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December 23, 2003

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Subject: Exploratory Drilling Results and Evaluation of Groundwater Pilot Test Extraction Sites (Plan A/Plan B)
PG&E Topock Compressor Station, Needles, California

Dear Mr. Yue:

This letter transmits the Exploratory Drilling Results and Evaluation of Groundwater Pilot Test Extraction Sites (Plan A/Plan B) for the Topock project. An investigation on PG&E property was conducted in November 2003 at DTSC direction to collect hydrogeologic groundwater data to support siting and design for the groundwater extraction Pilot Study. This report presents the results of the Plan B exploratory drilling program and PG&E's recommendations for the Pilot Study.

The intent of this submittal is to facilitate early review and input from DTSC and the CWG. The PG&E team looks forward to discussing this report during the scheduled January 8th, 2004 teleconference.

If you have any questions, please call me at (925) 974-4081.

Sincerely,

Terri Herson for

Linda Gonsalves
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Exploratory Drilling Results and Evaluation of Groundwater Pilot Test Extraction Sites

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Exploratory Drilling Results and Evaluation of Groundwater Pilot Test Extraction Sites (Plan A/Plan B)

Addendum to the Technical Memorandum Groundwater Pilot Study

PG&E Topock Compressor Station Needles, California

Prepared for
California Department of Toxic Substances Control

On behalf of
Pacific Gas & Electric Company

December 23, 2003

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1.0 Introduction

This Evaluation of Groundwater Pilot Test Extraction Sites (Plan A / Plan B) serves as an addendum to the Groundwater Pilot Study Technical Memorandum (PG&E, 2003). As presented in the Technical Memorandum, Pacific Gas and Electric Company (PG&E) will conduct pilot scale groundwater extraction and treatment at the Topock Compressor Station in San Bernardino County, California. The implementation strategy for the Pilot Study consists of installing one extraction (pumping) well, conveying extracted groundwater to a skid mounted treatment unit, and reusing treated water at the Compressor Station.

Two possible locations for the pilot test extraction well are considered: Plan A on the Havasu National Wildlife Refuge (HNWR) managed by the U.S. Fish and Wildlife Service (USFWS) and Plan B on PG&E property (Figure 1). The initial plan (Plan A) for the Pilot Study proposed using the existing well PGE-06 located on the HNWR. If well PGE-06 is not serviceable, PG&E may install a new extraction well nearby. Implementation of Plan A requires a Right of Way permit from the USFWS, which increases the time to implement this plan by a minimum of six months. Plan B is proposed as an alternative site for extraction of groundwater. Because the Right of Way permit would not be required, siting the well on PG&E-owned land thereby offers a scheduling advantage.

To assess the technical feasibility of Plan B, additional location-specific hydrogeologic information and groundwater data was needed. To obtain this data, PG&E conducted an exploratory drilling program at the Plan B site on PG&E property. The investigation was conducted in November 2003. The scope of work for the exploratory drilling was based on discussions with the California Environmental Protection Agency (CAL-EPA) Department of Toxic Substances Control (DTSC) and recommendations from the Topock Consultative Workgroup (CWG).

This report includes the results of the exploratory drilling program, evaluates Plan A and Plan B, and presents the rationale to implement the Pilot Study on PG&E property.

2.0 Pilot Study Background and Approach to Site Remediation

The Pilot Study is part of the overall approach to the RCRA corrective measure process and is a step in establishing a long-term strategy for site remediation. The results of the Pilot Study will be used in conjunction with the results of the following work to develop a long-term remedial strategy:

- *Chromium Background Study* - Planning for long-term remediation includes a background study to establish the range of naturally occurring hexavalent chromium [Cr(VI)] and total chromium [Cr(T)] concentrations near the site and in the surrounding region. Background concentrations ultimately will be considered when establishing cleanup goals for the site. In addition to the current groundwater monitoring program, PG&E will commence sampling for the background study in early 2004, upon DTSC's approval of the Background Study Work Plan (to be submitted in January 2004).
- *Groundwater Modeling* - A numerical model is being developed to understand groundwater flow at the site and to identify potential groundwater extraction

locations for the long-term remedial system. The uncalibrated model will be used to optimize extraction or observation well locations for use in aquifer testing during the Pilot Study. With the information gained from the Pilot Study, the model will be calibrated and used to design a long-term plume containment and remediation strategy.

- *RCRA Corrective Measures, Technology Evaluation* - The RCRA corrective measures process facilitates the screening and evaluation of remediation technologies. To maximize the reduction of chromium in groundwater, the final remedy will also incorporate in-situ technologies. PG&E will proceed with laboratory testing and field efforts in 2004 to evaluate in-situ technologies, upon DTSC's approval of the In Situ Studies Work Plan (to be submitted in early 2004).

3.0 Pilot Study Objective

The objective of this groundwater extraction Pilot Study is to initiate hydraulic control and mass removal of chromium in groundwater and acquire information necessary for the design of the final remedy. The Pilot Study will generate information on the hydraulic and hydrogeologic properties of the aquifer and the chromium reduction treatment process for full-scale application.

The Pilot Study system consists of the following components:

- Groundwater extraction from a single extraction well
- Conveyance of extracted water to a treatment unit located on PG&E property
- Treatment using chemical reduction / precipitation followed by filtration
- Reuse of the treated water in the compressor station cooling towers

The proposed extraction rate is 20 gallons per minute (gpm) and is limited by the capacity of PG&E's existing evaporation ponds (which serve as the discharge point for blowdown water from the cooling towers). The estimated influent concentration of Cr(VI) is expected to range from 1 to 5 milligrams per liter (mg/L). Other design parameters include influent concentrations of total dissolved solids (TDS) ranging from approximately 2,000 to 8,000 mg/L.

Additional hydraulic and geophysical testing will also be performed at other Topock Site locations as part of the Pilot Study. Details of the aquifer and geophysical testing activities will be presented in a separate document.

4.0 Exploratory Drilling Program (Plan B) Scope and Objectives

A lack of location-specific information regarding the hydrogeologic conditions at the Plan B site led to exploratory drilling on PG&E property. The exploratory drilling program included groundwater sampling and analysis and hydraulic testing activities. This investigation was conducted in November 2003 based on the *Summary Workplan, Groundwater Exploratory Boring and Test Well*, approved by DTSC on November 13, 2003. The objectives of this investigation at the Plan B site were to:

- Determine the saturated thickness of the unconsolidated alluvial aquifer and evaluate its hydrogeologic characteristics at this location.
- Evaluate aquifer capacity and verify that the designed pumping rate would be attainable from a new well at the Plan B site.
- Sample the test well to characterize Cr(T), Cr(VI), TDS, and other general chemistry concentrations in groundwater for the treatment process evaluation. The treatment process evaluation includes analysis of chromium and iron removal and performance of the reverse osmosis system.
- Compare groundwater quality composition at the test well to existing wells including PGE-06 (Plan A). This is necessary for verification of the treatment process design.

The scope of the exploratory program included:

- Drilling of an exploratory boring 20 feet into bedrock
- Depth-specific water sampling during drilling, if conditions allow
- Completion of a test well screened across the entire saturated alluvial aquifer
- Preliminary hydraulic testing of the test well to determine well yield and evaluate aquifer properties
- Sampling of the new test well to evaluate water quality
- Confirmation sampling of the new test well

5.0 Summary and Results of the Exploratory Drilling Program (Plan B)

The results of the exploratory drilling program are provided in this section.

5.1 Exploratory Boring and Well Completion at Plan B Site

The Plan B site is located on an upper terrace at the northern edge of the PG&E property. Figure 1 shows this location, approximately 300 feet south of the Plan A site (i.e., PGE-06) Fieldwork began on November 11, 2003 to drill and complete an exploratory boring and test well.

Exploratory Boring GTB-1

A 6 ? -inch boring was drilled by WDC Exploration and Wells using a Speedstar 3000 mud rotary drill rig to a depth of 312 feet below ground surface (bgs) at the Plan B site. The boring called GTB-1 was completed from November 11-13, 2003.

Drill cuttings were logged in the field according to the Unified Soil Classification System (USCS). Soil cores were also collected at selected intervals using a 94-mm wireline coring method and the core was archived in core boxes. A total of about 30 feet of core was collected from the boring. The soil boring log for GTB-1 is provided in Attachment A and core collection is summarized below.

Sample ID	Core Interval (ft bgs)	Core Recovery	Comment
GTB1-C01-160	160 - 160.7' (8")	8"	refusal after 8"; sand and gravel (alluvium)
GTB1-SP01C-170	170 - 171.7' (20")	18"	near full recovery
GTB1-C02-180	180 - 180.7' (8")	8"	1st core attempt at this depth; to refusal
GTB1-C03-181	181 - 183.2' (28")	28"	2nd core attempt at same depth; to refusal
GTB1-C04-183	183 - 186' (36")	36"	3rd core attempt at same depth
GTB1-C05-200	200 - 202' (24")	24"	
GTB1-C06-220	220 - 225' (60")	60"	
GTB1-C07-240	240 - 242' (24")	24"	
GTB1-C08-261	261 - 266' (60")	3"	refusal after 3"
GTB1-C09-266	266 - 271' (60")	30"	v. red, stiff, friable (old alluvium or weathered bedrock)
GTB1-C10-280	280 - 280.3' (3")	0"	refusal after 3"
GTB1-C11-281	281 - 283 (36")	30"	consolidated bedrock
GTB1-C12-295	295 - 298' (36")	32"	consolidated bedrock, less red than above
GTB1-C13-310	310 - 312' (24")	24"	consolidated bedrock, less red than above

Notes:
Core Interval reflects the attempted core interval (depth cored in parantheses); Core Recovery is the length of core recovered.

Depth-specific water sampling was attempted during drilling using a SimulProbe® sampling device, but was discontinued after multiple unsuccessful sampling attempts. The large gravel and cobbles in the soil proved incompatible with this sampling technique, which requires the sampling tool to be driven into the native formation below the bottom of the borehole.

After reaching the final depth of 312 feet bgs, geophysical logging was conducted in the open borehole to further characterize the lithology. The borehole remained filled with drilling mud to stabilize the hole during the logging operations. The suite of geophysical logs included gamma ray, spontaneous potential, resistivity (laterlog, short and long normal), and induction logs (medium and deep). The geophysical logs are presented on Figure 3.

Evaluation of the lithologic and geophysical logs indicates the water table is at approximately 165 feet bgs and that the bedrock contact is at approximately 270 feet bgs. Therefore, the saturated thickness of alluvial aquifer is approximately 105 feet. A hydrostratigraphic cross section is shown on Figure 2.

The saturated alluvial sediments were predominantly poorly sorted sands and silty sands with no significant interbedding or aquitards noted. Occasional 3-5 foot beds of clayey sand were encountered, and trace to nearly 50 percent gravel was observed throughout the section. Large cobbles to boulders were noted throughout the alluvium (observed by reduction in drilling rate) but not recovered in cuttings or cores. A more compacted alluvium was noted in core samples and on the gamma ray log from 244 to 271 feet bgs, with clayey sand and silt/clay dominant below 260 feet. This compacted alluvium is interpreted to be an older alluvium or a weathered bedrock unit (Figure 3). Grain size analysis was run on five selected core samples, and the results are presented in Table 1.

Test Well TW-1

Following drilling and geophysical logging of the GTB-1 exploratory boring, the lithologic and geophysical logs were evaluated to determine the design specifications for a test well at

the Plan B site. The contact with the bedrock (red fanglomerate) was determined to be 271 feet. The boring was then reamed to a final diameter 10 ? -inches from surface to 270 feet bgs, the specified final depth of the well. Prior to reaming, the open borehole in the bedrock below the bottom of the well was sealed with bentonite chips to prevent any possibility of cross contamination between groundwater in the bedrock and contaminated water in the overlying alluvium.

Well construction took place on November 16, 2003. Once it was completed as a well, test boring GTB-1 was re-named test well TW-1. Before constructing the well, the drilling mud within the borehole was thinned by circulating and adding water to reduce viscosity and caking and facilitate placement of annular materials. Well completion details are described below and shown on Figure 3.

Depth (feet bgs)	Well Completion	Annular Material
0 - 20	5" Sch. 80 PVC	Portland cement grout (11 1/2" hole)
20 - 156	5" Sch. 80 PVC	Portland cement grout (10 5/8" hole)
156 – 159	5" Sch. 80 PVC	Coated bentonite pellets
168 – 161	5" Sch. 80 PVC	Monterey #60 sand
161 – 162	5" Sch. 80 PVC	Monterey #30 sand
162 – 168.5	5" Sch. 80 PVC	Monterey Medium Aquarium sand
169 – 268.5	5" Sch. 80 PVC, 0.060-slot	Monterey Medium Aquarium sand
268.5 – 269	5" Sch. 80 PVC	Monterey Medium Aquarium sand
269 – 270	No well	Formation slough
270 – 312	No well	Bentonite grouted 6-5/8" hole

All annular materials were installed by tremie pipe. The filter pack (medium aquarium sand) was gently surged during placement and settled 12 feet. Additional filter pack sand was added to replace the settlement volume prior to placing the #30 and #60 transition sand. On November 17, the well was completed with a sub-grade well head, with a 24" x 24" flush-mount, hinged and lockable, steel box cemented in place.

Well development began on November 19, 2003 by bailing 350 gallons of water and drilling mud from the well. Development continued the next day with approximately three hours of alternating bailing surging producing an additional 300 gallons of water. Final well development was achieved by pumping the well at 90 gpm for approximately one hour removing a total of 5,700 gallons. Water levels were not measured during pumping as cascading water made the use of a sounding tape impossible. Following the preliminary bailing, sand production was observed to be minimal.

5.2 TW-1 Hydraulic Testing

Immediately following well development, a brief step-drawdown test was conducted at well TW-1. Based on the drawdown test data, the well is considered suitable for the pilot extraction system. TW-1 will likely sustain a pumping rate ranging from 35 to 60 gpm, meeting the Pilot Study design rate of 20 gpm.

The step-drawdown test took place on November 21, 2003 for a total duration of two hours. Pumping rates were split into four 30-minute steps as follows:

Summary of Step Test Results					
Step	**Time-weighted Average Pumping Rate (gpm)**	**Maximum Drawdown (cumulative ft)**	**Specific Capacity (gpm/ft)**	**Estimated Transmissivity (ft^2/d)**	**Estimated Hydraulic Conductivity (ft/d)**
1	22.1	1.35	16.4	3,300	31
2	35.2	2.40	14.6	2,900	28
3	61.7	4.88	12.6	2,500	24
4	88.3	8.20	10.8	2,200	21

Pumping rates were fairly constant at each step – the range in measured pumping rate was within seven percent of the time-weighted average. A graphical depiction of drawdown in TW-1 is included in Attachment B. Drawdown stabilized in Steps 1, 2, and 3, but was still increasing when Step 4 was terminated.

In addition to the pumped well, monitoring wells MW-10, MW-24A, and MW-24B were monitored with pressure transducers before, during, and after the step-drawdown test. These three monitoring wells are the closest to TW-1, each approximately 300 feet away (Figure 1). Wells MW-10 and MW-24A are screened in the upper part of the alluvial aquifer, whereas Well MW-24B is screened near the bottom of the unit. Plots of drawdown and recovery for the three monitoring wells are provided in Attachment B. Drawdown was greatest at the deeper MW-24B well, with a maximum of 0.23 feet during Step 4. The reason for this cannot be determined without further testing, but a contributing factor is likely the semi-confined nature of the deeper zones of the alluvium. Even without the presence of confining aquitards, the vertical anisotropy inherent in the formation likely creates semi-confining conditions that increase with depth. These conditions will cause drawdown from pumping to be propogated more quickly than in purely unconfined shallow zones. The test duration was very short, and a longer-term Pilot Study test will provide more representative aquifer information. Though drawdown in the shallow wells was minimal (less than 0.1 feet), there was a noticeably stronger response to the pumping in MW-10 than in MW-24A, suggesting a better hydraulic communication between the pumped zone and the MW-10 area, since the wells are approximately equidistant from TW-1.

The specific capacity data shown above suggest a transmissivity on the order of 2,000 to 3,000 ft^2/d, using the relationship:

$Q/s = T/1500$, where Q is the pumping rate in gpm, s is the drawdown for the time step in feet, and T is transmissivity in gallons per day / foot (gpd / ft) (Driscoll, 1986, p. 1021).

For a saturated thickness of 100 feet, this corresponds to a hydraulic conductivity of between 20 and 30 feet / day (ft / d). A second parameter estimation method using recovery data in addition to step-drawdown data yielded a higher estimate of 90 ft / d (Helweg et al., 1984, p. 60). Both of these methods use only pumping well data, and therefore are limited by a small areal extent and by well efficiency effects. Pilot Study testing will utilize the monitoring wells in a longer-term test, providing more representative hydraulic parameter estimates. The values noted above should be considered rough approximations.

A downhole velocity log will be run in Well TW-1 in mid-December 2003 to quantitatively determine which portions of the screened interval are providing most of the groundwater. If results are conclusive, this information will allow modeling of the step-drawdown test using the monitoring well data. Both horizontal and vertical hydraulic properties of the aquifer may be estimated through calibration of the model to the test data. If Plan B is selected for the Pilot Study, one or two piezometer clusters may be installed closer to TW-1 than existing monitoring wells and a long-term constant discharge test will be recommended to provide more accurate estimates of hydraulic properties.

In summary, the preliminary step-drawdown data suggest hydraulic conductivity ranging between 20 and 90 ft/d, indicative of productive sandy aquifer. A constant discharge test is needed to gain more accurate estimates, and this will be recommended as part of the Pilot Study. All data thus far indicate that Well TW-1 will easily produce the 20 gpm necessary for the Pilot Study. In addition, drawdown data in monitoring wells indicate that TW-1 will provide sufficient influence to initiate hydraulic control of the Cr(VI) plume volume. Though the numerical groundwater model is still in development, preliminary indications are that continuous pumping at 20 gpm from either the Plan A or Plan B site would result in an eastward influence to contain a portion of the plume.

5.3 TW-1 Water Quality Characterization

TW-1 was sampled during well development on November 20, 2004. Following well development, initial sampling was conducted on November 24, 2003. Confirmation sampling took place on December 16, 2003. Select water quality parameters and the results of Cr(VI), Cr(T) and TDS analyses are provided in Table 2 (for well development, initial and confirmation samples). A complete summary of analytical results from the initial sampling event is shown on Table 3.

Water from TW-1 is proposed as a possible influent source for the Pilot Study treatment plant (Plan B). The concentrations of key constituents (i.e., Cr(T) and Cr(VI)) in groundwater from TW-1 are consistent with historical data from nearby wells that were used to characterize the alluvial aquifer and to design the treatment process. The total dissolved solids concentration (TDS), which is an important factor in determining the best method for disposing of treated groundwater, is comparable to historical data. The Cr(VI), Cr(T) and TDS concentrations at TW-1 and selected wells are summarized below.

	Well				
Parameter	**MW-24A**	**MW-24B**	**PGE-06**	**PGE-07**	**TW-1**
Date	**Sep-03**	**Sep-03**	**Sep-03**	**Nov-01**	**Nov-03**
Hexavalent Chromium	2.97	4.76	0.30	4.80	3.94
Total Chromium	2.62	4.32	0.35	4.80	4.20
Total Dissolved Solids	2,040*	8,130*	2,740*	8,100	3,870

All concentrations are in mg/L.

* Indicated TDS results are from June 2003 except for PGE-06, which is from November 2001.

An evaluation of the major ion chemistry for groundwater from PGE-06 (Plan A), TW-1 (Plan B), and nearby monitoring wells also suggests similar water chemistry among the wells (Figure 4).

The source of influent previously evaluated for the Pilot Study included a range of constituent concentrations in groundwater from the MW-24 cluster wells and PGE-06 (Table 4). Concentrations considered "nominal average concentrations" were derived from data collected at PGE-06. Concentrations considered "probable maximum concentrations" came from well MW-24B, with selected values from PGE-06, MW-24A and MW-24BR. A concentration of Cr(VI) value at 13 mg/L was used as a "peak concentration" to add a level of conservatism; this was the highest Cr(VI) concentration exhibited at the site (well MW-20-70) and was considered in the process design regardless of source location. Water chemistry observed in TW-1 is consistent with the range of constituent concentrations reported for the MW-24 cluster wells and PGE-06. Consequently, TW-1 is a suitable source of feed water for the Pilot Study for which the treatment plant is now under design.

The main parameters of interest in pilot plant design are:

- Cr(VI)
- TDS
- Select minor constituents that might affect design or operation of the treatment process due to the potential to form mineral deposits within the process equipment

The current process design for Pilot Study treatment plant has an operational range for Cr(VI) of 1.2 to 13 mg/L. The Cr(VI) concentrations measured at TW-1 on November 24, 2003 and December 16, 2003 were 3.94 and 3.25 mg/L, respectively, which falls within the acceptable range of design criteria for the Pilot Study treatment plant.

Analytical results indicated a TDS concentration of 3,870 mg/L at TW-1. This TDS concentration is approximately 40 percent higher than the "nominal average" design concentration (2,783 mg/L) assumed for the treatment plant, but is well within the maximum expected design value of 8,130 mg/L. The TDS does not significantly affect the Cr(VI) removal effectiveness, but it can strongly influence downstream systems such as a reverse osmosis (RO) unit[1].

Minor constituents in water from TW-1 also fell within ranges that are compatible with treatment processes for Cr(VI) removal and with process equipment downstream of the Cr(VI) removal system. Water from TW-1 was lower in fluoride than other wells that had previously been considered as sources of water for pilot testing (Plan A). This means that a potential for calcium fluoride scale formation in the RO system is significantly reduced. All of the other scale-forming constituents are within design tolerances for the treatment plant.

[1] The TDS concentration in the RO unit reject stream cannot exceed 15,000 mg/L under provisions of the Colorado River Basin Regional Water Quality Control Board's (CRBRWQCB) waste discharge requirements (WDR) for the existing evaporation basins (Order No. 98-050).The discharge limit to the onsite evaporation pond places a constraint on the percentage of purified water that can be recovered for beneficial reuse at the Compressor Station. As a result, reuse of treated water is directly affected by the TDS concentrations in water from the extraction well.

The results of general chemistry analyses are attached as Table 2 (TW-1 initial and confirmation groundwater samples).

6.0 Evaluation of the Plan A and B Sites

In October 2003, the U.S. Fish and Wildlife Service indicated that a Right of Way permit is needed for the installation and operation of a pilot extraction system on USFWS property. The review time associated with the Right of Way permit applications would significantly extend the schedule of the pilot test. As a result, PG&E, DTSC and the CWG considered siting the extraction well on PG&E property based on the following rationale:

- PG&E land ownership eliminates the need for a federal permit and expedites the implementation of the Pilot Study.
- The Plan A extraction well (PGE-06) is not fully penetrating and likely needs significant rehabilitation or replacement.
- A new extraction well on PG&E property intercepts groundwater within the chromium plume (in close proximity to the chromium source area).
- The local terrain offers a flat bench with sufficient access for a drill rig, and temporary storage of investigation derived waste (IDW).
- The close proximity between the extraction well and treatment system minimizes piping and construction activities.

The Compressor Station's utilities provide a power supply.

Well TW-1 was drilled and completed at the Plan B location as part of the exploratory program. PG&E, DTSC and the CWG agreed that to locate the pilot extraction well, four key requirements must be met:

1. The extraction well must be capable of yielding groundwater at a rate of 20 gpm.
2. The extraction well must be sited in an area where groundwater chemistry is suitable for the pilot treatment plant.
3. The operation of the extraction well must meet the objectives of the Pilot Study. The objectives include:
    - Initiating hydraulic control and mass removal of chromium in groundwater
    - Acquiring information necessary for the design of the final remedy (hydrogeologic and hydraulic properties of the alluvial aquifer and information on the chromium reduction process for the full-scale application)
4. The pilot extraction and treatment system must be implemented in a timely manner.

As described in this report, TW-1 meets each of the key requirements identified above. Plan B fulfills the goals of the Pilot Study and can accelerate implementation since an access permit is not required from the federal agencies.

7.0 Conclusion and Recommendations

The conclusions from the exploratory program and the evaluation of the Plan A / Plan B are as follows:

- The water table and bedrock at the Plan B site are at 165 and 270 feet bgs, respectively, providing over 100 feet of saturated alluvial aquifer.
- Hydraulic testing at the Plan B site (TW-1) site indicates that the well is capable of yielding the 20 gpm required for the Pilot Study. The proposed extraction rate of 20 gpm is limited by the capacity of the existing evaporation ponds.
- Preliminary modeling indicates that continuous pumping at 20 gpm from well TW-1 will produce hydraulic control of at least a portion of the plume. These results are very similar to model simulations of Plan A pumping, and indicate that hydraulic control of the plume will be initiated with either plan. More quantitative estimates of hydraulic influence will be attainable when the model is fully calibrated following the Pilot Study.
- Cr(VI) concentrations in groundwater from either the Plan A (PGE-06) or Plan B (TW-1) site are suitable for the Pilot Study.
- Water chemistry (e.g., TDS, minor constituents) from either the Plan A (PGE-06) or Plan B (TW-1) site is compatible with other processes associated with reuse and disposal of the treated water.
- TW-1 can provide a suitable groundwater supply, fulfill the objectives of the pilot study, and because of the elimination of key permitting requirements, accelerate implementation of the Pilot Study.

Based on the above findings it is clear that both Plan A and Plan B can be implemented to meet the objectives of the Pilot Study. However, because the Plan B site is on PG&E property and does not require additional permits to install and operate the pilot system, it can expedite the implementation of the Pilot Study by at least six months.

The Plan B site is therefore the recommended location for the Pilot Study extraction well. Further, it is recommended that TW-1 be used as the extraction well.

The following tasks need to be completed to facilitate the Pilot Study startup using TW-1 at the Plan B site as the extraction well:

- Velocity logging and depth-specific sampling should be conducted at TW-1 to further characterize the well and to evaluate zones of preferential flow and vertical chromium concentration (completed in mid-December 2003).
- Additional monitoring wells should be completed near TW-1 in the upper and lower alluvial aquifer to facilitate aquifer testing and monitoring of drawdown and hydraulic capture created by TW-1 (scheduled for early 2004).
- A constant-rate pumping test should be conducted at TW-1 (following monitoring well installation and pilot treatment system) to further evaluate aquifer properties and well yield.

8.0 References

PG&E, 2003a. *Technical Memorandum, Groundwater Pilot Study*, PG&E Topock Compressor Station. September 2003.

PG&E, 2003b. *Field Activities Workplan for Groundwater Extraction Pilot System*, PG&E Topock Compressor Station. October 2003.

Driscoll, F.G. 1986. *Groundwater and Wells, 2nd ed.* St. Paul: Johnson Division. 1089 p.

Helweg, O.J., V.H. Scott, and J.C. Scalmanini. 1984. *Improving Well and Pump Efficiency*. American Water Works Association. 158 p.

Todd, D.K. 1980. *Groundwater Hydrology, 2nd ed.* New York: Wiley. 535 p.

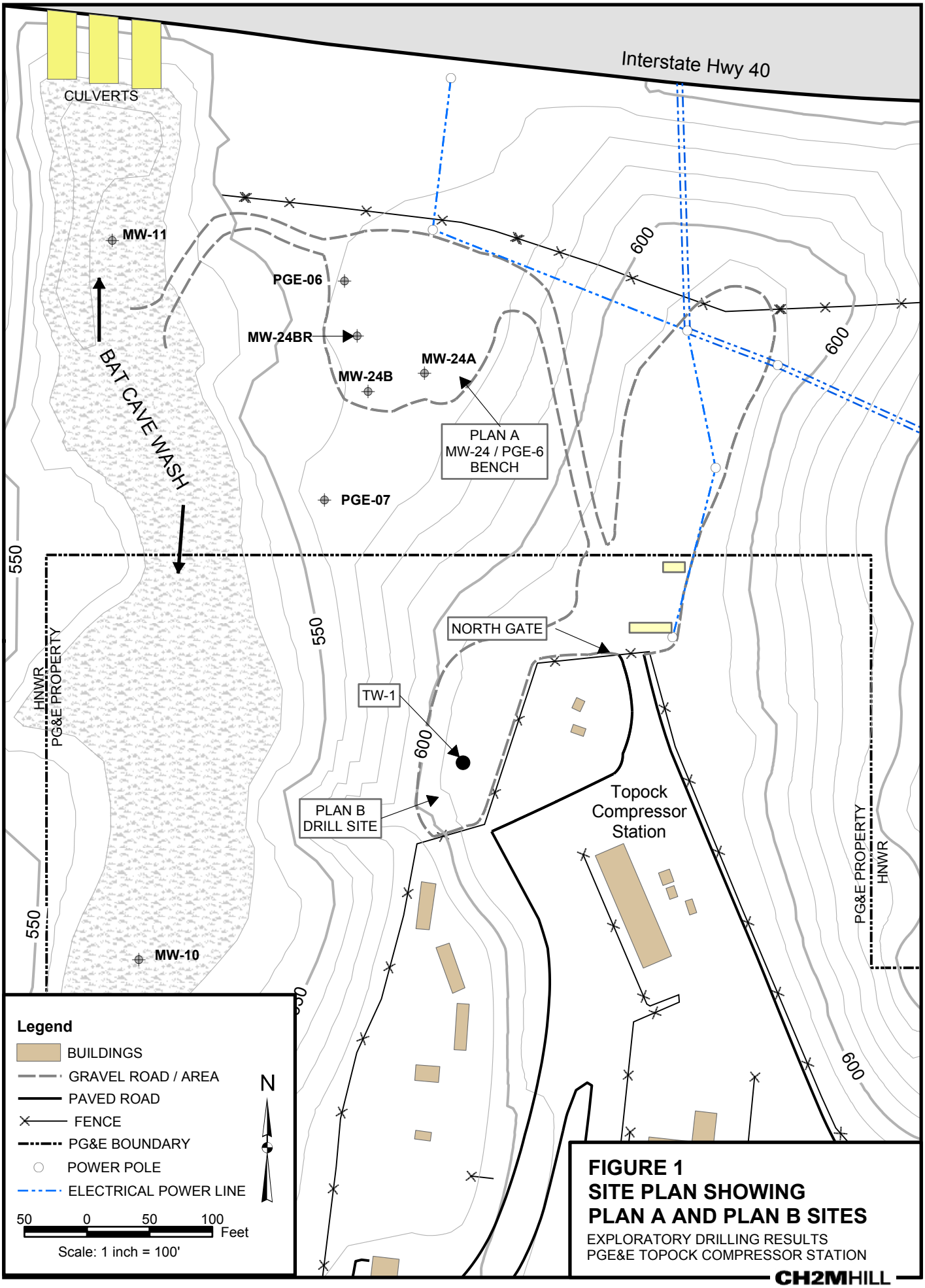


FIGURE 1
SITE PLAN SHOWING
PLAN A AND PLAN B SITES
EXPLORATORY DRILLING RESULTS
PGE&E TOPOCK COMPRESSOR STATION

CH2MHILL

South

HNWR Property

PG&E Property

BEND IN SECTION

PG&E Property

HNWR Property

MW-24 Bench

North

Bat Cave Wash

Boring XMW-9

PGE-08 proj. 70'

MW-09 proj. 90'

MW-10 proj. 160'

Boring GTB-1 Test Well TW-1

PGE-07 proj. 60'

MW-24A MW-24B

MW-24BR

PGE-06

MW-11 proj. 190'

ground surface

Approx. water table elevation

ALLUVIAL AQUIFER

METADIORITE BEDROCK

MIOCENE FANGLOMERATE

ALLUVIAL AQUIFER

Logged as Red Fanglomerate and Sandstone to 442'

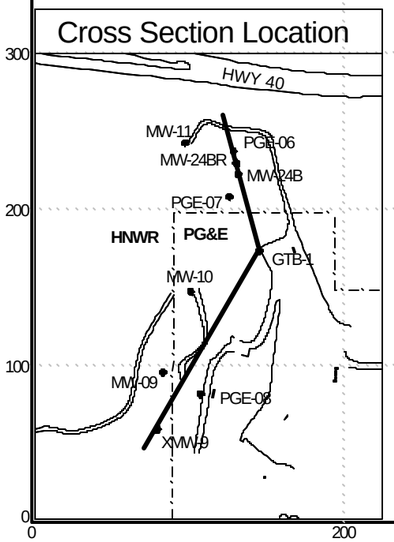
Elevation (feet msl)

Distance (feet)

0 200 400 600 800 1,000 1,200 1,400

0 100 200 300 400 500 600 700

Cross Section Location



Note:

Well ID

water level in well

Geologic contact; dashed where inferred, queried where uncertain

SOIL & LITHOLOGY

- Gravel (GP, GW)
- Sand (SP, SW)
- Silty-Clayey Sand (SM, SC)
- Silt (ML, MH)
- Clay (CL, CH)
- Miocene Fanglomerate
- Bedrock

FIGURE 2

HYDROGEOLOGIC CROSS SECTION

Pilot Groundwater Extraction Study Area

PG&E Topock Compressor Station

CH2MHILL

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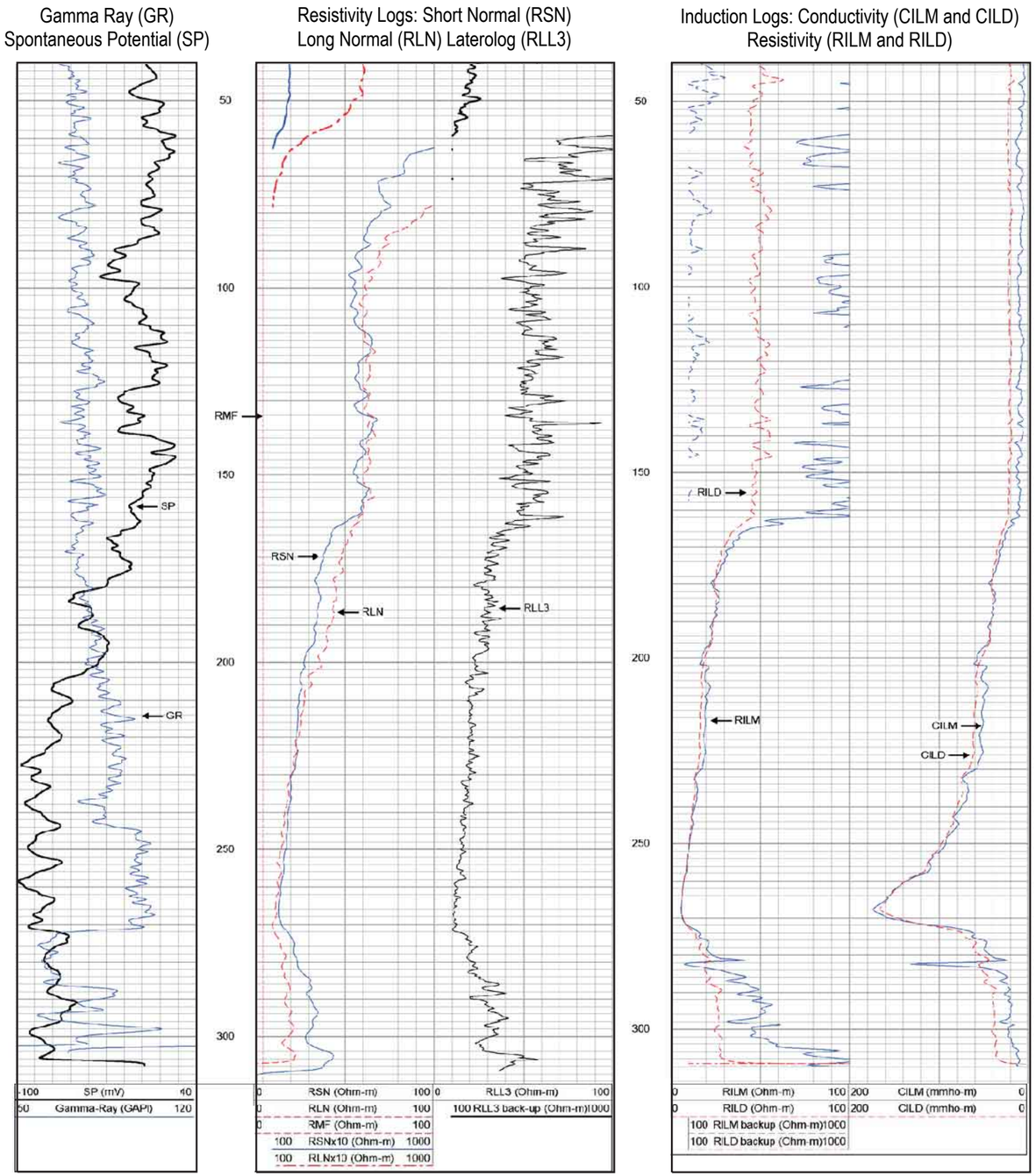
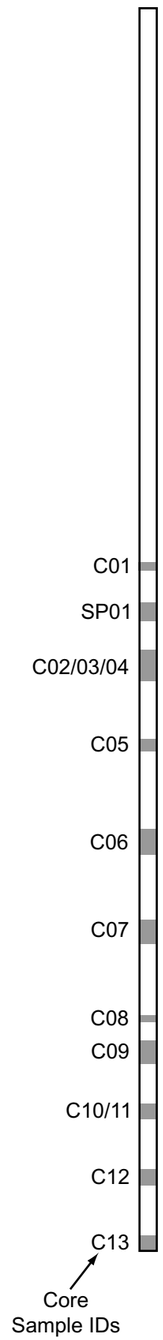
Printed on 12/15/2003

GEOPHYSICAL LOGS	CORES	WELL CONSTRUCTION	LITHOLOGY





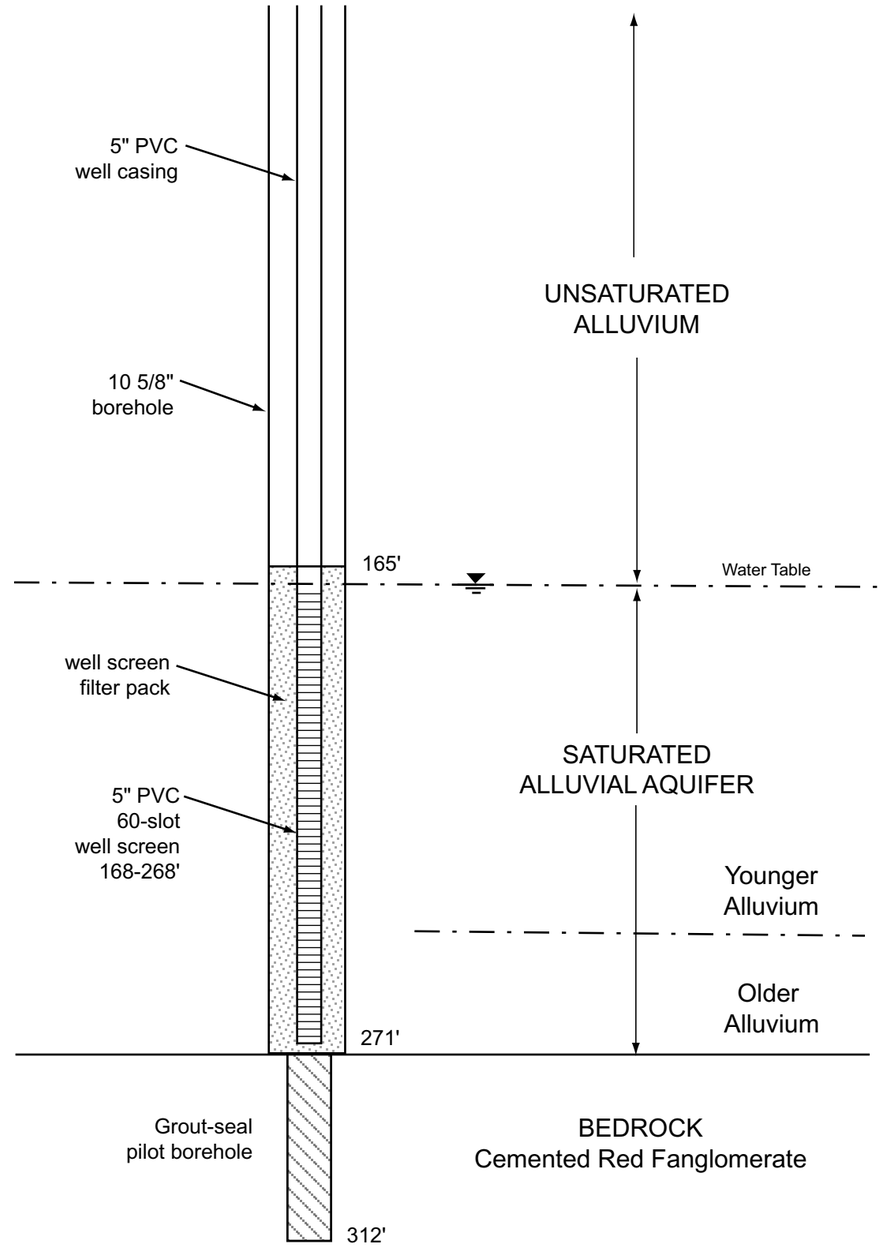


FIGURE 3
TW-1 WELL COMPLETION SHOWING GEOPHYSICAL LOGS, CORE COLLECTION AND LITHOLOGY
EXPLORATORY DRILLING RESULTS
PG&E TOPOCK

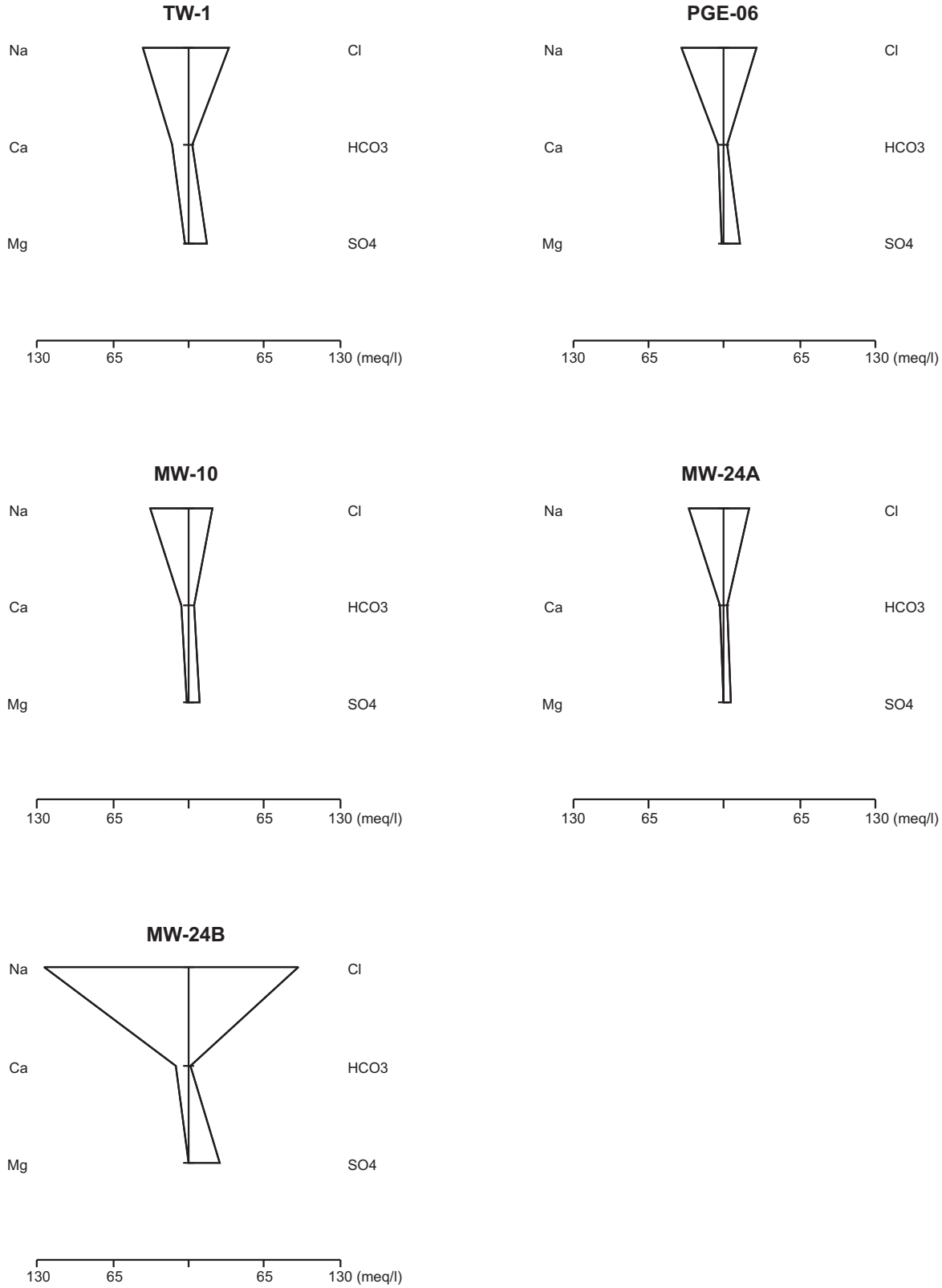


FIGURE 4

STIFF DIAGRAMS FOR KEY WELLS NEAR PLAN A AND PLAN B SITES

EXPLORATORY DRILLING RESULTS
PG&E TOPOCK COMPRESSOR STATION

TABLE 1
GRAIN SIZE RESULTS FROM TW-1 / GTB-1 CORE SAMPLES
Exploratory Drilling Results, Evaluation of Pilot Test Extraction Sites (Plan A/Plan B)
PG&E Topock Compressor Station

Sample-ID	Depth, ft.	Mean Grain Size Description	Median Grain Size mm	Particle Size Distribution (weight %)						
					Sand Size					
				Gravel	Coarse	Medium	Fine	Silt	Clay	Silt & Clay
GS-1	182	Medium sand	1.276	7.08	31.82	32.71	16.95	--	--	11.44
GS-2	201	Coarse sand	2.062	26.17	24.59	24.62	12.58	--	--	12.04
GS-3	221	Gravel	3.268	40.99	19.96	18.97	11.41	--	--	8.66
GS-4	268	Fine sand	0.069	0.00	0.00	22.47	26.34	32.64	18.54	51.19
GS-5	282	Silt	0.015	0.00	0.00	6.03	21.8	38.73	33.44	72.17

TABLE 2
SELECT WATER QUALITY PARAMETERS AT TW-1 (WELL DEVELOPMENT, INITIAL AND CONFIRMATION SAMPLING)
Exploratory Drilling Results, Evaluation of Pilot Test Extraction Sites (Plan A/Plan B)
PG&E Topock Compressor Station

A. Analytical Results

Sample ID	Date	Time	Cr(T) mg/L	Cr(VI) mg/L	pH --	EC uS/cm	TDS mg/L	Comment
Development/Step Test Sampling								
TW-1-30	11/20/2003	10:00	--	--	--	5,610	3,650	after 30 min purge or 2,700 gal
TW-1-60	11/20/2003	10:30	--	--	--	5,560	3,600	after 60 min purge or 5,400 gal
TW-1-90	11/20/2003	11:00	--	--	--	5,480	3,630	after 90 min purge or 8,100 gal
TW-1-120	11/20/2003	11:30	--	--	--	5,710	3,740	after 120 min purge or 10,800 gal
Initial Well Sampling								
TW-1-2CAS	11/24/2003	13:45	--	3.39	8.04	5,910	3,900	210 gal purged (2 casing volumes)
TW-1-4CAS	11/24/2003	13:55	--	3.79	8.03	5,810	3,840	420 gal purged (4 casing volumes)
TW-1-FIN	11/24/2003	14:05	4.2	3.94	7.97	5,750	3,870*	630 gal purged (Final; 6 casing volumes)
Confirmation Well Sampling								
TW-1_BT	12/16/2003		4.32	3.25	7.37	5,770	3,750	650 gal purged (6+ casing volumes)

* Split samples were collected at TW-1-FIN for TDS. The indicated value is the higher of the two results.

B. Field-Measured Parameters

Date	Time	pH --	EC uS/cm	Turbidity NTU	Dissolved Oxygen mg/L	Temp °C	Salinty %	TDS mg/L	ORP mV	
Initial Well Sampling										
11/24/2003	13:40	7.46	6,880	28	6.3	29.20	0.4	4,300	171	t=5 min; 105 gal. purged
11/24/2003	13:50	7.48	6,410	31	7.2	29.00	0.3	4,100	152	t=15 min; 315 gal purged
11/24/2003	13:54	7.47	6,400	46	7.3	29.16	0.3	4,000	147	t=19 min; 399 gal purged
11/24/2003	13:57	7.47	6,520	43	7.7	29.20	0.3	4,100	139	t=22 min; 462 gal purged
11/24/2003	14:04	7.47	6,440	8	7.9	29.20	0.3	4,000	133	t=29 min; 609 gal purged
Confirmation Well Sampling										
12/16/2003	9:28	7.32	5,950	-0.8	4.75	26.08	0.32	3,770	166	
12/16/2003	9:46	7.39	6,050	-1.5	4.69	26.61	0.32	3,810	144	
12/16/2003	10:03	7.37	6,110	-0.9	4.74	27.00	0.32	3,850	134	
12/16/2003	10:19	7.34	6,050	-0.1	4.82	27.34	0.32	3,810	128	
12/16/2003	10:48	7.32	6,030	1.9	4.90	21.85	0.32	3,800	121	

Notes:

Development/step test sampling took place on November 20, 2003 at variable flow rates.

Initial well sampling took place on November 24, 2003; flow rate was 21 gpm.

Confirmation well sampling took place on December 16, 2003; flow rate was 24 gpm.

Cr(T) - total dissolved chromium; Cr(VI) - hexavalent chromium; EC - conductance at 25°C; TDS - total dissolved solids, ORP - oxidation-reduction potential

TABLE 3
INITIAL TW-1 WATER QUALITY RESULTS
Exploratory Drilling Results, Evaluation of Pilot Test Extraction Sites (Plan A/Plan B)
PG&E Topock Compressor Station

Analyte	Result	Units	Method	MRL
General Chemistry				
Total Alkalinity	132	mg $CaCO_3$/L	EPA 310.1	5
Bicarbonate-Alkalinity	132	mg $CaCO_3$/L	Calculation	3
Carbonate-Alkalinity	<3	mg $CaCO_3$/L	Calculation	3
Ammonium	0.09 J	mg/L as N	Calculation	0.13
Carbon Dioxide, Total	121	mg/L CO_2	Calculation	3
Chloride	1250	mg/L	EPA 300.0-A	250
Color (APHA) True	110	color units	SM 2120B	5
Conductivity	5450	µmhos/cm	EPA 120.1	---
Conductivity	5750	µmhos/cm	EPA 120.1	20.0
Fluoride	0.95	mg/L	EPA 300.0-A	0.20
Nitrate/Nitrite	13.3	mg/L as N	EPA 300.0-A	2.00
pH	7.8	pH	EPA 150.1	---
pH[1]	7.97	pH	EPA 150.1	0.100
Silica, Reactive	18.8	mg/L	SM4500 Si-D	0.4
Sulfate	795 J	mg/L	EPA 300.0-A	1000
Total Dissolved Solids	3420	mg/L	Calculation	---
Total Dissolved Solids	3870	mg/L	EPA 160.1	10
Total Dissolved Solids[1]	3760	mg/L	EPA 160.1	10.0
Total Suspended Solids	2.4 J	mg/L	EPA 160.2	10
Total Phosphorus	0.03 J	mg/L	EPA 365.1	0.05
Total Organic Carbon	0.81	mg/L	EPA 415.1/2	0.50
Turbidity	0.4	NTU	EPA 180.1	0.1
Metals, Dissolved				
Chromium, Hexavalent[1]	3.94	mg/L	SW 7199	0.0300
Chromium, Total[1]	4.20	mg/L	SW 6010B	0.100
Iron, Fe	<0.100	mg/L	EPA 200.7	0.100
Metals				
Barium, Ba	0.0512	mg/L	EPA 200.7	0.0500
Calcium, Ca	282	mg/L	EPA 200.7	2.50
Iron, Fe	<0.100	mg/L	EPA 200.7	0.100
Potassium, K	21.4	mg/L	EPA 200.7	10.0
Magnesium, Mg	44.0	mg/L	EPA 200.7	2.50
Manganese, Mn	0.00626 B	mg/L	EPA 200.7	0.0100
Sodium, Na	918	mg/L	EPA 200.7	250
Strontium, Sr	5.65	mg/L	EPA 200.7	5.00
Microbiology				
Heterotrophic Bacteria Plate Count[1]	11,000	CFUs/mL	EPA 9215B	--

Notes:
Sample collected from TW-1 on November 24, 2003.
Analyses conducted by CH2M HILL Applied Sciences Laboratory unless otherwise noted.
[1] - Analysis conducted by Truesdail Laboratories (on rush turn-around).
< - Not detected at specified reporting limits
B - Reported value is between method detection limit and reporting limit (metals only).
J - Estimated value between method detection limit and reporting limit.
MRL - method reporting limit

TABLE 4
SOURCE OF INFLUENT FOR PILOT TREATMENT PLANT DESIGN
Exploratory Drilling Results, Evaluation of Piot Test Extraction Sites (Plan A/Plan B)
PG&E Topock Compressor Station

	Pilot System Design Concentrations		
Parameters	**Nominal Average (Plan A: PGE-6)**	**Probable Maximum (MW-24B, MW-24A, MW-24BR, PGE-06)**	**Plan B (TW-1)**
Key Parameters			
TDS, mg/L	2,783	8,130	3,870
Cr(VI), mg/L (as metal)	1.2	4.90	3.94
Cr(T), mg/L	1.2	5.38	4.2
pH	7.68	8.84	7.8
Cations			
Calcium, mg/L (as ion)	106.7	238	282
Magnesium, mg/L	*41.6*	--	44
Sodium, mg/L	*624.3*	--	918
Potassium, mg/L	*275.3*	--	21.4
Ammonium, mg/L (as ion)	3.1	--	0.09 [1]
Anions			
Chloride, mg/L	962.2	5,380	1,250
Sulfate, mg/L	624.8	1,450	795
Bicarbonate, mg/L (as ion)	141.3	181	161
Phosphate, mg/L (as ion)	<0.1	--	0.09
Fluoride, mg/L	4.9	5.78	0.95

Notes:
1 - Result is less than the reporting limit.
-- - Data not available
A Cr(VI) concentration of 13 mg/L is considered the absolute peak design value based on the maximum concentration detected at the site (well MW-20-70).