**Pacific Gas and Electric Company**

**Yvonne Meeks**
Manager

Environmental Remediation
Gas T&D Department

*Mailing Address*
4325 South Higuera Street
San Luis Obispo, CA 93401
*Location*
6588 Ontario Road
San Luis Obispo, CA 93405
Tel: (805) 234-2257
Email: yjm1@pge.com

August 12, 2008

Ms. Jennifer Barr
Manager, Voluntary Remediation Program Unit
Arizona Department of Environmental Quality
1110 West Washington Street, Mail Code 4415B-1
Phoenix, Arizona 85007

Subject: Installation Report for Wells on the Arizona Shore of the Colorado River at Topock, Arizona
PG&E Topock Compressor Station, Needles, California

Dear Ms. Barr:

This letter transmits the Installation Report for Wells on the Arizona Shore of the Colorado River at Topock, Arizona. The report is submitted in conformance with the March 1, 2007 *Revised Work Plan for Well Installation and Groundwater Characterization on Arizona Shore of the Colorado River at Topock, Arizona, PG&E Topock Compressor Station, Needles, California*, as approved by the Arizona Department of Environmental Quality and the United States Department of the Interior. This report also contains the post-construction report required by Lease PRC 8737.1 between the California State Lands Commission and PG&E and the reporting requirements of Right of Way No. 14-112077 between the Arizona State Land Department and CH2M HILL.

PG&E appreciates your consideration of the attached report. Please contact me at (805) 234-2257 with any questions or concerns.

Sincerely,

Yvonne Meeks
Topock Project Manager

cc: Joey Pace/ADEQ
Kris Doebbler/DOI
Aaron Yue/DTSC
Susan Young/California State Lands Commission
Nancy Garcia/Arizona State Lands Department

*Final Report*

# Installation Report for Wells on the Arizona Shore of the Colorado River at Topock, Arizona

## PG&E Topock Compressor Station Needles, California

Prepared for

**Arizona Department of Environmental Quality**

On Behalf of

**Pacific Gas and Electric Company**

August 12, 2008

CH2MHILL
155 Grand Avenue, Suite 1000
Oakland, CA 94612

# Installation Report for Wells on the Arizona Shore of the Colorado River at Topock, Arizona

## PG&E Topock Compressor Station
## Needles, California

**Prepared for**

**Arizona Department of Environmental Quality**

**On Behalf of**

**Pacific Gas and Electric Company**

**August 12, 2008**

This report was prepared under the supervision of an
Arizona Professional Geologist

Martin Barackman, P.G. No. 45424
Senior Hydrogeologist

Jennifer Low
Project Manager

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# Acronyms and Abbreviations

| | |
|---|---|
| µg/L | micrograms per liter |
| ADEQ | Arizona Department of Environmental Quality |
| ADWR | Arizona Department of Water Resources |
| bgs | below ground surface |
| Cr(T) | total dissolved chromium |
| Cr(VI) | hexavalent chromium |
| DOI | United States Department of the Interior |
| DTSC | California Department of Toxic Substances Control |
| GMP | Groundwater Monitoring Program |
| IM | Interim Measure |
| mg/L | milligrams per liter |
| mV | millivolt |
| MLABS® | Multilevel Angled Borehole System® |
| ORP | oxidation-reduction potential |
| PG&E | Pacific Gas and Electric Company |
| PVC | polyvinyl chloride |
| RCRA | Resource Conservation and Recovery Act of 1976 |
| RFI/RI | RCRA facility investigation/remedial investigation |

# 1.0 Introduction

Pacific Gas and Electric Company (PG&E) is addressing chromium in groundwater at the Topock Compressor Station located in San Bernardino County, approximately 15 miles to the southeast of Needles, California, as shown in Figure 1-1. Investigative and remedial activities at the Topock Compressor Station are being performed under the Resource Conservation and Recovery Act (RCRA) corrective action process, as well as the Comprehensive Environmental Response, Compensation and Liability Act, under agreements with the California Department of Toxic Substances Control (DTSC), and the Department of the Interior (DOI), respectively. In Arizona, PG&E is implementing investigative activities under the Voluntary Remediation Program of the Arizona Department of Environmental Quality (ADEQ). The Voluntary Remediation Program is a streamlined process for investigation or cleanup of contaminated sites to address applicable cross-program remediation efforts.

This report documents the installation of groundwater monitoring wells near the Arizona shore of the Colorado River in the vicinity of the Topock Compressor Station and presents the results of hydraulic monitoring and the initial two rounds of groundwater sampling. Groundwater monitoring wells were installed at three locations in Arizona to provide additional groundwater characterization data for the RCRA facility investigation/remedial investigation (RFI/RI) for the Topock site. Well installation and development activities occurred during March and April 2008, and hydraulic monitoring and initial sampling activities continued through June 2008. The primary technical objectives of the groundwater investigation in Arizona were to:

- Assess chromium concentrations in groundwater near the Arizona shore of the Colorado River to bound the eastern limit of the plume in the Alluvial Aquifer.
- Assess chromium concentrations in the fluvial sediments beneath the Colorado River downstream from the chromium plume observed in the California floodplain.
- Characterize the extent of geochemical conditions that limit hexavalent chromium mobility near the Arizona shore and beneath the Colorado River.

The well installation was completed as outlined in the *Revised Work Plan for Well Installation and Groundwater Characterization on Arizona Shore of the Colorado River at Topock, Arizona* (CH2M HILL, 2007a) and the *Technical Addendum: Arizona Slant Well Design Modifications Based on Experience from California Slant Well Installation* (CH2M HILL, 2007b). The drilling, well installation, and associated activities are collectively referred to in this report as the Arizona Drilling Program.

## 1.1 Approvals and Authorizations

The Arizona Drilling Program was executed in conformance with the following approvals and authorizations:

- ADEQ approval of the Work Plan (ADEQ, 2007a) and ADEQ approval of the Technical Addendum (ADEQ, 2007b)
- DOI, United States Bureau of Land Management, United States Fish and Wildlife Service, and United States Bureau of Reclamation approval letter (DOI, 2008)
- Lease agreement amendment between the California State Lands Commission and PG&E (CSLC, 2007)
- Right of Entry agreement between the Arizona State Land Department and CH2M HILL (ASLD, 2007)
- Arizona Department of Water Resources (ADWR) approved Notices of Intent (Well Registration Nos. 55-215408, 55-215409, 55-215410, and 55-215411)

## 1.2 Report Organization

This report summarizes the work conducted as part of the Arizona Drilling Program and presents the results of the drilling, well installation, and initial groundwater sampling.

- Section 2.0 summarizes the drilling, well installation, hydraulic monitoring, groundwater sampling, and associated field activities performed.
- Section 3.0 presents the results of the drilling investigation, including lithologic observations, depth-discrete borehole groundwater sample data, initial groundwater monitoring well sample data, and hydraulic monitoring.
- Section 4.0 summarizes the work performed and results of the Arizona Drilling Program.
- Section 5.0 provides a list of works cited while compiling this report.

# 2.0 Summary of Field Activities

This section summarizes the drilling, well installation, and associated field activities performed in accordance with the Work Plan (CH2M HILL, 2007a) and the Technical Addendum (CH2M HILL, 2007b). Figure 2-1 presents the locations investigated during the Arizona Drilling Program. Primary tasks conducted during this program include:

- Site preparation, including a pre- and post-construction site survey.
- Drilling of two vertical boreholes at Site 1: one vertical borehole at Site 2, and one angled borehole at Site AB-2.
- Collection of lithologic core and depth-specific groundwater samples during borehole drilling.
- Installation and development of one or more groundwater monitoring wells in each borehole at Sites 1 (MW-54 well series), 2 (MW-55 well series), and AB-2 (MW-56 well series).
- Geophysical logging in the deepest wells at the vertical well sites (MW-54 and MW-55).
- Collection of initial two rounds of groundwater samples for laboratory analysis from each newly installed monitoring well.
- Monitoring of hydraulic response in wells located on both sides of the Colorado River during a May 2008 Interim Measure (IM) No. 3 groundwater extraction/injection shutdown.

The Work Plan also described that a contingency well may be installed if chromium concentrations exceed 50 micrograms per liter (µg/L) or are above natural background levels. Because these levels of chromium were not found during this investigation, the contingency well was not installed.

## 2.1 Site Access, Preparation, and Compliance Monitoring

An onsite biologist conducted a pre-construction survey of the drilling sites before the mobilization of equipment and a post-construction survey following the completion of well installation activities. Results of the pre- and post-construction surveys, as well as information collected during biological monitoring to assess compliance with the *Programmatic Biological Assessment for the Pacific Gas and Electric Topock Compressor Station Remedial and Investigative Action* (CH2M HILL, 2007c) and Havasu National Wildlife Refuge-required conditions for well installation are provided in the *Biological Resources Completion Report for the Arizona Drilling Project: Topock Compressor Station, Needles, California* (CH2M HILL 2008a).

The drilling sites were accessed by the approved, pre-existing routes identified in the Work Plan. No vegetation was cleared during this investigation. No listed species or nesting birds were observed during the pre-activity or post-activity surveys. All construction occurred within previously disturbed areas. No additional areas were disturbed by the activities, and no habitat loss occurred. In addition, representatives of the Fort Mojave Indian Tribe and Colorado River Indian Tribe were present during portions of the work to observe borehole and well installation activities.

## 2.2 Drilling and Lithologic Logging

Borehole drilling was accomplished using a rotosonic drilling method, which involves advancing a steel drive casing and core barrel through the subsurface using a combination of rotation and vibration. This method was selected because it has the capability to drill vertically and at shallow angles; produces a continuous core from the land surface to the target drilling depth; generates minimal drilling wastes; and typically can drill through gravel, cobble, and softer bedrock formations. Water from the Colorado River was used as necessary to facilitate borehole drilling. River water has a chemical signature that is distinct from the groundwater in electrical conductivity, oxidation-reduction potential (ORP), and stable isotope ratio. Because the river water is distinctly different from the groundwater, by monitoring water chemistry during depth-specific sampling while the borehole is being drilled and during well development after the well is installed, it is possible to determine that all the water added during drilling and well installation has been removed.

The initial borehole at Site 1 and the boreholes at Sites 2[1] and AB-2[2] were drilled to the top of the consolidated Miocene Conglomerate. The continuous cores obtained from drilling were used to prepare the lithologic logs provided in Appendix A and subsequently were added to the Topock core archive. Lithologic descriptions for the initial borehole at Site 1 and the boreholes at Sites 2 and AB-2 were prepared under the supervision of an Arizona professional geologist based on visual inspection of the retrieved core.

Drilling activities for well installation at Sites 1 (MW-54 well series), 2 (MW-55 well series), and AB-2 (MW-56 well series) began on March 11, March 29, and April 9, 2008, respectively. Two vertical boreholes were drilled at Site 1 to 147 feet and 237 feet below ground surface (bgs), and one vertical borehole was drilled at Site 2 to 137 feet bgs. The deepest borehole at Site 1 and the borehole at Site 2 were drilled approximately 7 and 6 feet into consolidated Miocene Conglomerate bedrock, respectively. The vertical boreholes were drilled using a 6-inch-diameter core barrel followed by an 8-inch-diameter drive casing to total depth. A slant borehole at Site AB-2 was drilled at an angle of 30 degrees from horizontal with an azimuth of 270 degrees. The slant borehole was drilled to a vertical depth of 112 feet bgs, which is approximately 5 feet into consolidated Miocene Conglomerate bedrock, as referenced from the ground surface at the top of the borehole. The total drilled borehole length was 223 feet. The slant borehole was drilled using a 4-inch-diameter core barrel followed by a 6-inch-diameter drive casing to total depth. Drilling logs for each borehole are provided in Appendix A-1.

[1] The actual drilling site where work was conducted is referred to as “Site 2-Alternate” in the Work Plan; however, this site is referred to as “Site 2” throughout this document.

[2] The actual drilling site where work was conducted is referred to as “Site AB-2-Alternate” in the Work Plan; however, this site is referred to as “Site AB-2” throughout this document.

## 2.3 Depth-specific Groundwater Sampling

Depth-specific groundwater samples were collected during the installation of the deepest borehole at Site 1 and the boreholes at Sites 2 and AB-2 using the Isoflow® system. Specific sample zones and analytical results are discussed in Section 3.2.

Samples were obtained by installing the Isoflow® tools to the bottom of the borehole and retracting the drive casing to expose the Isoflow® sampling screen to the formation. Once exposed, an electric submersible pump was lowered into the Isoflow® system and was used to purge the sample interval and to obtain a sample.

To ensure the collection of a sample representative of formation groundwater, purging was conducted prior to sample collection to remove water that had been introduced during drilling. At a minimum, approximately twice the amount of water injected during the drilling of the subject interval was purged while monitoring field parameters (temperature, pH, specific conductance, and ORP). Once the minimum volume had been evacuated and field parameters had stabilized, final water quality parameters were recorded, and sample aliquots were collected for hexavalent chromium [Cr(VI)] and ferrous iron for analysis at the onsite IM No. 3 laboratory using the Hach colorimetric method. In addition, aliquots for dissolved total chromium [Cr(T)] and Cr(VI) were collected and held for confirmation laboratory analysis in the event that Cr(VI) was detected in the primary sample.

Water level in the cased borehole was monitored during purging for depth-discrete groundwater sample collection. By monitoring drawdown response with respect to the pumping rate, an estimate of borehole-specific capacity was obtained and was used as a relative measure of the permeability of the borehole at the depth of the sample. These data are considered qualitatively as screening-level data for use in selecting more permeable zones for well screens. These measurements are not considered suitable for more quantitative purposes such as model calibration.

## 2.4 Monitoring Well Installation and Development

The screen depth for each monitoring well was selected in consultation with ADEQ, DTSC, DOI, and other stakeholders. Screen depth selection was based on evaluation of lithologic logs and Isoflow® sample results from the initial (deepest) boreholes at each site. The materials and methods used for installation and development of vertical and slant groundwater monitoring wells are presented in the following subsections. Well installation details are summarized in Table 2-1. Well construction diagrams are provided in Appendix A-2. Notices of intent for well installation, which were filed with and approved by ADWR, and well completion reports filed with ADWR are provided in Appendix A-3 and A-4, respectively.

### 2.4.1 Vertical Monitoring Wells

Primary well construction activities were completed at Sites 1 and 2 on March 27 and April 2, 2008, respectively. A single monitoring well (MW-54-195) was installed in the deepest borehole at Site 1, and two nested monitoring wells (MW-54-85 and MW-54-140) were installed in the shallower borehole. Two nested monitoring wells (MW-55-40 and MW-55-120) were installed in the borehole drilled at Site 2.

Vertical groundwater monitoring wells were installed and developed in accordance with the methods and procedures defined in the *Sampling, Analysis, and Field Procedures Manual* (CH2M HILL, 2005). The vertical monitoring wells are constructed of 2-inch-diameter polyvinyl chloride (PVC) casings and screens. The well casing and screens were installed in the borehole through the 8-inch-diameter outer rotosonic drive casing. Plastic centralizers (Kwik-Zip®) were used to center the well casing and to screen in the borehole and, for nested completions, to maintain casing separation.

Each MW-54 and MW-55 monitoring well, or nested-well pair, was completed with a protective well vault installed nearly flush with the existing ground surface. Each vault is accessible by a 10-inch-diameter steel vault cover that is secured by two bolts. To reduce the potential for vandalism, bolts with unconventional heads were used. Each vault was installed within a 3-foot by 3-foot by 4-inch-thick concrete pad. Following completion, each well was surveyed for location, ground surface elevation, and measurement reference elevation.

Following well construction and annular seal placement, the monitoring wells were developed using a surge block, bailer, and submersible pump. During development, temperature, pH, specific conductance, and turbidity were measured using field instruments. Well development was continued until the minimum purge volume had been removed, and field water quality parameters had stabilized in ranges indicative of groundwater (i.e., different water quality signature than that from the river water used during installation).

### 2.4.2 Slant Monitoring Wells

A multilevel groundwater monitoring well with three discrete sample collection points was installed in the angled boring at MW-56. The same slant well installation and development methods used during the installation of the California Slant Drilling Program (MW-52 and MW-53) were used for MW-56. Primary well construction activities were completed at MW-56 on April 20, 2008. As approved by ADEQ, the Multilevel Angled Borehole System® (MLABS®) well assembly, fabricated by BESST, Inc., was used to meet the technical requirements of the project (ADEQ, 2007b). The well was constructed with three polyethylene MLABS® sample filters installed at selected depths based on lithologic and depth-specific groundwater sample data collected during drilling. Each well sample filter was identified with a one-letter suffix after the well number (shallow [S], middle [M], and deep [D]). For example, the deep sampling interval at location MW-56 is identified as "MW-56D."

The MLABS® is a modular system of 10-foot-long sections that were assembled sequentially and were inserted into the 6-inch drive casing. The individual sample filters were installed within a protective housing attached to the solid 1.5-inch-diameter PVC support riser. Sections of the riser and filter housing were joined together using specialized MLABS® centralizers and fiberglass pins. A 1.25-inch-outer-diameter steel tremmie pipe and 1-inch PVC conduit for a sounding device (used to "feel" material depths in the borehole) was inserted along with the well assembly (also in 10-foot sections), resting within grooves machined into each centralizer. At the bottom of the assembly, the support riser was permanently pinned to an anchor centralizer, while the tremmie pipe and sounding conduit temporarily attach to the anchor centralizer via left-handed threaded adaptors.

Each sample filter was constructed of one continuous piece of porous polyethylene 3 feet long and 1 inch in diameter (mean pore diameter is 60 microns). The filter is capped on the bottom and is attached to nylon sample conveyance tubing at the top with a compression fitting. The tubing extends up the well assembly within a longitudinal recess in the support riser to a transition centralizer, at which point the tubing is fastened to a chamber with another compression fitting. Three continuous threaded, 1-inch PVC pipes are threaded into the transition centralizer (one for each chamber/sample filter) and extend to the ground surface with additional 10-foot sections. The 1-inch PVC pipes facilitate the collection of groundwater samples and the installation of pressure transducers to monitor the hydrostatic pressure in each monitoring zone.

Once the well assembly was installed to depth, the tremmie pipe and sounding conduit were unscrewed from the anchor centralizer (clockwise rotation unscrews the left-handed thread at bottom while individual joints remain tight). Prior to retracting the steel drive casing, the total depth of the borehole was verified by inserting a 0.5-inch solid PVC measurement rod through the sounding conduit. The steel drive casing, tremmie pipe, and sounding conduit were then retracted in 10-foot sections. During drive casing removal, borehole collapse around the well assembly was monitored with the measurement rod. Bentonite slurry grout seals were placed between sampling intervals. Because the slant borehole collapsed immediately upon withdrawal of the drive casing, the grout had to be injected into the collapsed section of the borehole through a tremmie pipe that extended beyond the end of the drive casing. Once the drive casing had been removed to a depth adequately above the shallowest sample filter, a surface seal was constructed by placing a continuous column of Portland cement grout via tremmie into the drive casing, and the remaining casing was removed.

MW-56 was completed with an aboveground, protective monument installed at an angle and surrounded a 3-foot by 3-foot by 4-inch-thick concrete pad with concrete-filled steel bollards at each corner. Consistent with other wells at the Topock site, each monument was secured with a padlock and was painted a pale beige color. Following completion, MW-56 was surveyed for location, ground surface elevation, and measurement reference elevation. A universal measuring point was installed within the protective monument. This measuring point is used as a reference for all depth measurements for the MW-56 well group.

Following well construction and annular seal placement, each sampling interval of the slant well was developed by pumping using a peristaltic pump. During development, temperature, pH, specific conductance, and turbidity were measured using field instruments. Well development was continued until field water quality parameters had stabilized in ranges indicative of groundwater (i.e., different water quality signature than that from the river water used during installation).

## 2.5 Geophysical Logging

Following well installation, cased well geophysical logs (natural gamma ray and induction) were collected in MW-54-195 and MW-55-120, which are the deepest wells installed at each vertical drilling location. Geophysical logging could not be conducted at MW-56 because of the angle of the borehole and the small diameter of the well risers and sample tubing. The geophysical logs for these drilling locations are included in Appendix B and were used to further assess the hydrogeologic characteristics of the hydrostratigraphic units in the investigation area. The induction log conducted at MW-54-195 correlates well with the sequence of fluvial sediments (fine sand, gravelly sand, and cobble-boulder gravel) that overlie the older alluvial deposits below 138 feet bgs, as observed in core samples. The induction log conducted at MW-55-120 shows an increasing conductivity with depth in the older alluvial deposits (below 47 feet bgs), which is consistent with the groundwater quality data collected during drilling and well sampling (Sections 3.2 and 3.3).

## 2.6 Monitoring Well Groundwater Sampling

Initial groundwater samples were collected from all newly installed monitoring wells a minimum of 3 days after the completion of well development activities. Initial samples from the vertical wells were collected on April 14 and April 15, 2008, and the initial samples from the slant well were collected on April 29, 2008. A second round of groundwater samples was collected from all newly installed wells on June 2 through June 4, 2008, approximately one month after the collection of the last initial sample. Per ADEQ (2007a), the wells are to be sampled monthly for the first 6 months after installation; however, only data from the first two events are presented in this report. Laboratory analysis and results of the groundwater samples are discussed in Section 3.3.

The monitoring wells were sampled using the methods and procedures described in the Work Plan, which are consistent with sampling procedures used by the Topock Groundwater Monitoring Program (GMP). Groundwater samples were collected from the vertical wells using a temporary adjustable-rate, electric submersible pump. Due to the small well diameter and shallow depth to groundwater, the slant wells were purged and sampled using a peristaltic pump. All wells were purged and sampled using the three-casing volume method to obtain representative groundwater samples from the aquifer zone and to be consistent with the existing monitoring wells at the site. Further, field water quality parameters (temperature, pH, specific conductance, ORP, dissolved oxygen, and turbidity) were measured and recorded during purging with an in-line water quality meter (within a flow cell) during each sampling event. Groundwater sampling activities followed the procedures, analytical methods, reporting limits, and quality control plan used for the Topock GMP, as described in the *Sampling, Analysis, and Field Procedures Manual* (CH2M HILL, 2005).

## 2.7 Hydraulic Monitoring

An aquifer recovery test was conducted on May 29 and May 30, 2008 and used extraction and injection wells associated with the IM No. 3 groundwater treatment facility. The purpose of the recovery test was to collect a comprehensive set of hydraulic data from site wells, including in the newly installed wells on the Arizona side of the river, for subsequent groundwater model calibration. Groundwater extraction at wells PE-01 and TW-03D and treated groundwater injection at well IW-3 were systematically shut down and later were restarted. Forty monitoring wells were used as observation points during the test, including the five newly installed MW-54 and MW-55 vertical monitoring wells. Due to imprecision in the angle of the well casings, it is not possible to accurately determine the vertical depth of the transducers in the MW-56 wells. Therefore, the equivalent freshwater head cannot be calculated with the necessary degree of accuracy to tie the water level elevations at the slant wells into the rest of the monitoring network, and the wells were not included as monitoring wells for this recovery test. The schedule for extraction/injection shut-down and re-start is summarized as follows:

| Date (2008) | Time | Event |
|---|---|---|
| May 29 | 07:06 | IW-03 injection rate reduced from approximately 130 to 95 gpm |
| | | PE-01 extraction rate reduced from approximately 32 to 0 gpm (off) |
| May 29 | 14:58 | TW-03D extraction rate reduced from approximately 100 to 0 gpm (off) |
| May 29 | 21:58 | IW-03 injection rate reduced from approximately 95 to 0 gpm (off) |
| May 30 | 07:15 | TW-03D extraction restarted, pumping at approximately 100 gpm |
| May 30 | 13:55 | IW-03 injection restarted, rate at approximately 130 gpm |
| May 30 | 21:15 | PE-01 extraction restarted, pumping at approximately 32 gpm |

gpm = gallons per minute.

Water levels in each observation well were monitored throughout the test with pressure transducers equipped with data loggers. Baseline data (i.e., data collected before the change in extraction and injection rates) were collected a minimum of 5 days before extraction/injection shutdown. Similarly, data were collected for several days following the re-start of extraction/injection. Data analysis methods and associated results, as they pertain to the Arizona Drilling Program, are presented in Section 3.4.

## 2.8 Investigation-derived Waste Management

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

Approximately 10 cubic yards of drill cuttings were generated during this investigation and stored at the staging area located on the Topock Compressor Station. A composite soil characterization sample was collected following well construction activities. The sample was collected on April 30, 2008 and was submitted to the laboratory for the same analyses used for disposal characterization of drill cuttings during previous drilling projects, including CAM metals (6010B), mercury, and percent moisture. Based on the laboratory results of the characterization sample, the soils were non-hazardous and were therefore managed onsite in accordance with previous drilling projects.

# 3.0 Investigation Results

This section presents the results of the lithologic and water quality sampling conducted for the Arizona Drilling Program. More detailed analysis and interpretation of the investigation results, as well as integration of the data in the Topock site hydrogeologic conceptual model, will be provided in the RFI/RI Report Volume 2 Addendum currently scheduled for submittal in late 2008.

## 3.1 Hydrogeology

A primary objective of the Arizona Drilling Program was to further characterize the hydrogeologic conditions near the Arizona shore of the Colorado River, as well as beneath the river channel, downstream of the chromium plume observed in the California floodplain. As discussed in Section 2.2, continuous core was collected from ground surface to several feet into consolidated Miocene Conglomerate bedrock at three locations near the Arizona shoreline.

Two hydrogeologic cross-sections—A-A′, shown in Figure 3-1, and B-B′, shown in Figure 3-2—have been prepared to illustrate the drilling results and hydrogeologic data for the Arizona Drilling Program. Cross-section transect locations are illustrated in Figure 2-1. The cross-sections present the interpreted hydrostratigraphy, the installed well screen intervals, and the bedrock elevation data from Arizona drilling sites (MW-54 and MW-56) and several drilling sites on the California side of the river. Drilling data from within the channel (geotechnical CB-series borings drilled in 1962 by Caltrans) are also included on cross-section A-A′. The hydrogeologic information and bedrock elevation data from the Arizona Drilling Program will be incorporated in the site hydrogeologic conceptual model to be presented in the RFI/RI Report Volume 2 Addendum.

### 3.1.1 MW-54 Borehole

Both fluvial and alluvial sediments were observed in the core from the MW-54 borehole. Relatively fine-grained fluvial deposits, predominantly composed of poorly-graded fine to medium sand, were observed from ground surface to approximately 96 feet bgs. These relatively fine-grained fluvial sediments are representative of a low energy, over bank-type depositional environment; however, the sediments from the shallower portion of this interval have likely been re-deposited as dredge spoils from past efforts to widen/deepen the river channel. The deepest section of the fluvial sediments, from approximately 96 feet to 138 feet bgs (top of the alluvial sediments), are predominantly composed of cobbles, boulders, and well-graded gravels. These coarser deposits are representative of a higher-energy depositional environment (i.e., closer to the primary river channel). The alluvial sediments observed between the fluvial sequence and the underlying Miocene Conglomerate bedrock are predominantly well-graded sands that become finer-grained with depth. Approximately 35 feet of moderately consolidated sandy silt were logged above the Miocene bedrock surface (230 feet bgs). In contrast to the fluvial sediments, which are more rounded and largely yellowish-brown in color, the alluvial sediments observed are more angular and reddish in color, likely indicating that alluvial sediments are locally derived from Miocene-age bedrock. Qualitative borehole specific capacity data collected during Isoflow® sample collection indicate that the fluvial sediments are more permeable than the underlying alluvial sediments.

### 3.1.2 MW-55 Borehole

The MW-55 borehole was drilled adjacent to a surface outcrop of Miocene Conglomerate bedrock and outside the primary depositional area of the river. The material observed from ground surface to approximately 97 feet bgs is predominantly locally-derived alluvial sands and gravels. The material from below 97 feet to the top of consolidated Miocene Conglomerate bedrock (131 feet bgs) is similar to that above but includes clasts of consolidated Miocene Conglomerate. Additionally, a profile of increasing specific conductance with depth was observed during the collection of Isoflow® samples below 97 feet, which is consistent with water quality trends observed in the older Tertiary alluvium at other site locations.

### 3.1.3 MW-56 Borehole

Beneath the Colorado River, in the area of MW-56, fluvial sediments overlie the surface of the Miocene Conglomerate bedrock. As observed in the majority of the core, sediments from ground surface to approximately 90 feet bgs are composed primarily of poorly-graded, fine-to-medium sands with little to no silt or clay. Intervals containing organic material (i.e., wood and various plant debris) were observed sporadically throughout the fluvial sediments. Well-graded fluvial sands and gravels were observed from below the fine-grained fluvial deposits to the top of the consolidated Miocene Conglomerate bedrock (107 feet bgs). No appreciable layers or thicknesses of low-permeability clay or silt (potential aquitards) were encountered in MW-56.

## 3.2 Depth-specific Groundwater Sample Results

As described in Section 2.3, depth-specific groundwater samples were collected during borehole drilling using the Isoflow® system for Cr(VI) and ferrous iron field laboratory analysis and for field water quality measurement. Because the groundwater samples were obtained from open boreholes during drilling (i.e., grab samples) and were analyzed by the field laboratory, the sampling results are considered screening-level data for qualitative assessment of water quality conditions in the aquifer.

During drilling, grab samples were collected as shallowly as possible and then were collected at the intervals specified in the Work Plan and as directly above bedrock as technically practicable. Thirteen grab samples were collected from the deepest borehole at MW-54, six grab samples were collected from the MW-55 borehole, and nine grab samples were collected from the MW-56 borehole. Table 3-1 summarizes the depth-discrete groundwater sample results and field water quality measurement data.

With the exception of one grab sample, Cr(VI) was not detected in any the grab groundwater samples analyzed by the IM No. 3 field laboratory. The grab sample collected from the MW-55 borehole at 57 to 67 feet bgs initially resulted in an apparent detection of Cr(VI) at the reporting limit (10 µg/L). However, upon re-analysis of the sample, Cr(VI) was not detected at a concentration greater than or equal to the reporting limit. Ferrous iron was not detected in any of the grab samples collected at the MW-54 or MW-55 locations. However, ferrous iron was detected in seven of the nine grab samples collected below the river channel (MW-56 borehole) at concentrations ranging from 0.13 milligrams per liter (mg/L) to 2.67 mg/L. The most elevated concentrations of ferrous iron were observed at the vertical depth ranges of 22 to 27 and 52 to 57 feet bgs. Significant concentrations of ferrous iron are typical of the most geochemically reduced areas of the floodplain.

Field measurements of ORP were negative (i.e., indicative of reducing conditions) for every grab sample collected at each drilling location. Field measurements of ORP in grab groundwater samples from the vertical boreholes ranged from -65 millivolts (mV) to -244 mV. ORP measurements in grab samples from the slant MW-56 borehole ranged from -108 mV to -280 mV. Deeper grab samples generally had more negative ORP measurements (particularly in the MW-54 and MW-56 boreholes), indicating stronger reducing conditions with depth. Depth trends observed in the dissolved oxygen and specific conductance measurements also support this interpretation.

Estimations of specific capacity based on average pumping rates and drawdown measurements during grab sample collection are presented in Table 3-1. Several variables, including the degree of borehole collapse and the degree of formation disturbance induced by drilling, limit the precision of these data; however, in general, elevated specific capacity values correspond with zones of coarser-grained sediments, as observed in the core samples.

## 3.3 Multilevel Groundwater Monitoring Well Sampling

As discussed in Section 2.6, the initial groundwater samples were collected from each well at locations MW-54, MW-55, and MW-56 after the completion of well development. A second sample was collected approximately one month later. Results from the initial two sample events are presented in this section. Laboratory analytical results for chromium and field water quality measurement data are summarized in Table 3-2. In addition to Cr(VI) and Cr(T), groundwater samples collected during the first event (April 2008) were analyzed for a more comprehensive list of analytes including various cations and anions, total dissolved solids, and stable isotopes. The stable isotope data were useful in determining whether residual water from the Colorado River, which was used during drilling because it has an isotopic signature different than that of the groundwater, had been completely removed during well development. Results for the additional analyses are presented in Table 3-3.

Analytical results for Cr(VI) and Cr(T) for the newly installed wells from both initial sampling rounds were less than laboratory reporting limits. Concentrations of total dissolved solids increased with depth at each location, as was observed in the depth-specific samples during drilling. The cation and anion data indicate that the dissolved solids are predominantly sodium and chloride, with lesser sulfate concentrations.

Field measurements of ORP collected during the two initial groundwater sample collection events were all negative, ranging from -139 mV to -228 mV. Field measurements of specific conductance ranged from 1,580 to 24,500 microSiemens per centimeter. Generally, specific conductance increased with depth, and the highest concentrations measured in the field were observed in MW-56D during both the sampling events.

## 3.4 Hydraulic Monitoring

Water level data collected from pressure transducers with data loggers during the May 29 and May 30, 2008 IM No. 3 extraction/injection shutdown (detailed in Section 2.7) were analyzed to estimate aquifer response. The data were analyzed using the deconvolution method of Halford (USGS, 2006) to screen out the hydraulic effects of fluctuations in river stage, which will obscure aquifer response in wells hydraulically connected to the river. As detailed in the *Summary Report for Hydraulic Testing in Bedrock Wells* (CH2M HILL 2008b), this analytical method has been applied for previous hydraulic evaluations at the site. For this evaluation, the deconvolution fitting period applied to most of the hydraulic data was from May 22 to May 29, which was prior to extraction/injection shutdown and most representative of background conditions. In addition, for some observation wells, background data collected after extraction/injection was re-started was used to conduct additional calculation of the river effects, and/or by the use of one of the MW-40 wells as a benchmark well representative of baseline hydraulic conditions.

After deconvolution analysis, the magnitude of aquifer response (draw-up/draw-down) at 40 observation wells was evaluated. In general, the detection limit for observable water level fluctuation was 0.2 foot. However, the detection limit for water level change in MW-26 was 0.6 foot due to an equipment malfunction. Figure 3-3 presents the hydraulic response estimated at each observation well at approximately 7:00 a.m. on May 30, 2008, which is immediately before extraction/injection was re-started and is coincident with the maximum extent of water level response observed during the shutdown. Hydraulic response attributable to the shutdown of groundwater extraction in wells PE-01 and TW-03D was observed in wells up to 1,600 feet away from the nearest extraction well. The hydraulic response attributable to the shutdown of injection well IW-3 was observed in wells up to approximately 1,300 feet away. Hydraulic response is likely present but not quantifiable on the Arizona side of the river. For the MW-54 and MW-55 monitoring well clusters, the lack of quantifiable response is likely due, in part, to the strong influence of river stage on groundwater levels due to the proximity of these wells to the river.

## 3.5 Data Quality Assessment

The laboratory analytical data generated from the first and second sampling events of the monitoring wells installed during the Arizona Drilling Program were independently reviewed by project chemists to assess data quality and identify deviations from analytical requirements. The quality assurance and quality control requirements are outlined in the Quality Assurance Project Plan for the PG&E Topock Program, which is Appendix D of the *Sampling, Analysis, and Field Procedures Manual, Revision 1* (CH2M HILL, 2005). A summary discussion of data quality for Arizona sampling data is presented below. Additional details are provided in the data validation reports, which are kept in the project file and are available upon request.

- **Matrix Interference:** Matrix interference was encountered in three groundwater samples that affected the sensitivity for Cr(VI) when using United States Environmental Protection Agency Method E218.6. Two Cr(VI) sample results from MW-54-195 and one result from MW-56D reflect an adjusted reporting limit of 1 µg/L as a result of the serial dilution that was required to overcome the matrix interference and provide an acceptable matrix spike recovery. No qualifier flags were applied.
- **Matrix Spike Sample:** All matrix spike acceptance criteria were met.
- **Quantitation and Sensitivity:** In addition to the matrix interference issues, a sample from MW-56D had dissolved iron and dissolved manganese reported as non-detect with elevated reporting limits. All other method and analyte combinations met the project reporting limit objectives.
- **Holding Time Data Qualification:** All method holding time requirements were met.
- **Method Blanks:** Dissolved sodium was detected at a concentration greater than the reporting limit in one method blank. However, due to the high concentrations reported in the samples, no qualifier flags were applied.
- **Equipment Blanks:** All equipment blank acceptance criteria were met.
- **Laboratory Duplicate Samples:** All laboratory duplicate acceptance criteria for the methods were met.
- **Calibration:** All initial and continuing instrument calibration criteria were met.
- **Laboratory Control Samples:** Results for three total dissolved solids samples were qualified because the relative percent difference between the laboratory control sample result and the laboratory control sample duplicate result were greater then the upper control limit of 10 percent. The detect results were "J" flagged.

For first and second sampling events at the monitoring wells installed during the Arizona Drilling Program, the completeness objectives were met for all method and analyte combinations. The analyses and data quality met the Quality Assurance Project Plan and laboratory method quality control criteria, except as noted above. Overall, the analytical data are considered acceptable for the purposes of the Arizona Drilling Program.

# 4.0 Summary

This report presents a summary of the installation of monitoring wells near the Arizona shore of Colorado River at Topock, Arizona. Additionally, the results of laboratory analysis of the two initial rounds of groundwater sample collection are presented. The primary objectives of the well installation program were to assess chromium concentrations and groundwater geochemical conditions beneath the Colorado River downstream from the chromium plume observed in the California floodplain and near the Arizona shore east of the Topock site for completion of the RFI/RI and for corrective measures planning.

The field investigation and sampling tasks completed included:

- Completing the necessary site preparation, including pre- and post-construction surveys.
- Performing drilling and lithologic logging of three vertical borings and one angled boring (beneath the Colorado River).
- Collecting 28 depth-discrete groundwater grab samples during drilling to provide a screening assessment of groundwater quality in the sediments adjacent and beneath the Colorado River.
- Installing five vertical groundwater monitoring wells in the three vertical borings and one multilevel groundwater monitoring well in the angled boring.
- Performing cased-hole geophysical logging in the deepest wells at the two vertical well locations (MW-54-195 and MW-55-120).
- Performing initial groundwater sampling and analyses for Cr(VI), Cr(T), and general chemistry parameters for water quality characterization at the new monitoring well locations.
- Monitoring hydraulic response in 40 wells (including the five newly installed vertical wells in Arizona) during a May 2008 IM No. 3 extraction/injection well shutdown.

The Work Plan identified a contingency well that may be installed if chromium concentrations in groundwater in the slant boring exceed the California maximum contaminant level of 50 µg/L or if concentrations of Cr(VI) are above natural background levels of 31.8 µg/L (CH2M HILL, 2008c). Because these levels of chromium were not found during this investigation, the contingency well was not installed.

Activities conducted during the Arizona Drilling Program accomplished the Work Plan objectives for characterizing chromium concentrations and natural geochemical groundwater conditions in groundwater in the Alluvial Aquifer near the Arizona shore and beneath the Colorado River. Further, monitoring points were installed for ongoing water quality and water level monitoring.

The drilling and lithologic data collected during this project have further characterized the sediment characteristics and hydrostratigraphy beneath and adjacent to the Colorado River and have confirmed the overall hydrogeologic framework. The new data confirm the following:

- At the MW-54 location, Miocene Conglomerate bedrock is overlain by older Tertiary alluvium, which is overlain by a relatively thick sequence of coarse-grained, cobble-boulder gravel, and fine-grained fluvial deposits.
- Sand and gravel of alluvial fan origin overlie Miocene Conglomerate bedrock at the MW-55 location. Fluvial sediments were not logged at this location and therefore were either not deposited or were not preserved at this drilling location.
- Predominantly fine-grained (low energy) fluvial deposits overlie Miocene Conglomerate bedrock at the MW-56 location.
- The depth of the Miocene Conglomerate bedrock encountered in the borings at each location is generally consistent with the interpretation of bedrock structure presented in the RFI/RI Report, Volume 2 (CH2M HILL, 2008d).

Groundwater quality data collected during drilling and two well sampling events indicate that a moderately to strongly reducing natural geochemical environment exists in the sediments encountered by the borings/wells. Cr(VI) would be reduced to trivalent chromium in this geochemical environment. Other than an unrepeatable Cr(VI) reading at the detection limit in one grab sample, Cr(VI) was not detected in any of the depth-specific groundwater grab samples from the borings (on-site laboratory analyses) nor in the samples collected from the developed monitoring wells during the two initial rounds of sampling (certified laboratory analyses).

The characterization data collected during the Arizona Drilling Program will be integrated into the hydrogeologic conceptual model for the PG&E Topock site and will be discussed in the RFI/RI Volume 2 Addendum. In addition, as required by ADEQ, the wells will be sampled monthly for an additional 4 months (through October 2008) following the two initial sampling events presented in this report. The results from these additional monthly monitoring events will be reported under separate covers, as the data become available, and in routine GMP monitoring reports.

# 5.0 References

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# Tables

TABLE 2-1

Summary of Well Installation Details

Installation Report for Wells on the Arizona Shore of the Colorado River at Topock, Arizona

*PG&E Topock Compressor Station*

| Borehole Details | | | | | | | | | | Well Details | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **Site ID** | **Boring ID** | **Borehole Angle from Horizontal (degrees)** | **Azimuth (degrees)** | **Borehole Depth (feet drilled along slant)** | **Borehole Depth (feet bgs)** | **Lateral Projection** | **Ground Surface Northing** | **Ground Surface Eastings** | **Ground Surface Elevation (feet msl)** | **Wells Installed** | **Sample Filter Interval (feet drilled along slant)** | **Sample Filter Interval (feet bgs)** |
| Site 1 | MW-54S | --- | --- | --- | 147 | --- | 2102958.94 | 7617082.61 | 466.39 | MW-54-085 | - | 77-87 |
| Site 1 | MW-54S | --- | --- | --- | 147 | --- | 2102958.94 | 7617082.61 | 466.39 | MW-54-140 | - | 128-138 |
| Site 1 | MW-54D | --- | --- | --- | 237 | --- | 2102951.91 | 7617089.25 | 466.28 | MW-54-195 | - | 185-195 |
| Site 2 | MW-55 | --- | --- | --- | 137 | --- | 2102605.88 | 7618326.3 | 463.57 | MW-55-045 | - | 37-47 |
| Site 2 | MW-55 | --- | --- | --- | 137 | --- | 2102605.88 | 7618326.3 | 463.57 | MW-55-120 | - | 108-118 |
| Site AB-2 | MW-56 | 30 | 270 | 223 | 111.5 | 193 | 2101569 | 7617644.94 | 459.93 | MW-56S | 67-71 | 33.5-35.5 |
| Site AB-2 | MW-56 | 30 | 270 | 223 | 111.5 | 193 | 2101569 | 7617644.94 | 459.93 | MW-56M | 147-151 | 73.5-75.5 |
| Site AB-2 | MW-56 | 30 | 270 | 223 | 111.5 | 193 | 2101569 | 7617644.94 | 459.93 | MW-56D | 207-211 | 103.5-105.5 |

NOTES:

feet bgs feet below ground surface (datum is ground surface at top of borehole

ft msl mean sea level

North edge of protective monument is being used as a general vertical datum for each well until universal measurement datum can be installed and surveyed.

Survey Datum: North American Datum 1983, California State Plane, Zone V, Feet

TABLE 3-1
Depth-Discrete Groundwater Sample Results and Field Measurements
*PG&E Topock Compressor Station*

| Isoflow Sample Collection Date | | | | | | Analysis Results | | | Isoflow Purge WQ Parameters (final reading) | | | | | | Isoflow Purging Data | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Sample Interval Angle Boring Depth (feet drilled) | Vertical Depth (ft) | Lateral Distance (ft) | Sample Date | Sample Time | Sample ID | Cr (VI) Analysis IM3 Lab (µg/L) | Ferrous Iron IM3 Lab (mg/L) | Cr(T) Analysis Certified Lab | ORP (mV) | DO (mg/L) | Specific Conduct. (µS/cm) | Temp. (°C) | pH (pHunits) | Turbidity (NTU) | Volume Purged (gallons) | Average Pumping Rate (gpm) | Drawdown (ft from TOC) | Specific Capacity (gpm/ft) | Remarks |
| **MW-54** | | | | | | | | | | | | | | | | | | | |
| 27-37 | --- | --- | 3/12/2008 | 1:30 PM | MW54-GGW-01 | ND (10) S | ND (0.05) S | NA | -180 | 1.04 | 4,440 | 27.0 | 7.78 | 8.91 | 250 | 12 | 0.2 | 60.00 | 150 gal of water injected during drilling |
| 37-47 | --- | --- | 3/12/2008 | 3:35 PM | MW54-GGW-02 | ND (10) S | ND (0.05) S | NA | -169 | 0.30 | 6,140 | 27.1 | 7.65 | 18.6 | 309 | 13 | 10 | 1.30 | 180 gal of water injected during drilling |
| 57-67 | --- | --- | 3/13/2008 | 9:31 AM | MW54-GGW-03 | ND (10) S | ND (0.05) S | NA | -129 | 1.11 | 8,430 | 26.4 | 7.47 | 25.0 | 500 | 20 | 4.9 | 4.08 | 300 gal of water injected during drilling |
| 77-87 | --- | --- | 3/13/2008 | 1:05 PM | MW54-GGW-04 | ND (10) S | ND (0.05) S | NA | -112 | 1.68 | 9,570 | 25.7 | 7.48 | 26.7 | 430 | 20 | 4.5 | 4.44 | 300 gal of water injected during drilling |
| 87-97 | --- | --- | 3/13/2008 | 3:50 PM | MW54-GGW-05 | ND (10) S | ND (0.05) S | NA | -132 | 0.43 | 10,300 | 26.0 | 7.29 | 184 | 410 | 20 | 8.2 | 2.44 | 350 gal of water injected during drilling |
| 97-107 | --- | --- | 3/14/2008 | 8:45 AM | MW54-GGW-06 | ND (10) S | ND (0.05) S | NA | -130 | 0.29 | 10,600 | 26.0 | 7.40 | | 450 | 10 | 9.6 | 1.04 | 400 gal of water injected during drilling |
| 107-117 | --- | --- | 3/14/2008 | 12:55 PM | MW54-GGW-07 | ND (10) S | ND (0.05) S | NA | -153 | 0.36 | 10,300 | 26.5 | 7.52 | 209 | 560 | 15 | 17.0 | 0.88 | 500 gal of water injected during drilling |
| 127-137 | --- | --- | 3/14/2008 | 3:40 PM | MW54-GGW-08 | ND (10) S | ND (0.05) S | NA | -117 | 0.79 | 12,000 | 25.1 | 7.87 | 171 | 560 | 20 | 4.7 | 4.26 | 500 gal of water injected during drilling |
| 147-157 | --- | --- | 3/15/2008 | 9:10 AM | MW54-GGW-09 | ND (10) S | ND (0.05) S | NA | -156 | 0.11 | 15,500 | 24.9 | 7.92 | 69.0 | 660 | 15 | 7.5 | 2.0 | 600 gal of water injected during drilling |
| 167-177 | --- | --- | 3/15/2008 | 2:25 PM | MW54-GGW-10 | ND (10) S | ND (0.05) S | NA | -181 | 1.66 | 18,700 | 24.8 | 8.13 | 38.0 | 1080 | 20 | 16 | 1.3 | 1000 gal of water injected during drilling |
| 187-197 | --- | --- | 3/16/2008 | 7:55 AM | MW54-GGW-11 | ND (10) S | ND (0.05) S | NA | -244 | 0.18 | 19,800 | 25.3 | 8.34 | 144 | 880 | 20 | 13.6 | 1.5 | 800 gal of water injected during drilling |
| 207-217 | --- | --- | 3/17/2008 | 7:05 AM | MW54-GGW-12 | ND (10) S | ND (0.05) S | NA | -243 | 0.36 | 25,100 | 25.5 | 8.06 | | 330 | 10 | 70.4 | 0.1 | 250 gal of water injected during drilling |
| 227-237 | --- | --- | 3/18/2008 | 9:25 AM | MW54-GGW-13 | ND (10) S | ND (0.05) S | NA | -239 | 0.21 | 29,700 | 27.0 | 8.00 | 216 | 380 | 6 | 45.1 | 0.1 | 300 gal of water injected during drilling |
| **MW-55** | | | | | | | | | | | | | | | | | | | |
| 27-37 | --- | --- | 3/29/2008 | 3:55 PM | MW55-GGW-01 | ND (10) S | ND (0.05) S | NA | -152 | 3.51 | 1,480 | 28.9 | 7.67 | 293 | 380 | 12 | 1.8 | 6.67 | 200 gal of water injected during drilling |
| 37-47 | --- | --- | 3/30/2008 | 7:20 AM | MW55-GGW-02 | ND (10) S | ND (0.05) S | NA | -96 | 0.36 | 1,790 | 28.1 | 7.64 | | 280 | 15 | 1.7 | 8.82 | 200 gal of water injected during drilling |
| 57-67 | --- | --- | 3/30/2008 | 10:35 AM | MW55-GGW-03 | ND (10) S | ND (0.05) S | NA | -120 | 0.43 | 1,440 | 28.6 | 7.77 | 417 | 580 | 15 | 9 | 1.67 | 500 gal of water injected during drilling |
| 77-87 | --- | --- | 3/30/2008 | 1:25 PM | MW55-GGW-04 | ND (10) S | ND (0.05) S | NA | -65 | 1.05 | 1,520 | 28.6 | 8.14 | 65.0 | 555 | 12 | 9.5 | 1.26 | 450 gal of water injected during drilling |
| 97-107 | --- | --- | 3/31/2008 | 10:20 AM | MW55-GGW-05 | ND (10) S | ND (0.05) S | NA | -142 | 0.54 | 7,400 | 30.1 | 7.90 | | 350 | 12 | 39.7 | 0.30 | 250 gal of water injected during drilling |
| 117-127 | --- | --- | 3/31/2008 | 12:35 PM | MW55-GGW-06 | ND (10) S | ND (0.05) S | NA | -77 | 0.60 | 9,340 | 30.5 | 7.88 | | 280 | 12 | 21.7 | 0.55 | 200 gal of water injected during drilling |
| **MW-56** | | | | | | | | | | | | | | | | | | | |
| 43-53 | 27 | 46 | 4/10/2008 | 7:01 AM | MW56-GGW-01 | ND (10) JS | 2.67 S | NA | -237 | 0.42 | 1,890 | 23.2 | 7.26 | 11.9 | 106 | 2.0 | NA | --- | 27 vertical depth, 46 horizontal |
| 63-73 | 37 | 63 | 4/10/2008 | 9:00 AM | MW56-GGW-02 | ND (10) S | ND (0.05) S | NA | -108 | 0.81 | 7,080 | 22.4 | 7.26 | 7.10 | 262 | 12 | 5 | 7.47 | 170 gal water injected; 37 vertical depth, 63 horizontal |
| 83-93 | 47 | 81 | 4/10/2008 | 11:20 AM | MW56-GGW-03 | ND (10) JS | 0.375 S | NA | -174 | 0.34 | 10,300 | 24.7 | 7.22 | 4.00 | 178 | 4 | 9.5 | 1.31 | 150 gal of water injected; 47 vertical depth, 81 horizontal |
| 103-113 | 57 | 98 | 4/10/2008 | 3:37 PM | MW56-GGW-04 | ND (10) JS | 2.56 S | NA | -198 | 0.27 | 13,600 | 29.3 | 7.13 | 63.0 | 159 | 0.5 | 14.4 | 0.11 | 150 gal of water injected; 57 vertical depth, 98 horizontal |
| 123-133 | 67 | 115 | 4/11/2008 | 11:10 AM | MW56-GGW-05 | ND (10) S | 0.222 S | NA | -146 | 0.00 | 14,800 | 24.4 | 6.98 | 14.6 | 185 | 2 | 19.8 | 0.31 | 150 gal of water injected; 67 vertical depth, 115 horizontal |
| 143-153 | 77 | 133 | 4/11/2008 | 2:22 PM | MW56-GGW-06 | ND (10) S | 0.75 S | NA | -175 | 0.00 | 14,700 | 24.2 | 7.13 | 15.4 | 178 | 1.7 | 14.4 | 0.37 | 150 gal of water injected; 77 vertical depth, 133 horizontal |
| 163-173 | 87 | 150 | 4/12/2008 | 7:30 AM | MW56-GGW-07 | ND (10) S | 0.13 S | NA | -248 | 0.00 | 17,000 | 22.9 | 7.80 | 5.72 | 227 | 3.5 | 4.5 | 2.42 | 170 gal of water injected; 87 vertical depth, 150 horizontal |
| 183-193 | 97 | 167 | 4/12/2008 | 10:18 AM | MW56-GGW-08 | ND (10) S | 0.148 S | NA | -254 | 0.00 | 18,600 | 24.2 | 7.92 | 8.26 | 275 | 4 | 15.8 | 0.79 | 220 gal of water injected; 97 vertical depth, 167 horizontal |
| 203-213 | 107 | 184 | 4/12/2008 | 1:11 PM | MW56-GGW-09 | ND (10) S | ND (0.05) S | NA | -280 | 0.00 | 18,700 | 25.5 | 8.07 | 4.66 | 350 | 4.5 | 12.7 | 1.10 | 300 gal of water injected; 107 vertical depth, 184 horizontal |

NOTES:

µS/cm microSiemens per centimeter
°C degree centigrade
ORP oxidation reduction potential, results rounded off to whole point
mV millivolts
µg/L micrograms per liter
mg/L milligrams per liter
% percentage
NTU Nephelometric Turbidity Unit
ND not detected at listed reporting limit
J analyte was present, but reported value was estimated
S Screening level data
--- not collected

TABLE 3-2
Groundwater Analytical Results for New Arizona Monitoring Wells, Chromium and Field Water Quality Parameters
Installation Report for Wells on the Arizona Shore of the Colorado River at Topock, Arizona
*PG&E Topock Compressor Station*

| | | Lab Data | | Field Data | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| **Location** | **Sampling Date** | **Chromium (µg/L)** | **Hexavalent Chromium (µg/L)** | **Specific Conductance (µS/cm)** | **Temperature (°C)** | **pH (pH units)** | **ORP (mV)** | **Dissolved Oxygen (mg/L)** | **Salinity (%)** | **Turbidity (NTU)** |
| MW-54-085 | 15-Apr-08 | ND (1.0) | ND (0.2) | 10,100 | 25.9 | 7.67 | -202 | 0.20 | 0.565 | 16.0 |
| MW-54-085 | 03-Jun-08 | ND (1.0) | ND (0.2) | 11,500 | 25.8 | 7.45 | -139 | 0.26 | 0.741 | 4.00 |
| MW-54-140 | 14-Apr-08 | ND (1.0) | ND (0.2) | 12,400 | 25.0 | 7.66 | -162 | 0.16 | 0.71 | 5.00 |
| MW-54-140 | 03-Jun-08 | ND (1.0) | ND (0.2) | 13,900 | 24.9 | 7.70 | -139 | 0.20 | 0.898 | 1.70 |
| MW-54-195 | 14-Apr-08 | ND (1.0) | ND (1.0) | 21,800 | 25.1 | 8.18 | -202 | 0.15 | 1.31 | 4.00 |
| MW-54-195 | 03-Jun-08 | ND (1.0) | ND (1.0) | 21,500 | 24.9 | 8.22 | -199 | 0.13 | 1.39 | 8.84 |
| MW-55-045 | 15-Apr-08 | ND (1.0) | ND (0.2) | 1,580 | 22.9 | 8.08 | -222 | 0.13 | 0.079 | 26.0 |
| MW-55-045 | 03-Jun-08 | ND (1.0) | ND (0.2) | 1,700 | 27.6 | 7.66 | -176 | 0.09 | 0.11 | 3.00 |
| MW-55-120 | 15-Apr-08 | ND (1.0) | ND (0.2) | 8,940 | 28.6 | 8.10 | -206 | 0.17 | 0.497 | 7.00 |
| MW-55-120 | 03-Jun-08 | ND (1.0) | ND (0.2) | 9,810 | 28.5 | 7.91 | -170 | 0.23 | 0.634 | 4.68 |
| MW-56S | 29-Apr-08 | ND (1.0) | ND (0.2) | 6,760 | 22.3 | 7.39 | -214 | 0.00 | 0.37 | 0.60 |
| MW-56S | 04-Jun-08 | ND (1.0) | ND (0.2) | 7,220 | 22.1 | 7.95 | -173 | 0.23 | 0.467 | 1.30 |
| MW-56M | 29-Apr-08 | ND (1.0) | ND (0.2) | 18,700 | 23.0 | 7.38 | -228 | 0.30 | 1.15 | 0.70 |
| MW-56M | 04-Jun-08 | ND (1.0) | ND (0.2) | 18,900 | 22.3 | 7.56 | -210 | 0.02 | 1.22 | 4.10 |
| MW-56D | 29-Apr-08 | ND (5.0) | ND (1.0) | 24,500 | 23.3 | 8.00 | -181 | 3.50 | 1.50 | 0.70 |
| MW-56D | 04-Jun-08 | ND (1.0) | ND (1.0) | 21,900 | 22.7 | 7.91 | -146 | 6.52 | 1.41 | 1.22 |

NOTES:

µg/L micrograms per liter
µS/cm microSiemens per centimeter
°C degree centigrade
ORP oxidation reduction potential, results rounded off to whole point
mV millivolts
mg/L milligrams per liter
% percentage
NTU Nephelometric Turbidity Unit
ND not detected at listed reporting limit

TABLE 3-3

Groundwater Analytical Results for New Arizona Monitoring Wells, General Chemistry Parameters

Installation Report for Wells on the Arizona Shore of the Colorado River at Topock, Arizona

*PG&E Topock Compressor Station*

| Loc ID | Sample Date | Dissolved Metal | | | | | | Alkalinity, as carbonate (mg/L) | Alkalinity, bicarbonate as CaCo3 (mg/L) | Alkalinity, total as CaCO3 (mg/L) | Chloride (mg/L) | Sulfate (mg/L) | Nitrate/Nitrite as nitrogen (mg/L) | Total Dissolved Solids (mg/L) | Total Organic Carbon (mg/L) | Ammonia as nitrogen (mg/L) | Total Kjeldahl Nitrogen (mg/L) | Deuterium (0/00) | Oxygen 18 (0/00) |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | Sodium (mg/L) | Potassium (mg/L) | Calcium (mg/L) | Magnesium (mg/L) | Manganese (mg/L) | Iron (mg/L) | | | | | | | | | | | | |
| MW-54-085 | 15-Apr-08 | 1790 | 17.8 | 225 | 91.6 | 0.771 | 0.892 | ND (5.0) | 145 | 145 | 3140 | 351 | ND (0.5) | 5680 J | 1.33 | ND (0.5) | ND (0.5) | -82.8 | -11.5 |
| MW-54-140 | 14-Apr-08 | 2550 | 19.3 | 135 | 14.8 | 1.41 | ND (0.5) | ND (5.0) | 110 | 110 | 3920 | 498 | ND (0.5) | 6900 | 3.26 | ND (0.5) | ND (0.5) | -85.3 | -12 |
| MW-54-195 | 14-Apr-08 | 5020 | 39.2 | 131 | 5.90 | 0.837 | ND (0.5) | ND (5.0) | 55.0 | 55.0 | 7150 | 1100 | ND (0.5) | 13000 | 5.01 | ND (0.5) | ND (0.5) | -86.1 | -12.4 |
| MW-55-045 | 15-Apr-08 | 267 | 8.63 | 32.7 | 9.48 | 0.547 | ND (0.5) | ND (5.0) | 195 | 195 | 315 | 74.9 | ND (0.5) | 865 J | 2.77 | ND (0.5) | ND (0.5) | -80.1 | -11.4 |
| MW-55-120 | 15-Apr-08 | 1780 | 27.6 | 136 | 8.21 | 0.935 | ND (0.5) | ND (5.0) | 70.0 | 70.0 | 2750 | 290 | ND (0.5) | 4870 J | 4.09 | ND (0.5) | ND (0.5) | -81 | -11.3 |
| MW-56S | 29-Apr-08 | 1240 | 13.6 | 88.9 | 34.5 | 0.787 | 2.59 | ND (5.0) | 520 | 520 | 1550 | 396 | ND (0.5) | 3770 | 6.97 | ND (0.5) | ND (0.5) | -77.2 | -10 |
| MW-56M | 29-Apr-08 | 2530 | 19.0 | 285 | 73.6 | 0.754 | 3.98 | ND (5.0) | 423 | 423 | 3690 | 931 | ND (0.5) | 8140 | 6.15 | ND (0.5) | 0.574 | -84.3 | -10.9 |
| MW-56D | 29-Apr-08 | 4360 | 35.5 | 343 | 65.5 | ND (2.5) | ND (2.5) | ND (5.0) | 105 | 105 | 6640 | 946 | ND (0.5) | 12400 | 4.79 | ND (0.5) | ND (0.5) | -85.3 | -11.2 |

**NOTES:**

ND not detected at listed reporting limit
mg/L milligrams per liter
0/00 differences from global standard in parts per thousand

# Figures

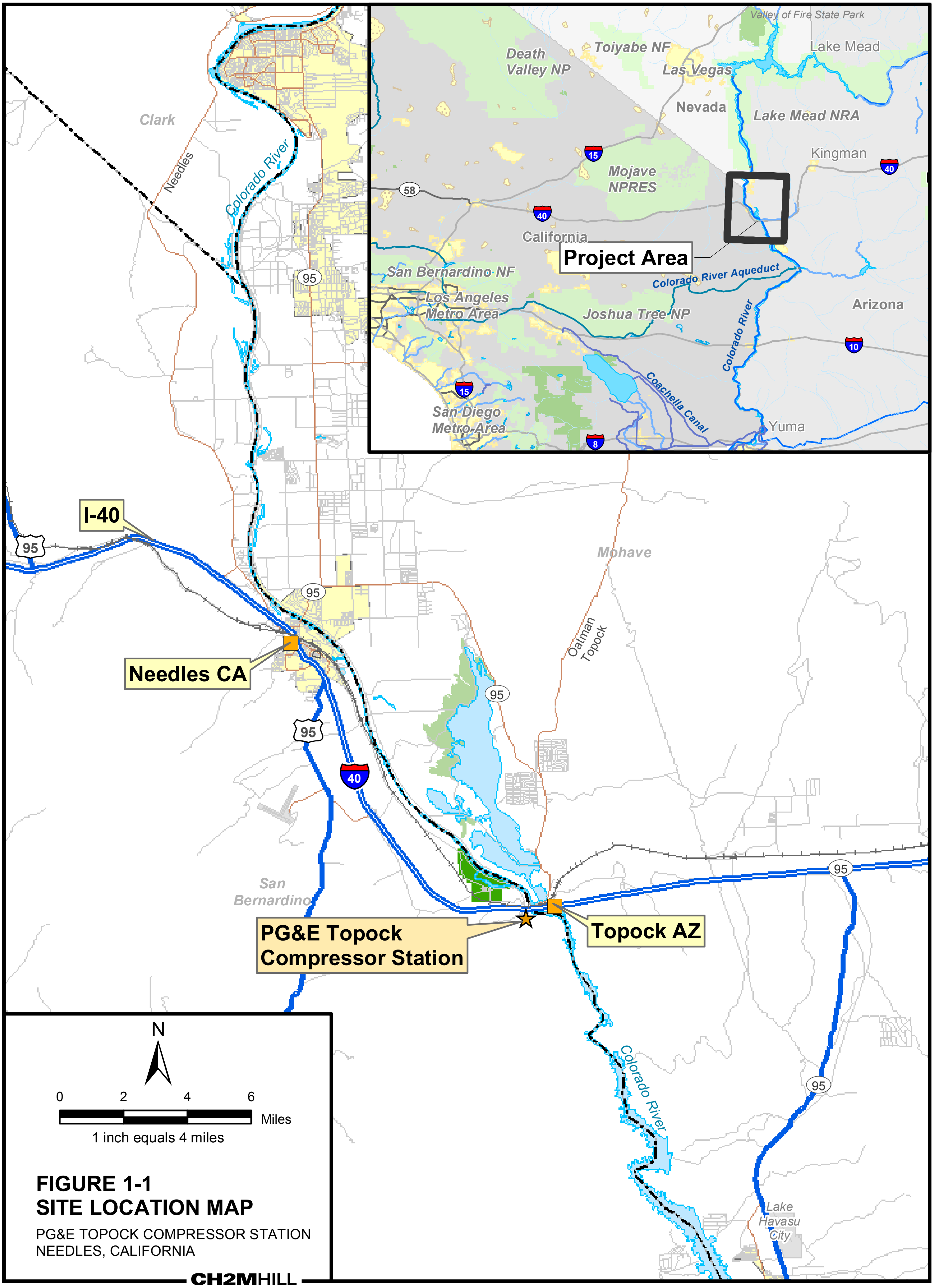


**FIGURE 1-1**
**SITE LOCATION MAP**
PG&E TOPOCK COMPRESSOR STATION
NEEDLES, CALIFORNIA

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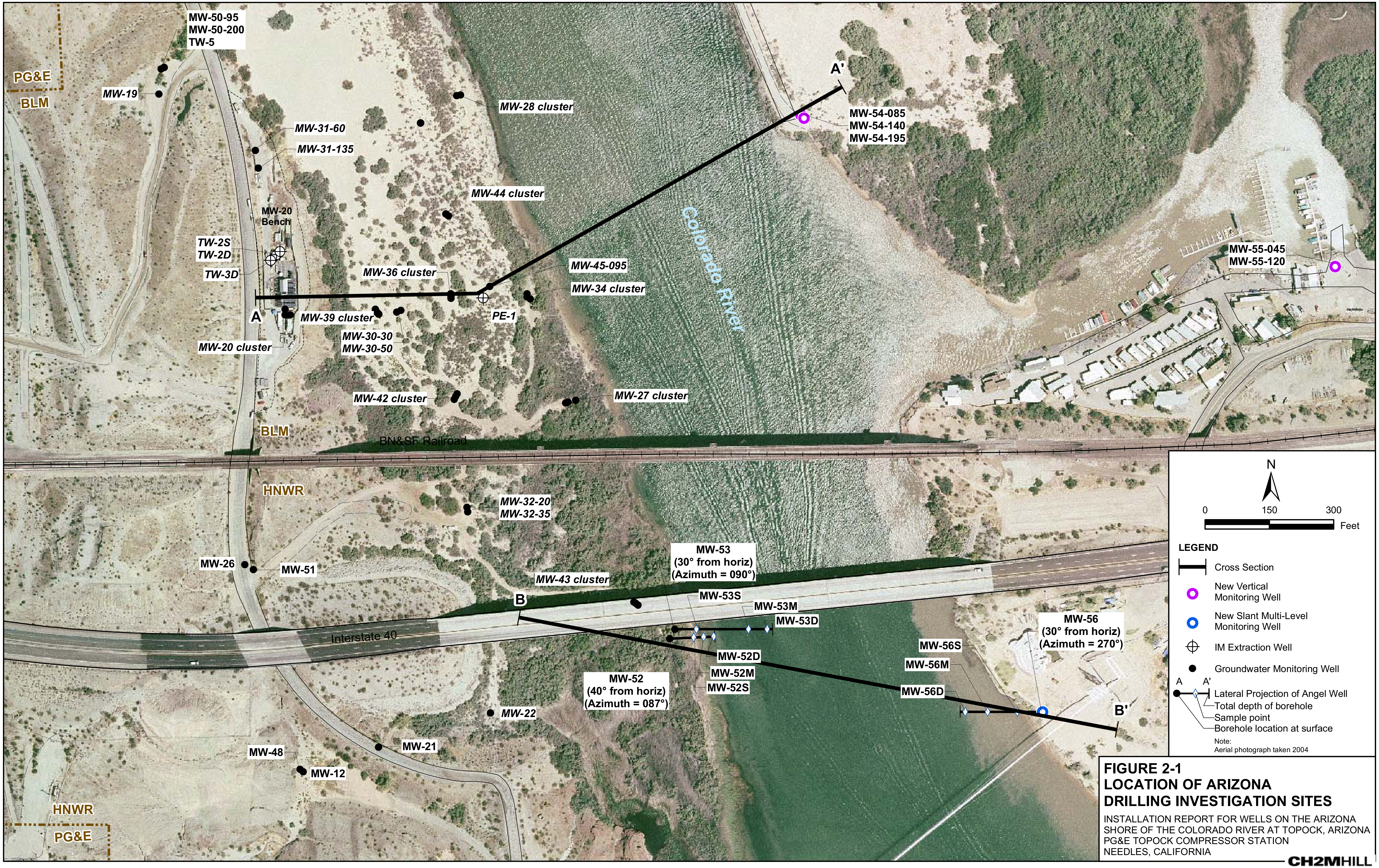


**FIGURE 2-1**
**LOCATION OF ARIZONA DRILLING INVESTIGATION SITES**

INSTALLATION REPORT FOR WELLS ON THE ARIZONA SHORE OF THE COLORADO RIVER AT TOPOCK, ARIZONA
PG&E TOPOCK COMPRESSOR STATION
NEEDLES, CALIFORNIA

CH2MHILL

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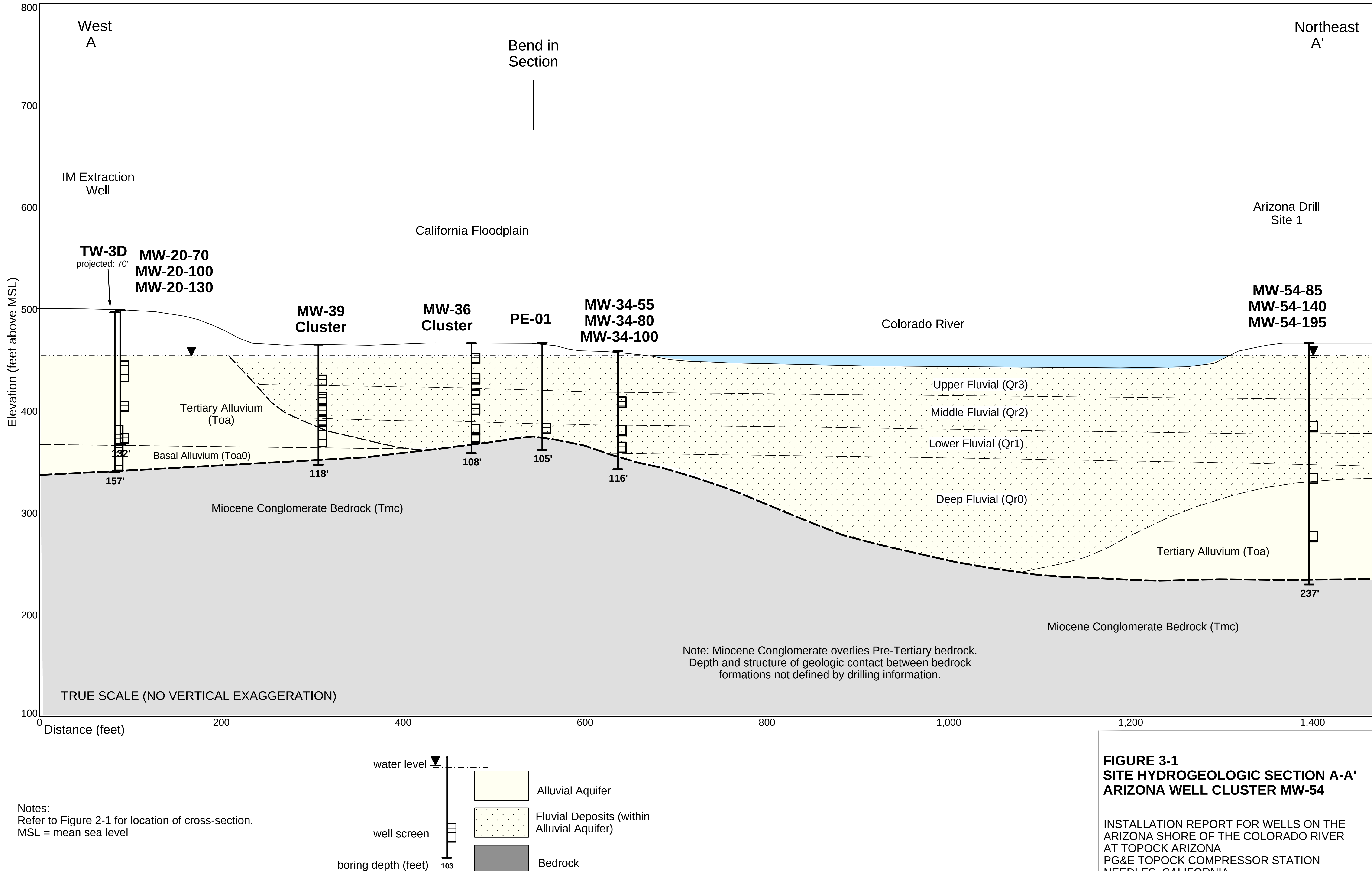
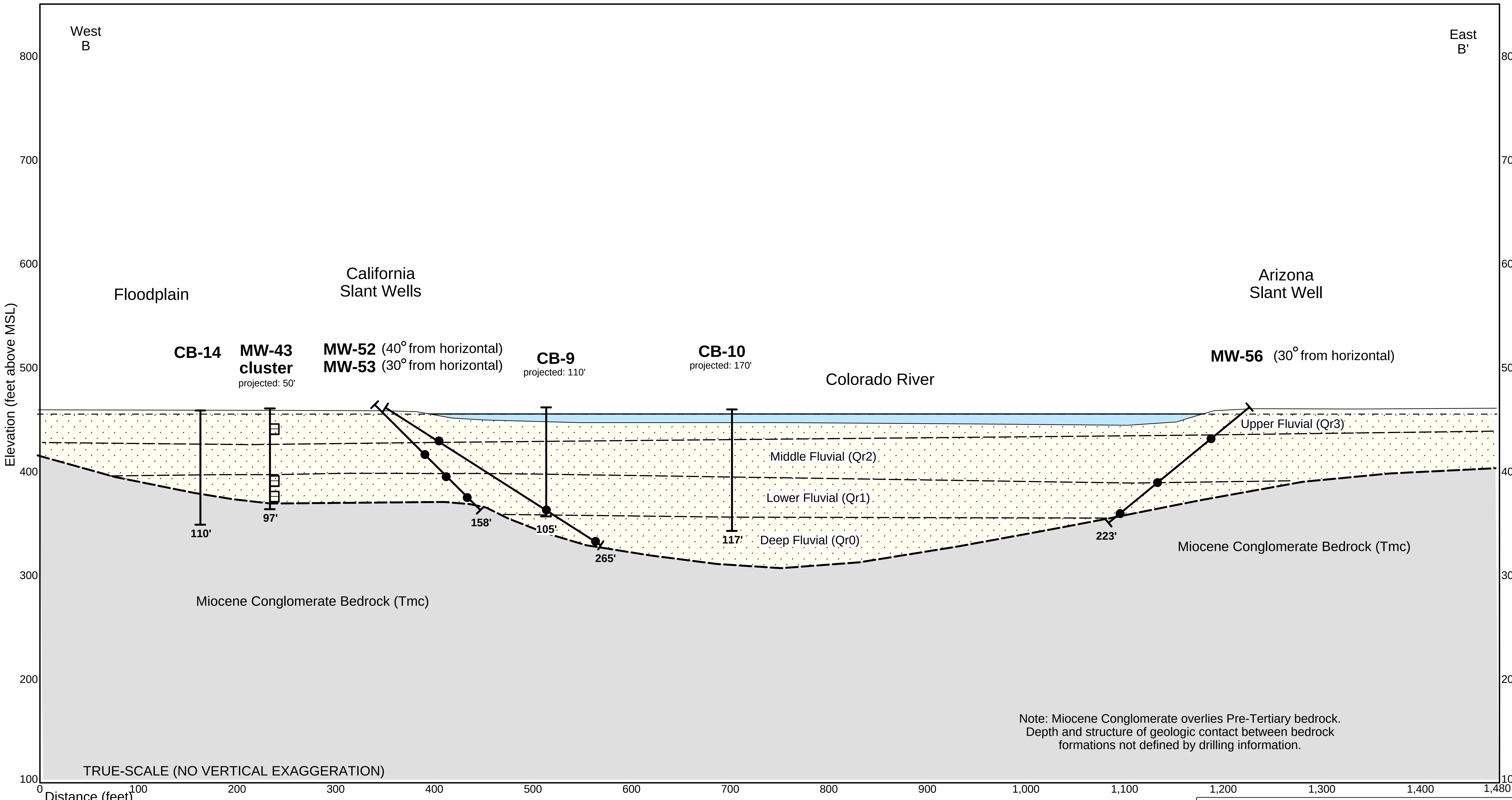



Notes:
Refer to Figure 2-1 for location of cross-section.
MSL = mean sea level

**FIGURE 3-1**
**SITE HYDROGEOLOGIC SECTION A-A'**
**ARIZONA WELL CLUSTER MW-54**

INSTALLATION REPORT FOR WELLS ON THE ARIZONA SHORE OF THE COLORADO RIVER AT TOPOCK ARIZONA
PG&E TOPOCK COMPRESSOR STATION
NEEDLES, CALIFORNIA

CH2MHILL




Notes:
Refer to Figure 2-1 for location of cross-section.
MSL = mean sea level

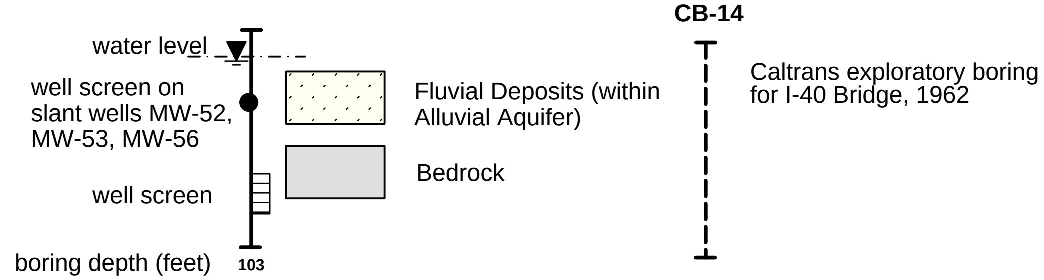
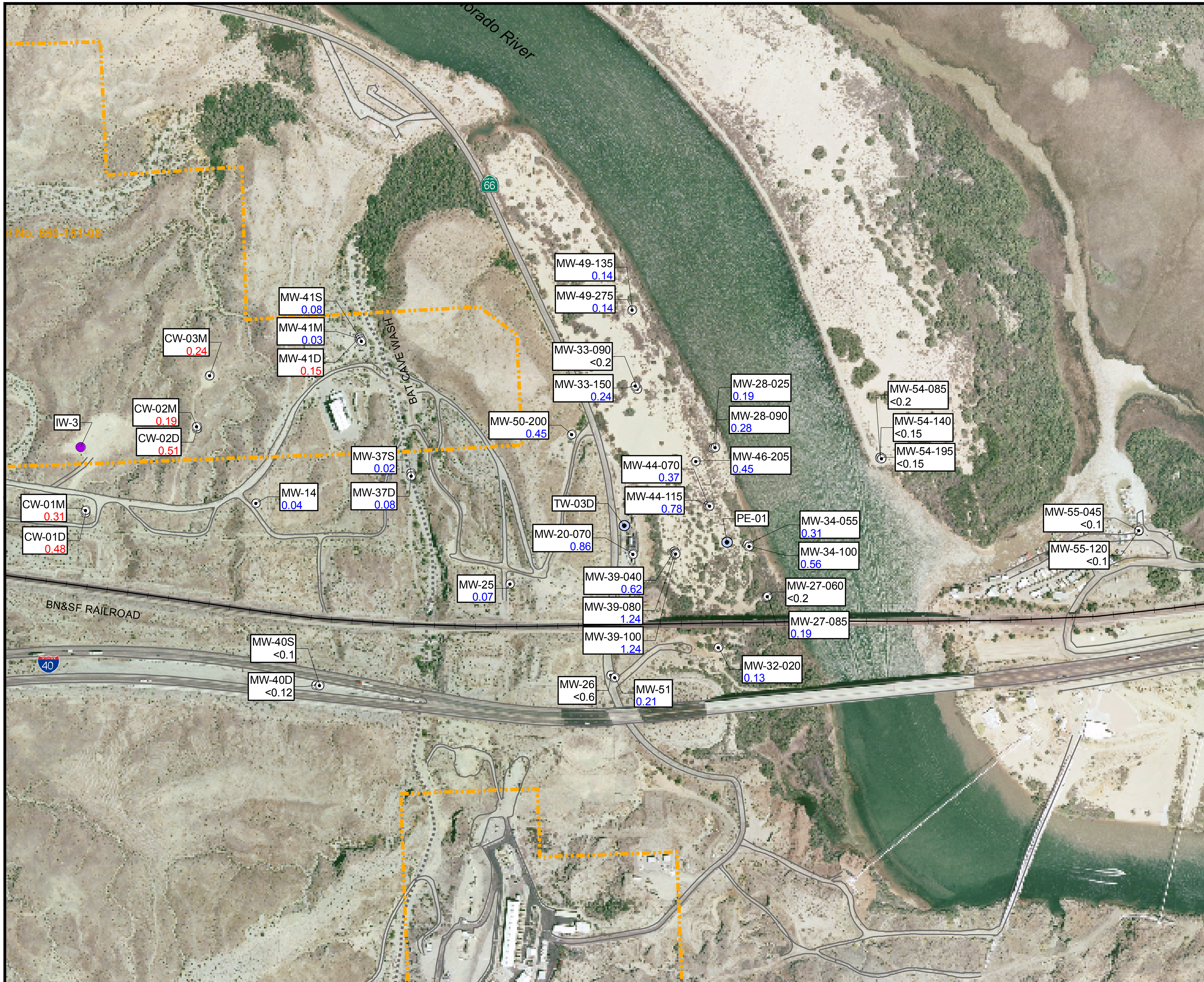



**FIGURE 3-2**
**HYDROGEOLOGIC SECTION B-B'**
**ARIZONA SLANT WELL MW-56**

INSTALLATION REPORT FOR WELLS ON THE
ARIZONA SHORE OF THE COLORADO RIVER
AT TOPOCK ARIZONA
PG&E TOPOCK COMPRESSOR STATION
NEEDLES, CALIFORNIA

CH2MHILL





**LEGEND**

- PG&E Property Boundary
- Aquifer Test Extraction Well
- Aquifer Test Injection Well
- MW-51 0.21 — Observation Well for Aquifer Test; Aquifer Response in Feet

Red = Estimated Water Level Decrease
Blue = Estimated Water Level Increase
Black = Water Level Response was Below the Estimated Detection Limit. Detection Limits are Indicated by "<."

Note:
Aquifer responses were estimated at approximately 7:00am on May 30, 2008, prior to the re-start of extraction well TW-03D.

N

0 500 1,000 Feet

# FIGURE 3-3
# MAY 2008 HYDRAULIC RESPONSES IN OBSERVATION WELLS

INSTALLATION REPORT FOR WELLS ON THE ARIZONA SHORE OF THE COLORADO RIVER AT TOPOCK, ARIZONA
PG&E TOPOCK COMPRESSOR STATION
NEEDLES, CALIFORNIA

CH2MHILL