

CALIFORNIA REGIONAL WATER QUALITY CONTROL BOARD
CENTRAL VALLEY REGION

ORDER NO. R5-2005-0178

WASTE DISCHARGE REQUIREMENTS

FOR
AIR FORCE REAL PROPERTY AGENCY
FORMER MCCLELLAN AIR FORCE BASE
IN-SITU CHEMICAL OXIDATION TREATABILITY STUDY
AT FORMER DAVIS GLOBAL COMMUNICATIONS SITE
YOLO COUNTY

The California Regional Water Quality Control Board, Central Valley Region, (hereafter Regional Board) finds that:

1. On 11 August 2005, the Air Force Real Property Agency (hereafter Discharger) submitted the *Draft Treatability Study Work Plan, Former Davis Global Communications Site, California* (Work Plan). The inactive Davis Global Communications Site (hereafter Davis Site) was an annex of the former McClellan Air Force Base and is currently owned and managed by the Discharger. This Work Plan describes an in-situ chemical oxidation (ISCO) treatability study to evaluate the potential for in-situ treatment of groundwater containing volatile organic compounds (VOCs) at the Davis Site. The project is being conducted as part of a performance-based contract between the Discharger and CH2MHill. CH2MHill will be constructing and operating the treatability study. The Work Plan provides the information necessary for preparation of waste discharge requirements. The Discharger is cleaning up polluted groundwater pursuant to the federal Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA) (42 U.S.C. 9601-9675) and also must comply with state requirements.
2. The ISCO treatability study will be conducted in two phases. Waste Discharge Order R5-2005-0178 and the attached Monitoring and Reporting Program (MRP) No. R5-2005-0178 cover the activities for Phase 1 and Phase 2. Phase 2 is expected to follow procedures similar to Phase 1. Specific details of Phase 2 will be developed using the results of Phase 1. Minor changes in Phase 2 may require revisions to the MRP. Significant changes in Phase 2, if necessary, may require a separate Order and MRP.
3. The Discharger has stated that the substantive requirements in this Order will be incorporated into the Final Work Plan (in preparation). The project site location is shown on Attachment A, which is attached hereto and made part of this Order by reference.
4. The Davis Site is located approximately 20 miles southwest of the former McClellan Air Force Base in Yolo County, 3 miles southeast of the City of Davis, as shown on Attachment A. It is situated in a predominantly agricultural area near the Yolo-Solano County border, approximately 5 miles south of Interstate 80 at the intersection of County Roads 104 and 36. The Davis Site comprises approximately 316 acres. The project site plan is shown on Attachment B, which is attached hereto and made part of this Order by reference.

5. The primary objectives of the treatability study are to demonstrate ISCO's effectiveness at remediating VOCs at the site and to collect the necessary data to optimize ISCO implementation. Other objectives of the study are to collect additional groundwater samples to better define the extent of groundwater contamination and to modify the ongoing groundwater-monitoring program.
6. Current efforts at the site are focused on remediation of VOC contamination in groundwater. A groundwater pump-and-treat system has operated at the site since 1996. In addition, a soil vapor extraction (SVE) system operated at the site from 1996 through 1999 to remediate VOCs in the vadose zone, and a biovent system operated from 1993 through 2002 to remediate residual diesel contamination in soil. The SVE system effectively remediated the vadose zone and was shut down in 1999 with regulatory agency approval.

Treatability Study Layout and Operation

7. The treatability study will be targeting groundwater in the uppermost water bearing zone. The vadose zone at the Davis Site extends from the ground surface to approximately 65 feet bgs. Because of large fluctuations in the elevation of the water table, however, portions of the vadose zone are saturated for long periods each year. The water table typically reaches its highest point during spring and then decreases through the summer because of agricultural pumping. During a typical year, the water table fluctuates between 15 and 55 feet bgs; however, it may rise higher than 10 feet bgs or drop to over 70 feet bgs during extreme years.

The permeable aquifer units underlying the seasonal vadose zone have been divided into five zones: A, B, C, D, and E, with A being the shallowest and E the deepest. An aquitard separates each of the permeable zones. Clays comprise most of the vadose zone with an approximately 10-foot-thick sand deposit found between 20 and 40 feet bgs. The sand deposit is found consistently beneath and east of the fenced compound area shown in Attachment B. The deep vadose zone (below 40 feet bgs) is saturated during portions of the year. This deep vadose zone when seasonally saturated is referred to as the A zone. This zone is composed of fine-grained materials of relatively low permeability and low organic carbon. In the B zone, permeable deposits are thickest near the southeast corner of the main fenced compound, with about 25 feet of well-sorted gravel and sand intermixed with silty sand. The permeable deposits are bounded above and below by sandy and silty clays. In the C zone, the aquifer materials become more permeable with depth, changing from silty sand to sand or gravel with sand. The most significant remaining contaminants at the Davis Site are VOCs present in heterogeneous aquifer materials distributed throughout the B zone and in deeper portions of the seasonally saturated A zone.

Horizontal and vertical gradients in groundwater are in a constant state of flux because of seasonal changes in recharge and agricultural pumping. In general, winter conditions show relatively flat horizontal gradients and upward vertical gradients, and summer conditions generally show horizontal gradients to the south-southwest with strong downward vertical gradients. Although flow directions vary at the site, the flow is predominately to the southwest, toward the regional depression caused by summer agricultural pumping.

8. At the Davis site, the effectiveness of the groundwater pump-and-treat system is limited by the presence of lenses of low permeability materials and large-scale groundwater elevation fluctuations due to local seasonal agricultural pumping that leave the most contaminated zone unsaturated for much of the year. The inability of the existing pump-and-treat system to clean up the residual contamination at the site is demonstrated by the lack of decreasing contaminant concentration trends in recent years in the most contaminated wells, despite nearly 10 years of operation. To expedite remediation of the residual contamination, CH2M HILL is proposing application of ISCO, initially during a phased treatability test. Chemical oxidation has the capability to reduce the contaminant mass in the subsurface in a much shorter timeframe than a pump-and-treat approach. ISCO potentially can permanently degrade VOCs in months, allowing contaminants in the seasonally saturated zone to be treated during the short periods the zone is saturated. The objective of a full-scale ISCO application would be to remediate the residual VOC contamination in the deeper B aquifer zone and seasonally saturated portion of the shallower A aquifer zone and thereby facilitate the Discharger's goals of property transfer and site closure.
9. Groundwater beneath the Davis Site contains VOCs, primarily trichloroethene (TCE) and tetrachloroethene (PCE) and their degradation products. TCE and PCE are solvents used primarily in cleaning operations and have Maximum Contaminant Level (MCLs), or Primary Drinking Water Standards, of 5 micrograms per liter ($\mu\text{g/L}$). In addition, the California Office of Environmental Health Hazard Assessment has established a Public Health Goals for TCE in water of $0.8 \mu\text{g/L}$ and $0.06 \mu\text{g/L}$ for PCE. The maximum historical concentration of TCE in the groundwater beneath the Davis Site is $3,000 \mu\text{g/L}$. The maximum historical concentration of PCE in the groundwater beneath the Davis Site is $1,400 \mu\text{g/L}$.
10. The treatability study includes a field investigation. The scope of the field investigation will include the drilling of cone penetrometer testing borings and the installation of groundwater monitoring wells. The proposed cone penetrometer testing borings and new groundwater monitoring well locations are shown on Attachment C, which is attached hereto and made part of this Order by reference. The overall purpose of the field investigation is to establish baseline groundwater VOC contaminant distribution at the site and to install additional monitoring wells that will be used as part of the in situ treatability study. Since the lithology at the site has been extensively characterized, only limited lithology sampling will be conducted during the field investigation.
11. ISCO involves the injection of a chemical oxidant into subsurface source zones and the associated downgradient plumes. Upon contact with the oxidant, chlorinated VOCs are broken down into inert materials such as carbon dioxide, hydrogen, chloride, and water. The treatability study will involve injection of potassium permanganate as the primary oxidant. This treatability study will be implemented to evaluate the behavior and response of ISCO using permanganate application at the Davis Site. The specific test objectives for this study are as follows: evaluate COC destruction in the seasonally saturated portion of the vadose zone, A aquitard, and B zone through groundwater performance monitoring; evaluate the dosage of oxidant(s) for site soil and groundwater; evaluate the injection of permanganate by direct push techniques; evaluate the radius of treatment, dilution, and consumption of the chemical oxidant(s) within the target zone; evaluate the effectiveness and

permanence of COC removal after single and/or multiple injections; evaluate the effect of the ISCO treatment on secondary water quality parameters, and; provide information concerning implementation parameters, such as flow rates and productivity.

12. The treatability study will be conducted in three parts, including two injection events (Phases 1 and 2) to provide flexibility. The proposed ISCO treatability study injection areas for the Phase 1 and Phase 2 injection events are shown on Attachment D, which is attached hereto and made part of this Order by reference. The treatability study will include the following activities:

Pre-injection phase

- Bench-scale testing
- Preparation of the work plan
- Baseline groundwater monitoring
- Re-evaluation of dose, volume, and type of permanganate to be used in the field

Initial injection event (Phase 1)

- Site preparation and mobilization.
- Permanganate preparation and mixing.
- Advancing the injection tool to each zone for injection using direct-push technology in a unit cell pattern.
- Initial injections of permanganate into each 5-foot injection interval over a 60-foot-thick target zone.
- Post-injection performance monitoring events.

Second injection event (Phase 2)

- Modification of oxidant injection parameters, if necessary, based on results from the initial injection event.
- Permanganate preparation and mixing.
- Advancing the injection tool to each zone for injection using direct-push technology in a unit cell pattern.
- Initial injections of permanganate into each 5-foot injection interval over 60-foot target zone.
- Post-injection performance monitoring events.

13. The first injections during the treatability study will use temporary injection borings installed by direct-push drilling methods. The injection tool will be advanced to the first injection interval at about 30 feet bgs that is just below the approximate seasonal high water elevation. Subsequent injections will be spaced at 5-foot vertical intervals below the seasonal high water elevation, down to a maximum depth of approximately 90 feet bgs. Top-down injection techniques will be used to ensure the injected permanganate does not migrate down an open borehole into the more permeable zones at the bottom of the treatment zone. The 3-foot long injection tool will be positioned in the middle of each injection zone and the target volume of 800 gallons per interval will be delivered at approximately 10 gpm, dependent on the target zone geology. Nine injection locations will be

completed in an 80-by-80-foot area as shown on Attachment D. These initial design calculations estimate that the Phase 1 treatability study chemical requirement is approximately 18,000 pounds of potassium permanganate with a total injection volume of 86,000 gallons at a concentration of 25 grams potassium permanganate per liter of water. These calculations represent an upperbound of the oxidant mass and volume. It is likely that the low hydraulic conductivity in the shallow intervals will reduce the injectability of the oxidant.

14. Prior to injection activities and baseline groundwater sampling, three new monitoring wells will be installed in the treatability test area as shown on Attachment C. Two wells are planned in or immediately adjacent to the Phase 1 treatment area for the B zone. One new well is planned for the transition zone screened in the C zone.
15. The phased treatability testing is intended to treat those areas with the highest concentrations of TCE and PCE. In total, the targeted areas include an estimated 70 percent of the contaminant mass remaining in the B zone. The highest measured concentrations of TCE in groundwater are found in monitoring wells MW-3 and MW-7. As such, the initial injection treatability testing will be conducted in the vicinity of monitoring well MW-3 at depths from 30 to 90 feet below bgs over the area shown on Attachment D.

Phase 1 area is approximately 80 by 80 feet. The injection will consist of nine direct-push injection locations in a square pattern of three rows and three columns. The distance between each injection location will be approximately 25 feet. The Phase 1 area, injection well spacing, and possible Phase 2 injection area are depicted on Attachment D. As currently planned, the Phase 2 area includes MW-3, MW-7, and MW-1 and extends approximately 150 feet east to west and north to south along the north and east boundaries. The Phase 2 area may be revised based on the results of the additional groundwater characterization activities and the results of Phase 1 of the treatability test. Any proposed changes will be presented in an addendum to the work plan for review and approval prior to execution.

16. The potassium permanganate solution used for injection will be mixed onsite to achieve the concentration determined by bench-scale testing. A water supply with a minimum flow rate of 75 gpm will be required. The onsite production well will be tested for adequate flow, pressure, and water quality prior to being used for preparing the potassium permanganate solution.

Two separate mixing vessels will be in use during the injection process to mix and deliver solution in approximately 800-gallon batches. Based on the injection reaction to the hydrogeological conditions at the site, it is estimated that approximately 9,600 gallons of solution will be delivered per 60-foot injection interval per day. The design potassium permanganate concentration and the volume of solution proposed for injection during the treatability study will likely be refined prior to and/or during the injection event(s) based on the bench-scale test, SOD analyses, and/or other geologic factors as encountered during the injection process.

The 3-foot long injection tool will be advanced using direct-push techniques to the first 5-foot injection interval. The 2-foot offset in the vertical between targeted injection zones is designed to

minimize the potential for return of the injected solution to the ground surface along the injection tooling.

After verifying that all connections and hoses are secure, potassium permanganate will be delivered by pressurized injection. The injection pressure will be maintained below 25 pounds per square inch gauge (psig) at the outlet of the injection tool. The pressure losses along the injection hose and tooling will be estimated prior to mobilization to the field to determine the maximum pressure reading on the injection assembly.

The design volume per injection interval is 800 gallons. When an injection interval is completed, the injection tool will be advanced 5 feet and another 800-gallon volume of potassium permanganate will be injected, if feasible. This process will be repeated from 30 feet bgs until a depth of 90 feet bgs is reached. This top-down injection is expected to allow for greater control in placement of injected potassium permanganate solution than would be obtained with a continuously screened monitoring well or a bottom-up injection approach. If an injection interval does not accept fluid at the maximum operating pressure then the injection volume will be delivered to the next deeper zone.

If flow rates into an injection interval are less than 10 gpm then adjustments to the injection volume may be made in the field. In general, if the flow rate is less than 1 gpm then injections will be performed at the next deeper depth that accepts significant fluid flow. At 10 gpm, the injection process should allow one injection location to be completed per day. Ten days of injection are planned for Phase 1, and assuming the target flow rates can be achieved, all nine injection locations will be treated.

17. ISCO causes some secondary effects such as increases in total dissolved solids (TDS) and redox sensitive metals. Potassium permanganate contains impurities including chromium and is known to oxidize trivalent chromium (CrIII) from soil to the more soluble hexavalent form (CrVI). Many factors may affect the rate and extent of mobilization and attenuation. For example, MnO_2 , the product of potassium permanganate reduction, has been reported to both oxidize soil CrIII to CrVI and adsorb CrVI from solution. In addition, ion exchange processes may also be involved in Cr formation and attenuation during permanganate treatment. The literature and prior laboratory testing has shown that CrVI is normally mobilized to some degree during potassium permanganate treatment, but tends to attenuate in groundwater in weeks to months after the permanganate has been consumed. The potential for formation and attenuation of CrVI at the Davis Site will be evaluated during the treatability study. These adverse byproducts created by injection of the potassium permanganate are expected to be transient. Any persistent adverse byproducts created by the treatability study can be captured by the existing groundwater extraction system, if necessary.
18. If monitoring during injection indicates unexpected conditions, excessive water level rise, or unsafe conditions, the injections will be stopped. If the cause can be explained and then corrected as appropriate, the injections will proceed. If monitoring indicates potassium permanganate solution is leaving the transition zone, then a reducing agent, such as a 6-percent sodium thiosulfate ($Na_2O_3S_2$) solution, may be injected to neutralize the permanganate.

Monitoring following injection will be performed. During Phase 1, samples will be collected from ten monitoring wells at frequencies ranging from bi-weekly to quarterly to evaluate effects of the injection on the aquifer. If permanganate is leaving the treatability test volume in excessive amounts, especially downward into the C aquifer, a reducing agent, such as a 6-percent sodium thiosulfate ($\text{Na}_2\text{O}_3\text{S}_2$) solution may be injected to neutralize the permanganate. During the treatability testing, the groundwater extraction system will remain shut down, but operable. If required to control unexpected migration of permanganate or CrVI, it could be restarted.

Basin Plan, Beneficial Uses, and Regulatory Considerations

19. The *Water Quality Control Plan for the Sacramento River and San Joaquin River Basins, Fourth Edition*, (hereafter Basin Plan) designates beneficial uses, establishes water quality objectives, contains implementation plans and policies for protecting waters of the basin, and incorporates by reference plans and policies adopted by the State Water Resources Control Board (State Board). Pursuant to §13263(a) of the California Water Code (CWC), waste discharge requirements must implement the Basin Plan.
20. Surface water at the Davis Site consists of ephemeral rainwater pools onsite and agricultural drainage ditches along the site boundary. There are no permanent ponds or creeks in the area nor any direct connections to Putah Creek, approximately 1.5 miles north of the site.
21. The Basin Plan identifies the beneficial uses of the underlying groundwater as municipal and domestic supply, agricultural supply, industrial service supply, and industrial process supply.
22. State Board Resolution No. 68-16 – “Statement of Policy with Respect to Maintaining High Quality of Waters in California” (hereafter Resolution 68-16) requires the Regional Board in regulating discharges to maintain high quality waters of the state until it is demonstrated that any change in quality will be consistent with maximum benefit to the people of the State, will not unreasonably affect beneficial uses, and will not result in water quality less than that described in plans and policies (e.g., quality that exceeds water quality objectives). Any activity which produces a or may produce a waste or increased volume or concentration of waste must be required to meet waste discharge requirements which will result in best practicable treatment or control of the discharge necessary to assure that pollution or nuisance will not occur and the highest water quality consistent with maximum benefit to the people of the state will be maintained. Temporal degradation of groundwater at this site due to the permanganate injection may occur. The temporary degradation allowed by this Order is consistent with Resolution 68-16 since (1) the purpose is to accelerate and enhance remediation of unacceptable concentrations of several waste constituents and such remediation is consistent with maximum benefit to the people of the state; (2) the discharge facilitates a treatability study to evaluate the effectiveness of cleanup technology in accord with State Board Resolution 92-49 and is limited in scope and duration; (3) best practicable treatment, including adequate monitoring and contingency plans to assure protection of water quality, are required; and (4) the injection will not cause water quality objectives to be exceeded beyond the project target area.

23. Section 13267(b) of California Water Code provides that:

“In conducting an investigation specified in subdivision (a), the Regional Board may require that any person who has discharged, discharges, or is suspected of having discharged or discharging, or who proposes to discharge within its region, or any citizen or domiciliary, or political agency or entity of this state who has discharged, discharges, or is suspected of having discharged or discharging, or who proposes to discharge waste outside of its region that could affect the quality of the waters of the state within its region shall furnish, under penalty of perjury, technical or monitoring program reports which the Regional Board requires. The burden, including costs of these reports, shall bear a reasonable relationship to the need for the reports and the benefits to be obtained from the reports. In requiring those reports, the Regional Board shall provide the person with a written explanation with regard to the need for the reports, and shall identify the evidence that supports requiring that person to provide the reports.”

The technical reports required by this Order and the attached MRP No. R5-2005-0178 are necessary to assure compliance with these waste discharge requirements. The Discharger operates the facility that discharges the waste subject to this Order.

24. The California Department of Water Resources sets standards for the construction and destruction of groundwater wells, as described in *California Well Standards Bulletin 74-90* (June 1991) and *Water Well Standards: State of California Bulletin 94-81* (December 1981). These standards, and any more stringent standards adopted by the State or county pursuant to California Water Code Section 13801, apply to all monitoring wells that may be installed to perform the treatability study.
25. Issuance of this Order is an action to assure the restoration of the environment and is, therefore, exempt from the provisions of the California Environmental Quality Act (Public Resources Code, Section 21000, et seq.), in accordance with Title 14 California Code of Regulations (CCR) Section 15308 and 15330.
26. This discharge is exempt from the requirements of *Consolidated Regulations for Treatment, Storage, Processing, or Disposal of Solid Waste*, as set forth in Title 27, CCR, Section 20005, et seq., (hereafter Title 27). The exemption pursuant to Section 20090(b), is based on the following:
- a. The Regional Board is issuing waste discharge requirements,
 - b. The discharge complies with the Basin Plan, and
 - c. The wastewater does not need to be managed according to Title 22 CCR, Division 4.5, and Chapter 11, as a hazardous waste.
27. Pursuant to California Water Code Section 13263(g), discharge is a privilege, not a right, and adoption of this Order does not create a vested right to continue the discharge.
28. All the above and the supplemental data and information and details in the attached Information Sheet, which is incorporated by reference herein, were considered in establishing the following conditions of discharge.

29. The Discharger and interested agencies and persons were notified of intent to prescribe waste discharge requirements for this discharge and provided with an opportunity for a public hearing and an opportunity to submit written views and recommendations.
30. In a public meeting, all comments pertaining to the discharge were heard and considered.

IT IS HEREBY ORDERED that pursuant to Sections 13263 and 13267 of the California Water Code, the Air Force Real Property Agency, its agents, successors, and assigns, in order to meet the provisions contained in Division 7 of the California Water Code and regulations adopted thereunder, shall comply with the following while conducting the above-described treatability study:

[Note: Other prohibitions, conditions, definitions, and some methods of determining compliance are contained in the attached "Standard Provisions and Reporting Requirements for Waste Discharge Requirements" dated 1 March 1991, incorporated herein.]

A. Discharge Prohibitions

1. Discharge of wastes to surface waters or surface water drainage courses is prohibited.
2. Discharge of waste classified as 'hazardous' under Title 23 CCR Section 2521 or 'designated', as defined in California Water Code Section 13173 is prohibited.
3. The discharge/injection of potassium permanganate by the Discharger at a location or in a manner different from that described in Findings 14 through 18, is prohibited.

B. Discharge Specifications

1. The Discharger shall maintain the ability for hydraulic control and containment within the transition zone (defined as the area within a 200 foot radius from the edge of the treatment zone, as shown on Attachment D) of any groundwater pollutants, amendments, and breakdown products either injected or created by the treatability study. The Discharger shall maintain the ability for hydraulic control throughout the treatability study and until the aquifer has recovered to pre-injection conditions, or until the Discharger can demonstrate that any parameters that exceed water quality objectives as a result of potassium permanganate injection show a decreasing trend.
2. The groundwater shall not be amended with materials other than potassium permanganate, or if necessary, sodium thiosulfate.
3. The Discharger shall not cause the permeability of the aquifer, either inside or outside of the test cells, to be affected to such a degree that the Discharger is unable to effectively operate extraction wells for the purpose of containing the injected material and or its byproducts.

4. Objectionable odor originating at the test cells shall not be perceivable beyond the limits of the Davis Site.
5. The discharge shall not cause pollution or nuisance as defined by the California Water Code.
6. The Discharger shall not add more than 0.5 grams of potassium permanganate per kilogram of soil.

C. Groundwater Limitations

1. The Discharger shall not cause the groundwater to contain persistent waste constituents statistically greater than ambient concentrations. Temporary increases of TDS and redox sensitive metals are expected and permitted in the pilot test area, but these constituents shall not migrate outside the capture zone of the existing groundwater extraction system.

D. Provisions

1. The Discharger shall notify Regional Board staff a minimum of two weeks prior to the initial start date for injection of the potassium permanganate.
2. Prior to any modifications that would result in material change in the quality or quantity of the potassium permanganate discharge, or any material change in the character, location, or volume of the discharge, the Discharger shall submit information describing the modifications to the Regional Board for review. The attached Monitoring and Reporting Program (MRP) and/or this Order may be revised prior to implementation of any modifications.
3. The Discharger shall provide an alternate water supply source to any affected well owner if the treatability study adversely affects any water supply wells.
4. Reports shall be submitted pursuant to Section 13267 of the California Water Code. In accordance with California Business and Professions Code sections 6735, 7835, and 7835.1, engineering and geologic evaluations and judgments shall be performed by or under the direction of registered professionals competent and proficient in the fields pertinent to the required activities. All technical reports specified herein that contain work plans for, that describe the conduct of investigations and studies, or that contain technical conclusions and recommendations concerning engineering and geology shall be prepared by or under the direction of appropriately qualified professional(s), even if not explicitly stated. Each technical report submitted by the Discharger shall contain a statement of qualifications of the responsible licensed professional(s) as well as the professional's signature and/or stamp of the seal.
5. The Discharger shall submit a Draft Phase 1 Treatability Report/Phase 2 Addendum summarizing the results of the treatability study and addressing the objectives outlined in Finding 6. The Phase 1 ISCO field work is scheduled to be completed 22 June 2006. Within

60 days after completion of the Phase 1 ISCO treatability study, the Discharger shall submit a Draft Phase 1 Treatability Study Report/Phase 2 Addendum to the Regional Board.

6. The Discharger shall comply with the attached MRP No. R5-2005-0178, which is part of this Order, and any revisions thereto as ordered by the Executive Officer. Modifications to MRP No. R5-2005-0178 may be made to continue process monitoring if any parameter does not return to pre-injection conditions.
7. The Discharger shall comply with the "Standard Provisions and Reporting Requirements for Waste Discharge Requirements," dated 1 March 1991, which are by reference, a part of this Order. This attachment and its individual paragraphs are commonly referenced as "Standard Provision(s)."
8. The Discharger must comply with all conditions of this Order, including timely submittal of technical and monitoring reports as directed by the Executive Officer. Violations may result in enforcement action, including a Regional Board or court order requiring corrective action or imposing civil monetary liability, or in revision or rescission of this Order.
9. Should evaluation of the treatability study data reveal adverse effects on groundwater quality that were not anticipated, including the migration of any amendments or breakdown products outside of the transition zone, as shown on Attachment D, the Discharger shall notify the Regional Board within 24 hours of detection of the adverse effect, followed by a written summary within two weeks. The Discharger shall clean up and abate these effects, including extraction of any byproducts. The Discharger shall provide a status summary report within two months detailing activities to implement the abatement plan.
10. The Discharger shall at all times properly operate and maintain all facilities and systems of treatment and control that are installed or used by the Discharger to achieve compliance with this Order. Proper operation and maintenance also includes adequate laboratory controls and appropriate quality assurance procedures. This provision requires the operation of backup or auxiliary facilities or similar systems which are to be installed by the Discharger only when necessary to achieve compliance with the conditions of this Order.
11. The Discharger shall maintain records of all monitoring information including all calibration and maintenance records, copies of all reports required by this Order, and records of all data used to complete the application for this Order. Records shall be maintained for a minimum of three years from the date of the sample, measurement, or report. This period may be extended during the course of any unresolved litigation regarding this discharge or when requested by the Executive Officer.
13. A copy of this Order shall be kept at the discharge facility for reference by operating personnel. Key operating personnel shall be familiar with its contents.

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AIR FORCE REAL PROPERTY AGENCY
FORMER MCCLELLAN AFB
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AT FORMER DAVIS GLOBAL COMMUNICATIONS SITE
YOLO COUNTY

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I, THOMAS R. PINKOS, Executive Officer, do hereby certify the foregoing is a full, true, and correct copy of an Order adopted by the California Regional Water Quality Control Board, Central Valley Region, on 29 November 2005.

THOMAS R. PINKOS, Executive Officer

12/6/05 JDT

CALIFORNIA REGIONAL WATER QUALITY CONTROL BOARD
CENTRAL VALLEY REGION

MONITORING AND REPORTING PROGRAM NO. R5-2005-0178
FOR
AIR FORCE REAL PROPERTY AGENCY
FORMER MCCLELLAN AIR FORCE BASE
IN-SITU CHEMICAL OXIDATION TREATABILITY STUDY
AT FORMER DAVIS GLOBAL COMMUNICATIONS SITE
YOLO COUNTY

This Monitoring and Reporting Program (MRP) describes requirements for monitoring during the in-situ chemical oxidation (ISCO) treatability study at the Davis Site. The ISCO treatability study will be conducted in two phases. Waste Discharge Order R5-2005-0178 and this MRP cover the activities for Phase 1 and Phase 2. Phase 2 is expected to follow procedures similar to Phase 1. Specific details of Phase 2 will be developed using the results of Phase 1. Minor changes in Phase 2 may require revisions to the MRP. Significant changes in Phase 2, if necessary, may require a separate Order and MRP. This MRP is issued pursuant to Water Code Section 13267. The Regional Board recognizes that some changes to this monitoring program may be warranted after review of the initial post-injection monitoring data; therefore, the Discharger may request changes to the Regional Board to modify this MRP. However, the Discharger shall not implement any changes to this MRP unless and until a revised MRP is issued by the Executive Officer.

GROUNDWATER MONITORING

Prior to injection activities and baseline groundwater sampling, three new monitoring wells will be installed in the treatability test area. Two wells are planned in or immediately adjacent to the Phase 1 treatment area for the B zone. One new well is planned for the transition zone screened in the C zone.

Data will be collected during the treatability test to:

- Evaluate the effectiveness of the remedial technology at reducing contaminant concentrations.
- Evaluate impacts on secondary water quality parameters resulting from application of the remedial technology.

The treatability study groundwater monitoring program varies by location. For the treatability study, the wells are subdivided as being within the treatment zone, within the transition zone immediately downgradient of the treatment zone, and downgradient of the transition zone (compliance wells). Treatment zone wells are inside the area of expected permanganate contact. Transition zone wells are located downgradient within a 6- to 12-month travel time from the treatment zone. The compliance zone wells are farther downgradient than the transition zone wells and will be used for contingency treatment if permanganate or treatment byproducts move out of the transition zone.

Water levels will be obtained using a decontaminated down-hole probe, with an accuracy of 0.01 feet or greater. Geochemical parameters measured in the field will be collected from wells using a down-hole

water quality meter that measures temperature, ORP, pH, and conductivity. Potassium permanganate concentrations will be measured colorimetrically using a Hach colorimeter or offsite analysis.

Monitoring of the treatability study will include measurement of field parameters during each scheduled event. These parameters include water levels, oxidation-reduction potential, pH, temperature, and electrical conductivity. The treatability study monitoring program is shown on Table 1, which is attached hereto and made part of this Order by reference. Field testing instruments (such as those used to test oxidation-reduction potential and conductivity) may be used provided that:

1. The operator is trained in proper use and maintenance of the instruments;
2. The instruments are field calibrated prior to each monitoring event;
3. Instruments are serviced and/or calibrated by the manufacturer at the recommended frequency; and
4. Field calibration reports are provided with the appropriate monitoring report.

All wells will be sampled using a low-flow purge and sampling technique.

Treatability Study Monitoring

Recommendations for monitoring during the treatability test are summarized in Table 1. Secondary water quality parameters included for analysis incorporate results from the bench-scale testing. The treatability study monitoring will be initiated in January 2006 and will continue through the second phase of the treatability study into 2007. Prior to the treatability study, each of the wells included in Table 1 will be analyzed for the specified parameters to establish baseline conditions during the fourth Quarter 2005. The well locations are shown on Attachment B.

The samples submitted for laboratory analyses will be analyzed by a state-certified laboratory. For groundwater samples collected from the treatment zone wells when permanganate is present, no quality control/quality assurance samples will be collected. Samples from these wells will be collected frequently as indicated in Table 1 and will require neutralization prior to the VOC analyses being performed. For groundwater samples collected from transition zone and compliance wells, all of the quality control/quality assurance protocols stipulated in the McClellan Basewide QAPP (URS, 2003) will be followed. If permanganate is present, the samples for VOC analysis will be neutralized in the field prior to shipment to the analytical laboratory. A complete analyte list with a rationale for each analysis is presented in Table 2, which is attached hereto and made part of this Order by reference.

Baseline Sampling

In order to obtain an accurate representation of baseline groundwater conditions at the site, groundwater extraction will be stopped on October 31, 2005, prior to baseline sampling and the first phase of ISCO treatability testing. (During the treatability testing, the groundwater extraction system will remain shutdown, but operable.) This will allow time for groundwater elevations, VOC concentrations, and geochemical conditions to stabilize prior to collecting baseline groundwater samples during the week of November 28, 2005, at existing wells (MW-3, MW-2, MW-4, MW-8, MWB-14, EW-1C, and MWC-14). Baseline groundwater samples will be collected from the proposed wells after installation and well development (MWB-25, MWB-26, and MWC-27). Baseline samples will be analyzed for temperature, ORP, pH, and conductivity in the field and for TDS, VOCs, dissolved metals (see Table 2), and hexavalent chromium in the laboratory.

Treatability Test Zone Wells

Subsequent to the injection, the treatability test zone wells (MW-3, MWB-25, and MWB-26 for Phase 1) will be sampled twice during the first month, and samples will be analyzed in the field for ORP, conductivity, pH, and permanganate. After the first month, the wells will be sampled monthly for two months. Samples will be analyzed for the same field parameters as during the first month. In addition, the samples will be analyzed in an offsite analytical laboratory for TDS, VOCs, and the seven dissolved metals listed in Table 1. If permanganate is present in the samples as indicated by a pink or purple color, the samples for VOC analysis will be neutralized prior to shipment to the analytical laboratory. When permanganate is present in the samples, all chromium is expected to be in the hexavalent state. However, permanganate and the neutralization procedure interfere with the hexavalent chromium analysis. Therefore, the samples will be analyzed for total chromium. In addition, the last quarterly samples for each phase of the treatability test will be analyzed for hexavalent chromium if permanganate is not present in the samples. Subsequent to the initial semi-monthly sampling, the treatment zone wells will be sampled monthly for 2 months and then quarterly until the start of the Phase 2 treatability test. At that time, it is anticipated that the treatability test zone will be expanded into Phase 2 and the sampling program will restart for these wells. In addition, wells MW-1 and MW-7 will be added to the list of treatment zone wells for Phase 2. After completion of the Phase 2 treatability test in 2007, the sampling frequency will revert to semi-annually for these wells.

Transition and Compliance Zone Wells

Monitoring in the transition and compliance zones will be accomplished through use of existing wells and one newly installed well (Table 1). The placement of the new wells, and the assignment of existing wells for monitoring these zones are based largely on the estimated groundwater flow velocities, as described below.

Groundwater Velocities as Basis for Assignment

Groundwater levels and gradients at the Davis Site fluctuate widely in direction and magnitude due to the influence of agricultural pumping in the basin. During the RI/FS, gradient measurements were collected monthly from July 1992 through July 1993. These gradients are summarized in Figure 3-4 of the RI/FS Report (CH2M HILL, 1994). This figure shows that the gradient is generally south to southwesterly during the irrigation season (May through November) and swings to the north or northeast during the winter and spring months (December through March). The gradient was flat during April 1992. In order to estimate an average groundwater flow velocity, it is necessary to average the vectors representing the gradients for each month. Using the data presented on Figure 3-4 of the RI/FS report, the average groundwater gradient in the B zone was calculated to be 0.0029 ft/ft. The average gradient in the C zone was calculated to be about 0.0019 ft/ft. The direction of the average gradient in both B and C zones was to the southwest, which is consistent with the axis of the VOC plume. Based on short-term aquifer tests, the hydraulic conductivity of the B and C zones were estimated to range from 3 to 30 feet/day and 25 to 200 feet/day, respectively (CH2M HILL, 1994). Assuming an effective porosity of 25 percent and using the average gradients from the 1992 water year, the range of groundwater velocities would be 13 to 128 feet/year in the B zone and 68 to 547 feet/year in the C zone.

Transition Zone Wells

As indicated in Table 1, there are four existing wells and one proposed C zone well located within the transition zone for both the Phase 1 and Phase 2 treatability studies. Some impacts from the treatability studies are expected within this zone, such as detectable concentrations of permanganate, elevated ORP, or elevated secondary water quality parameter concentrations (for example, dissolved metals and TDS). Based on the velocities estimated, effects to the transition zone wells (MW-4 and MW-8) might be observed within approximately 1 year. Samples will be analyzed in the field for ORP, conductivity, pH, and permanganate, and in an offsite analytical laboratory for TDS, VOCs, and the seven dissolved metals listed on Table 1. In addition, samples will be analyzed for hexavalent chromium (if permanganate is not present in the sample) during the last quarterly monitoring event of each phase of the treatability test. Quarterly sampling will continue until the Phase 1 and 2 treatability tests are completed in 2007. At that time, the sampling frequency will revert to semi-annually.

Samples will be preserved according to the sample analysis method unless the sample is pink or purple, indicating the presence of permanganate. In the case of a pink or purple sample, permanganate will be neutralized in the field prior to analysis for VOCs. Permanganate and the neutralization agent would invalidate CrVI results; therefore, samples with visual evidence of permanganate cannot be analyzed for CrVI. However, total chromium will be analyzed. All other parameters can be analyzed in the presence of permanganate and will be handled according to the analytical method, including sample preservation and bottle selection.

Compliance Wells

As indicated in Table 1, there is one existing B zone and one existing C zone compliance well located downgradient of the transition zone. Impacts from the treatability studies are not expected at these wells. The compliance wells in the B zone are located approximately 200 feet downgradient from the Phase 1 treatment zone. Estimated travel times through the B zone to these wells, based on the velocity calculations, would range from about 1.5 to 15 years. During this time, impacts from the treatability studies are expected to dissipate as the ORP and concentrations of TDS and dissolved metals return to baseline conditions. Samples will be analyzed in the field for ORP, conductivity, pH, and permanganate, and in an offsite analytical laboratory for TDS, VOCs, and the seven dissolved metals listed in Table 1. In addition, samples will be analyzed for hexavalent chromium during the last quarterly monitoring event of each phase of the treatability test. Quarterly sampling will continue until the Phase 1 and 2 treatability tests are completed in 2007. At that time, the sampling frequency will revert to semi-annually.

QUALITY CONTROL

For quality control purposes, the Discharger shall conduct sampling of transition zone and compliance wells and associated analysis in accordance with the latest version of *Basewide Quality Assurance Project Plan, McClellan AFB*. All samples shall be representative of the volume and nature of the discharge and matrix of the sampled media.

REPORTING

The treatability study schedule is summarized in Table 3, which is attached hereto and made part of this Order by reference. The Phase 1 ISCO field work is scheduled to be completed 22 June 2006. Within 60 days after completion of the Phase 1 ISCO treatability study, the Discharger shall submit a Draft Phase 1 Treatability Study Report/Phase 2 Addendum to the Regional Board. At a minimum, the Phase 1 Treatability Study Report/Phase 2 Addendum shall include:

1. A summary of the implementation of the Phase 1 study, describing primarily any deviations from the scope described in this Order.
2. Key findings of site characterization actions, with emphasis on findings that impacted or caused any deviation to implementation of the Phase 1 treatability study.
3. A summary of key findings of the Phase 1 treatability study.
4. Proposed changes to plans for implementation of the Phase 2 treatability study.
5. Tabulated analytical data for each monitoring event.
6. Site map with all monitoring wells, groundwater flow direction, and other pertinent site features.

7. Discussion of compliance record with Waste Discharge Order R5-2005-0178 and any corrective actions taken or planned.
8. Copies of all laboratory analytical report(s).

The Discharger shall submit a Feasibility Study Addendum to the Regional Board no later than 1 December 2007 after completion of the Phase 2 treatability study. The Feasibility Study Addendum shall contain both tabular and graphical summaries of all monitoring data obtained during the treatability study, including the evaluations described in Provision D5 of Order R5-2005-0178. The results of any monitoring done more frequently than required at the locations specified in the Monitoring and Report Program shall also be reported to the Regional Board. In addition, the Discharger shall discuss the compliance record and the corrective actions taken or planned which may be needed to bring the discharge into full compliance with these waste discharge requirements. The report shall include:

1. Results of groundwater monitoring.
2. A narrative description of all preparatory, monitoring, sampling, and analytical testing activities for the groundwater monitoring. The narrative shall be sufficiently detailed to verify compliance with the WDR, this MRP, and the Standard Provisions and Reporting Requirements. The narrative shall be supported by field logs for each well documenting depth to groundwater; parameters measured before, during, and after purging; method of purging; calculation of casing volume; and total volume of water purged;
3. Calculation of groundwater elevations, an assessment of groundwater flow direction and gradient on the date of measurement, comparison of previous flow direction and gradient data, and discussion of seasonal trends if any;
4. A narrative discussion of the analytical results for all groundwater locations monitored including spatial and temporal trends, with reference to summary data tables, graphs, and appended analytical reports (as applicable);
5. A comparison of monitoring data to applicable groundwater limitations;
6. Summary data tables of historical and current water table elevations and analytical results;
7. A scaled map showing relevant structures and features of the facility, the locations of monitoring wells and any other sampling stations, and groundwater elevation contours referenced to mean sea level datum; and
8. Copies of laboratory analytical report(s) for groundwater monitoring.

A letter of transmittal shall accompany the Draft Phase 1 Treatability Study Report/Phase 2 Addendum and Feasibility Study Addendum. Such a letter shall include a discussion of requirement violations found during the reporting period, and actions taken or planned for correcting noted violations, such as operation or facility modifications. If the discharger has previously submitted a report describing corrective actions and/or a time schedule for implementing the corrective actions, reference to the

MONITORING AND REPORTING PROGRAM NO. R5-2005-0178
AIR FORCE REAL PROPERTY AGENCY
FORMER MCCLELLAN AFB
IN-SITU CHEMICAL OXIDATION TREATABILITY STUDY
AT FORMER DAVIS GLOBAL COMMUNICATIONS SITE
YOLO COUNTY

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previous correspondence will be satisfactory. The transmittal letter shall contain a statement by the discharger, or the discharger's authorized agent, under penalty of perjury, that to the best of the signer's knowledge the report is true, accurate and complete.

Ordered by: _____
THOMAS R. PINKOS, Executive Officer

(Date)

12/6/05 JDT

INFORMATION SHEET

ORDER NO. R5-2005-0178
AIR FORCE REAL PROPERTY AGENCY
FORMER MCCLELLAN AIR FORCE BASE
IN-SITU CHEMICAL OXIDATION TREATABILITY STUDY
AT FORMER DAVIS GLOBAL COMMUNICATIONS SITE
YOLO COUNTY

The Air Force Real Property Agency (hereafter Discharger) owns and operates a groundwater extraction and treatment system at the Davis Global Communications Site (hereafter Davis Site) in Yolo County. The inactive Davis Site was an annex of the former McClellan Air Force Base and is now managed by the Discharger. This system is being utilized to contain and remove numerous chlorinated solvents (primarily tetrachloroethene and trichloroethene) plumes present in the groundwater. The Discharger is evaluating potential alternative technologies that may replace the existing groundwater extraction and treatment system and reduce the time required to reach applicable water quality standards. The project is being conducted as part of a performance-based contract between the Discharger and CH2MHill. CH2MHill will be constructing and operating the treatability study.

The Discharger proposes to conduct an in-situ chemical oxidation (ISCO) treatability study to evaluate the potential for in-situ treatment of groundwater containing chlorinated solvents at the Davis Site. The Davis Site is located approximately 20 miles southwest of the former McClellan Air Force Base in Yolo County and 3 miles southeast of the City of Davis. It is situated in a predominantly agricultural area near the Yolo-Solano County border, approximately 5 miles south of Interstate 80 at the intersection of County Roads 104 and 36. The Davis Site comprises approximately 316 acres. Contaminants associated with the Davis Site include fuels and solvents. The treatability study will involve injection of potassium permanganate into a test cell.

To expedite remediation of the residual contamination, the Discharger is proposing application of ISCO, initially during a phased treatability test. The ISCO treatability study will be conducted in two phases. Waste Discharge Order R5-2005-0178 and Monitoring and Reporting Program No. R5-2005-0178 cover the activities for Phase 1 and Phase 2. Phase 2 is expected to follow procedures similar to Phase 1. Specific details of Phase 2 will be developed using the results of Phase 1. Minor changes in Phase 2 may require revisions to the MRP. Significant changes in Phase 2, if necessary, may require a separate Order and MRP. Chemical oxidation has the capability to reduce the contaminant mass in the subsurface in a much shorter timeframe than a pump-and-treat approach. ISCO can permanently degrade VOCs in months, allowing contaminants in the seasonally saturated zone to be treated during the short periods the zone is saturated. The objective of a full-scale ISCO application would be to remediate the residual VOC contamination in the B aquifer zone and seasonally saturated portion of the A aquifer zone and thereby facilitate the Discharger's goals of property transfer and site closure.

INFORMATION SHEET - ORDER NO. R5-2005-XXXX
AIR FORCE REAL PROPERTY AGENCY
FORMER MCCLELLAN AIR FORCE BASE
IN-SITU CHEMICAL OXIDATION TREATABILITY STUDY
AT FORMER DAVIS GLOBAL COMMUNICATIONS SITE
YOLO COUNTY

ISCO causes some secondary effects such as increases in total dissolved solids (TDS) and redox sensitive metals. Potassium permanganate contains impurities including chromium and is known to oxidize trivalent chromium (CrIII) from soil to the more soluble hexavalent form (CrVI). Many factors may affect the rate and extent of mobilization and attenuation. For example, MnO_2 , the product of potassium permanganate reduction, has been reported to both oxidize soil CrIII to CrVI and adsorb CrVI from solution. In addition, ion exchange processes may also be involved in Cr formation and attenuation during permanganate treatment. The literature and prior laboratory testing has shown that CrVI is normally mobilized to some degree during potassium permanganate treatment, but tends to attenuate in groundwater in weeks to months after the permanganate has been consumed. The potential for formation and attenuation of CrVI at the Davis Site will be evaluated during the treatability study. These adverse byproducts created by injection of the potassium permanganate are expected to be transient. Any persistent adverse byproducts created by the treatability study can be captured by the existing groundwater extraction system, if necessary.

12/6/05 JDT

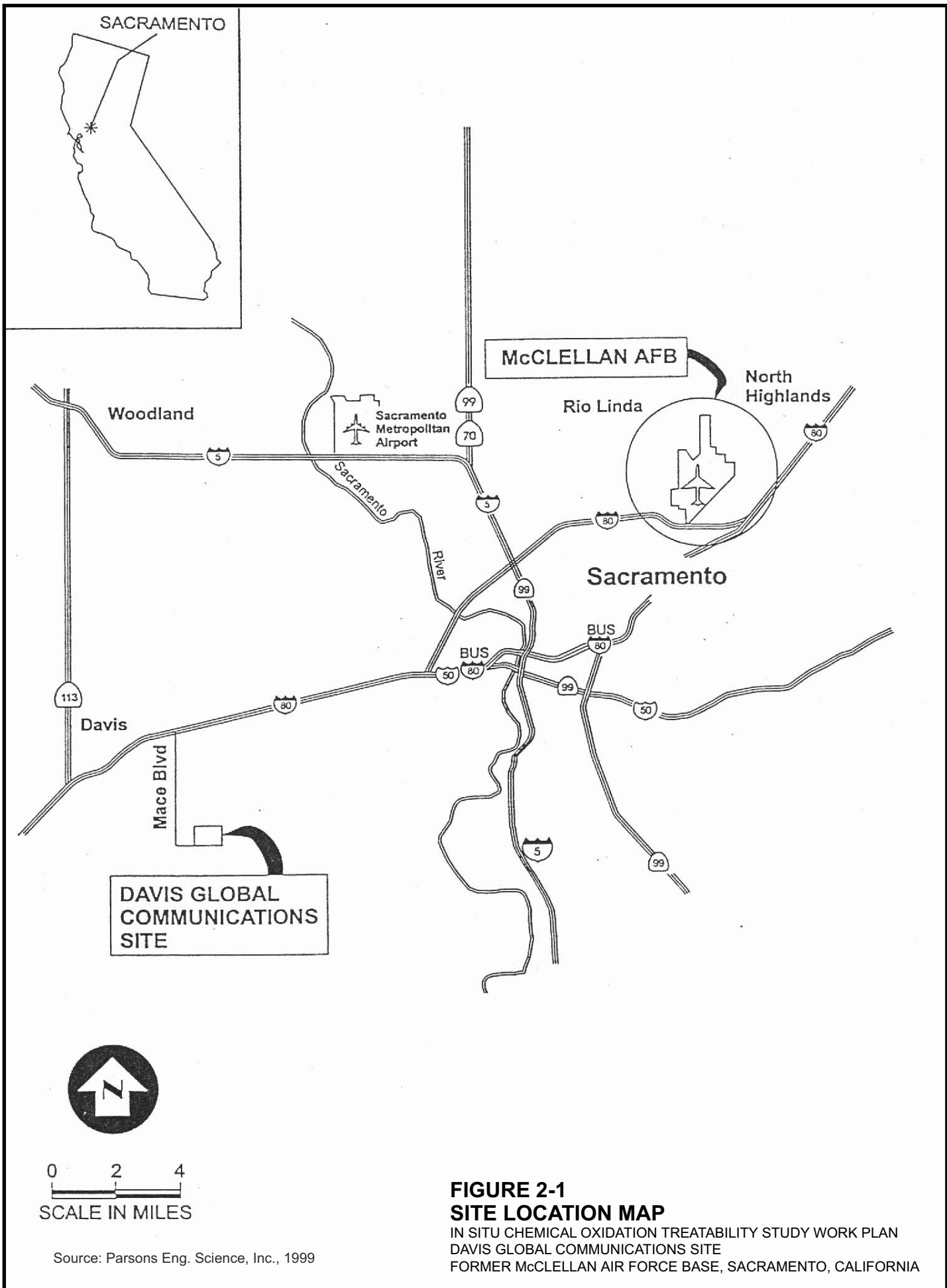
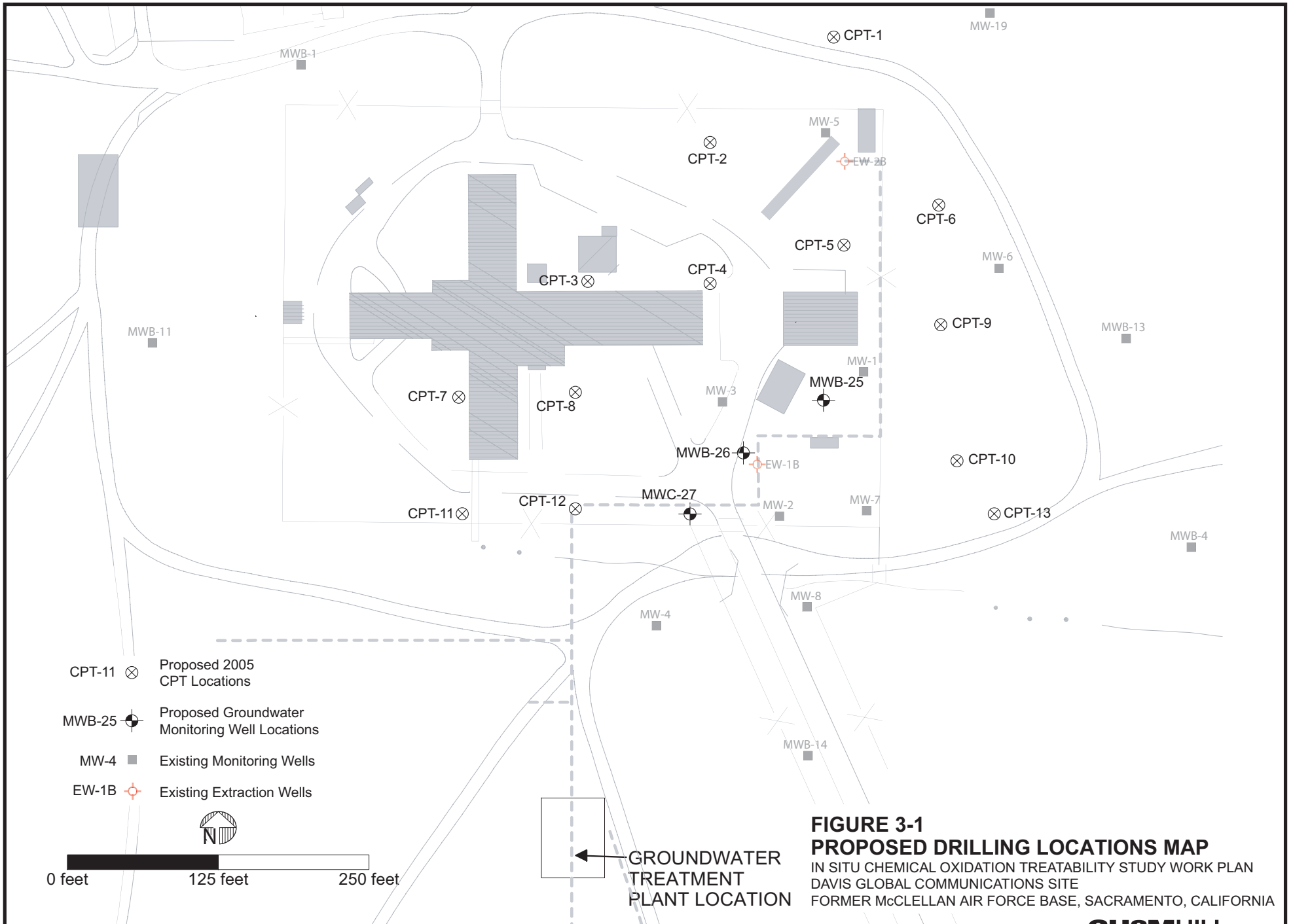


FIGURE 2-1
SITE LOCATION MAP
 IN SITU CHEMICAL OXIDATION TREATABILITY STUDY WORK PLAN
 DAVIS GLOBAL COMMUNICATIONS SITE
 FORMER McCLELLAN AIR FORCE BASE, SACRAMENTO, CALIFORNIA

Source: Parsons Eng. Science, Inc., 1999



**FIGURE 3-1
PROPOSED DRILLING LOCATIONS MAP**
IN SITU CHEMICAL OXIDATION TREATABILITY STUDY WORK PLAN
DAVIS GLOBAL COMMUNICATIONS SITE
FORMER McCLELLAN AIR FORCE BASE, SACRAMENTO, CALIFORNIA

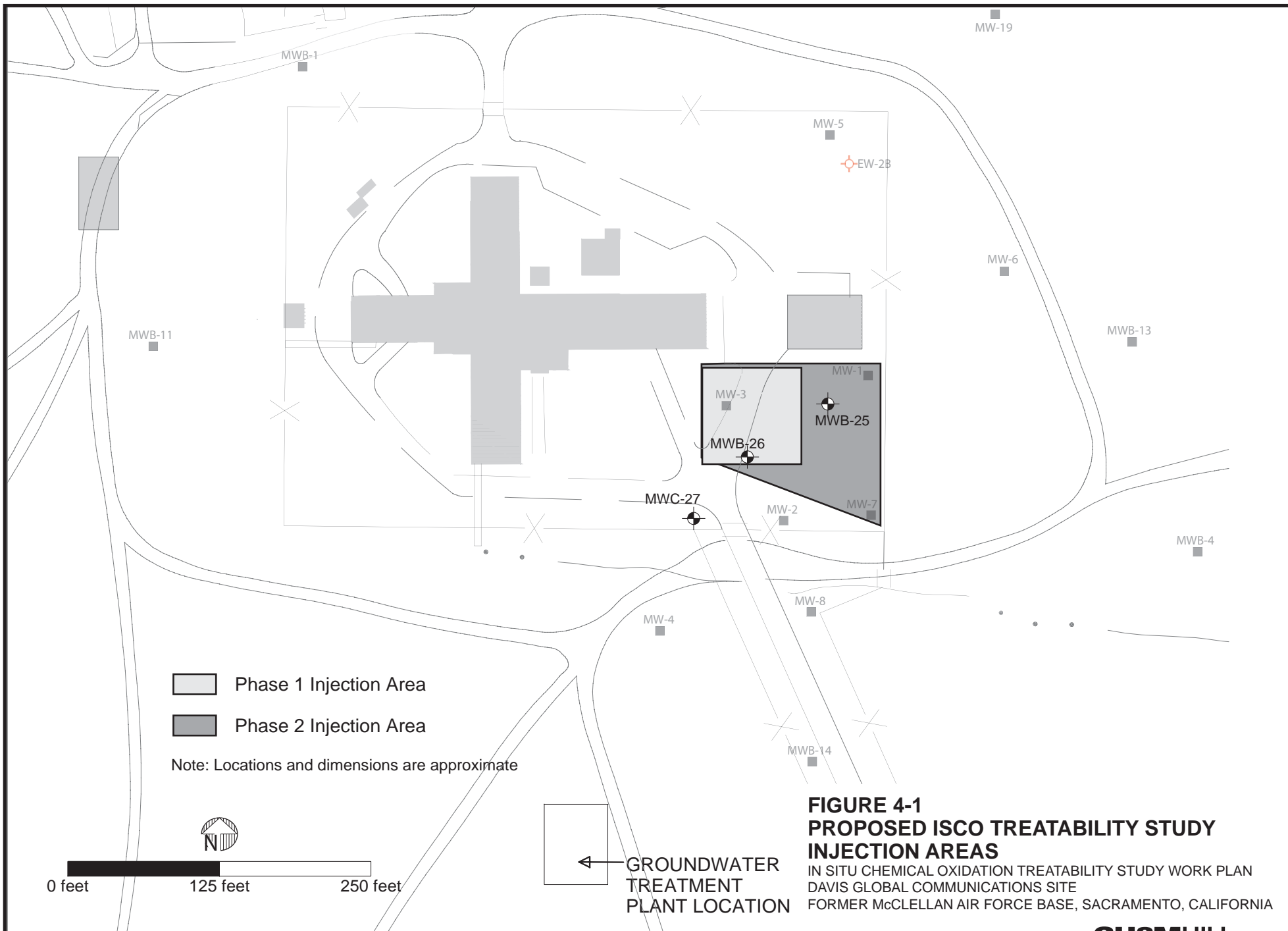


TABLE 1

Treatability Monitoring

In Situ Chemical Oxidation Treatability Study Work Plan, Davis Global Communications Site

Well Type	Phase 1 Locations	Phase 2 Locations	Frequency and Analyses ^{a,d}
Treatment Zone	MW-3, MWB-25 , and MWB-26 ^b	MW-1 ^c , MW-3, MW-7 ^c , MWB-25 , and MWB-26	<p>During injection process monitoring—WL, temperature, ORP, pH, and conductivity (every two hours for the first two days, and then three times a day thereafter until injection is complete). Samples for permanganate will be collected daily from wells with ORP readings greater than 400 mV.</p> <p>Every other week for one month—permanganate, ORP conductivity, and pH.</p> <p>Monthly for two months—TDS, VOCs, permanganate, ORP, conductivity, pH, Mn, Cd, Pb, Hg, Ni, Ag, and Total Cr.</p> <p>Quarterly until Phase 2—same analytes as for monthly and Cr(VI) during the last quarterly event if permanganate is not present.</p>
Transition Zone	MW-2, MW-4, MW-8, EW-1C, MW-C-27 ^b	MW-2, MW-4, MW-8, EW-1C, MW-C27 ^b	Quarterly until Phase 2—TDS, VOCs, permanganate, ORP, conductivity, pH, Mn, Cd, Pb, Hg, Ni, Ag, Total Cr, and Cr(VI) during the last quarterly event if permanganate is not present.
Compliance Well	MWB-14 and MWC-14	MWB-14 and MWC-14	Quarterly until Phase 2—TDS, VOCs, permanganate, ORP, conductivity, pH, Mn, Cd, Pb, Hg, Ni, Ag, Total Cr, and Cr(VI) during the last quarterly event if permanganate is not present.

^a Groundwater elevations will be measured at all well locations semi-annually. If permanganate is present in any samples, the samples for VOCs will be neutralized with permanganate in the field. All other samples will be submitted with permanganate in the samples to limit influence on the result. Cr(VI) cannot be analyzed if permanganate is present in a sample due to potential to damage the instrument and influence of field neutralization on sample results.

^b Wells shown in bold text are recommended for installation.

^c MW-1 and MW-7 will continue to be sampled semi-annually until the start of the Phase 2 treatability study.

^d Sulfate will be added as an analyte if sodium thiosulfate is injected during implementation of the contingency plan.

Samples for metals analyses will be field filtered.

TABLE 2

List of Sampling Analytes and Monitoring Parameters

In Situ Chemical Oxidation Treatability Study Work Plan, Davis Global Communications Site

Parameter	Method	Sample Container, Volume, and Preservative	Reason for Monitoring
Water Level	Field measurement	Not applicable	Measure hydraulic response to injection and may be used to infer flow directions.
Conductivity	Field measurement	Not applicable	Measures the ability of a solution to conduct an electrical current. Provides an indirect measurement of the concentration of dissolved ions in solution.
Temperature	Field measurement	Not applicable	Increased temperature indicates occurrence of oxidation reactions; however, temperature should not rise significantly.
Oxygen Reduction Potential (ORP)	Field measurement	Not applicable	Permanganate is an oxidizer and will increase the redox potential. Provides useful first indication of effect of injection prior to arrival of permanganate.
pH	Field measurement	Not applicable	The optimum pH for the desired reaction is near neutral; however, reactions will continue to take place between pH 3 and pH 12.
Permanganate	Colorimetric Ag Sol SOP v1.3		A direct measurement of oxidant permanganate indicating longevity of treatment and in situ reaction rates.
Dissolved Metals (specifically total chromium, manganese, cadmium, lead, mercury, nickel, and silver)	EPA Method 6010B	500-ml polyethylene bottle, Nitric acid to pH < 2	The oxidation state of metals may be increased or metals may be released by oxidation of metal complexes as a result of oxidant addition to the subsurface, which may lead to metal mobility. Metals mobilization and attenuation may influence the applicability of permanganate treatment for soil and groundwater treatment. Manganese is a direct product of permanganate reaction but tends to precipitate, thus measurement is necessary. CAM-17 metals were evaluated during the bench-scale test and the metals that were elevated at the completion of the bench-test were retained for field monitoring, thus measurement is necessary.
Hexavalent Chromium	EPA Method 7199	500 ml polyethylene or glass bottle	Likely to be generated by oxidation of the aquifer materials. While permanganate is present, all chromium will be in hexavalent state. Analysis cannot be performed on neutralized samples.
VOCs	EPA Method 8260B	40 ml VOA, Hydrochloric acid to pH < 2	The COCs. A decrease in concentration (after taking into account dilution) will provide a direct indication that the oxidation reactions are being effective.
Sulfate	EPA Method 300.1	500 ml polyethylene bottle	An indirect measurement of thiosulfate which is a reactive form of sulfate. Sulfate will be analyzed if sodium thiosulfate is injected during implementation of the contingency plan.
Total Dissolved Solids	EPA Method 160.2	500 ml polyethylene bottle	A bulk measure of groundwater cations that is often influenced by the injection of K ⁺ or Na ⁺ along with permanganate.

TABLE 3

Treatability Study Schedule Summary

In Situ Chemical Oxidation Treatability Study Work Plan, Davis Global Communications Site

Task/Deliverable	Tentative Date
Approve SAP to Support Bench-scale Study	June 30, 2005
Perform Bench-scale Study	July 1 to August 1, 2005
Submit Draft Work Plan to RWQCB	August 11, 2005
RWQCB Completes Review of Draft Work Plan	October 10, 2005
Shut Down Groundwater Pump and Treat	October 31, 2005
Submit Draft Final Work Plan to RWQCB	November 9, 2005
RWQCB Completes Review of Draft Final Work Plan	December 12, 2005
Baseline and Semi-annual GW Monitoring Event	November 28 to December 2, 2005
Submit Final Work Plan to RWQCB	December 24, 2005
Perform Groundwater Characterization	December 24, 2005 to January 11, 2006
RWQCB Waste Discharge Requirements Complete	January 21, 2006
Install Monitoring Wells	January 14 to February 4, 2006
Conduct Phase 1 ISCO	January 23 to June 22, 2006
Submit Draft Phase 1 Treatability Report/Phase 2 Addendum	July 22, 2006
Install Phase 2 Monitoring Wells (if needed)	October 5 to October 16, 2006
Conduct Phase 2 ISCO	October 16, 2006 to July 16, 2007
Submit Draft FS Addendum	October 14, 2007
Submit Final ROD	June 2008