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December 8, 2005

Mr. Norman Shopay
Project Manager/Senior Engineering Geologist
California Department of Toxic Substances Control
700 Heinz Avenue, Suite 200
Berkeley, California 94710-2721

Subject: Final Addendum to the *In-Situ Hexavalent Chromium Reduction Pilot Test Work Plan – Floodplain Reductive Zone Enhancement*
PG&E Topock Compressor Station, Needles, California

Dear Mr. Shopay:

Enclosed is a technical addendum to the August 2005 *In-Situ Hexavalent Chromium Reduction Pilot Test Work Plan – Floodplain Reductive Zone Enhancement*. This technical addendum is required by the August 2005 work plan prior to the initiation of field work and provides refinements and minor revisions to the planned field activities. Proposed revisions include an increase in the number of injection wells from two to three, elimination of one of the two biological reductants and subsequent decrease in the quantity of reductant to be injected, and use of three tracer compounds (one for each injection well), rather than one tracer. Other refinements include the shortening of well screen lengths, and minor adjustments to monitoring well locations and the groundwater monitoring program.

No change is proposed to the project footprint. Project construction and operation activities remain substantially similar to the description provided in the August 2005 work plan. Accounting for the proposed refinements in the enclosed technical addendum, the project description and impact conclusions provided in the October 2005 CEQA Initial Study/Negative Declaration prepared and distributed by DTSC remain valid. It is recommended that the enclosed technical addendum be considered in the project administrative record, for consideration by DTSC prior to adopting the Negative Declaration.

If you have any questions, please feel free to contact me.

Sincerely,

Julie Eakins for Yvonne Meeks

Enclosure

Cc: Karen Baker
Aaron Yue
Kate Burger

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TECHNICAL MEMORANDUM

To:
Distribution

Copies:

From:
Neill Morgan-Butcher, PE
Jim Harrington

Date:
5 December 2005

ARCADIS Project No.:
RC000689.0001

Subject:
Final Addendum to the *In-Situ Hexavalent Chromium Reduction Pilot Test Work Plan – Floodplain Reductive Zone Enhancement* for the Pacific Gas and Electric Company Topock Compressor Station

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In accordance with the *In-Situ Hexavalent Chromium Reduction Pilot Test Work Plan – Floodplain Reductive Zone Enhancement* (*Work Plan*) prepared by MWH in August 2005, ARCADIS has prepared this Final Addendum to the *Work Plan* prior to the initiation of field work. This addendum details proposed modifications and implementation specifics to the *Work Plan* based on continued refinement of Site knowledge, review of recent groundwater gradient data and consideration of potential responses to future changes in groundwater extraction, evaluation of the pilot test objectives, and timeframe.

The purpose of the floodplain pilot test is to evaluate the efficacy of using food grade materials to reduce hexavalent chromium (CrVI) in groundwater to form stable, insoluble trivalent chromium. As specified in the *Work Plan*, the results will be used to assess the feasibility and performance (including delivery capabilities and persistence) of selected food grade organic carbon reductants under actual Site conditions, provide additional information on Site conditions necessary to develop an enhanced reductive zone along the river floodplain, and assist with the selection of specific methodologies for long-term Site management.

Proposed Work Plan Modifications

The following modifications are proposed to the *Work Plan*:

- Eliminate the use of emulsified vegetable oil in the pilot study, and focus on lactate as the sole reductant reagent;

- Modify construction of the nested injection well from a doublet to a triplet, and shorten each screen length from 40 feet to 10 feet;

- Confirm monitoring well locations in the field, and allow for some adjustments during field staking to avoid vegetation or other obstacles;

- Modify the tracer test to include three tracers (one each for the shallow, middle, and deep locations in the aquifer) rather than one; and

- Modify the groundwater monitoring schedule and list of analytes.

The proposed changes to the *Work Plan* are discussed in detail in the following text.

Reductant Reagent

The *Work Plan* included an assessment both chemical and biological reduction at the Site. Biological reduction was selected for the floodplain test because it involves the injection of food-grade materials. Emulsified vegetable oil (EVO) and lactate were the organic carbon reductants proposed in the *Work Plan* to support biological reduction.

The 6-month duration of the proposed pilot test may limit the potential to evaluate the long-term slow release of carbon from EVO. Further, because of the potential for localized vertical heterogeneity and vertical gradients, it would be difficult to confirm uniform distribution of the less-soluble EVO across the screened aquifer profile through well injection. For these reasons, it is proposed that EVO be eliminated from the pilot study, and a fully dissolved carbon source (e.g. lactate, corn syrup, or molasses) be the sole reductant reagent. These carbon sources have good distribution characteristics because they are highly water soluble and will move with the groundwater. Since lactate was proposed in the *Work Plan*, lactate will be used for the pilot test.

The amount of total reductant to be used in each injection well will be reduced, from 7,947 lbs per well (306 lbs of lactate and 7,641 lbs of EVO were proposed in the *Work Plan*) to 500 lbs per well (all lactate). The total water to be used in each injection well will stay the same, at 6,000 gallons.

However, it is now proposed that these quantities be injected into each of three injection wells (located in one cluster) rather than two injection wells, as was initially proposed in the *Work Plan*. The result will be a decrease in the total amount of reductant injected in the well cluster – from 15,894 lbs to 1,500 lbs; and an increase in the total amount of water injected, from 12,000 gallons to 18,000 gallons. The lactate for each of the three wells will be diluted in the water prior to injection (the "reagent solution"). A minor amount of yeast extract (not to exceed the 14 lbs per well proposed in the *Work Plan*) will be added to this solution to provide nutrients and enhance the growth rate of microbes that are performing the chromium reduction. The reagent solution will then be injected into each injection well, as described in the *Work Plan*.

The use of "chaser" water was proposed in the *Work Plan* because EVO is of limited solubility and must be pushed out of the well to the maximum extent possible. Because the EVO has been eliminated and because the chaser water has the potential to complicate the tracer study data interpretation, chaser water will not be used. The emulsifier will also not be used in the reagent solution because the lactate is fully soluble in the water. Since there will be no chaser water, the reagent solution can be mixed offsite. The result will be less staging than was proposed in the *Work Plan*. There will be no need for separate holding tanks for lactate and water. The reagent solution can mixed at the Compressor Station and brought to the site in three tanker truck trips (one for each tracer, see discussion below) during each injection event.

Injection Well Construction

The *Work Plan* details the construction standards for the injection well cluster, PTI 1S/D (a doublet). According to the *Work Plan*, the well will be constructed within two separate borings (one shallow and one deep). PTI-1S was to be constructed with 4 inch schedule 80 PVC with the screen interval at 440 to 400 feet above mean sea level (msl), using 0.02 inch slotted PVC screen. PTI-1D was to be constructed with 4-inch schedule 80 PVC with the screen interval at 400 to 360 feet msl, using 0.02-inch slotted PVC screen.

Upon further consideration of site specific conditions, it may not be feasible to distribute reagents equally across a 40 foot screen interval. In this situation, most of the reductant could be injected into a thin section of the aquifer, which may or may not be the same zone that is being monitored in the surrounding monitoring well network.

As an improvement, it is proposed that the injection well cluster be modified to consist of three (rather than two) separate borings (shallow, intermediate, and deep) with 10-foot (rather than 40-foot) screens for each. The suggested elevations for the screen intervals are the following approximate elevations: 435 to 425 feet msl, 410 to 400 feet msl, and 375 to 365 feet msl, which is the same as the monitoring well intervals. The nomenclature for these three wells will now be PTI-1S/M/D (shallow, middle, and deep depth intervals).

In addition to the screen interval change, it is proposed to change the screen material from 0.02-inch slotted PVC screen to 0.02-inch slotted stainless steel wire-wrapped screen. The stainless steel wire-wrapped screen will provide a stable, more permeable section to which the lactate is less likely to clog during injection activities. The well installation activities are anticipated to require two additional days to complete as a result of these injection well changes.

The well installation activities are expected to require two additional days to complete as a result of these injection well changes. Well construction activities for this study are proposed to begin in mid-January, and be completed by March 15.

Staging of equipment and materials will be performed on the MW-20 bench, in the vicinity of well MW-35, and on PG&E compressor station property. Staging will not be performed at IM-3.

Introduction of intrusive vibrations and noise will be minimized to the extent possible. Noise will be limited to well construction activities, reductant injection, and periodic groundwater monitoring activities. Vibration will be limited to well construction activities in the floodplain.

Visual impacts of the proposed wells can be evaluated by observing the existing floodplain wells, which are very similar in appearance to the proposed wells.

Monitoring Well Locations

The *Work Plan* describes the pilot test location area. Four areas within the floodplain were evaluated to compare their suitability for the in-situ pilot test. The areas were evaluated based upon seven criteria. The *Work Plan* indicates that multi-level monitoring well nests will be installed west, southwest, southeast and north of the injection well cluster.

Although no change is proposed to the configuration of the monitoring wells, or to the overall footprint of the monitoring well network, the exact locations of some wells may be adjusted in the field in consideration of vegetation and other localized obstacles, with concurrence from appropriate stakeholders. At each of the monitoring well locations, three vertical zones will be targeted for monitoring. It is proposed that the three targeted monitoring zones will correspond directly with the three zones of the injection well cluster.

Tracer Study

The *Work Plan* proposes a groundwater tracer utilizing a single tracer (bromide). Due to the potential variability of aquifer characteristics with depth and the vertical effects of expected groundwater pumping on groundwater flow, it is now proposed to conduct the tracer study with each of the injection well triplets receiving its own tracer - i.e., PTI-1S will receive fluorescein, PTI-1M will receive bromide, and PTI 1D will receive iodide. Fluorescein will be injected at approximately 5 milligrams per liter (mg/L) in the reductant solution, while bromide and iodide will be injected at 2000 mg/L in the reductant solution. These concentrations are equivalent to 0.25 lbs of fluorescein and 100 lbs each of bromide and iodide The resulting information will be used to track groundwater movement at different depth intervals. All of the tracers are nontoxic and will be captured by the groundwater extraction system (IM-3). Iodide and bromide occur naturally and will be collected by reverse osmosis in the treatment plant, and fluoroscein degrades naturally in a fairly short time.

Based on existing aquifer information and modeling results, the center of the tracer mass and reductant reagents should travel approximately 0.4 feet per day. The tracers should appear at monitoring well PT 1 within three weeks, and at monitoring well PT-2 within three months.

Based on observations of site groundwater chemistry and a comparison of reductant (total organic carbon) concentrations with tracer concentrations, a reduction efficiency can be determined. If the initial reduction efficiency indicates a high rate of consumption of the reductant by compounds other than hexavalent chromium, a second injection may be performed with a higher concentration of lactate, as proposed in the *Work Plan.*

The test will conclude 6 months after the initial injection. Continued monitoring after the 6 month pilot test may be proposed after results from the initial 6 month monitoring period have been obtained, in addition to any RWQCB monitoring requirements.

Groundwater Monitoring Program

Groundwater monitoring will be conducted to evaluate the effectiveness of the reagent introduction to the aquifer. Drilling, well installation, well development and associated field activates will be performed in accordance with the *Work Plan.*

The *Work Plan* proposed that the monitoring wells would be sampled pre-injection (two baseline events), immediately following injection, and then daily for the first week, weekly for the first month, and monthly thereafter. The groundwater samples were to be submitted for analysis of various specified analytes. It is proposed that the post-injection monitoring program be modified, as described below, based on additional evaluations that were performed since the *Work Plan* was submitted (Table 1).

Sampling Phase 1 (Day 1 through Day 6) will be refocused on the injection well cluster (PTI-1S/M/D) because the injected solution is not anticipated to be present in the nearest monitoring wells (PT-1, PT-3, and PT-4) for the first week. It is proposed that the Sampling Phase 1 be modified by performing daily tracer and total organic carbon (TOC) sampling and analysis at the injection well cluster (PTI-1S/M/D) for the first six days after injection The rate of decrease of tracer concentration in each injection well will provide information about the rate of groundwater movement at each depth interval, and by comparison of the concentrations at different depths, the relative rates of groundwater movement across the profile will be better understood. The TOC data will supplement the tracer data and will provide an estimate of both aquifer sorption and initial degradation rates. In addition, if the injected solution is not observed to intercept the monitoring wells during later sampling phases, the injection well cluster data will provide key information for the evaluation of reductant effectiveness. Monitoring wells PT-1, PT-3 and PT-4 will be monitored for tracer during this phase, in case highly heterogeneous lithology is encountered and leads to stratified, preferential flow and early arrival at a well. The schedule for Sampling Phases 2 and 3 may be adjusted based on the data derived during Phase 1, to ensure that an optimal data set is acquired during the pilot test.

In addition to the TOC and tracer monitoring, an additional sampling round for all analytes (as proposed below) will be added at Day 3 for monitoring wells PT-1, PT 3, and PT-4, in case highly heterogeneous lithology is encountered.

Consistent with the *Work Plan* and the changes to Sampling Phase 1, Sampling Phase 2 (Day 7 through Day 21) will continue the tracer and TOC monitoring in the injection well cluster. During Phase 2, all analytes will be monitored (as proposed below) in each monitoring well that is close enough to the injection wells that it could show impacts, i.e., PT-1, PT-3, PT-4, and PT-6. Wells PT-2 and PT-5 will only be monitored at baseline and during Phase 3 of the sampling, unless the tracer data indicates earlier sampling would be appropriate.

Sampling Phase 3 (Day 28 through Day 168) will also be modified to include sampling of the injection well cluster (PTI-1S/M/D). As proposed in the *Work Plan*, monitoring wells PT-1, PT-2, PT-3, PT-4, PT-5, and PT-6 and extraction wells TW-2D and PE-1 (and TW-3D if installed and operational during the pilot test). The sampling frequency will be performed monthly, as described in the *Work Plan*.

It is also proposed that the analyte list be slightly modified as follows: The chromium, nitrate/nitrite, iron, manganese, sulfate and TOC data are directly relevant to the test and should be analyzed at each well at the frequency described above. Calcium, magnesium, arsenic, potassium, sodium, carbonate/bicarbonate, chloride, phosphorus, and sulfide provide some beneficial information, and will be analyzed prior to injection (baseline), at the end of month 3 (Day 84), and at the end of month 6 (Day 168). Fatty acids, ammonia, and methane are not particularly relevant to the study, and will not be analyzed.

Field instruments are reliable for measurement of a variety of parameters, including pH, temperature, and specific conductance. These parameters will all be analyzed as described in the *Work Plan*. Samples will also be taken for field analysis of hexavalent chromium at the IM-3 laboratory. However, field measurements for dissolved oxygen and oxidation-reduction potential can be unreliable, and field monitoring for these field parameters is no longer proposed during the test to determine whether or not to take samples for laboratory analysis.

The *Work Plan* discusses the reporting needs for the pilot test activities at the Site. In accordance with the *Work Plan*, frequent communications between PG&E and the DTSC will occur. Quarterly update reports will be prepared and submitted beginning immediately after the introduction of reagent and continuing for the duration of the study period. A final report will be submitted within approximately three months of completion of the pilot study.

TABLE 1
Summary of Proposed Modifications to Groundwater Monitoring Program
December 2005 Work Plan Addendum
Floodplain In-Situ Pilot Test

Sampling Program Element	Original August 2005 Workplan	Updated December 2005 Addendum
Sampling Phase 1 – Day 1 through Day 6		
§ Frequency	§ Daily tracer and field analyte monitoring from Day 1 through Day 5 § Lab analyses after field data indicates arrival of injection solution	§ Daily tracer and field analyte monitoring from Day 1 through Day 6 § Lab analyses after field data indicates arrival of injection solution § Day 3 sampling for full lab analyte list
§ Locations	§ PT-1, PT-3, and PT-4	§ Addition of PTI-1S/M/D for tracer, field analytes, and total organic carbon (TOC)
Sampling Phase 2 – Day 7 (Week 1) through Day 21 (Week 3)		
§ Frequency	§ Weekly	§ Weekly
§ Locations	§ PT-1 to PT-6 for tracer and field and laboratory analytes	§ Addition of PTI-1S/M/D for tracer, field analytes, and TOC only § PT-2 and PT-5 (more distant wells) removed from this phase. Others – no change
Sampling Phase 3 – Day 28 (Week 4) to Day 168 (Month 6)		
§ Frequency	§ Monthly to bimonthly	§ No change
§ Locations	§ PT-1 to PT-6, TW-2D and PE-1	§ Addition of PTI-1S/M/D for tracer, field analytes, and TOC only
Analytes – Lab Tests	§ CrVI , total chromium, iron (ferric and ferrous), manganese, arsenic, calcium, magnesium, potassium, sodium, carbonate, bicarbonate, nitrate, nitrite, chloride, phosphorus (as phosphate), sulfate, TOC, sulfide, volatile fatty acids, ammonia, and methane	§ CrVI , total chromium, iron (ferric and ferrous), manganese, nitrate, nitrite sulfate and TOC – no change § Arsenic, calcium, magnesium, potassium, sodium, carbonate, bicarbonate, nitrate, nitrite, chloride, phosphorus (as phosphate), and sulfide – reduced sampling frequency § Volatile fatty acids, ammonia, methane – eliminated
Analytes – Field Tests	§ pH, temperature, dissolved oxygen (DO), ORP, specific conductance, and CrVI	§ pH, temperature, specific conductance, and CrVI. DO and ORP – eliminated