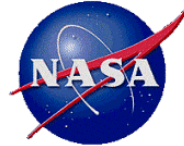


**FINAL  
GROUNDWATER  
MONITORING REPORT  
JULY - AUGUST 2004**



**NATIONAL AERONAUTICS AND SPACE ADMINISTRATION  
JET PROPULSION LABORATORY  
4800 Oak Grove Drive  
Pasadena, California 91109**

**Contract No. N68711-01-D-6008**

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Prepared for:



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San Diego, California 92132-5187**

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## ACRONYMS/ABBREVIATIONS

1,1-DCA	1,1-dichloroethane
1,2-DCA	1,2-dichloroethane
1,1-DCE	1,1-dichloroethene
APCL	Applied Physics and Chemistry Laboratory
As	total arsenic
CCl <sub>4</sub>	carbon tetrachloride
CERCLA	Comprehensive Environmental Response, Compensation, and Liability Act
ClO <sub>4</sub> <sup>-</sup>	perchlorate
Cr	total chromium
Cr(VI)	hexavalent chromium
DHS	California Department of Health Services
DLR	detection level for the purpose of reporting
DQOs	data quality objectives
DTSC	Department of Toxic Substance Control
EPA	United States Environmental Protection Agency
GEOFON	GEOFON Incorporated
IAL	State Interim Action Level
J	indicates an estimated value
JPL	Jet Propulsion Laboratory
LAWC	Lincoln Avenue Water Company
LCID	La Canada Irrigation District
LDC	Laboratory Data Consultants, Inc.
LFWC	Las Flores Water Company
MCLs	Maximum Contaminant Levels
µg/L	micrograms per liter
mg/L	milligrams per liter
MIBK	4-methyl-2-pentanone
mL	milliliter
MS	matrix spikes
MSD	matrix spike duplicates
MTBE	Methyl-T-Butyl Ether
MW	monitoring well
NASA	National Aeronautics and Space Administration
NDMA	N-nitrosodimethylamine
OU	operable unit
Pb	total lead



## ACRONYMS/ABBREVIATIONS (CONT'D)

PCE	tetrachloroethene
PQL	practical quantitation limit
QA/QC	quality assurance/quality control
QAPP	Quality Assurance Project Plan
RCLWC	Rubio Canon Land & Water Company
RWQCB	California Regional Water Quality Control Board
SOTA	SOTA Environmental Technology, Inc.
TCE	trichloroethene
TDS	total dissolved solids
VOCs	volatile organic compounds
VWC	Valley Water Company
Westbay	Westbay Instruments, Inc.

## EXECUTIVE SUMMARY

Presented in this report are the results of the July - August 2004 groundwater sampling event completed as part of the long-term groundwater monitoring program at the National Aeronautics and Space Administration (NASA) Jet Propulsion Laboratory (JPL) under contract with Naval Facilities Engineering Command. This sampling event was conducted from July 27 through August 18, 2004.

During the July - August 2004 quarterly sampling event, groundwater samples were collected from 21 JPL monitoring wells, both on- and off-facility, and analyzed for volatile organic compounds (VOCs), metals, and perchlorate. MW-1 and MW-9 were not sampled during this event, and MW-2 has not been sampled since it was replaced with well MW-14 as a JPL sampling location.

All laboratory analytical data collected were subject to data validation pursuant to the Navy's Level IV quality assurance requirements. Some of the analytical data were qualified based on data validation reviews in accordance with applicable United States Environmental Protection Agency (EPA) guidelines. No data were rejected for non-compliance with method requirements during the course of validation and no data were qualified as unusable. The analytical results are summarized below.

- Seven on-facility wells and three off-facility wells contained concentrations of one or more of three VOCs (carbon tetrachloride, trichloroethene, and tetrachloroethene) that exceeded State or Federal Maximum Contaminant Levels (MCLs) for drinking water. Concentration contour maps generally indicate slow migration of the contaminant plumes over the last year.
- Perchlorate was detected in thirteen on-facility wells and four off-facility wells, with concentrations in eight on-facility and three off-facility wells that exceeded the State Interim Action Level (IAL).
- Total chromium (Cr) was detected in all 20 wells sampled and analyzed for Cr during this monitoring event; however, none of the concentrations exceeded the State or Federal MCL. Hexavalent chromium [Cr(VI)] was detected at trace concentrations in two on-facility wells. As of April 7, 2004, Cr(VI) is regulated under the 0.050 mg/L MCL for Cr. The California Department of Health Services (DHS) will be adopting an MCL that is specific for Cr(VI) at a later date (DHS, 2004a).

Groundwater gradients and flow directions before and after sampling activities were consistent with the results from the July - August 2004 sampling event observations. The natural seasonal fluctuation of the hydraulic head is believed to be the main factor contributing to the difference in water level elevations between each quarterly sampling event. Other factors that might influence the water level can be caused by several hydrologic phenomena operating simultaneously including, but not limited to, extraction and/or artificial recharge.

## 1.0 INTRODUCTION

The locations of the JPL groundwater monitoring wells are shown on Figure 1-1. Monitoring wells MW-3, MW-4, MW-11, MW-12, MW-14, and MW-17 through MW-24 are deep multi-port wells, each containing five screened intervals equipped with a Westbay Instruments, Inc. (Westbay) multi-port casing system. Monitoring wells MW-1, MW-5 through MW-10, MW-13, MW-15, and MW-16 are relatively shallow standpipe wells, each containing a single screened interval located just below the water table. A summary of the well construction details for the JPL groundwater monitoring wells is included in Table 1-1.

During the July - August 2004 event, GEOFON, Incorporated (GEOFON) personnel collected samples from all JPL monitoring wells except MW-1, MW-2, and MW-9. Shallow well MW-2 has not been sampled since it was replaced with deep multi-port well MW-14 as a JPL sampling location. Groundwater samples were collected and analyzed in accordance with the sampling program that was previously approved by the Environmental Protection Agency (EPA), Department of Toxic Substance Control (DTSC), and California Regional Water Quality Control Board (RWQCB).

In addition, the water-level elevation at each well was measured on July 27, 2004 (prior to sampling), and on August 18, 2004 (after sampling) to evaluate groundwater flow directions and gradients.

All of the JPL groundwater samples were shipped to Applied Physics and Chemistry Laboratory (APCL) in Chino, California, for chemical analysis. APCL is certified by the California Department of Health Services and approved for use by the Naval Facilities Engineering Command, Quality Assurance/Quality Control (QA/QC) program. Sample collection procedures and sample analysis were conducted by GEOFON in accordance with the Work Plan for Performing a Remedial Investigation/Feasibility Study (Ebasco, 1993a), which was approved by the regulatory agencies.

In addition to groundwater samples, field QA/QC samples, including trip blanks, equipment blanks, duplicate samples, and a field blank, were collected for laboratory analyses. Sampling records for each shallow well and field data sheets for deep multi-port wells are included in Appendix A. Piezometric pressure profiling records for each deep multi-port well are included in Appendix B. Laboratory analytical reports and associated chain-of-custody forms are included in Appendix C, and data validation reports are provided in Appendix D.

Appendices E and F present summaries of analytical results for volatile organic compounds (VOCs) and metals, respectively, that were reported by others prior to GEOFON's initiation of

the Long-Term Groundwater Monitoring activities at the JPL facility in January of 2003. Pursuant to the Navy's request, the format of the tables summarizing the results of the groundwater sampling was modified by GEOFON to present the data qualifiers as reported by the company performing data validation.

## **2.0 FIELD SAMPLING PROCEDURES**

Two different procedures were used to collect groundwater samples at JPL, one designed for the shallow wells and the other for the deep multi-port wells. These procedures are outlined below.

### **2.1 Shallow Monitoring Wells**

The sampling procedure described below was applied to all the shallow JPL monitoring wells, including MW-5, MW-6, MW-7, MW-8, MW-10, MW-13, MW-15, and MW-16.

- The primary equipment used to sample the shallow wells included dedicated 2-inch diameter Grundfos Redi-Flo2® pumps, a pump controller, and a 220-volt generator. All of the dedicated Grundfos Redi-Flo2® pump systems were previously decontaminated prior to their permanent installation. Details of the decontamination procedures for the Grundfos Redi-Flo2® pump systems are outlined in the Operable Unit (OU) OU-1 Field Sampling and Analysis Plan (Ebasco, 1993b).
- Prior to sample collection, the water in each shallow well casing was purged (by pumping between 1.5 and 4 gallons per minute) to remove groundwater that may have been exposed to the atmosphere and thus may not be representative of undisturbed aquifer conditions. This purged groundwater was discharged into 500 or 1,000-gallon polyethylene storage tanks for subsequent disposal by GEOFON in accordance with Federal, State, and local regulations.
- Temperature, pH, electrical conductivity, and turbidity of the water removed from each well were monitored during purging. Pursuant to the approved work plan (Ebasco, 1993b), a minimum of three casing volumes of water was purged and temperature, pH, electrical conductivity and turbidity were monitored for stabilization. When two successive measurements, made approximately 5 minutes apart, were within 10 percent of each other, groundwater samples were collected using the dedicated pump. During sampling for VOCs, the pumping rate was reduced to minimize sample agitation and volatilization. All information concerning sampling was noted on the Groundwater Collection and Sample Log forms included in Appendix A.
- All sample bottles were filled completely without overflowing, capped, labeled, and immediately placed in a cooler with ice. Samples collected for VOCs had zero headspace.

- Calibration, or standardization of the field instruments used to measure temperature, pH, electrical conductivity, and turbidity, was performed according to the manufacturer's specifications at the beginning of each sampling day.

## **2.2 Deep Multi-Port Monitoring Wells**

Sampling of the deep multi-port monitoring wells at JPL required specialized sampling equipment manufactured by Westbay Instruments, Inc. (Westbay). This equipment included a pressure profiling/sampling probe with a surface control unit. To ensure proper use, GEOFON field personnel using this equipment were trained by Westbay personnel. Copies of the detailed operations manuals for the Westbay pressure profiling/sampling probe are included in the OU-1 and OU-3 Field Sampling and Analysis Plans (Ebasco, 1993b; 1994).

The Westbay sampling probe and sample-collection bottles were decontaminated prior to sampling each screened interval in the deep multi-port wells according to the following procedures:

- Each 250-mL stainless-steel sample-collection bottle was washed in a solution of non-phosphate detergent (Liquinox<sup>®</sup>) and distilled water, followed by a solution of an acidic detergent (Citranox<sup>®</sup>) and distilled water.
- Each bottle was rinsed with distilled water.
- The interior surfaces of the Westbay sampling probe, and the hoses and valves associated with the Westbay sample bottles were decontaminated by forcing several volumes of a solution of Liquinox<sup>®</sup> and distilled water through them, followed by several volumes of a solution of Citranox<sup>®</sup> and distilled water. A final rinse with distilled water was then carried out. Each of these decontamination procedures was completed using clean plastic spray bottles for this purpose only.

Purging before sampling was not required in the deep multi-port monitoring wells because the groundwater samples were collected directly from the aquifer, thus ensuring that the groundwater samples were not exposed to the atmosphere. However, at each screened interval, an initial sample was collected in order to check temperature, pH, electrical conductivity, and turbidity in the field. Samples for laboratory analysis were then collected and transferred to sample containers as described in Section 2.1. Results of the field analyses were recorded on groundwater sampling field data sheets (Appendix A). Calibration of field instruments was carried out according to procedures described previously.

### 2.3 Field Quality Assurance/Quality Control Samples

Field QA/QC samples were collected to verify the quality of sampling procedures. The field QA/QC program included the collection of duplicate samples, equipment blanks, trip blanks, and source blanks. Laboratory QA/QC samples were used by the laboratory according to analytical method requirements.

Duplicate samples for VOCs, metals (including hexavalent chromium [Cr(VI)], total chromium (Cr), and/or perchlorate ( $\text{ClO}_4^-$ ) analyses were collected from deep multi-port monitoring wells MW-3 (Screen 3), MW-11 (Screen 4), MW-14 (Screen 5), and MW-19 (Screen 1). Duplicate samples were also collected from shallow wells MW-5 and MW-10.

Matrix-Spike (MS) and Matrix-Spike Duplicate (MSD) samples were collected for 10% of samples that were analyzed for VOCs, Cr, Cr(VI) and/or  $\text{ClO}_4^-$ . These samples were used for laboratory QA/QC requirements.

One equipment blank was collected from the Westbay sample-collection bottles during each day of sampling the deep multi-port wells. Equipment blank samples consisted of distilled water that was passed through the sampling equipment after the equipment was decontaminated. Equipment blanks were analyzed for the same constituents as the groundwater samples, except for cations and anions, total dissolved solids, and pH, to identify potential cross contamination due to inadequate decontamination. Because only dedicated sampling equipment was used, equipment blanks were not collected during sampling of the shallow wells.

A trip blank, consisting of American Society for Testing Materials Type II water placed in two 40-mL glass vials by the laboratory, was transported with the empty sample bottles to the field and back to the laboratory with the groundwater samples. One trip blank was submitted for VOC analysis with each shipment of groundwater samples to the laboratory. Trip blanks were used to identify potential cross contamination of groundwater samples during transport.

### 3.0 ANALYTICAL RESULTS

The groundwater samples collected during this sampling event were analyzed for one or more of the following:

- Volatile Organic Compounds (VOCs)
- Total Chromium (Cr)
- Hexavalent Chromium [Cr(VI)]
- Perchlorate ( $\text{ClO}_4^-$ )

A summary of the samples collected and the analyses performed on each sample is presented in Table 3-1. Analytical laboratory reports and associated chain-of-custody forms are included in Appendix C. Please note that analyte concentrations flagged with a “J” qualifier indicate that the result is an estimated value according to the laboratory and/or the data validation company.

The aquifer beneath JPL was divided into four aquifer layers based primarily on correlations interpreted from lithologic cross sections (Foster Wheeler, 2000). Table 3-2 provides a list of the JPL monitoring well screens and their corresponding aquifer layers. Concentration contours of carbon tetrachloride ( $\text{CCl}_4$ ), trichloroethene (TCE), tetrachloroethene (PCE), and perchlorate ( $\text{ClO}_4^-$ ) reported during this event are presented for aquifer layers one, two, and three on Figures 3-1 through 3-12.

#### 3.1 Volatile Organic Compounds

Groundwater samples collected during the July - August 2004 sampling event were analyzed for over 60 different VOCs in accordance with EPA Method 524.2. Results of the analyses for VOCs are summarized in Table 3-3 along with the State and Federal Maximum Contaminant Levels (MCLs) for drinking water as listed in Title 22 of the California Code of Regulations and in the EPA Health Advisory Guidelines.

A small number of compounds were detected in the JPL samples, and three VOCs [ $\text{CCl}_4$ , TCE, and PCE] were found in one or more wells at concentrations that exceeded State and/or Federal MCLs. The concentrations of  $\text{CCl}_4$ , TCE, and PCE detected in each aquifer layer were contoured on site maps to show the spatial distribution of each constituent (Figures 3-1 through 3-9). The analytical results for compounds that exceeded MCLs are discussed below.

- Concentrations of  $\text{CCl}_4$  in excess of the State MCL [0.5 micrograms per liter ( $\mu\text{g/L}$ )] were reported in samples from six on-facility wells [MW-3 (Screen 2), MW-7, MW-12 (Screens 2, 4, and 5), MW-13, MW-16, and MW-24 (Screens 1 and 2)] and two off-facility wells [MW-17 (Screens 2 and 3) and MW-18 (Screens 3 and 4)]. The Federal MCL (5.0  $\mu\text{g/L}$ ) was



exceeded in MW-7, MW-17 (Screen 3) and MW-24 (Screen 1). The highest concentration of  $\text{CCl}_4$  was reported in well MW-7 at 58.0  $\mu\text{g/L}$ .

- TCE was detected in eleven on-facility wells and four off-facility wells. Reported TCE concentrations exceeded the State and Federal MCL (5.0  $\mu\text{g/L}$ ) in three on-facility wells MW-7, MW-10, and MW-13. The highest concentration of TCE was reported in the duplicate sample (Dupe-6-3Q04) of well MW-10 (16.6  $\mu\text{g/L}$ ).
- PCE was detected in ten on-facility and five off-facility wells. The State and Federal MCL (5.0  $\mu\text{g/L}$ ) was exceeded in one on-facility well MW-7 (15.0  $\mu\text{g/L}$ ) and one off-facility well MW-21 (8.5  $\mu\text{g/L}$  in Screen 5).

A summary of the VOC results compiled from the long-term sampling events since January 2003 that have been completed to date is provided in Table 3-4. Nine chemicals have been most commonly reported with concentrations above the laboratory detection limits [ $\text{CCl}_4$ , TCE, PCE, 1,1-dichloroethane (1,1-DCA), 1,2-dichloroethane (1,2-DCA), 1,1-dichloroethene (1,1-DCE), Freon 113, chloroform, and  $\text{ClO}_4^-$ ]. The concentrations of these compounds versus time were plotted, if at any time they exceeded their respective MCL from August/September 1996 through July - August 2004. The plots are presented on Figures 3-13 through 3-63.

Additional data regarding VOC concentrations in samples collected from July 1, 2004 to September 30, 2004 from fourteen municipal production wells in the vicinity of JPL were requested from the California Department of Health Services (DHS) Drinking Water Program. Data was requested from the following purveyors; La Canada Irrigation District (LCID), Lincoln Avenue Water Company (LAWC), Valley Water Company (VWC), Rubio Canon Land & Water Company (RCLWC), and Las Flores Water Company (LFWC). However, according to DHS, only seven of fourteen municipal wells in the vicinity of JPL were sampled for VOCs during the time period requested (DHS, 2004b).

$\text{CCl}_4$  was detected at concentrations above the State MCL (0.5  $\mu\text{g/L}$ ) at LAWC Well #3 (maximum concentration of 2.7  $\mu\text{g/L}$ ). PCE was detected at concentrations above the State and Federal MCL (5.0  $\mu\text{g/L}$ ) at LFWC Well #2 (maximum concentration of 6.5  $\mu\text{g/L}$ ). TCE was detected at concentrations above the State and Federal MCL (5.0  $\mu\text{g/L}$ ) at LAWC Well #5 (maximum concentration of 6.0  $\mu\text{g/L}$ ). Chloroform was detected in all VWC wells that were sampled from July 1 to September 30, 2004; however none of the concentrations reported exceeded the State and Federal MCL (100.0  $\mu\text{g/L}$ ) (DHS, 2004b). The drinking water data from the municipal wells are summarized in Table 3-5.

### 3.2 Perchlorate

$\text{ClO}_4^-$  analyses were conducted on groundwater samples from the July - August 2004 event using ion chromatography modified EPA Method 314.0 and the results are summarized in Table 3-3.  $\text{ClO}_4^-$  is among the unregulated chemicals requiring monitoring (Title 22, California Code of Regulations §64450). Although, no MCL has been established for  $\text{ClO}_4^-$ , the DHS has implemented an interim action level (IAL) to protect the public from the adverse health effects of  $\text{ClO}_4^-$ . On March 11, 2004, DHS revised its perchlorate IAL to 6  $\mu\text{g/L}$  (from the previous 4  $\mu\text{g/L}$ ). To protect consumers until an MCL is in place, DHS will use a 6  $\mu\text{g/L}$  action level (DHS, 2004c).

Concentrations of  $\text{ClO}_4^-$  in excess of the State IAL (6.0  $\mu\text{g/L}$ ) were reported in samples from eight on-facility wells [MW-3 (Screen 2), MW-7, MW-8, MW-10, MW-13, MW-14 (Screens 2, 3, and 4), MW-16, and MW-24 (Screens 1 and 2)] and three off-facility wells [MW-17 (Screens 2 and 3), MW-18 (Screens 3 and 4), and MW-19 (Screens 2 and 3)].

The highest levels of  $\text{ClO}_4^-$  were reported in samples MW-7 (3,760  $\mu\text{g/L}$ ), MW-13 (296  $\mu\text{g/L}$ ), MW-16 (833  $\mu\text{g/L}$ ), and MW-24 (2,170  $\mu\text{g/L}$  in Screen 1). The maximum  $\text{ClO}_4^-$  concentration detected continues to decrease significantly in MW-7 from 7,690  $\mu\text{g/L}$  in February 2004 and 4,680  $\mu\text{g/L}$  in April - May 2004 to 3,760  $\mu\text{g/L}$  in July - August 2004.  $\text{ClO}_4^-$  concentrations have been contoured on Figures 3-10, 3-11, and 3-12 for aquifer layers 1, 2, and 3, respectively.

Additional data regarding  $\text{ClO}_4^-$  concentrations in samples collected from July 1, 2004 to September 30, 2004 from fourteen municipal production wells in the vicinity of JPL were requested from the DHS Drinking Water Program. However, according to DHS, only five of the fourteen municipal wells in the vicinity of JPL were sampled for  $\text{ClO}_4^-$  during the time period requested (DHS, 2004b). In summary,  $\text{ClO}_4^-$  concentrations exceeded the State IAL (6.0  $\mu\text{g/L}$ ) only in LAWC Well #3, with a maximum concentration of 17.0  $\mu\text{g/L}$  (DHS, 2004b).

### 3.3 Metals

Groundwater samples collected during the July - August 2004 event were analyzed for the following metals: Cr(VI) and Cr. The results of the metals analyses are presented in Table 3-6, and are summarized below.

- Cr(VI) was detected at trace concentrations in two on-facility wells. The maximum concentration was reported in MW-13 at 0.011 milligrams per liter (mg/L). As of April 7, 2004, Cr(VI) is regulated under the 0.050 mg/L MCL for Cr. DHS will be adopting an MCL that is specific for Cr(VI) at a later date (DHS, 2004a).

- Cr was detected in all 20 wells sampled and analyzed for Cr during this monitoring event. However, the State MCL (50.0 µg/L) was not exceeded in any well. The maximum concentration of Cr was reported in MW-6 at an estimated concentration of 28.4 µg/L.

A summary of the metals results compiled from the long-term sampling events since January 2003 that have been completed to date is provided in Table 3-7.

### **3.5 Quality Assurance/Quality Control**

Review of the QA/QC data provided with the laboratory analytical results indicates that all of the analytical results obtained from July - August 2004 samples are acceptable for their intended use of characterizing aquifer quality. Surrogate compound, matrix and blank spike, and method blank results were used by the laboratory to determine the accuracy and precision of the analytical techniques with respect to the JPL groundwater matrix, and to identify anomalous results due to laboratory contamination or instrument malfunction. In addition to laboratory QA/QC samples, GEOFON personnel collected QA/QC samples in the field in general accordance with the Quality Assurance Project Plan (QAPP) (Ebasco, 1993c). The field QA/QC samples included duplicate samples, equipment rinsate blanks, and trip blanks.

Duplicate samples were used to evaluate the precision of the laboratory analyses. Duplicate samples for VOCs, metals, and/or  $\text{ClO}_4^-$  analyses were collected from monitoring wells MW-3 (Screen 3), MW-5, MW-10, MW-11 (Screen 4), MW-14 (Screen 5), and MW-19 (Screen 1).

All of the analytical results for the duplicate samples were comparable to the results of the original groundwater samples (Tables 3-3 and 3-6).

Equipment rinsate blanks were collected each day non-dedicated sampling equipment was used. The equipment rinsate blanks, consisting of distilled water run through the sampling equipment after decontamination, were analyzed for all contaminants of concern to monitor possible cross-contamination of samples due to inadequate decontamination. 2-Butanone, Cr, ethylbenzene, methylene chloride, toluene, o-xylenes, and m,p-xylenes were detected at low concentrations in six equipment blanks. A laboratory-prepared trip blank, consisting of reagent-grade water placed in a vial and transported with the sample bottles to the field, was submitted to the laboratory with each daily shipment of groundwater samples. Trip blanks were used to help identify cross-contamination of groundwater samples during transport and/or deficiencies in the laboratory bottle cleaning and sample handling procedures. Low concentrations of 2-Butanone were detected in four trip blanks during the July - August 2004 sampling event. Table 3-8 presents a summary of contaminants detected in quality control samples collected during the July - August 2004 sampling event.

## **4.0 DATA VERIFICATION AND VALIDATION**

The purpose of data verification and validation is to assure that the data collected meet the data quality objectives (DQOs) outlined in the Quality Assurance Project Plan of the Groundwater Monitoring Plan (Ebasco, 1993c). The process is intended to ensure that the data are of sufficient quality for use in meeting the objectives outlined in the Groundwater Monitoring Plan.

### **4.1 Data Verification**

All data collected were subjected to data verification. In general, verification identifies non-technical errors in the data package that can be corrected (e.g., typographical errors). Data verification included proofreading and editing hard-copy data reports to assure that data correctly represent the analytical measurement. Data verification also included verifying that the sample identifiers on laboratory reports (hard copy) matched those on the chain-of-custody record.

### **4.2 Data Validation**

Data validation is a systematic process that is used to interpret, define, and document analytical data quality and determine whether the data quality is sufficient to support the intended use(s) of the data. Validation of a data package includes reconstruction of sample preparation, analysis of the raw data, reconciliation of the raw data with the reduced results, identification of data anomalies, and qualification of data to identify data usability limitations.

Data validation was performed by an independent subcontractor, Laboratory Data Consultants, Inc. (LDC), Carlsbad, CA. One hundred percent of all data analyzed by a fixed-base analytical laboratory (APCL) were validated. Ten percent of the data were subjected to Level IV quality assurance requirements of the Navy (Navy, 1996 and Navy, 1999). The data were further evaluated to help ensure suitability and usability for the purpose of the groundwater monitoring report.

### **4.3 Data Validation Qualifiers**

Analytical data were qualified based on data validation reviews. For chemical data, qualifiers were assigned in accordance with the applicable EPA National Functional Guidelines for Data Validation (EPA, 1994a and 1994b). Individual laboratory data flags can be found in Appendix D. No data were rejected for non-compliance with method requirements during the course of validation.

## 5.0 WATER LEVEL MEASUREMENTS

Water level measurements were recorded before the sampling event on July 27, 2004 and after the sampling event on August 18, 2004 to evaluate groundwater flow directions and gradients beneath and adjacent to JPL. Water levels in the shallow wells were measured using a Solinst® water level meter. In the deep multi-port wells, the hydraulic head at each sampling port was measured with a Westbay pressure-transducer probe.

Water table elevation measurements taken before sampling are provided in Table 5-1 and have been contoured on Figure 5-1. Water table elevation measurements taken after sampling are provided in Table 5-2 and have been contoured on Figure 5-2. Piezometric pressure readings from the deep multi-port wells are generally recorded at the first screen interval. However, the recorded pressure readings from other screen intervals are used to validate the accuracy of the reading instrument or to screen for an erroneous field measurement at the first screen. Occasionally, the piezometric readings are determined to be out of range, when compared to the readings from the underlying screens. This could be attributed to several factors such as false readings or instrument errors. In either case, the piezometric pressure data that are deemed not usable are rejected and data from the underlying screens are used in the calculation of the water table elevation.

The hydraulic heads measured at each deep multi-port well screen before and after sampling are presented graphically on Figure 5-3. The piezometric pressure-profile records for the deep wells are included in Appendix B.

From July 27 to August 18, 2004, water levels in the shallow wells and in Aquifer Layer 1 decreased an average of about 3.2 feet, ranging from a rise of 16.2 feet to a decrease 9.8 feet. Water levels in Aquifer Layer 2 decreased an average of about 5.2 feet, ranging from a decrease of 0.2 feet to a decrease of 17.3 feet. Water levels in Aquifer Layer 3 decreased an average of about 6.3 feet, ranging from a decrease of 2.5 feet to a decrease of 14.1 feet. The only well screen in Aquifer Layer 4 (MW-20 Screen 5) showed a decrease of about 5.1 feet. Water levels in all aquifer layers generally decreased during this event.

Water level fluctuations can result from a wide variety of hydrologic phenomena, some natural and some induced by man. It is likely that several of these phenomena are operating simultaneously including, but not limited to:

- Groundwater recharge/infiltration to the water table,
- Air entrapment during groundwater recharge,
- Groundwater extraction, and/or

- Artificial recharge from the spreading grounds.

As depicted on Figures 5-1 and 5-2, the estimated groundwater flow direction both before and after sampling was generally consistent with previous observations. The flow was primarily to the south-southwest through the eastern portion of JPL and to the east-southeast in the southwest portion of JPL, Arroyo, and plain. The estimated groundwater gradients measured both at the beginning and end of the event ranged from about 0.18 feet per foot near MW-9, at the northern end of the Arroyo, to 0.005 feet per foot across the Arroyo and plain.

## 6.0 CONCLUSIONS AND RECOMMENDATIONS

The following conclusions are based upon interpretation of analytical data and field measurements collected during the July - August 2004 event and previous events of the JPL Monitoring Program:

- The chemical plumes beneath JPL are adequately defined and relatively stable. The concentration contour maps generally indicate slow migration of the contaminant plumes over the last year. Comparison of the July - August 2004 results with previous monitoring events showed that VOCs and metals concentrations are relatively stable. However, there was a decrease in  $\text{ClO}^{4-}$  concentrations from April - May 2004 to July - August 2004 at wells MW-7, MW-16, and MW-24 (Screen 1), which have historically contained the highest  $\text{ClO}^{4-}$  concentrations. In summary, the July - August 2004 analytical results indicate the following:
  - ◆ Three VOCs ( $\text{CCl}_4$ , TCE, and PCE) were detected in one or more monitoring wells at concentrations above the State or Federal MCLs for drinking water. Although there were no significant changes in  $\text{CCl}_4$ , TCE, and PCE concentrations from the previous event to the July - August 2004 event, 1,1-DCE did show a decrease in well MW-7 from 7.9  $\mu\text{g/L}$  in April - May 2004 to 5.5  $\mu\text{g/L}$  in July - August 2004, dropping below the State and Federal MCLs (6.0  $\mu\text{g/L}$  and 7.0  $\mu\text{g/L}$ , respectively).
  - ◆  $\text{ClO}^{4-}$  concentrations exceeded the State IAL for drinking water in eight on-facility wells and three off-facility wells. During the July - August event, the highest levels of  $\text{ClO}^{4-}$  concentrations were reported in samples from MW-7, MW-13, MW-16, and MW-24 (Screen 1).  $\text{ClO}^{4-}$  concentrations decreased at MW-7, MW-16, and MW-24 (Screen 1) from 4,430  $\mu\text{g/L}$ , 929  $\mu\text{g/L}$  and 2,240  $\mu\text{g/L}$  in April - May 2004 to 3,760  $\mu\text{g/L}$ , 833  $\mu\text{g/L}$ , and 2,170  $\mu\text{g/L}$ , respectively, in July - August 2004. However,  $\text{ClO}^{4-}$  concentrations increased at MW-13 and MW-17 (Screen 3) from 205  $\mu\text{g/L}$  and non-detect in April - May 2004 to 296  $\mu\text{g/L}$  and 109  $\mu\text{g/L}$  in July - August 2004, respectively.
  - ◆ Cr(VI) was detected in two on-facility wells at concentrations below the practical quantitation limit (PQL). Cr(VI) is currently regulated under the 0.050 mg/L MCL for Cr. The DHS will be adopting an MCL that is specific for Cr(VI) (DHS, 2004a).

- ◆ Cr was detected in all 20 wells sampled and analyzed for Cr during this monitoring event; however, none of the concentrations exceeded the State or Federal MCL (50.0 µg/L).
- ◆ Moderate decreases in hydraulic head were measured during this event in shallow wells and Westbay well screens in all Aquifer Layers (1, 2, 3, and 4). The water level fluctuations are likely due to several hydrologic phenomena operating simultaneously including, but not limited to, groundwater recharge, pumpage, and/or artificial recharge.
- ◆ Groundwater gradient maps prepared using the July - August 2004 water level measurements indicate that groundwater gradients and flow directions are generally consistent with previous observations (GEOFON, 2004, SOTA, 2002, 2001 and Foster Wheeler, 2000).

GEOFON recommends that the Groundwater Monitoring program be continued at the site. The next quarterly event is scheduled to be performed during October - November 2004.



## 7.0 REFERENCES

- RWQCB, Central Valley Region, 2000. A Compilation of Water Quality Goals. August 2000.
- DHS, 2004a. Chromium-6 in Drinking Water: Regulation and Monitoring Update. <http://www.dhs.ca.gov/ps/ddwem/chemicals/Chromium6/Cr+6index.htm>. April 7, 2004.
- DHS, 2004b. Public Records Act Request Test Results Information on Groundwater Quality. October 19, 2004.
- DHS, 2004c. Perchlorate in Drinking Water: Status of the California MCL. <http://www.dhs.ca.gov/ps/ddwem/chemicals/perchl/perchlorateMCL.htm>. March 12, 2004.
- EPA, 1991. Management of Investigation-Derived Wastes During Site Inspections: EPA Office of Research and Development: EPA/540/G-91/009, May 1991, 35 pp.
- EPA, 1992. Guide to Management of Investigation-Derived Wastes: EPA Office of Solid Wastes and Emergency Response, Publication: 9345.3-03FS, April 1992.
- EPA, 1994a. Laboratory Data Validation Functional Guidelines for Evaluating Organics Analysis. February 1994.
- EPA, 1994b. Laboratory Data Validation Functional Guidelines for Evaluating Inorganics Analysis. February 1994.
- Ebasco, 1993a. Work Plan for Performing a Remedial Investigation/Feasibility Study, National Aeronautics and Space Administration Jet Propulsion Laboratory, Pasadena, California December 1993.
- Ebasco, 1993b. Field Sampling and Analysis Plan for Performing a Remedial Investigation at Operable Unit 1: On-Site Groundwater. National Aeronautics and Space Administration Jet Propulsion Laboratory, Pasadena, California. December 1993.
- Ebasco, 1993c. Quality Assurance Program for Performing a Remedial Investigation for the National Aeronautics and Space Administration Jet Propulsion Laboratory, Pasadena, California. December 1993.
- Ebasco, 1994. Field Sampling and Analysis Plan for Performing a Remedial Investigation at Operable Unit 3: Off-Site Groundwater. National Aeronautics and Space Administration Jet Propulsion Laboratory, Pasadena, California. May 1994.
- Foster Wheeler, 2000. Report Quarterly Groundwater Monitoring Results. July-August 2000.
- Freeze, A. R. and Cherry, J. A., 1979. Groundwater. Prentice Hall, Englewood Cliffs, New Jersey, 604 pp.
- GEOFON, Incorporated (GEOFON), 2004. Final Groundwater Monitoring Report, April - May 2004, National Aeronautics and Space Administration, Jet Propulsion Laboratory Pasadena, California. September 8.

Navy Installation Restoration Chemical Data Quality Manual (IR CDQM), Naval Facilities Engineering Service Center (NFESC). September, 1999.

Navy Installation Restoration Laboratory Quality Assurance Guide, NFESC. 1996.

SOTA Environmental Technology, Inc. (SOTA), 2001. Quarterly Groundwater Monitoring Report, January-February 2001, National Aeronautics and Space Administration, Jet Propulsion Laboratory Pasadena, California. January, 2001.

SOTA Environmental Technology, Inc. (SOTA), 2002. Groundwater Monitoring Report, January-February 2002, National Aeronautics and Space Administration, Jet Propulsion Laboratory Pasadena, California. April, 2002.