702.79	2101817.51	1	455.31	455.13	0.18
MW-43-025	319.00	7616702.79	2101817.51	1	455.59	455.35	0.25
MW-43-025	350.00	7616702.79	2101817.51	1	454.77	454.50	0.26
MW-43-090	15.00	7616693.22	2101824.65	3	454.42	453.93	0.49
MW-43-090	46.00	7616693.22	2101824.65	3	453.26	452.66	0.60
MW-43-090	77.00	7616693.22	2101824.65	3	454.50	453.99	0.51
MW-43-090	105.00	7616693.22	2101824.65	3	454.71	454.17	0.54
MW-43-090	136.00	7616693.22	2101824.65	3	456.48	455.88	0.60
MW-43-090	166.00	7616693.22	2101824.65	3	457.11	456.46	0.65
MW-43-090	197.00	7616693.22	2101824.65	3	456.37	455.74	0.63
MW-43-090	227.00	7616693.22	2101824.65	3	456.25	455.61	0.64
MW-43-090	258.00	7616693.22	2101824.65	3	455.80	455.18	0.61
MW-43-090	289.00	7616693.22	2101824.65	3	455.70	455.13	0.57
MW-43-090	319.00	7616693.22	2101824.65	3	455.98	455.36	0.62
MW-43-090	350.00	7616693.22	2101824.65	3	455.07	454.50	0.57
MW-44-070	15.00	7616255.62	2102728.31	2	454.03	453.70	0.33
MW-44-070	46.00	7616255.62	2102728.31	2	452.91	452.47	0.44
MW-44-070	77.00	7616255.62	2102728.31	2	453.96	453.58	0.38
MW-44-070	105.00	7616255.62	2102728.31	2	454.23	453.79	0.43
MW-44-070	136.00	7616255.62	2102728.31	2	455.82	455.40	0.42
MW-44-070	166.00	7616255.62	2102728.31	2	456.53	456.09	0.44

Name	Time (day)	X	Y	Layer	Observed Water Level (ft msl)	Computed Water Level (ft	Residual (ft)
MW-44-070	197.00	7616255.62	2102728.31	2	455.88	455.49	0.39
MW-44-070	227.00	7616255.62	2102728.31	2	455.68	455.28	0.40
MW-44-070	258.00	7616255.62	2102728.31	2	455.27	454.89	0.39
MW-44-070	289.00	7616255.62	2102728.31	2	455.22	454.87	0.35
MW-44-070	319.00	7616255.62	2102728.31	2	455.40	455.02	0.37
MW-44-070	350.00	7616255.62	2102728.31	2	454.68	454.23	0.45
MW-44-115	15.00	7616262.10	2102723.85	3	453.65	453.66	-0.01
MW-44-115	46.00	7616262.10	2102723.85	3	452.68	452.43	0.25
MW-44-115	77.00	7616262.10	2102723.85	3	453.57	453.53	0.04
MW-44-115	105.00	7616262.10	2102723.85	3	453.79	453.75	0.04
MW-44-115	136.00	7616262.10	2102723.85	3	455.14	455.34	-0.21
MW-44-115	166.00	7616262.10	2102723.85	3	455.89	456.05	-0.15
MW-44-115	197.00	7616262.10	2102723.85	3	455.51	455.45	0.06
MW-44-115	227.00	7616262.10	2102723.85	3	455.26	455.23	0.02
MW-44-115	258.00	7616262.10	2102723.85	3	454.89	454.84	0.05
MW-44-115	289.00	7616262.10	2102723.85	3	454.92	454.84	0.08
MW-44-115	319.00	7616262.10	2102723.85	3	454.98	454.99	-0.01
MW-44-115	350.00	7616262.10	2102723.85	3	454.28	454.18	0.10
MW-44-125	15.00	7616255.55	2102728.48	3	454.18	453.67	0.51
MW-44-125	46.00	7616255.55	2102728.48	3	453.19	452.43	0.76
MW-44-125	77.00	7616255.55	2102728.48	3	454.07	453.53	0.54
MW-44-125	105.00	7616255.55	2102728.48	3	454.35	453.75	0.60
MW-44-125	136.00	7616255.55	2102728.48	3	455.77	455.35	0.42
MW-44-125	166.00	7616255.55	2102728.48	3	456.51	456.05	0.46
MW-44-125	197.00	7616255.55	2102728.48	3	456.08	455.45	0.62
MW-44-125	227.00	7616255.55	2102728.48	3	455.75	455.24	0.51
MW-44-125	258.00	7616255.55	2102728.48	3	455.17	454.85	0.32
MW-44-125	289.00	7616255.55	2102728.48	3	455.15	454.84	0.31
MW-44-125	319.00	7616255.55	2102728.48	3	455.38	454.99	0.39
MW-44-125	350.00	7616255.55	2102728.48	3	454.72	454.18	0.54
MW-45-095a	15.00	7616358.12	2102559.75	3	452.77	452.74	0.04
MW-45-095a	46.00	7616358.12	2102559.75	3	451.66	451.50	0.16
MW-45-095a	77.00	7616358.12	2102559.75	3	452.76	452.61	0.15
MW-45-095a	105.00	7616358.12	2102559.75	3	452.99	452.81	0.18
MW-45-095a	136.00	7616358.12	2102559.75	3	454.53	454.42	0.12
MW-45-095a	166.00	7616358.12	2102559.75	3	455.27	455.21	0.06
MW-45-095a	197.00	7616358.12	2102559.75	3	454.76	454.64	0.12
MW-45-095a	227.00	7616358.12	2102559.75	3	454.44	454.30	0.14
MW-45-095a	258.00	7616358.12	2102559.75	3	454.06	453.91	0.15
MW-45-095a	289.00	7616358.12	2102559.75	3	454.46	454.04	0.42
MW-45-095a	319.00	7616358.12	2102559.75	3	455.12	454.38	0.74
MW-45-095a	350.00	7616358.12	2102559.75	3	453.39	453.23	0.16
MW-45-095B	15.00	7616358.12	2102559.75	3	452.77	452.74	0.03
MW-45-095B	46.00	7616358.12	2102559.75	3	451.66	451.50	0.16
MW-45-095B	77.00	7616358.12	2102559.75	3	452.77	452.61	0.15
MW-45-095B	105.00	7616358.12	2102559.75	3	452.99	452.81	0.18

Name	Time (day)	X	Y	Layer	Observed Water Level (ft msl)	Computed Water Level (ft	Residual (ft)
MW-45-095B	136.00	7616358.12	2102559.75	3	454.54	454.42	0.12
MW-45-095B	166.00	7616358.12	2102559.75	3	455.27	455.21	0.07
MW-45-095B	197.00	7616358.12	2102559.75	3	454.76	454.64	0.11
MW-45-095B	227.00	7616358.12	2102559.75	3	454.48	454.30	0.18
MW-45-095B	258.00	7616358.12	2102559.75	3	454.08	453.91	0.18
MW-45-095B	289.00	7616358.12	2102559.75	3	454.46	454.04	0.42
MW-45-095B	319.00	7616358.12	2102559.75	3	455.13	454.38	0.74
MW-45-095B	350.00	7616358.12	2102559.75	3	453.41	453.23	0.18
MW-46-175	15.00	7616196.86	2102940.02	4	454.33	453.91	0.42
MW-46-175	46.00	7616196.86	2102940.02	4	453.41	452.68	0.73
MW-46-175	77.00	7616196.86	2102940.02	4	454.19	453.78	0.41
MW-46-175	105.00	7616196.86	2102940.02	4	454.44	454.00	0.44
MW-46-175	136.00	7616196.86	2102940.02	4	455.74	455.59	0.15
MW-46-175	166.00	7616196.86	2102940.02	4	456.32	456.27	0.05
MW-46-175	197.00	7616196.86	2102940.02	4	455.93	455.67	0.25
MW-46-175	227.00	7616196.86	2102940.02	4	455.74	455.48	0.26
MW-46-175	258.00	7616196.86	2102940.02	4	455.46	455.09	0.37
MW-46-175	289.00	7616196.86	2102940.02	4	455.43	455.05	0.38
MW-46-175	319.00	7616196.86	2102940.02	4	455.49	455.20	0.29
MW-46-175	350.00	7616196.86	2102940.02	4	454.82	454.44	0.38
MW-47-055	15.00	7615629.48	2103450.05	1	454.66	454.46	0.20
MW-47-055	46.00	7615629.48	2103450.05	1	453.80	453.27	0.53
MW-47-055	77.00	7615629.48	2103450.05	1	454.38	454.10	0.28
MW-47-055	105.00	7615629.48	2103450.05	1	454.70	454.38	0.32
MW-47-055	136.00	7615629.48	2103450.05	1	455.85	455.80	0.05
MW-47-055	166.00	7615629.48	2103450.05	1	456.72	456.53	0.19
MW-47-055	197.00	7615629.48	2103450.05	1	456.34	456.09	0.25
MW-47-055	227.00	7615629.48	2103450.05	1	456.13	455.90	0.23
MW-47-055	258.00	7615629.48	2103450.05	1	455.81	455.54	0.27
MW-47-055	289.00	7615629.48	2103450.05	1	455.72	455.45	0.27
MW-47-055	319.00	7615629.48	2103450.05	1	455.77	455.57	0.20
MW-47-055	350.00	7615629.48	2103450.05	1	455.28	454.94	0.34
MW-47-115	15.00	7615629.75	2103450.10	3	454.75	454.46	0.29
MW-47-115	46.00	7615629.75	2103450.10	3	453.92	453.27	0.65
MW-47-115	77.00	7615629.75	2103450.10	3	454.42	454.10	0.32
MW-47-115	105.00	7615629.75	2103450.10	3	454.74	454.39	0.36
MW-47-115	136.00	7615629.75	2103450.10	3	455.82	455.81	0.01
MW-47-115	166.00	7615629.75	2103450.10	3	456.65	456.53	0.12
MW-47-115	197.00	7615629.75	2103450.10	3	456.36	456.09	0.27
MW-47-115	227.00	7615629.75	2103450.10	3	456.17	455.90	0.27
MW-47-115	258.00	7615629.75	2103450.10	3	455.87	455.55	0.33
MW-47-115	289.00	7615629.75	2103450.10	3	455.78	455.45	0.33
MW-47-115	319.00	7615629.75	2103450.10	3	455.74	455.58	0.16
MW-47-115	350.00	7615629.75	2103450.10	3	455.32	454.94	0.38
MW-49-135	15.00	7615889.63	2103667.52	3	454.77	454.32	0.45
MW-49-135	46.00	7615889.63	2103667.52	3	453.83	453.10	0.73

Name	Time (day)	X	Y	Layer	Observed Water Level (ft msl)	Computed Water Level (ft	Residual (ft)
MW-49-135	77.00	7615889.63	2103667.52	3	454.61	454.16	0.45
MW-49-135	105.00	7615889.63	2103667.52	3	454.88	454.40	0.48
MW-49-135	136.00	7615889.63	2103667.52	3	456.19	455.96	0.23
MW-49-135	166.00	7615889.63	2103667.52	3	457.19	456.61	0.58
MW-49-135	197.00	7615889.63	2103667.52	3	456.19	456.04	0.15
MW-49-135	227.00	7615889.63	2103667.52	3	456.26	455.88	0.38
MW-49-135	258.00	7615889.63	2103667.52	3	455.93	455.49	0.45
MW-49-135	289.00	7615889.63	2103667.52	3	455.83	455.40	0.43
MW-49-135	319.00	7615889.63	2103667.52	3	455.93	455.59	0.34
MW-49-135	350.00	7615889.63	2103667.52	3	455.33	454.85	0.49
MW-50-095	15.00	7615599.84	2103069.27	2	454.42	454.31	0.11
MW-50-095	46.00	7615599.84	2103069.27	2	453.98	453.15	0.84
MW-50-095	77.00	7615599.84	2103069.27	2	454.17	453.84	0.32
MW-50-095	105.00	7615599.84	2103069.27	2	454.30	454.14	0.16
MW-50-095	136.00	7615599.84	2103069.27	2	455.23	455.50	-0.27
MW-50-095	166.00	7615599.84	2103069.27	2	456.15	456.28	-0.13
MW-50-095	197.00	7615599.84	2103069.27	2	455.94	455.91	0.03
MW-50-095	227.00	7615599.84	2103069.27	2	455.71	455.69	0.02
MW-50-095	258.00	7615599.84	2103069.27	2	455.49	455.35	0.13
MW-50-095	289.00	7615599.84	2103069.27	2	455.43	455.27	0.16
MW-50-095	319.00	7615599.84	2103069.27	2	455.35	455.33	0.02
MW-50-095	350.00	7615599.84	2103069.27	2	455.02	454.77	0.26
MW-51	15.00	7615807.51	2101900.11	3	454.67	454.55	0.12
MW-51	46.00	7615807.51	2101900.11	3	454.13	453.46	0.68
MW-51	77.00	7615807.51	2101900.11	3	454.08	453.84	0.24
MW-51	105.00	7615807.51	2101900.11	3	454.34	454.17	0.17
MW-51	136.00	7615807.51	2101900.11	3	454.95	455.34	-0.38
MW-51	166.00	7615807.51	2101900.11	3	455.82	456.20	-0.39
MW-51	197.00	7615807.51	2101900.11	3	456.02	456.03	-0.01
MW-51	258.00	7615807.51	2101900.11	3	455.58	455.49	0.09
MW-51	289.00	7615807.51	2101900.11	3	455.55	455.38	0.17
MW-51	319.00	7615807.51	2101900.11	3	455.43	455.39	0.04
MW-51	350.00	7615807.51	2101900.11	3	455.35	454.95	0.40
MW-54-085	15.00	7617082.61	2102958.94	3	454.56	454.11	0.45
MW-54-085	46.00	7617082.61	2102958.94	3	453.45	452.84	0.61
MW-54-085	77.00	7617082.61	2102958.94	3	454.73	454.08	0.66
MW-54-085	105.00	7617082.61	2102958.94	3	454.85	454.29	0.56
MW-54-085	136.00	7617082.61	2102958.94	3	456.45	455.94	0.51
MW-54-085	166.00	7617082.61	2102958.94	3	457.07	456.55	0.52
MW-54-085	197.00	7617082.61	2102958.94	3	456.41	455.89	0.52
MW-54-085	227.00	7617082.61	2102958.94	3	456.22	455.74	0.48
MW-54-085	258.00	7617082.61	2102958.94	3	456.16	455.33	0.84
MW-54-085	289.00	7617082.61	2102958.94	3	455.69	455.25	0.44
MW-54-085	319.00	7617082.61	2102958.94	3	455.90	455.47	0.42
MW-54-085	350.00	7617082.61	2102958.94	3	455.17	454.66	0.51
MW-54-140	15.00	7617082.16	2102959.12	4	454.86	454.13	0.74

Name	Time (day)	X	Y	Layer	Observed Water Level (ft msl)	Computed Water Level (ft	Residual (ft)
MW-54-140	46.00	7617082.16	2102959.12	4	454.43	452.87	1.56
MW-54-140	77.00	7617082.16	2102959.12	4	455.01	454.07	0.95
MW-54-140	105.00	7617082.16	2102959.12	4	455.15	454.29	0.86
MW-54-140	136.00	7617082.16	2102959.12	4	456.52	455.92	0.60
MW-54-140	166.00	7617082.16	2102959.12	4	457.14	456.54	0.60
MW-54-140	197.00	7617082.16	2102959.12	4	456.55	455.90	0.65
MW-54-140	227.00	7617082.16	2102959.12	4	456.37	455.74	0.63
MW-54-140	258.00	7617082.16	2102959.12	4	455.99	455.33	0.65
MW-54-140	289.00	7617082.16	2102959.12	4	455.78	455.26	0.52
MW-54-140	319.00	7617082.16	2102959.12	4	456.03	455.47	0.56
MW-54-140	350.00	7617082.16	2102959.12	4	455.46	454.67	0.79
MW-54-195	15.00	7617089.25	2102951.90	5	455.00	454.15	0.85
MW-54-195	46.00	7617089.25	2102951.90	5	454.20	452.90	1.30
MW-54-195	77.00	7617089.25	2102951.90	5	455.22	454.07	1.16
MW-54-195	105.00	7617089.25	2102951.90	5	455.40	454.30	1.11
MW-54-195	136.00	7617089.25	2102951.90	5	456.68	455.91	0.77
MW-54-195	166.00	7617089.25	2102951.90	5	457.29	456.53	0.76
MW-54-195	197.00	7617089.25	2102951.90	5	456.75	455.91	0.83
MW-54-195	227.00	7617089.25	2102951.90	5	456.50	455.75	0.75
MW-54-195	258.00	7617089.25	2102951.90	5	456.13	455.35	0.78
MW-54-195	289.00	7617089.25	2102951.90	5	456.00	455.27	0.73
MW-54-195	319.00	7617089.25	2102951.90	5	456.15	455.48	0.67
MW-54-195	350.00	7617089.25	2102951.90	5	455.69	454.69	1.00
MW-55-045	15.00	7618326.30	2102605.89	2	455.37	454.11	1.26
MW-55-045	46.00	7618326.30	2102605.89	2	455.05	452.85	2.20
MW-55-045	77.00	7618326.30	2102605.89	2	455.47	454.16	1.31
MW-55-045	105.00	7618326.30	2102605.89	2	455.66	454.35	1.30
MW-55-045	136.00	7618326.30	2102605.89	2	456.57	456.05	0.51
MW-55-045	166.00	7618326.30	2102605.89	2	457.18	456.63	0.55
MW-55-045	197.00	7618326.30	2102605.89	2	456.76	455.91	0.85
MW-55-045	227.00	7618326.30	2102605.89	2	456.47	455.78	0.68
MW-55-045	258.00	7618326.30	2102605.89	2	456.23	455.36	0.87
MW-55-045	289.00	7618326.30	2102605.89	2	456.07	455.29	0.78
MW-55-045	319.00	7618326.30	2102605.89	2	456.21	455.53	0.68
MW-55-045	350.00	7618326.30	2102605.89	2	455.92	454.68	1.24
MW-55-120	15.00	7618326.13	2102606.18	3	455.42	454.13	1.29
MW-55-120	46.00	7618326.13	2102606.18	3	455.10	452.87	2.23
MW-55-120	77.00	7618326.13	2102606.18	3	455.46	454.16	1.30
MW-55-120	105.00	7618326.13	2102606.18	3	455.65	454.35	1.29
MW-55-120	136.00	7618326.13	2102606.18	3	456.47	456.03	0.44
MW-55-120	166.00	7618326.13	2102606.18	3	457.06	456.61	0.45
MW-55-120	197.00	7618326.13	2102606.18	3	456.71	455.92	0.79
MW-55-120	227.00	7618326.13	2102606.18	3	456.41	455.79	0.62
MW-55-120	258.00	7618326.13	2102606.18	3	456.23	455.37	0.86
MW-55-120	289.00	7618326.13	2102606.18	3	456.04	455.30	0.75
MW-55-120	319.00	7618326.13	2102606.18	3	456.16	455.53	0.63

Name	Time (day)	X	Y	Layer	Observed Water Level (ft msl)	Computed Water Level (ft	Residual (ft)
MW-55-120	350.00	7618326.13	2102606.18	3	455.99	454.69	1.30
OW-01S	15.00	7613419.20	2103040.48	1	456.18	456.41	-0.23
OW-01S	46.00	7613419.20	2103040.48	1	455.72	455.43	0.28
OW-01S	77.00	7613419.20	2103040.48	1	455.50	455.42	0.08
OW-01S	105.00	7613419.20	2103040.48	1	455.80	455.82	-0.01
OW-01S	136.00	7613419.20	2103040.48	1	456.32	456.69	-0.38
OW-01S	166.00	7613419.20	2103040.48	1	457.14	457.48	-0.34
OW-01S	197.00	7613419.20	2103040.48	1	457.23	457.57	-0.34
OW-01S	227.00	7613419.20	2103040.48	1	457.15	457.45	-0.30
OW-01S	258.00	7613419.20	2103040.48	1	457.02	457.20	-0.18
OW-01S	289.00	7613419.20	2103040.48	1	456.93	456.92	0.01
OW-01S	319.00	7613419.20	2103040.48	1	456.85	457.05	-0.20
OW-01S	350.00	7613419.20	2103040.48	1	456.77	456.78	0.00
OW-02S	15.00	7613373.76	2103153.89	1	456.14	456.38	-0.24
OW-02S	46.00	7613373.76	2103153.89	1	455.67	455.40	0.27
OW-02S	77.00	7613373.76	2103153.89	1	455.49	455.42	0.07
OW-02S	105.00	7613373.76	2103153.89	1	455.83	455.79	0.03
OW-02S	136.00	7613373.76	2103153.89	1	456.35	456.72	-0.37
OW-02S	166.00	7613373.76	2103153.89	1	457.21	457.47	-0.26
OW-02S	197.00	7613373.76	2103153.89	1	457.29	457.54	-0.25
OW-02S	227.00	7613373.76	2103153.89	1	457.19	457.42	-0.23
OW-02S	258.00	7613373.76	2103153.89	1	457.06	457.18	-0.12
OW-02S	289.00	7613373.76	2103153.89	1	456.98	456.92	0.07
OW-02S	319.00	7613373.76	2103153.89	1	456.88	457.05	-0.17
OW-02S	350.00	7613373.76	2103153.89	1	456.80	456.76	0.04
OW-05D	15.00	7613185.55	2102998.32	6	457.03	456.76	0.27
OW-05D	46.00	7613185.55	2102998.32	6	456.51	455.78	0.73
OW-05D	77.00	7613185.55	2102998.32	6	456.57	455.82	0.75
OW-05D	105.00	7613185.55	2102998.32	6	456.96	456.38	0.58
OW-05D	136.00	7613185.55	2102998.32	6	457.08	456.91	0.17
OW-05D	166.00	7613185.55	2102998.32	6	457.92	457.95	-0.04
OW-05D	258.00	7613185.55	2102998.32	6	457.62	457.58	0.04
OW-05D	289.00	7613185.55	2102998.32	6	457.38	457.06	0.33
OW-05D	319.00	7613185.55	2102998.32	6	457.50	457.30	0.21
OW-05D	350.00	7613185.55	2102998.32	6	457.45	457.09	0.36
OW-05M	15.00	7613185.86	2103008.06	4	456.96	456.82	0.14
OW-05M	46.00	7613185.86	2103008.06	4	456.42	455.84	0.57
OW-05M	77.00	7613185.86	2103008.06	4	456.54	455.85	0.69
OW-05M	105.00	7613185.86	2103008.06	4	457.11	456.45	0.66
OW-05M	136.00	7613185.86	2103008.06	4	456.98	456.92	0.06
OW-05M	166.00	7613185.86	2103008.06	4	458.08	458.00	0.08
OW-05M	197.00	7613185.86	2103008.06	4	458.37	458.12	0.25
OW-05M	227.00	7613185.86	2103008.06	4	458.41	458.05	0.37
OW-05M	258.00	7613185.86	2103008.06	4	457.99	457.64	0.36
OW-05M	289.00	7613185.86	2103008.06	4	457.47	457.08	0.40
OW-05M	319.00	7613185.86	2103008.06	4	457.58	457.32	0.26

Name	Time (day)	X	Y	Layer	Observed Water Level (ft msl)	Computed Water Level (ft	Residual (ft)
OW-05M	350.00	7613185.86	2103008.06	4	457.62	457.13	0.49
OW-05S	15.00	7613186.80	2103017.60	1	456.30	456.48	-0.18
OW-05S	46.00	7613186.80	2103017.60	1	455.83	455.52	0.31
OW-05S	77.00	7613186.80	2103017.60	1	455.63	455.48	0.15
OW-05S	105.00	7613186.80	2103017.60	1	455.94	455.93	0.02
OW-05S	136.00	7613186.80	2103017.60	1	456.43	456.67	-0.24
OW-05S	166.00	7613186.80	2103017.60	1	457.13	457.55	-0.41
OW-05S	197.00	7613186.80	2103017.60	1	457.34	457.66	-0.32
OW-05S	227.00	7613186.80	2103017.60	1	457.32	457.55	-0.23
OW-05S	258.00	7613186.80	2103017.60	1	457.18	457.27	-0.09
OW-05S	289.00	7613186.80	2103017.60	1	457.06	456.92	0.14
OW-05S	319.00	7613186.80	2103017.60	1	456.98	457.07	-0.08
OW-05S	350.00	7613186.80	2103017.60	1	456.88	456.83	0.05
PT2D	46.00	7616017.74	2102646.24	3	451.85	452.09	-0.24
PT2D	77.00	7616017.74	2102646.24	3	452.72	453.02	-0.30
PT2D	105.00	7616017.74	2102646.24	3	452.96	453.24	-0.28
PT2D	136.00	7616017.74	2102646.24	3	454.27	454.76	-0.50
PT2D	166.00	7616017.74	2102646.24	3	455.17	455.57	-0.40
PT2D	197.00	7616017.74	2102646.24	3	454.82	455.06	-0.24
PT2D	227.00	7616017.74	2102646.24	3	454.49	454.77	-0.28
PT2D	258.00	7616017.74	2102646.24	3	454.15	454.42	-0.27
PT2D	289.00	7616017.74	2102646.24	3	454.25	454.45	-0.20
PT2D	319.00	7616017.74	2102646.24	3	454.05	454.43	-0.39
PT2D	350.00	7616017.74	2102646.24	3	453.60	453.77	-0.18
PT5D	15.00	7616112.09	2102629.47	3	453.42	453.48	-0.06
PT5D	46.00	7616112.09	2102629.47	3	452.46	452.27	0.19
PT5D	77.00	7616112.09	2102629.47	3	453.25	453.25	-0.01
PT5D	105.00	7616112.09	2102629.47	3	453.50	453.48	0.02
PT5D	136.00	7616112.09	2102629.47	3	454.84	455.02	-0.18
PT5D	166.00	7616112.09	2102629.47	3	455.71	455.79	-0.08
PT5D	197.00	7616112.09	2102629.47	3	455.34	455.25	0.09
PT5D	227.00	7616112.09	2102629.47	3	455.02	454.99	0.02
PT5D	258.00	7616112.09	2102629.47	3	454.68	454.62	0.06
PT5D	289.00	7616112.09	2102629.47	3	454.75	454.64	0.11
PT5D	319.00	7616112.09	2102629.47	3	454.68	454.71	-0.03
PT5D	350.00	7616112.09	2102629.47	3	454.26	453.98	0.29
PT6D	15.00	7616074.62	2102672.77	3	453.47	453.44	0.03
PT6D	46.00	7616074.62	2102672.77	3	452.52	452.23	0.29
PT6D	77.00	7616074.62	2102672.77	3	453.29	453.20	0.09
PT6D	105.00	7616074.62	2102672.77	3	453.55	453.43	0.12
PT6D	136.00	7616074.62	2102672.77	3	454.88	454.97	-0.08
PT6D	166.00	7616074.62	2102672.77	3	455.76	455.74	0.02
PT6D	197.00	7616074.62	2102672.77	3	455.31	455.21	0.11
PT6D	227.00	7616074.62	2102672.77	3	454.95	454.95	0.01
PT6D	258.00	7616074.62	2102672.77	3	454.60	454.58	0.02
PT6D	289.00	7616074.62	2102672.77	3	454.67	454.60	0.07

Name	Time (day)	X	Y	Layer	Observed Water Level (ft msl)	Computed Water Level (ft	Residual (ft)
PT6D	319.00	7616074.62	2102672.77	3	454.56	454.64	-0.08
PT6D	350.00	7616074.62	2102672.77	3	454.02	453.93	0.09

Residual Statistics	
Residual Mean (ft)	0.16
Residual Std. Deviation (ft	0.42
Sum of Squares (ft2)	169.01
Number of Observations	827
Range in Observations (ft)	6.75
Scaled Residual Std. Deviation	0.06

ARCADIS Design & Consultancy for natural and built assets

Arcadis U.S., Inc.

10 Friends Lane

Suite 200

Newtown, Pennsylvania 18940

Tel 267 685 1800

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BOD Appendix D
Plans (Engineering Drawings)

Appendix D1
Equipment Lists

- Table D1-24: Aboveground Non-Emergency Equipment and Associated Sound Level Information
- Attachment to Table D1-24: Sound Datasheet from Cummins

TABLE D1-24
ABOVEGROUND NON-EMERGENCY REMEDY EQUIPMENT WITH ASSOCIATED SOUND LEVEL INFORMATION
(Prepared in response to 60% RTC # FMIT-51, Hualapai-37/Chemehuevi-37/Cocopah-37/CRIT-37)
Groundwater Remedy Basis of Design Report/Final (100%) Design
PG&&E Topock Compressor Station, Needles, California

100% TAG NO.	SYSTEM LOCATION	EQUIPMENT	DESCRIPTION	POWER (HP, unless noted otherwise)
XFMR 01	Transwestern Bench Area	Transformer	Cooper Power Systems. *Technical Data 210-12, Three-phase pad-mounted compartmental type transformer.* August 2013. Page 3. (see Appendix C of O&M Manual Volume 1),56 dBA [1,2]	225 KVA
XFMR 02	MW-20 Bench Area	Transformer	Cooper Power Systems. *Technical Data 210-12, Three-phase pad-mounted compartmental type transformer.* August 2013. Page 3. (see Appendix C of O&M Manual Volume 1),56 dBA [1,2]	225 KVA
XFMR 03	MW-20 Bench Area	Transformer	Cooper Power Systems. *Technical Data 210-12, Three-phase pad-mounted compartmental type transformer.* August 2013. Page 3. (see Appendix C of O&M Manual Volume 1),56 dBA [1,2]	225 KVA
XFMR 04	North Riverbank Area	Transformer	Cooper Power Systems. *Technical Data 210-12, Three-phase pad-mounted compartmental type transformer.* August 2013. Page 3. (see Appendix C of O&M Manual Volume 1), 56 dBA [1,2]	300 KVA
XFMR 05	Upland Area	Transformer	Cooper Power Systems. *Technical Data 210-12, Three-phase pad-mounted compartmental type transformer.* August 2013. Page 3. (see Appendix C of O&M Manual Volume 1),56 dBA [1,2]	225 KVA
XFMR 99	Compressor Station Area	Transformer	Cooper Power Systems. *Technical Data 210-12, Three-phase pad-mounted compartmental type transformer.* August 2013. Page 3. (see Appendix C of O&M Manual Volume 1), 58 dBA [1,2]	1000 KVA
Node 2	MW-20 Bench Area	Communication Panel Air Conditioning Unit	Rittal. *Assembly and Operating Instructions.* July 2011. Page 41. www.rittal.com/imf/none/3_821/, <64 dBA [1]	
Node 4	North Riverbank Area	Communication Panel Air Conditioning Unit	Rittal. *Assembly and Operating Instructions.* July 2011. Page 41. www.rittal.com/imf/none/3_821/, <64 dBA [1]	
Node 5	Upland Area	Communication Panel Air Conditioning Unit	Rittal. *Assembly and Operating Instructions.* July 2011. Page 41. www.rittal.com/imf/none/3_821/, <64 dBA [1]	
CU-1, CU-2	Transwestern Bench Operations Building	Split System Condensing Unit	TBD	
	MW-20 Bench Carbon Amendment Building	Heat Pump	*P-Series Full-line Catalog.* 2011. Page 15. http://www.mitsubishicomfort.com/media/382152/p%20series_3_11-r_pages.pdf Cooling: 48 dBA[1] Heating: 50 dBA[1]	
	MW-20 Bench Carbon Amendment Building	Ventilation Fan	TBD	

TABLE D1-24
ABOVEGROUND NON-EMERGENCY REMEDY EQUIPMENT WITH ASSOCIATED SOUND LEVEL INFORMATION
(Prepared in response to 60% RTC # FMIT-51, Hualapai-37/Chemehuevi-37/Cocopah-37/CRIT-37)
Groundwater Remedy Basis of Design Report/Final (100%) Design
PG&&E Topock Compressor Station, Needles, California

100% TAG NO.	SYSTEM LOCATION	EQUIPMENT	DESCRIPTION	POWER (HP, unless noted otherwise)
	MW-20 Bench Carbon Amendment Building	Ventilation Fan	TBD	
CH-1300	Remedy-produced Water Conditioning Plant	Potable Water Heat Pump Chiller	Multiaqua. *Multiaqua Equipment Sound Levels.* January 2008. (see attachment to Multiaqua manual in Appendix C of O&M Manual Volume 1) 69 dBA[1]	
COND-703	Remedy-produced Water Conditioning Plant	Mini-split Condenser	Mitsubishi Electric. *Outdoor Unit Service Manual, No. OBH502.* January 2009. Page 4. (see Appendix C of O&M Manual Volume 1) Cooling: 56 dBA[1] Heating: 57 dBA[1]	
COND-711	Remedy-produced Water Conditioning Plant	Mini-split Condenser	Mitsubishi Electric. *Outdoor Unit Service Manual, No. OBH502.* January 2009. Page 4. (see Appendix C of O&M Manual Volume 1) Cooling: 56 dBA[1] Heating: 57 dBA[1]	
COND-721	Remedy-produced Water Conditioning Plant	Mini-split Condenser	Mitsubishi Electric. *Outdoor Unit Service Manual, No. OBH502.* January 2009. Page 4. (see Appendix C of O&M Manual Volume 1) Cooling: 56 dBA[1] Heating: 57 dBA[1]	
PMP-*1101	Influent Tank Farm	Recirculation Pump	Fybroc series 1530 horizontal pump[5]. Final model number and motor size are to be determined. Motor size listed is approximate.	30
PMP-*1102	Influent Tank Farm	Recirculation Pump	Fybroc series 1530 horizontal pump[5]. Final model number and motor size are to be determined. Motor size listed is approximate.	30
PMP-*1103	Influent Tank Farm	Recirculation Pump	Fybroc series 1530 horizontal pump[5]. Final model number and motor size are to be determined. Motor size listed is approximate.	30
PMP-*1104	Influent Tank Farm	Recirculation Pump	Fybroc series 1530 horizontal pump[5]. Final model number and motor size are to be determined. Motor size listed is approximate.	30

TABLE D1-24
ABOVEGROUND NON-EMERGENCY REMEDY EQUIPMENT WITH ASSOCIATED SOUND LEVEL INFORMATION
(Prepared in response to 60% RTC # FMIT-51, Hualapai-37/Chemehuevi-37/Cocopah-37/CRIT-37)
Groundwater Remedy Basis of Design Report/Final (100%) Design
PG&&E Topock Compressor Station, Needles, California

100% TAG NO.	SYSTEM LOCATION	EQUIPMENT	DESCRIPTION	POWER (HP, unless noted otherwise)
PMP-*1210	Influent Tank Farm	Filter Feed Pump 1 - A Side	Fybroc series 1530 horizontal pump[5]. Final model number and motor size are to be determined. Motor size listed is approximate.	1.5
PMP-*1220	Influent Tank Farm	Filter Feed Pump 2 - A Side	Fybroc series 1530 horizontal pump[5]. Final model number and motor size are to be determined. Motor size listed is approximate.	1.5
PMP-*1230	Influent Tank Farm	Filter Feed Pump 1 - B Side	Fybroc series 1530 horizontal pump[5]. Final model number and motor size are to be determined. Motor size listed is approximate.	3
PMP-*1240	Influent Tank Farm	Filter Feed Pump 2 - B Side	Fybroc series 1530 horizontal pump[5]. Final model number and motor size are to be determined. Motor size listed is approximate.	3
PMP-*1403	RPWCP Decontamination Pad	TCS Truck Fill Pump	AMT-2876-95 or Teel 3P707	7.5
PMP-*1405	Conditioned Water Tank Farm	Conditioned Water Transfer Pump	Fybroc series 1530 horizontal pump[5]. Final model number and motor size are to be determined. Motor size listed is approximate.	1.5
PMP-*1406	Conditioned Water Tank Farm	Conditioned Water Transfer Pump	Fybroc series 1530 horizontal pump[5]. Final model number and motor size are to be determined. Motor size listed is approximate.	1.5
PMP-*1201	Remedy-produced Water Conditioning Plant	Air Compressor	Quincy Northwest or Gardner Denver single-stage rotary screw air-cooled, oil injected. 106 actual cubic feet per minute at 100 pounds per square inch.	25

TABLE D1-24
ABOVEGROUND NON-EMERGENCY REMEDY EQUIPMENT WITH ASSOCIATED SOUND LEVEL INFORMATION
(Prepared in response to 60% RTC # FMIT-51, Hualapai-37/Chemehuevi-37/Cocopah-37/CRIT-37)
Groundwater Remedy Basis of Design Report/Final (100%) Design
PG&&E Topock Compressor Station, Needles, California

100% TAG NO.	SYSTEM LOCATION	EQUIPMENT	DESCRIPTION	POWER (HP, unless noted otherwise)
EF-1300	Remedy-produced Water Conditioning Plant	Gable End Exhaust Fan	TBD	
	Remedy-produced Water Conditioning Plant	Office Sample Room Exhaust Fan	Broan. Models 508, 509, & 509S Wall Fans, Specification Sheet. http://www.broan.com/common/productDigitalAssethandler.ashx?id=03f16dec-399e-4aab-9594-73ddcd8db191 55 dBA +/- 2dBA [1,3]	
	TCS Ponds	Electric Power Generator	Cummins. Cummins GGMC Reciprocating Internal Combustion Engine (RICE) Electrical Generator[4]	
	TCS Ponds	Transformer	Sound level not available[5] Larson Electronics LLC. 75 kVA Transformer - 480V 3 Phase - 480V Delta Primary - 120/240V Secondary - NEMA 3R Enclosure. http://www.larsonelectronics.com/images/product/specsheet/68841.pdf (Product specification only. Does not include equipment sound generation)	

Notes:
Select equipment manuals are located in Append C, Volume 1 of the Operations and Maintenance Manual.
dB - decibels
dBA - A-weighted decibels
TBD - To Be Determined
1. Distance of sound level is not specified in the equipment manual but is assumed to be 5 feet based on verbal communication with the manufacturer.
2. Transformers designed to meet NEMA® TR-1 Standard dBA rating.
3. Sound rating provided in vendor specification is 6.5 Sones. Sound rating of 55 dBA +/- 2dBA calculated using formula of dBA = 33.2 Log_{10} (sones) + 28, Accuracy +/- 2dBA.
4. See attached sound data sheet from Cummins. Note that options are available for sound attenuation.
5. Sound rating for equipment is not available. PG&E is in communication with vendor to obtain the information.

Power Generation

Sound Data

30GGMC 60Hz

Sound Pressure Levels @ 7 meters dB(A)

Configuration		Position (Note 1)								8 Position Average
		1	2	3	4	5	6	7	8	
Standard-Unhoused (Note 3)	Infinite Exhaust	70.7	73	73	72.7	72.1	72.8	72.6	74.2	72.7
F216 – Weather w/ Exhaust Silencer		79.8	80.4	80.2	78.6	78.3	77.1	76.7	79.9	79.1
F217 – Quite Site II Second Stage		67.1	66.9	67.4	67	68	65.8	66	68.5	67

Note:
1. Position 1 faces the engine front at 23 feet (7 m) from the surface of the generator set. The positions proceed around the generator set in a counter-clockwise direction in 45° increments.
2. Data based on full rated load with standard radiator-fan package.
3. Sound data for generator set with infinite exhaust do not include exhaust noise.
4. Sound pressure levels per ANSI S1.13-1971 as applicable.
5. Reference sound pressure is 10 µPa.
6. Sound pressure levels are subject to instrumentation, measurement, installation and generator set variability.
7. Sound data with remote-cooled sets are based on rated loads without fan noise.

Sound Power Levels dB(A)

Configuration		Octave Band Center Frequency (Hz)								Sound Power Level
		63	125	250	500	1000	2000	4000	8000	
Standard-Unhoused (Note 3)	Infinite Exhaust	63.9	78.0	89.3	91.8	94.6	93.3	90.3	89.7	99.8
F216 – Weather w/ Exhaust Silencer		90.3	102.8	102.3	97.6	96.8	95.9	93.6	89.0	107.4
F217 – Quite Site II Second Stage		87.8	80.5	85.7	84.7	84.8	84.4	83.7	83.1	93.8

Note:
1. Sound pressure levels per ANSI S12.34-1988 and SIO 3744 as applicable.
2. Data based on full rated load with standard radiator-fan package.
3. Sound data for generator set with infinite exhaust do not include exhaust noise.
4. Reference sound pressure is 1pW-1x10^{-12} W.
5. Sound pressure levels are subject to instrumentation, measurement, installation and generator set variability.
6. Sound data with remote-cooled sets are based on rated loads without fan noise.

Exhaust Sound Pressure Levels @ 1 meter dB(A)

	Octave Band Center Frequency (Hz)								Sound Pressure Level
Open Exhaust (No Muffler) @ Rated Load	63	125	250	500	1000	2000	4000	8000	
	82.48	96.87	99.62	103.6	101.0	101.2	101.8	97.9	109

Note: Sound pressure level per ISO 6798 Annex A as applicable.

Appendix D2
Engineering Drawings

- 07 Pipeline
  - Drawing C-07-02: Pipeline Segment Map
- 15 Park Moabi Facilities
  - Drawing C-15-01: Construction Headquarters Yard Plan
  - Drawing C-15-02: Construction Headquarters Utility Connections
  - Drawing C-15-03: Construction Headquarters Piping Plan
  - Drawing C-15-04: Construction Headquarters Security Plan
  - Drawing C-15-05: Park Moabi Soil Staging and Storage Site Plan
  - Drawing C-15-08: Construction Headquarters Grading Plan
  - Drawing E-15-03: Construction Headquarters Electrical Plan
  - Drawing F-15-01: Construction Headquarters Fire Suppression Yard Plan

- FINAL DESIGN -
FOR AGENCY APPROVAL ONLY

REGISTERED PROFESSIONAL ENGINEER BENJAMIN J. WUERL C 67811 EXP. 6/30/17 CIVIL STATE OF CALIFORNIA

ETIC ENGINEERING

ARCADIS

NO.	DATE	DESCRIPTION	GM/SPEC	DWN	CHKD	SUPV	APVD BY	
6	11/9/16	100% BOD ERRATA INFO PACKAGE		AJW	WLM	BW	RAO	

REVISIONS

NO.	DATE	DESCRIPTION	GM/SPEC	DWN	CHKD	SUPV	APVD BY	
5	10/28/16	PIPELINE LABELS REVISION		AJW	WLM	BW	RAO	
4	11/18/15	FINAL DESIGN		AJW	WLM	BW	RAO	
3	12/30/14	SUPPLEMENTAL PRE-FINAL (90%) DESIGN		MD	VMB	VMB	VMB	
2	9/8/14	PRE-FINAL (90%) DESIGN		PH	VMB	VMB	VMB	
1	4/5/13	INTERMEDIATE (60%) DESIGN		PH	VMB	VMB	VMB	
0	11/11/11	PRELIMINARY (30%) DESIGN		PC	VMB	VMB	VMB	

REVISIONS

APPROVED BY: RAO

SO
SUPV
DSGN
DWN
CHKD
OK
DATE
SCALES

TOPOCK GROUNDWATER REMEDIATION PROJECT

PIPELINE SEGMENT MAP

GAS TRANSMISSION & DISTRIBUTION
PACIFIC GAS AND ELECTRIC COMPANY
SAN FRANCISCO, CALIFORNIA

MICROFILM
BILL OF MATL
DWG LIST
SUPSDS
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SHEET NO. of SHEETS
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LEGEND:

FENCE LINE

NOTES:

1. PARKING SURFACE WILL BE GRAVEL DURING INITIAL CONSTRUCTION, BUT MAY BE PAVED WITH ASPHALT IN THE FUTURE.
2. CONFIGURATION AND COMPOSITION OF THE REMEDY SUPPORT AREA MAY CHANGE OVER THE LIFE OF THE REMEDY. EXPECTED CONFIGURATION DURING CONSTRUCTION IS DEPICTED HERE.
3. FINAL LAYOUT OF TEMPORARY CONSTRUCTION AND LAYDOWN AREAS TO BE DETERMINED BY CONTRACTOR. REPRESENTATIVE USE OF THE AREA IS DEPICTED HERE.

0 30' 60' 90'

SCALE: 1"=30'

- FINAL DESIGN - FOR AGENCY APPROVAL ONLY

REGISTERED PROFESSIONAL ENGINEER BENJAMIN J. WUERL C 67811 EXP. 6/30/17 CIVIL STATE OF CALIFORNIA

ETIC ENGINEERING

ARCADIS

NO.	DATE	DESCRIPTION	GM/SPEC	DWN	CHKD	SUPV	APVD BY
3	11/9/16	100% BOD ERRATA INFO PACKAGE		AJW	WLM	BW	RAO
2	11/18/15	FINAL DESIGN		AJW	WLM	BW	RAO
1	8/5/15	90% RTC RESOLUTION		AJW	KLD	WLM	BJW
0	2/2/15	SUPPLEMENTAL PRE-FINAL (90%) DESIGN		AJW	MSL	JPB	JEF

REVISIONS

APPROVED BY: RAO

SO / SUPV / DSGN / DWN / CHKD / OK / DATE / SCALES

TOPOCK GROUNDWATER REMEDIATION PROJECT

CONSTRUCTION HEADQUARTERS YARD PLAN

GAS TRANSMISSION & DISTRIBUTION
PACIFIC GAS AND ELECTRIC COMPANY
SAN FRANCISCO, CALIFORNIA

MICROFILM / BILL OF MATL / DWG LIST / SUPSDS / SUPSD BY

SHEET NO. of SHEETS: C-15-01 — REV 3

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H1806

LEGEND:

- FENCE LINE
- ELECTRICAL AND TELECOMMUNICATIONS CONNECTION
- FIRE PROTECTION WATER AND SEWER CONNECTION
- WATER CONNECTION

NOTES:

1. CONFIGURATION AND COMPOSITION OF THE REMEDY SUPPORT AREA MAY CHANGE OVER THE LIFE OF THE REMEDY. EXPECTED CONFIGURATION DURING CONSTRUCTION IS DEPICTED HERE.
2. FINAL LAYOUT OF TEMPORARY CONSTRUCTION AND LAYDOWN AREAS TO BE DETERMINED BY CONTRACTOR. REPRESENTATIVE USE OF THE AREA IS DEPICTED HERE.

- FINAL DESIGN - FOR AGENCY APPROVAL ONLY

REGISTERED PROFESSIONAL ENGINEER BENJAMIN J. WUERL C 67811 EXP. 6/30/17 CIVIL STATE OF CALIFORNIA

ETIC ENGINEERING

ARCADIS

NO.	DATE	DESCRIPTION	GM/SPEC	DWN	CHKD	SUPV	APVD BY
3	11/9/16	100% BOD ERRATA INFO PACKAGE		AJW	WLM	BW	RAO
2	11/18/15	FINAL DESIGN		AJW	WLM	BW	RAO
1	8/5/15	90% RTC RESOLUTION		AJW	KLD	WLM	BJW
0	2/2/15	SUPPLEMENTAL PRE-FINAL (90%) DESIGN		AJW	MSL	JPB	JEF

REVISIONS

APPROVED BY: RAO

SO / SUPV / DSGN / DWN / CHKD / OK / DATE / SCALES

TOPOCK GROUNDWATER REMEDIATION PROJECT

CONSTRUCTION HEADQUARTERS UTILITY CONNECTIONS

GAS TRANSMISSION & DISTRIBUTION
PACIFIC GAS AND ELECTRIC COMPANY
SAN FRANCISCO, CALIFORNIA

MICROFILM
BILL OF MATL
DWG LIST
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SHEET NO. of SHEETS
C-15-02 REV 3

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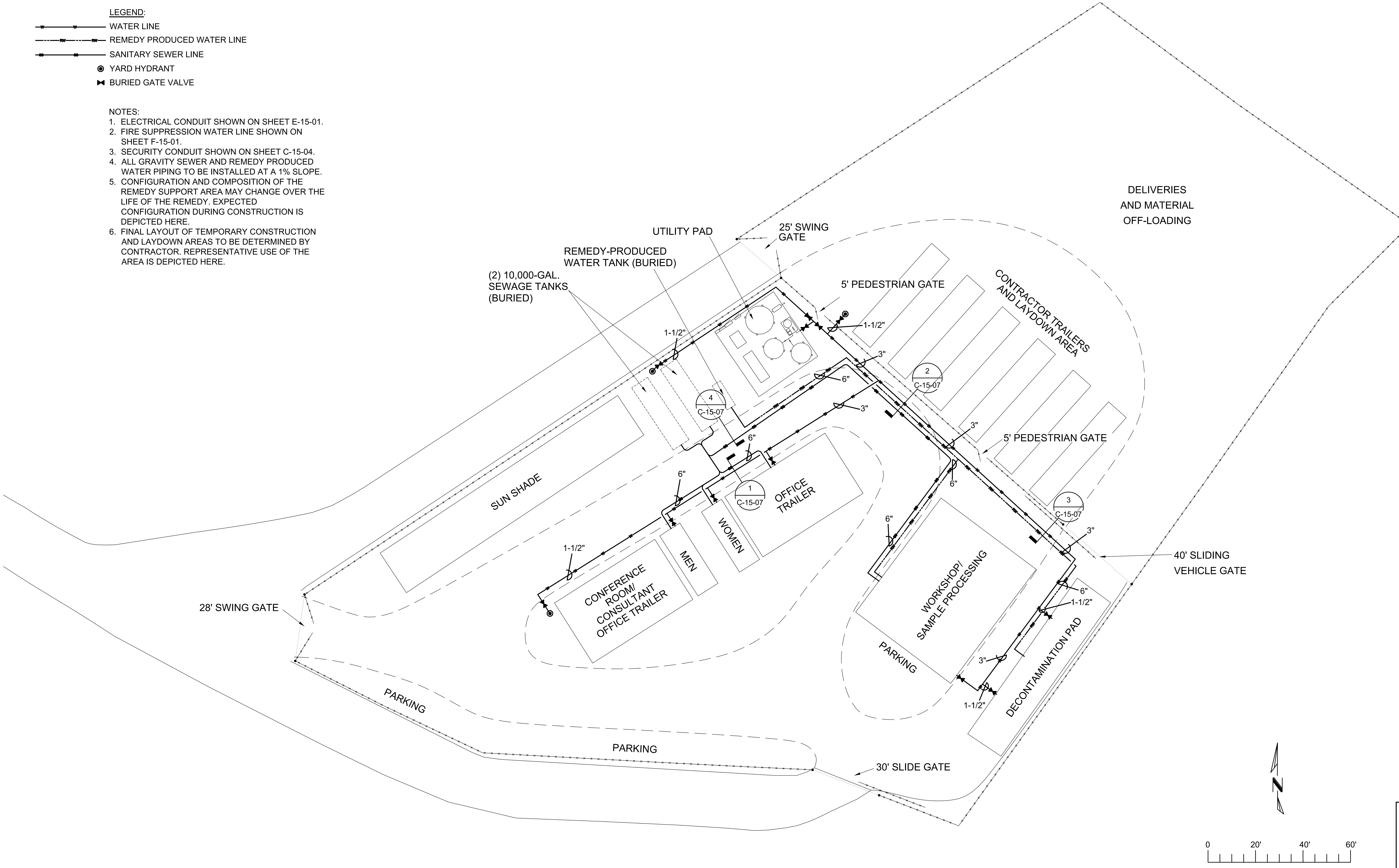
LEGEND:

- WATER LINE
- REMEDY PRODUCED WATER LINE
- SANITARY SEWER LINE
- YARD HYDRANT
- BURIED GATE VALVE

NOTES:

1. ELECTRICAL CONDUIT SHOWN ON SHEET E-15-01.
2. FIRE SUPPRESSION WATER LINE SHOWN ON SHEET F-15-01.
3. SECURITY CONDUIT SHOWN ON SHEET C-15-04.
4. ALL GRAVITY SEWER AND REMEDY PRODUCED WATER PIPING TO BE INSTALLED AT A 1% SLOPE.
5. CONFIGURATION AND COMPOSITION OF THE REMEDY SUPPORT AREA MAY CHANGE OVER THE LIFE OF THE REMEDY. EXPECTED CONFIGURATION DURING CONSTRUCTION IS DEPICTED HERE.
6. FINAL LAYOUT OF TEMPORARY CONSTRUCTION AND LAYDOWN AREAS TO BE DETERMINED BY CONTRACTOR. REPRESENTATIVE USE OF THE AREA IS DEPICTED HERE.



- FINAL DESIGN -
FOR AGENCY APPROVAL ONLY

REGISTERED PROFESSIONAL ENGINEER BENJAMIN J. WUERL C 67811 EXP. 6/30/17 CIVIL STATE OF CALIFORNIA

ETIC ENGINEERING

ARCADIS

NO.	DATE	DESCRIPTION	GM/SPEC	DWN	CHKD	SUPV	APVD BY
3	11/9/16	100% BOD ERRATA INFO PACKAGE		AJW	WLM	BW	RAO
2	11/18/15	FINAL DESIGN		AJW	WLM	BW	RAO
1	8/5/15	90% RTC RESOLUTION		AJW	KLD	WLM	BJW
0	2/2/15	SUPPLEMENTAL PRE-FINAL (90%) DESIGN		AJW	MSL	JPB	JEF

REVISIONS

APPROVED BY: RAO

SO / SUPV / DSGN / DWN / CHKD / OK / DATE / SCALES

TOPOCK GROUNDWATER REMEDIATION PROJECT

CONSTRUCTION HEADQUARTERS PIPING PLAN

GAS TRANSMISSION & DISTRIBUTION
PACIFIC GAS AND ELECTRIC COMPANY
SAN FRANCISCO, CALIFORNIA

MICROFILM
BILL OF MATL
DWG LIST
SUPSDS
SUPSD BY
SHEET NO. of SHEETS
C-15-03
REV 3

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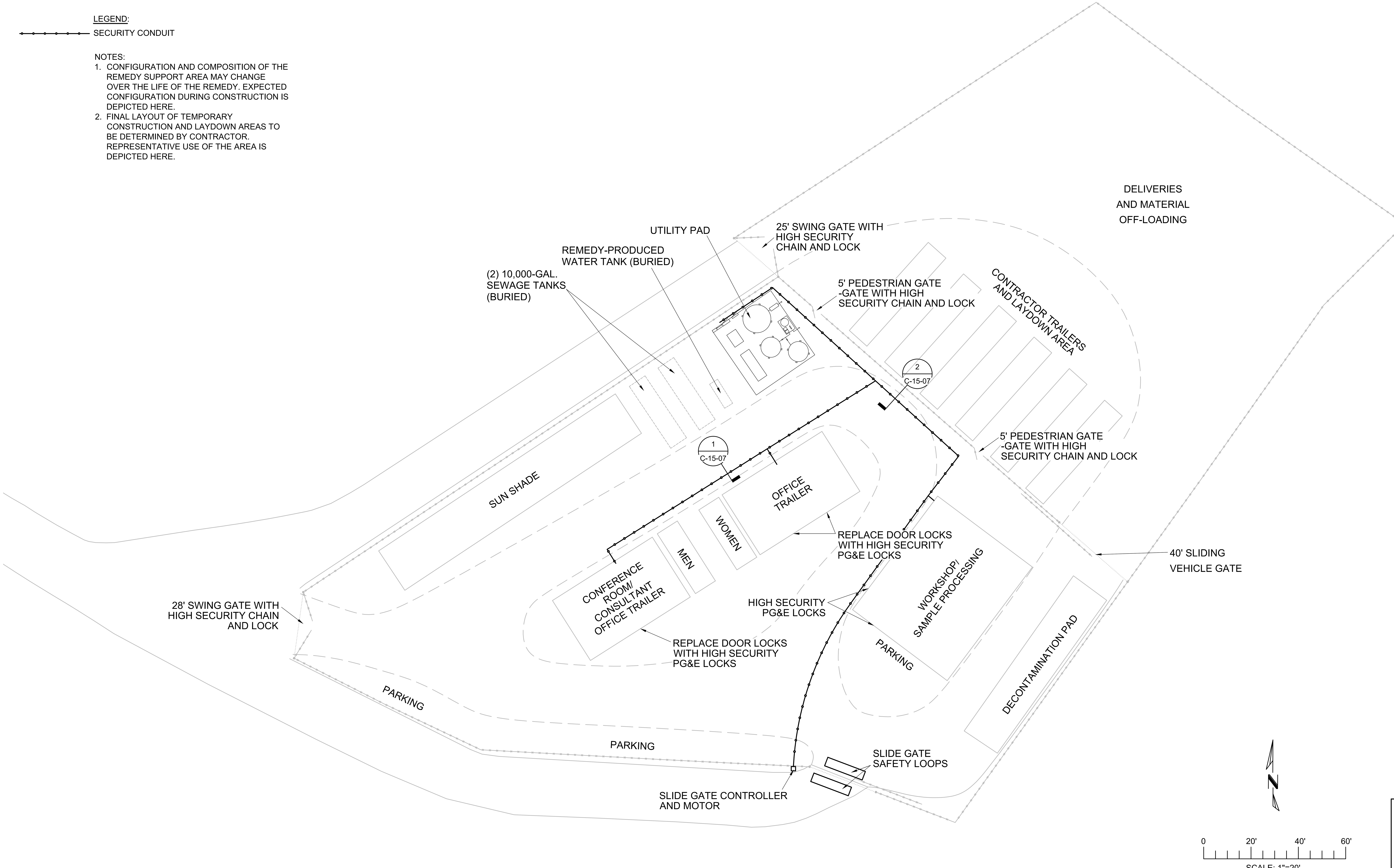
N1808

LEGEND:

SECURITY CONDUIT

NOTES:
1. CONFIGURATION AND COMPOSITION OF THE REMEDY SUPPORT AREA MAY CHANGE OVER THE LIFE OF THE REMEDY. EXPECTED CONFIGURATION DURING CONSTRUCTION IS DEPICTED HERE.
2. FINAL LAYOUT OF TEMPORARY CONSTRUCTION AND LAYDOWN AREAS TO BE DETERMINED BY CONTRACTOR. REPRESENTATIVE USE OF THE AREA IS DEPICTED HERE.



- FINAL DESIGN - FOR AGENCY APPROVAL ONLY

REGISTERED PROFESSIONAL ENGINEER BENJAMIN J. WUERL C 67811 EXP. 6/30/17 CIVIL STATE OF CALIFORNIA

NO.	DATE	DESCRIPTION	GM/SPEC	DWN	CHKD	SUPV	APVD BY
3	11/9/16	100% BOD ERRATA INFO PACKAGE		AJW	WLM	BW	RAO
2	11/18/15	FINAL DESIGN		AJW	WLM	BW	RAO
1	8/5/15	90% RTC RESOLUTION		AJW	KLD	WLM	BJW
0	2/2/15	SUPPLEMENTAL PRE-FINAL (90%) DESIGN		AJW	JMS	JPB	JEF

REVISIONS

APPROVED BY: RAO

SO / SUPV / DSGN / DWN / CHKD / OK / DATE / SCALES

ETIC ENGINEERING

ARCADIS

TOPOCK GROUNDWATER REMEDIATION PROJECT

CONSTRUCTION HEADQUARTERS SECURITY PLAN

GAS TRANSMISSION & DISTRIBUTION
PACIFIC GAS AND ELECTRIC COMPANY
SAN FRANCISCO, CALIFORNIA

MICROFILM / BILL OF MATL / DWG LIST / SUPSDS / SUPSD BY / SHEET NO. of SHEETS

C-15-04 REV 3

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NOTES:
1. FOR FENCING AND GRAVEL ROAD DETAILS, SEE SHEETS C-00-05, C-00-06, AND C-00-07.
2. FINAL LAYOUT OF TEMPORARY CONSTRUCTION AND LAYDOWN AREAS TO BE DETERMINED BY CONTRACTOR. REPRESENTATIVE USE OF THE AREA IS DEPICTED HERE.

- FINAL DESIGN -
FOR AGENCY APPROVAL ONLY

REGISTERED PROFESSIONAL ENGINEER
BENJAMIN J. WUERL
C 67811
EXP. 6/30/17
CIVIL
STATE OF CALIFORNIA

ETIC ENGINEERING

ARCADIS

NO.	DATE	DESCRIPTION	GM/SPEC	DWN	CHKD	SUPV	APVD BY
3	5/18/16	ROAD ALIGNMENT REVISION		AJW	JPB	JPB	RAO
2	11/18/15	FINAL DESIGN		AJW	WLM	BW	RAO
1	8/5/15	90% RTC RESOLUTION		AJW	KLD	WLM	BJW
0	2/2/15	SUPPLEMENTAL PRE-FINAL (90%) DESIGN		AJW	MSL	JPB	JEF

REVISIONS

APPROVED BY: RAO

SO / SUPV / DSGN / DWN / CHKD / OK / DATE / SCALES

TOPOCK GROUNDWATER REMEDIATION PROJECT

PARK MOABI SOIL STAGING AND STORAGE SITE PLAN

GAS TRANSMISSION & DISTRIBUTION
PACIFIC GAS AND ELECTRIC COMPANY
SAN FRANCISCO, CALIFORNIA

MICROFILM
BILL OF MATL
DWG LIST
SUPSDS
SUPSD BY

SHEET NO.	REV
C-15-05	3

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PRELIMINARY EARTHWORK VOLUMES
CONSTRUCTION HEADQUARTERS

	2d Area(Sq. Ft.)	Cut (Cu. Yd.)	Fill(Cu. Yd.)	Net(Cu. Yd.)
Total	114851.97	1558.33	2319.08	760.75 <Fill>

(SEE NOTE 2)

NOTES:
1. V-DITCH AND FENCE WILL NOT ENCROACH ON THE TOE OF THE SLOPE.
2. EARTHWORK VOLUMES WERE NOT UPDATED DURING REVISION TO V-DICTH LOCATION.

- FINAL DESIGN -
FOR AGENCY
APPROVAL ONLY

REGISTERED PROFESSIONAL ENGINEER
BENJAMIN J. WUERL
C 67811
EXP 6/30/17
CIVIL
STATE OF CALIFORNIA

ETIC ENGINEERING

ARCADIS

NO.	DATE	DESCRIPTION	GM/SPEC	DWN	CHKD	SUPV	APVD BY
3	11/9/16	100% BOD ERRATA INFO PACKAGE		AJW	WLM	BW	RAO
2	11/18/15	FINAL DESIGN		AJW	WLM	BW	RAO
1	8/5/15	90% RTC RESOLUTION		AJW	MSL	JPB	JEF
0	2/2/15	SUPPLEMENTAL PRE-FINAL (90%) DESIGN		AJW	MSL	JPB	JEF

REVISIONS

APPROVED BY: RAO

SO / SUPV / DSGN / DWN / CHKD / OK / DATE / SCALES

TOPOCK GROUNDWATER REMEDIATION PROJECT

CONSTRUCTION HEADQUARTERS GRADING PLAN

GAS TRANSMISSION & DISTRIBUTION
PACIFIC GAS AND ELECTRIC COMPANY
SAN FRANCISCO, CALIFORNIA

MICROFILM
BILL OF MATL
DWG LIST
SUPSDS
SUPSD BY
SHEET NO. of SHEETS
C-15-08
REV 3

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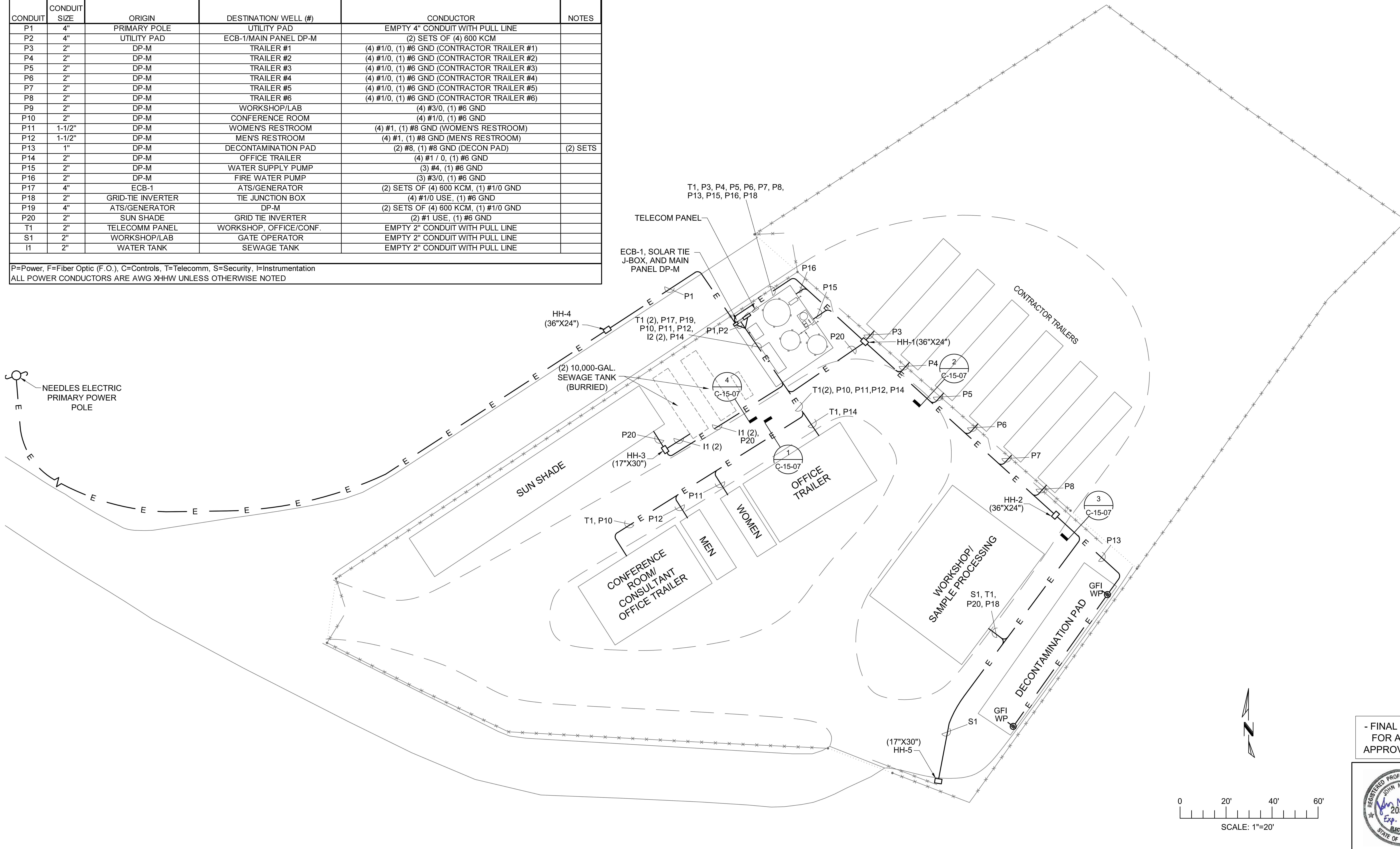
CONSTRUCTION HEADQUARTERS YARD CONDUIT AND CABLE SCHEDULE

CONDUIT	CONDUIT SIZE	ORIGIN	DESTINATION/ WELL (#)	CONDUCTOR	NOTES
P1	4"	PRIMARY POLE	UTILITY PAD	EMPTY 4" CONDUIT WITH PULL LINE	
P2	4"	UTILITY PAD	ECB-1/MAIN PANEL DP-M	(2) SETS OF (4) 600 KCM	
P3	2"	DP-M	TRAILER #1	(4) #1/0, (1) #6 GND (CONTRACTOR TRAILER #1)	
P4	2"	DP-M	TRAILER #2	(4) #1/0, (1) #6 GND (CONTRACTOR TRAILER #2)	
P5	2"	DP-M	TRAILER #3	(4) #1/0, (1) #6 GND (CONTRACTOR TRAILER #3)	
P6	2"	DP-M	TRAILER #4	(4) #1/0, (1) #6 GND (CONTRACTOR TRAILER #4)	
P7	2"	DP-M	TRAILER #5	(4) #1/0, (1) #6 GND (CONTRACTOR TRAILER #5)	
P8	2"	DP-M	TRAILER #6	(4) #1/0, (1) #6 GND (CONTRACTOR TRAILER #6)	
P9	2"	DP-M	WORKSHOP/LAB	(4) #3/0, (1) #6 GND	
P10	2"	DP-M	CONFERENCE ROOM	(4) #1/0, (1) #6 GND	
P11	1-1/2"	DP-M	WOMEN'S RESTROOM	(4) #1, (1) #8 GND (WOMEN'S RESTROOM)	
P12	1-1/2"	DP-M	MEN'S RESTROOM	(4) #1, (1) #8 GND (MEN'S RESTROOM)	
P13	1"	DP-M	DECONTAMINATION PAD	(2) #8, (1) #8 GND (DECON PAD)	(2) SETS
P14	2"	DP-M	OFFICE TRAILER	(4) #1 / 0, (1) #6 GND	
P15	2"	DP-M	WATER SUPPLY PUMP	(3) #4, (1) #6 GND	
P16	2"	DP-M	FIRE WATER PUMP	(3) #3/0, (1) #6 GND	
P17	4"	ECB-1	ATS/GENERATOR	(2) SETS OF (4) 600 KCM, (1) #1/0 GND	
P18	2"	GRID-TIE INVERTER	TIE JUNCTION BOX	(4) #1/0 USE, (1) #6 GND	
P19	4"	ATS/GENERATOR	DP-M	(2) SETS OF (4) 600 KCM, (1) #1/0 GND	
P20	2"	SUN SHADE	GRID TIE INVERTER	(2) #1 USE, (1) #6 GND	
T1	2"	TELECOMM PANEL	WORKSHOP, OFFICE/CONF.	EMPTY 2" CONDUIT WITH PULL LINE	
S1	2"	WORKSHOP/LAB	GATE OPERATOR	EMPTY 2" CONDUIT WITH PULL LINE	
I1	2"	WATER TANK	SEWAGE TANK	EMPTY 2" CONDUIT WITH PULL LINE	

P=Power, F=Fiber Optic (F.O.), C=Controls, T=Telecomm, S=Security, I=Instrumentation
ALL POWER CONDUCTORS ARE AWG XHHW UNLESS OTHERWISE NOTED



- FINAL DESIGN - FOR AGENCY APPROVAL ONLY

REGISTERED PROFESSIONAL ENGINEER JOHN M. SIDOTI 20532 Exp. 9-30-17 ELECTRICAL STATE OF CALIFORNIA

ETIC ENGINEERING

ARCADIS

NO.	DATE	DESCRIPTION	GM/SPEC	DWN	CHKD	SUPV	APVD BY
2	11/9/16	100% BOD ERRATA INFO PACKAGE		AJW	JPB	JMS	RAO
1	11/18/15	FINAL DESIGN		AJW	JPB	JMS	RAO
0	2/2/15	SUPPLEMENTAL PRE-FINAL (90%) DESIGN		AJW	JMS	JPB	JEF

REVISIONS

APPROVED BY: RAO

SO / SUPV / DSGN / DWN / CHKD / OK / DATE / SCALES

TOPOCK GROUNDWATER REMEDIATION PROJECT

CONSTRUCTION HEADQUARTERS ELECTRICAL PLAN

GAS TRANSMISSION & DISTRIBUTION
PACIFIC GAS AND ELECTRIC COMPANY
SAN FRANCISCO, CALIFORNIA

MICROFILM / BILL OF MATL / DWG LIST / SUPSDS / SUPSD BY

SHEET NO. of SHEETS: E-15-03

REV 2

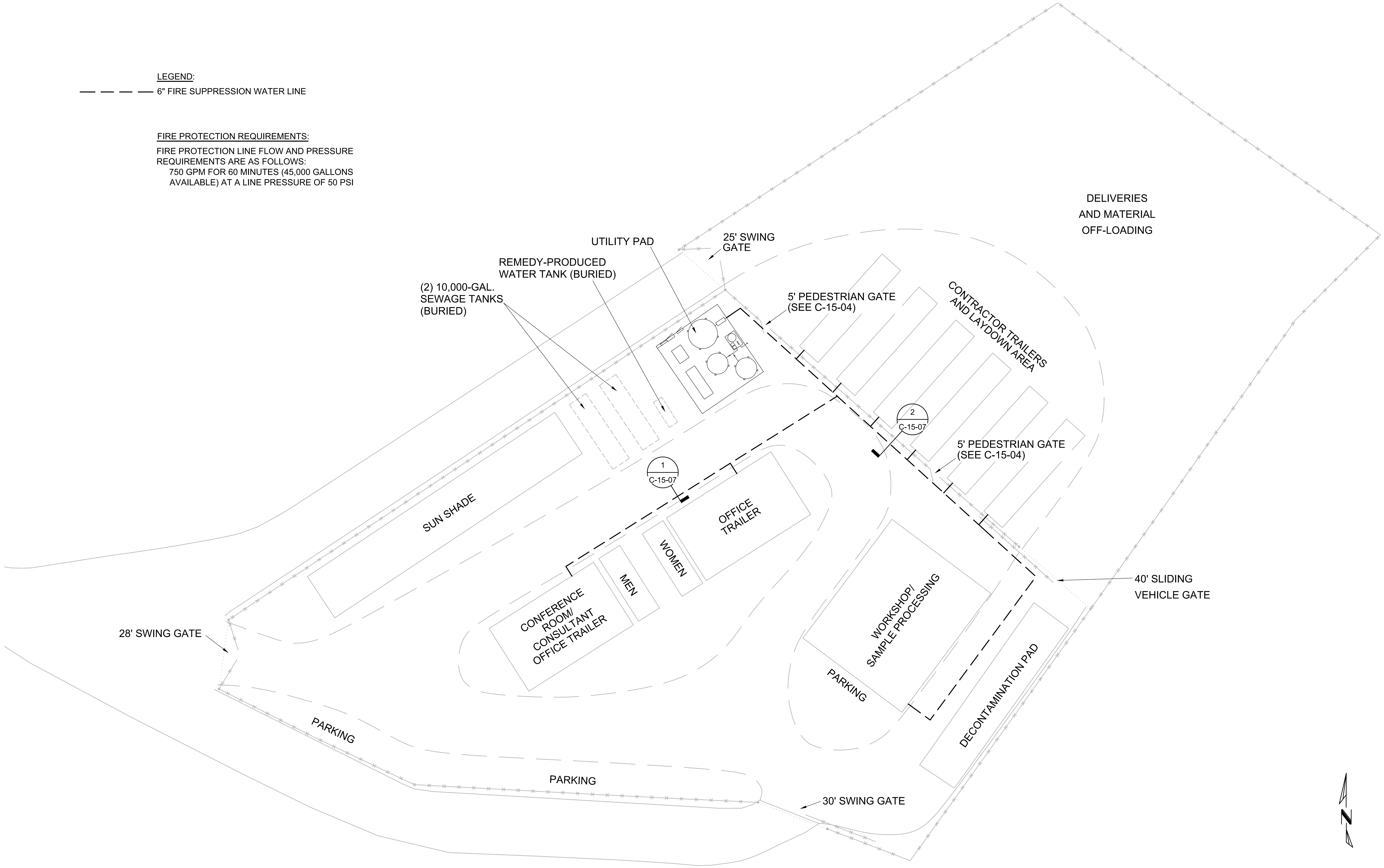
N1808

LEGEND:

— — — — 6" FIRE SUPPRESSION WATER LINE

FIRE PROTECTION REQUIREMENTS:

FIRE PROTECTION LINE FLOW AND PRESSURE REQUIREMENTS ARE AS FOLLOWS:
750 GPM FOR 60 MINUTES (45,000 GALLONS AVAILABLE) AT A LINE PRESSURE OF 50 PSI



N

0 20' 40' 60'
SCALE: 1"=20'

- FINAL DESIGN -
FOR AGENCY
APPROVAL ONLY

LICENSED FIRE PROTECTION CONTRACTOR — MARQUEE FIRE PROTECTION ENGINEERING — CLASSIFICATION C-16 — LICENSE No. 570970 — STATE OF CALIFORNIA

ETIC ENGINEERING

ARCADIS

NO.	DATE	DESCRIPTION	GM/SPEC	DWN	CHKD	SUPV	APVD BY
3	11/9/16	100% BOD ERRATA INFO PACKAGE		AJW	TPH	JJA	RAO
2	11/18/15	FINAL DESIGN		TPH	TPH	JJA	RAO
1	8/5/15	90% RTC RESOLUTION		AJW	JMS	JPB	JEF
0	2/2/15	SUPPLEMENTAL PRE-FINAL (90%) DESIGN		AJW	JMS	JPB	JEF

REVISIONS

APPROVED BY: RAO

SO / SUPV / DSGN / DWN / CHKD / OK / DATE / SCALES

TOPOCK GROUNDWATER REMEDIATION PROJECT

CONSTRUCTION HEADQUARTERS FIRE SUPPRESSION YARD PLAN

GAS TRANSMISSION & DISTRIBUTION
PACIFIC GAS AND ELECTRIC COMPANY
SAN FRANCISCO, CALIFORNIA

MICROFILM
BILL OF MATL
DWG LIST
SUPSDS
SUPSD BY
SHEET NO. of SHEETS

F-15-01 REV 3

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