

**APPENDIX G – GROUNDWATER CHEMISTRY**

**FINAL REMEDIAL INVESTIGATION REPORT  
CASMALIA RESOURCES SUPERFUND SITE  
CASMALIA, CALIFORNIA**

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1,1-DCE	1,1-dichloroethene
1,1,1-TCA	1,1,1-trichloroethane
1,1,2-TCA	1,1,2-trichloroethane
1,2-DCB	1,2-dichlorobenzene
1,2,4-TMB	1,2,4-trimethylbenzene
1,3,5-TMB	1,3,5-trimethylbenzene
<sup>3</sup> H	tritium
<sup>3</sup> He	helium-3
<sup>13</sup> C/ <sup>12</sup> C	carbon-13/carbon-12
<sup>14</sup> C	carbon-14
<sup>15</sup> N/ <sup>14</sup> N	nitrogen-15/nitrogen-14
<sup>18</sup> O/ <sup>16</sup> O	oxygen-18/oxygen-16
°F	temperature degree Fahrenheit
µg/L	micrograms per liter
o/oo	per mil or parts per thousand
BC Laboratory	BC Analytical Laboratories
beta-BHC	beta-benzenehexachloride
BOD	biological oxygen demand
BP	before present
BTA	Burial Trench Area
BTEX	benzene, toluene, ethylbenzene, and xylenes
CE	Canonie Environmental Services, Inc.
CFR	Code of Federal Regulations
cis-1,2-DCE	cis-1,2-dichloroethene
COC	chemical of concern
COD	chemical oxygen demand
COPC	chemical of potential concern
CPT	cone penetrometer testing
CSC	Casmalia Steering Committee
DBCP	1,2 dibromo 3 chloropropane
DIC	Dissolved Inorganic Carbon
DNAPL	dense non-aqueous phase liquid
DO	dissolved oxygen
DQO	data quality objective
EDB	Ethylene dibromide
EPA	Environmental Protection Agency
Freon 113	1,1,2-trichloro-1,2,2-trifluoroethane
FS	Feasibility Study
FSP	field sampling plan
ft/yr	feet per year
gpm	gallons per minute
HNO <sub>3</sub>	nitric acid
HpCDD	heptachlorinated dibenzo- <i>p</i> -dioxin
HpCDF	heptachlorinated dibenzofuran
HSCER	Hydrogeologic Site Characterization and Evaluation Report
HSU	Hydrostratigraphic Unit

HT	hydrogen (tritium) gas
HTO	tritiated water vapor
HxCDF	hexachlorinated dibenzofuran
IPR	Interim Progress Report
LS/MS/MS	liquid chromatography tandem mass spectrometry
LNAPL	light non-aqueous phase liquid
MACTEC	MACTEC Engineering and Consulting, Inc.
MCL	maximum contaminant level
MEK	Methyl ethyl ketone
mg/L	milligrams per liter
MIBK	methyl isobutyl ketone
MIP	Membrane Interface Probe
ml	milliliters
ml/min	milliliters per minute
MNA	monitored natural attenuation
MTBE	Methyl tert butyl ether
NAPL	non-aqueous phase liquid
NDMA	n-nitrosodimethylamine
OCDD	octachlorodibenzo-p-dioxin
OCDF	octachlorodibenzofuran
ORP	oxidation-reduction potential (redox)
P/S Landfill	Pesticide/Solvent Landfill
PAH	polycyclic aromatic hydrocarbon
PCB	polychlorinated biphenyl
pCBSA	Parachlorobenzene sulfonic acid
PCE	tetrachloroethylene/tetrachloroethene
PE	Performance Evaluation
pg/L	picograms per liter
pH	unit of measurement for acid/base properties
PRGs	Preliminary Remediation Goals
PSCT	Perimeter Source Control Trench
PVC	polyvinyl chloride
QA/QC	Quality Assurance/Quality Control
QAPP	Quality Assurance Project Plan
QC	Quality Control
QED	QED Environmental Systems is a company specializing in water quality remediation/sampling products
RCRA	Resource Conservation and Recovery Act
RDX	an explosive nitroamine also known as cyclonite, hexogen, T4, and cyclotrimethylenetrinitramine
RGMEW	Routine Groundwater Monitoring Element of Work
RI	Remedial Investigation
RICF	Remedial Investigation change forms
RI/FS	Remedial Investigation/Feasibility Study
SA	semiannual
Site	Casmalia Resources Superfund Site
SOW	Scope of Work
SVOC	semi-volatile organic compound
TCE	trichloroethylene/trichloroethene
TDS	total dissolved solids

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TOC	total organic carbon
TPH	total petroleum hydrocarbons
trans-1,2-DCE	trans-1,2- dichloroethene
TU	tritium unit
UM	University of Miami (Florida)
USDOE	United States Department of Energy
USEPA	United States Environmental Protection Agency
UVIF	ultraviolet induced fluorescence
VC	vinyl chloride
VOC	volatile organic compound
WCC	Woodward-Clyde Consultants
WHO	World Health Organization
ybp	years before present



## 1.0 INTRODUCTION

This Appendix to the Final Remedial Investigation (RI) Report documents the groundwater sampling activities performed at Casmalia Resources Superfund Site (Site) pursuant to the RI groundwater sampling requirements set forth in the Remedial Investigation/Feasibility Study (RI/FS) Work Plan and subsequent United States Environmental Protection Agency (EPA) requirements. The Casmalia Steering Committee (CSC) has conducted groundwater sampling at the Site since 1997 as a part of the Routine Groundwater Monitoring Element of Work (RGMEW).

Additional groundwater sampling focused on RI Data Objectives was performed:

- During the fourteenth and fifteenth semiannual (SA) sampling events completed in the Fall 2004 and Spring 2005, respectively;
- During the seventeenth and eighteenth SA sampling events, completed in the Spring and Fall 2006, respectively (sampling of RIPZ-15 and RIPZ-16);
- During the eighteenth SA sampling event (sampling of RIMW-10, RIMW-11, and temporary piezometer RIPZ-37); and
- During Phase II sampling of seven hydropunch borings advanced in January 2007 and one hydropunch boring advanced in May 2007.

The majority of the groundwater sampling activities for the fourteenth SA event were conducted between October 11 and November 15, 2004, although the RI groundwater quality monitoring wells, installed during the Summer and Fall 2004, were sampled in January 2005 and March 3, 2005. The fifteenth SA event was conducted from March 21 through April 18, 2005, with additional sampling on May 12, 2005. The fourteenth, fifteenth, seventeenth, and eighteenth SA sampling events met the performance standards for the RGMEW. In addition, groundwater sampling during the fourteenth and fifteenth SA events also met the performance standards for additional sampling points and an expanded suite of analyses that were detailed in the *Field Sampling Plan (FSP) Routine Groundwater Monitoring Element of Work and Remedial Investigation Casmalia Hazardous Waste Management Facility Revision 4.0* (CSC, 2004a) and the *RI/FS Work Plan* (CSC, 2004b).

In addition to the large number of groundwater monitoring points sampled and the expanded laboratory analytical program performed, the RI groundwater chemistry investigation included:

- Analyses for groundwater age-dating and source area evaluation purposes;
- Analyses for evaluation of the appropriateness of monitored natural attenuation (MNA) as part of the site remediation strategies,
- Collection and analysis of light non-aqueous phase liquid (LNAPL) and dense non-aqueous phase liquid (DNAPL) samples from several site monitoring and extraction wells.

Tables, figures and attachments to this appendix are included on the enclosed compact disc (CD).

### **1.1 Data Collection Objectives**

The RGMEW includes groundwater quality sampling for the purposes of achieving Performance Standards specified in Section 2.12 of the Casmalia Consent Decree Statement of Work. The expanded sampling program performed during the fourteenth and fifteenth SA events, sampling of new wells and piezometers during the seventeenth and eighteenth SA events, and Phase II hydropunch sampling were performed conjunctively with RI/FS investigation tasks. These additional data were required, to further characterize the nature and extent of groundwater contamination at the Site, refine the Site conceptual model, and to provide additional data for the groundwater model. The specific data collection objectives for this task included sampling existing but previously unsampled wells and piezometers, along with new RI monitoring wells, and additional laboratory analyses for potential chemicals of concern (Tables G-1 and G-2).

### **1.2 Scope of Work**

The Scope of Work (SOW) for the Groundwater Chemistry Investigation included sample collection from groundwater monitoring wells, extraction wells, and pond samples during the expanded sampling programs of the fourteenth and fifteenth SA events and from the newly installed wells, temporary wells, and piezometers during the seventeenth and eighteenth SA sampling events.

During the fourteenth and fifteenth SA events, an additional thirty monitoring wells and piezometers, two liquid control features, and four offsite water wells were sampled as part of the groundwater RI/FS Investigations. Also, nine new RI chemical quality wells (RIMW-1 through -3, RIMW-5 through -9, and RIPZ-8), one replacement chemical quality well, and one replacement piezometer installed at the Site during Fall 2004 as part of the RI/FS were sampled. One new chemical quality well (RIMW-4) was ultimately dropped from the RI/FS well and piezometer installation program after it was determined that the well would be co-located with newly installed piezometer RIPZ-8 and therefore redundant (see Appendix E for more discussion and Appendix Q for the RI change forms [RICF]). RIPZ-8 was subsequently added to the sampling program to replace well RIMW-4. The seventeenth and eighteenth SA events were the first sampling event for new piezometers RIPZ-15 and RIPZ-16. The eighteenth SA event was also the first sampling event for two new wells (RIMW-10 and RIMW-11) and one temporary piezometer (RIPZ-37). The seven hydropunch borings were sampled during 2007.

Consistent with past SA events, Blaine Tech Services assisted MACTEC Engineering and Consulting (MACTEC) during sample collection.

For sampling work conducted during the fourteenth SA event, groundwater quality samples were collected from 102 of 108 RI/FS Work Plan proposed locations:

- 88 groundwater monitoring wells/piezometers/offsite production wells;
- Nine liquid control features; and
- Five ponds.

Sampling was not performed at 6 of the proposed 108 sampling locations during the fourteenth SA sampling event:

- Two new wells were not sampled due to insufficient sample recovery or the well was dry (RIMW-6 and RG-11B-2);
- Well RG-2B was not sampled due to insufficient sample recovery; and
- Three piezometers were not sampled due to bent or damaged polyvinyl chloride (PVC) well casings (RGPZ-11B, RGPZ-11D, and RGPZ-13D).

For the sampling work conducted during the fifteenth SA sampling event, groundwater quality samples were collected from 104 of 108 RI/FS Work Plan proposed locations:

- 90 groundwater monitoring wells/piezometers/offsite production wells;
- Nine liquid control features; and
- Five ponds.

Sampling was not performed at 4 of the proposed 108 sampling locations during the fifteenth SA sampling event:

- Piezometer RGPZ-10B was not sampled due to insufficient sample recovery; and
- Three piezometers were not sampled due to bent or damaged PVC well casings (RGPZ-11B, RGPZ-11D, and RGPZ-13D).

Tables G-3a and G-3b list the sampling dates and analyses that were performed at each location sampled during the fourteenth and fifteenth SA sampling events. Sample locations are shown on Figure G-1 for the Upper and Lower Hydrostratigraphic Units (HSUs). Table 3-4 presents the sampling dates and analyses that were performed at each location during the May 2008 twenty-first SA event.

## 2.0 METHODOLOGY

This section documents the sampling methods used during the fourteenth and fifteenth SA events, including the various purge and sampling techniques used at each monitoring well and analytical methods. All samples were collected in laboratory-supplied containers provided by the analytical laboratory (BC Laboratory, Bakersfield, CA), as required by RGMEW protocol. Methods for wells sampled as part of the RI during the sixteenth through eighteenth SA events were similar to those used during the fourteenth and fifteenth SA events.

### 2.1 *RI and RGMEW Groundwater Sampling Program*

The expanded fourteenth and fifteenth SA sampling events employed several well purging and sampling methods, as described below.

#### 2.1.1 **Passive Micropurge Sampling Using Dedicated QED Pumps**

Twenty wells and piezometers were sampled using dedicated QED pumps (A2B, C3M, MW-7C, RG-3B, RGPZ-5B, RGPZ-6B [only during the fourteenth SA sampling event], RIMW-3, RIPZ-8, RP-1D, RP-17B, RP-28B, RP-59B, RP-65B, RP-72A, RP-75A, RP-75B, RP-76A, RP-100A, RP-103B, and RP-109B). The procedure for performing passive micropurge sampling was as follows:

- Static depth to groundwater was measured to the nearest 0.01 foot using an electrical sounder;
- In setting up the sampling equipment, care was taken to locate the generator downwind of the sampling location and tubing connections were confirmed to be water-tight. The dedicated discharge hose was directed through a flow cell and into a graduated cylinder. Purge water was then transferred into a truck-mounted tank for temporary storage;
- Purging was initiated at a rate of approximately 200 milliliters per minute (ml/min). The depth to water was monitored throughout the purging process, and this information was recorded on the groundwater purging log;
- Water quality parameter readings (pH, conductivity, temperature, turbidity, oxidation-reduction potential [ORP], and dissolved oxygen [DO]) were collected using meters within the flow-cell, and were recorded on the groundwater purge log. Water quality parameters were not collected from wells RG-3B, RIMW-3, or RIPZ-8 due to the presence of non-aqueous phase liquids (NAPLs). Purging was complete when one calculated system volume had been removed from the well. One system volume is equal to the capacity of the bladder within the pump and the volume of the discharge tubing. QED Model T1200M pumps have a bladder capacity of 495 milliliters (ml). The 3/8-inch discharge tubing has a capacity of 9.5 ml per foot; and
- Sampling proceeded immediately after one system volume had been purged and the flow cell was removed.
- Water levels were monitored while purging and sampling to ensure that the stagnant water column above the top of the screened interval was not lowered into to the pump intake.

## 2.1.2 Micropurge Sampling Using Grundfos Redi-Flo Submersible Pumps

Eleven wells were sampled by the low flow micropurge method using Grundfos Redi-Flo submersible pumps (RGPZ-4C, RGPZ-6C, RP-54C, RP-72D, RP-75C, RP-107D, SW-31, SW-44, WP-8S, WS-1 and WS-4). The micropurge method using Grundfos Redi-Flo submersible pumps was also attempted in RP-53C and fifteen additional wells that were sampled for the first time as part of the RI groundwater sampling program (PZ-P18-5, RGPZ-2C, RGPZ-2D, RGPZ-3D, RGPZ-6D, RGPZ-8D, RGPZ-11C, RGPZ-12C, RGPZ-12D, RGPZ-13C, RGPZ-14D, RGPZ-15B, RGPZ-16D, SW-17, and WS-3). However, water levels in these sixteen wells failed to stabilize during purging activities, and the wells were subsequently sampled following the protocol established for wells that do not stabilize during micropurging.

Ten newly installed, or wells to be sampled for the first time as part of the expanded SA program could not be sampled using the micropurge method as intended, because the static depth to water in the well was measured below or immediately above the top of the screen interval (RIMW-1, RIMW-5 through RIMW-9, RGPZ-2B, RGPZ-9B, RGPZ-10B, and RGPZ-10B-2). Three wells (RIMW-1, RIMW-7, and RIMW-9) were purged by removing three casing volumes using a bailer or Grundfos Redi-Flo pump. The remaining seven wells were purged dry using bailers or Grundfos Redi-Flo pumps. All proposed new wells were sampled with the exception of Well RIMW-6, which did not contain sufficient groundwater volume to collect a sample.

The procedure for performing low flow, micropurge sampling using Grundfos Redi-Flo submersible pumps was as follows:

- Static depth to groundwater was measured using a well sounder to the nearest 0.01 foot;
- A portable Grundfos Redi-Flo pump was lowered to the approximate center of the screened interval of the well. The pump was lowered slowly to minimize mixing in the water column. Care was taken to avoid disturbance of the well bottom and minimize agitation of possible accumulated silt. This was accomplished by strapping an electronic well sounder to the pump so that the pump could be set at the desired depth without first having to touch the bottom. The sounder was attached so that it could then be removed from the well once the pump was emplaced and then lowered to the top of the water column for liquid measurements;
- In setting up the sampling equipment, care was taken to locate the generator downwind of the sampling location and tubing connections were confirmed to be water-tight. The dedicated discharge hose was directed through a flow cell and into a truck-mounted tank for temporary storage;
- Purging was initiated by pumping at a rate of 1/4 gallons per minute (gpm). The flow rate was adjusted until the water column stabilized. Stabilization was achieved when the water level in the well was either relatively stable or increasing slightly. The water level was monitored continuously throughout the purge process and the purge rate adjusted as necessary to maintain the water column stability. Information on drawdown height, stabilized water level elevation, and estimated pumping rates were recorded on the groundwater purge logs; and
- Once water level stabilization had occurred, water quality parameter readings (pH, conductivity, temperature, turbidity, ORP, and DO) were collected using meters within the flow-cell, and were recorded on the groundwater purge logs. Water parameters were not collected from well RIMW-7 due to the presence of NAPLs. Purging was complete when the water parameters had stabilized and a minimum volume of

groundwater was removed from the monitoring well as described in Section 6.2.1 of the FSP.

- Once the minimum volume of groundwater was removed, water quality samples were immediately collected for sample analysis upon removal of the flow cell. The flow rate while sampling remained the same as during purging to maintain the water column stability and ensure that only formation water was being sampled.
- Samples for dissolved metals analysis were field filtered with in-line filters and placed in nitric acid (HNO<sub>3</sub>) preserved bottles. When it was necessary to install the in-line filter, the pump was briefly turned off, or the discharge line was momentarily crimped. The filter was then installed and the pump restarted or the discharge line was uncrimped.

### 2.1.3 Sampling Wells Known Not To Stabilize Using Grundfos Redi-Flo Submersible Pumps and Bailers

Thirty-two groundwater samples were collected using Grundfos Redi-Flo pumps from wells that have historically shown they will not stabilize during attempts to micropurge, or had initial depths to water within the screen interval (DB-1, RG-1B, RG-7B, RG-9B, RGPZ-2C, RGPZ-2D, RGPZ-3C, RGPZ-3D, RGPZ-6D [only during the fifteenth SA sampling event], RGPZ-8D, RGPZ-11C, RGPZ-12D, RGPZ-13C, RGPZ-14D, RGPZ-15B, RGPZ-16D, RIMW-1, RIMW-2, RIMW-8, RIMW-9, RP-4D, RP-53C, RP-62B1, RP-62D2, RP-63C, RP-94D, RP-109D, SW-17, SW-46, WP-3D, WP-7D, and WP-8D). Groundwater samples were also collected using a bailer from twenty-two of twenty-three wells where the initial depth to water measurement was measured within the screen interval (B3M, MW-18C, PZ-P18-5, RG-2B, RG-4B, RG-5B, RG-6B, RG-8B, RG-10B, RG-11B, RG-11B-2, RGPZ-2B, RGPZ-9B, RGPZ-10B, RGPZ-10B-2, RIMW-5, RIMW-6, RIMW-7, RP-20B, SW-29, SW-47, WP-3S, and WP-7S). Well RG-2B was purged dry but there was not sufficient recovery to collect a sample during the fourteenth SA sampling event.

For wells where, historically, the water level could not be stabilized, the well was purged using one of two methods:

1. For wells where the depth to water was above the screen interval, the sampling procedure was as follows:
  - Static depth to groundwater was measured using a well sounder to the nearest 0.01 foot;
  - A portable Grundfos Redi-Flo pump was lowered to the approximate center of the screened interval of the well. The pump was lowered slowly to minimize mixing in the water column. Care was taken to avoid disturbance of the well bottom to minimize agitation of possible accumulated silt. This was accomplished by strapping an electronic well sounder to the pump so that the pump could be set at the desired depth without first having to touch the bottom. The sounder was attached so it could then be removed from the well once the pump was emplaced and then lowered to the top of the water column for liquid measurements;
  - The generator was located downwind of the sampling location. The samplers checked the connections and directed the discharge hose through a flow cell and subsequently into a truck-mounted polytank for temporary storage;
  - Purging was initiated at a maximum rate of 5 gpm. The water level was monitored continuously throughout the purge process to ensure that the top of the water column never fell below the top of the screen interval. Purging continued until a volume

- equal to the sample volume plus the volume in the screen interval was removed. If the water level dropped to below the top of the screen, pumping was momentarily halted, the pump was lowered to near the bottom of the casing, and the well was pumped dry (i.e., 1 to 2 feet of water column above the bottom of the well);
- Water quality parameter readings (pH, conductivity, temperature, turbidity, ORP, and DO) were collected during the purge process using a meter within the flow-cell, and were recorded on the groundwater purge logs;
  - Once a volume equal to the sample volume plus the volume in the screen interval was purged, the pump and discharge tubing were removed from the well. The discharge tubing was carefully wrapped in sealed plastic bags and staged near the well for use when the well had sufficiently recovered for sampling; and
  - The well was then allowed to recharge until the water column had recovered to one half of the screened interval plus the volume required to collect sufficient sample for a full suite of analyses. Wells that had not recovered sufficiently for a full suite of analyses within 96 hours were sampled following the priority list of analyses detailed in the Section 6.2.1 of the FSP.
2. For wells where the initial depth to water was observed to be within the screened interval, the sampling procedure was as follows:
- An attempt was first made to purge three casing volumes of water from the well.
  - If the well did not generate enough water for three casing volumes, the well was subsequently purged dry using a Grundfos Redi-Flo pump, or a bailer. Wells purged dry were sampled as soon as sufficient volume was recovered for a full analytical suite. Wells that had not recovered sufficiently for a full suite of analyses within 96 hours were sampled following the priority list of analyses detailed in the Section 6.2.1 of the FSP.

Wells that were purged during the fourteenth SA event using the protocols described in number one above, and did not produce enough volume for a full suite of analyses, were subsequently purged dry and sampled in January 2005 following the protocols detailed in number two above (B3M, RGPZ-11C, RGPZ-12C, and WP-3D).

#### **2.1.4 Chemical Quality Sampling from Liquid Control Features**

Ten liquid control features were sampled during the expanded fourteenth and fifteenth SA sampling events (Gallery Well, PSCT-1 through PSCT-4, Sump 9B, C5, RAP-1A, RAP-1B, RAP-1C, and RAP-3A). The methodology for sampling liquid control features was as follows:

- Depth to groundwater was measured using a well sounder to the nearest 0.01 foot;
- The initial flow totalizer value and the time were noted before purging was initiated by opening the spigot along the purge line;
- For PSCT-1 the manual control switch for the dedicated pump was turned to the off position several hours prior to sampling to ensure sufficient sample quantity for both the prime and EPA split-sample volumes required; and
- Water quality parameters were monitored during purging, and were recorded on the purge log. Water quality parameters were not collected from PSCT-1, Gallery Well, and Sump 9B due to the presence of NAPLs.

In addition, Sump 9B, PSCT-1, and PSCT-4 were sampled monthly between October 2003 and March 2004 to evaluate volatile organic compound (VOC) concentration trends.

The Site water production well (WS-2) was also sampled from the dedicated pump following the same protocols as for liquid control features.

### **2.1.5 Chemical Quality Sampling from Ponds**

Five pond samples were collected during the fourteenth and fifteenth SA sampling events (RCF Pond, Pond 13, A-Series Pond, Pond A-5, and Pond 18). The procedure for sampling ponds was as follows:

- Sampling was performed from within the Site boat anchored near the approximate geographic center of the pond. The total depth of the pond was measured from the top of the pond surface;
- A discrete interval bailer was lowered to a depth approximately halfway between the pond surface and the pond bottom. The bailer was opened to allow water to enter by pulling a string affixed to the check ball and then reclosed while still suspended at the intended sample depth to capture a discrete sample. The bailer was then raised into the boat and the sample was transferred into designated bottles;
- The procedure was repeated until a sufficient volume of water had been collected; and
- The sample aliquots to be analyzed for dissolved metals were filtered in the field.

### **2.1.6 Hydropunch Sampling**

Seven hydropunch borings were advanced during the 2007 Phase II RI/FS to close minor data gaps that remained following the 2004 Phase I RI/FS. The purpose of hydropunch borings RIHP-1 through RIHP-6 was to determine the extent within the Upper HSU of chemicals of concern (COCs) south of the Perimeter Source Control Trench (PSCT). These hydropunch borings were installed in January 2007 by using a direct-push drilling rig to advance cone penetrometer testing (CPT) rods to the desired depth. Upon completion of the total depth, the CPT rods were removed and the borehole was reamed open to approximately 2-inches by advancing steel push rods to the target depth. Temporary PVC casings were installed for sample collection and a bentonite seal was placed around the casing at the ground surface to prevent surface water from entering the borehole. The casings were subsequently removed and the boreholes grouted.

Hydropunch boring RIHP-7 was advanced in May 2007 to monitor groundwater downgradient of soil boring RISBON59, which was considered a potential NAPL location, based on 2004 RI ultraviolet induced fluorescence/membrane interface probe (UVIF/MIP) data. The boring was advanced, using a direct push rig and approximately 2-inch diameter rods equipped with 4-foot length clear acetate liners used for core collection and lithologic logging by an onsite geologist. Upon advancement to total depth, temporary PVC casing was installed and the push rods were removed. A bentonite seal was placed around the well casing at the ground surface to prevent surface water from entering the borehole. The temporary casing is still in place at hydropunch RIHP-7.

Logs of the hydropunch borings are included in Appendix E. Grab groundwater samples were obtained from the borings using disposable bailers. Samples from RIHP-1 through RIHP-7 were

analyzed for VOCs. Additionally, samples from RIHP-02 and RIHP-06 were analyzed for semi-volatile organic compounds (SVOCs).

## **2.2 RI and RGMEW Analytical Program**

The major components of the analytical program include: 1) specification of EPA Test Methods, target compound list, and reporting limits for analysis of project samples, 2) specification of acceptance criteria and required frequency of field and laboratory quality control (QC) samples, 3) EPA conducted performance and system audits of analytical laboratories prior to project sample submittal, and 4) data validation. As presented in the Quality Assurance Project Plan (QAPP, Appendix B of the RI/FS Work Plan), the analytical program for the RI and RGMEW was designed to allow for the collection of data during sampling and analysis activities that are sufficiently accurate and representative to support the data quality objectives described in the RI/FS Work Plan.

### **2.2.1 Laboratory Program**

Samples from the RI and RGMEW programs were collected in accordance with the procedures specified in the QAPP and FSP, and were submitted to the following laboratories for one or more of the following analyses:

BC Laboratory, Bakersfield, CA:

- VOCs by EPA Test Methods 504.1 and 8260B;
- Poor Purging Compounds by EPA Test Method 8015B (Direct Inject);
- SVOCs by EPA Test Method 8270C;
- Metals by EPA Test Methods 200.8, 6010B, and 7000;
- Chlorinated Herbicides by EPA Test Method 8151A;
- Organochlorine Pesticides and Polychlorinated Biphenyls (PCBs) by EPA Test Methods 8081A and 8082;
- Organophosphorous Pesticides by EPA Test Method 8141A;
- Polynuclear Aromatic Hydrocarbons (PAHs) by EPA Test Method 8270 SIM;
- Total Petroleum Hydrocarbon (TPH), Benzene, Xylenes, Ethylbenzene, and Xylenes (BTEX) and Methyl tert-butyl ether (MTBE) by EPA Test Methods 8015B and 8021B;
- Perchlorate by EPA Test Method 314.0;
- Nitroaromatics and Nitrosamines by EPA Test Method 8330; and
- Inorganic compounds by EPA Test Methods SM2320 (alkalinity), 150.1 (pH), 300.0 (anions), 160.1 (total dissolved solids [TDS]), 405.1 (biological oxygen demand [BOD]), 410.4 (chemical oxygen demand [COD]), and 415.1 (total organic carbon [TOC]).

Frontier Analytical, El Dorado Hills, CA:

- World Health Organization (WHO) List PCB Congeners by EPA Test Methods 680 and 1668; and
- Dioxins and Furans by EPA Test Method 8290.

West Coast Analytical, Santa Fe Springs, CA:

- Parachlorobenzene sulfonic acid (pCBSA) by in house method using liquid chromatography tandem mass spectrometry (LC/MS/MS).

Truesdale Laboratory, Tustin, CA:

- Hydrazine by EPA Test Method 8315.

The samples were analyzed by each of the analytical laboratories using the target analyte list for each analytical method and required reporting limits as presented in the QAPP. Tables G-3a, G-3b, and G-4 present the specific analysis performed at each of the sampling stations for the fourteenth, fifteenth, and twenty-first SA events, respectively.

## 2.2.2 Radionuclide and Stable Isotope Sampling

### 2.2.2.1 Age-Dating Program

As agreed to with the EPA, the CSC collected additional groundwater samples from wells screened within the Alluvium, Upper HSU, and Lower HSU to allow for comparison to historical groundwater age dating data. Samples were collected from seven wells/piezometers (RGPZ-2C, RGPZ-15B, RGPZ-16D, RP-65B, RP-76A, RP-107D, and SW-31), including one duplicate (SW-31), during the fourteenth SA sampling event. Samples were collected from three wells (RGPZ-2D, RP-62B-1, and RP-62D-2) during the fifteenth SA sampling event, and one sample was collected from the Gallery Well during the nineteenth SA sampling event.

Each sample was analyzed for tritium ( $^3\text{H}$ ) and carbon-14 ( $^{14}\text{C}$ ). The  $^3\text{H}$  samples collected during the fourteenth and fifteenth SA sampling events were submitted to the Rosenstiel School of Marine and Atmospheric Science, Tritium Laboratory, University of Miami, Miami, Florida. The  $^{14}\text{C}$  samples collected during the fourteenth and fifteenth SA sampling events were submitted to Beta Analytic Inc., Miami, Florida. The single  $^{14}\text{C}$  and  $^3\text{H}$  sample collected in the nineteenth SA sampling event was submitted to Isotech Laboratories, Inc., Champaign, Illinois. Results of the age dating program are discussed in Section 3.2.2.

### 2.2.2.2 Gallery Well Recharge Investigation

Groundwater samples were collected during the nineteenth SA event from the Gallery Well, RP-68-C2, and SW-44 in an effort to determine the source of recharge water for the Gallery Well. The samples were submitted to Isotech Laboratories, Inc., Champaign, Illinois and analyzed for carbon-13/carbon-12 ( $^{13}\text{C}/^{12}\text{C}$ ) isotope ratios and nitrogen-15/nitrogen-14 ( $^{15}\text{N}/^{14}\text{N}$ ) isotope ratios in order to identify unique isotopic signatures for the individual well locations. Results of the Gallery Well investigation are discussed in Section 3.2.2.

## 2.2.3 NAPL Chemistry Program

The comprehensive program for the RI/FS NAPL investigation included a number of integrated tasks including: soil sampling and soil gas surveys (Appendices B and C), drilling new wells and piezometers (Appendix E), monitoring NAPL levels in site wells and piezometers (Appendix F), geological and geophysical investigations (Appendices E and L), soil investigations for NAPL presence using CPT with UVIF and MIP (Appendix M), and chemical and physical analyses of LNAPL and DNAPL samples. Current NAPL thicknesses in site wells and piezometers including those sampled for chemical composition are presented in Appendix F.

Samples of LNAPL and DNAPL detected in several wells were collected by Site operations personnel and submitted to BC Laboratories for chemical composition and physical properties analysis. Sampling of five Central Drainage Area wells was performed on December 15 and 16, 2004. LNAPL samples were collected from three wells or piezometers; Gallery Well, Gallery Well Piezometer GW-PZ-W, and Sump 9B Piezometer Sump 9B-PB. DNAPL samples were collected from three wells or piezometers; Gallery Well, RGPZ-7C, and RGPZ-7D. The NAPL samples were analyzed for physical properties including density and viscosity, as well as those chemicals listed in Appendix IX of 40 Code of Federal Regulations (CFR) part 264, and additional chemicals of potential concern (COPCs; Table G-3a).

#### **2.2.4 Monitored Natural Attenuation Evaluation**

An assessment of historical and recent inorganic and organic chemistry data from across the site was performed to evaluate whether MNA should be included as an appropriate part of the site remedial strategies. An analysis of the distribution of various dissolved gasses via bubble strip sampling, and an evaluation of evidence of biodegradation of solvent class COCs and fuel derived hydrocarbons was performed as well as identifying potential data gaps for future MNA analyses. The results of the MNA evaluation are presented in Appendix O.

#### **2.2.5 Quality Assurance/Quality Control Program**

Field and laboratory QC samples are used to assess the efficacy of the field sampling program and quality of laboratory data. Field QC samples including field duplicates, trip blanks, and rinsate blanks were collected and submitted to the analytical laboratory in accordance with the QAPP to assess the quality of the data resulting from the field sampling program. Laboratory QC samples including laboratory control samples, laboratory duplicates, matrix spikes and matrix spike duplicates, and method blanks were produced and analyzed by the laboratory in accordance with the QAPP to assess the quality of data resulting from laboratory procedures and matrix effects from the site.

Additional split samples were provided to EPA representatives by MACTEC sampling personnel during the fourteenth and fifteenth SA sampling events for additional external QC evaluations. WP-7D was one of the EPA split sample locations.

Prior to start of the sampling program, EPA conducted performance audits of the analytical laboratories used in the RI and RGMEW programs. The performance audits consisted of the blind submittal of a sample of a known concentration of target compounds to the laboratory for analysis, known as a performance evaluation (PE) sample. PE samples were analyzed and reported to EPA with passing results for each of the PE samples except for Mercury by EPA Test Method 7470A from BC Laboratory and Hydrazine by EPA Test Method 8315 from Truesdale Laboratories. PE samples for mercury and hydrazine were re-submitted to the respective laboratories and reported with passing results on the second sample. In addition to performance audits, EPA conducted a system audit, consisting of an on-site laboratory review of BC Laboratory prior to the start of the sampling program. All corrective action items and other audit findings were resolved with EPA and the laboratory prior to the start of the sampling program.

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Independent, third party validation of the data was performed on all sample results to assess the data provided by the laboratory for completeness and compliance with stipulated requirements in the QAPP. The data validation process was in compliance with the EPA Functional Guidelines for Organic and Inorganic Data Review (EPA 1999 and 1994), and employed both cursory data review of all samples (EPA Level III review) and a minimum of 10 percent full raw data (EPA Level IV) review. Details of each level of data review performed were provided in the QAPP.

## 3.0 INVESTIGATION RESULTS

### 3.1 Groundwater Chemistry

This section describes the groundwater chemistry for the expanded fourteenth and fifteenth SA sampling events for the various sampling location groups, sampling of RIPZ-15 and RIPZ-16 during the seventeenth and eighteenth SA sampling events, sampling of RIMW-10, RIMW-11, and temporary Piezometer RIPZ-37 during the eighteenth SA sampling event; and sampling of six hydropunch borings advanced in January 2007 and one hydropunch advanced in May 2007. Figures G-2 through G-13 shows the wells, chemicals, and concentrations that were detected with exceedances of maximum contaminant level/preliminary remediation goals (MCL/PRGs) presented in bold font. These figures include posting of twelve representative chemicals in the Upper and Lower HSUs between 1997 and March 2005; VOCs, ethylene dibromide (EDB), and 1,2-dibromo-3-chloropropane (DBCP) in the Upper HSU, northern area and southern area (separated for clarity) and the Lower HSU for October 2004 and March 2005; and other organic compounds in the Upper HSU, northern area and southern area and the Lower HSU; cyanide and dissolved metals in the Upper HSU, northern area and southern area and the Lower HSU for October 2004 and March 2005. Figures G-14 through G-17 present stiff diagrams of inorganic/general mineral groundwater chemistry for each sampling location for October 2004 and March 2005 by HSU. Figures G-18 and G-19 present dioxins/furans in the Upper and Lower HSUs, and Figures G-20 and G-21 show detections of explosives, n-nitrosodimethylamine (NDMA), and perchlorate in the Upper HSU for October 2004 and March 2005.

Concentration contour maps were created for benzene, tetrachloroethene (PCE), trichloroethene (TCE), cis-1,2-dichloroethene (cis-1,2-DCE), vinyl chloride (VC), total VOCs, arsenic, nickel, cadmium, and selenium for the Upper and Lower HSUs (Figures G-22 through G-42). Concentration contour values for the individual VOCs include a non-detect contour, the MCL concentration, and 1 percent of the solubility concentration, taken to be an indicator of potential NAPL presence in the area of a monitoring point. Where applicable, the figures also show 10 percent of solubility concentration contours (note that for the chemicals shown, PCE is the only chemical exceeding 10 percent of its solubility concentration). The concentration contour values for arsenic and nickel include a non-detect contour and the MCL concentration contour. The concentration contour values for total VOCs are increased logarithmically.

Note that all of these figures include additional historical chemistry data for wells not sampled during the fourteenth and fifteenth SA Events, but sampled during a prior RGMEW event(s), and chemistry data for wells/piezometers that were installed after the fourteenth and fifteenth SA events. Data for these wells, piezometers, and seeps, are flagged on the maps and include the results of the two most recent prior events, or two subsequent sampling events as noted.

Time concentration plots were generated for selected VOCs and general minerals for each well sampled. The time concentration plots for VOCS and general minerals are presented in Attachment G-1 and Attachment G-2, respectively. The time concentration plots are also posted on the concentration contour maps for total VOCs (Figures G-27, G-28, and G-34).

Inorganic concentration trends in groundwater were evaluated by generating “box and whisker” plots for sample data acquired from select wells during the Fourteenth and Fifteenth SA

sampling events that were expanded in scope for the RI assessment. The plots are presented in Attachment G-3.

### 3.1.1 Metals, Caustic/Cyanide, and Acids Landfill Area

This sampling location group included six Upper HSU wells and five Lower HSU wells adjacent to and near three separate landfills: the Metals Landfill, the Caustic/Cyanide Landfill, and the Acids Landfill. The data for the fourteenth and fifteenth SA events are presented in Table G-5a. The data for the twenty-first SA event is presented in Table G-5b.

#### 3.1.1.1 Organics Results

##### 3.1.1.1.1 *Upper HSU*

During the fourteenth (Fall 2004) SA event:

- SW-31 had 24 organic chemicals that exceeded their MCLs/PRGs with 1,1-dichloroethene (1,1-DCE) as the chemical with the highest concentration at 2,300 micrograms per liter ( $\mu\text{g/L}$ );
- RG-9B had 23 exceedances with 1,1,2-trichloro-1,2,2-trifluoroethane (Freon 113) as the chemical with the highest concentration at 2,500  $\mu\text{g/L}$ ;
- RG-8B had 22 exceedances with 1,1-dichloroethane (1,1-DCA) as the chemical with the highest concentration at 1,500  $\mu\text{g/L}$ ; and
- WP-8S had 15 exceedances with Freon 113 as the chemical with the highest concentration at 7,800  $\mu\text{g/L}$ .

During the fifteenth (Spring 2005) SA event:

- RG-8B had 22 organic chemicals that exceeded their MCLs/PRGs with 1,1-DCA as the chemical with the highest concentration at 1,100  $\mu\text{g/L}$ ;
- SW-31 had 20 exceedances with 1,1-DCE as the chemical with the highest concentration at 3,200  $\mu\text{g/L}$ ;
- RG-9B had 15 exceedances with Freon 113 as the chemical with the highest concentration at 5,000  $\mu\text{g/L}$ ; and
- WP-8S had 13 exceedances with 1,1-DCE as the chemical with the highest concentration at 3,200  $\mu\text{g/L}$ .

During Pre-RI SA events:

- TP-4 had 12 organic chemicals that exceeded their MCLs/PRGs during Fall 1999 SA event and 13 exceedances during Summer 2000 SA event with Freon 113 as the chemical with the highest concentration during both events at concentrations of 2,700  $\mu\text{g/L}$  and 1,900  $\mu\text{g/L}$ , respectively, Freon 113 detections are considered suspect because it was found in an associated blank sample during both SA events; and
- LCW-1 had 2 exceedances during Winter 1999 SA event with 1,1-DCE as the chemical with the highest concentration at 13  $\mu\text{g/L}$ .

Many of the detections and exceedances during the fourteenth and fifteenth SA events were for VOCs and PAHs. Well SW-31 contained the highest concentrations for the majority of the chemicals that were detected in this area, which is located south and downgradient of the

metals and caustic/cyanide landfills and east and downgradient of the acids. Well RG-8B and RG-9B were the only two wells that had detections of dioxins/furans in this area. Well RG-8B contained the highest concentration of dioxin/furans, which is located at the southwest edge and downgradient of the Acids Landfill. As shown on Figures G-22 through G-28, the extent of contamination in this area begins in the southern portion of the Metals Landfill, western portion of the Caustic/Cyanide Landfill, and the western half of the Acids Landfill, which then flows into the Central Drainage Area. Wells RG-9B, SW-31, TP-4, and WP-8S have maintained stable concentrations of chlorinated VOCs over time, which are presented in Attachment G-1. Well RG-8B has more irregular concentrations of chlorinated VOCs. The irregular concentrations show natural degradation is taking place in this area of the site (Attachment G-1), and is discussed further in Appendix O. Well RG-8B typically has higher concentrations of VC. VC is the break down product of PCE, TCE, 1,1-DCE, cis-1,2-DCE, and trans-1,2-dichloroethene (trans-1,2-DCE). Concentrations of cis-1,2-DCE and trans-1,2-DCE have been stable in this well. SA events with low VC concentrations and high PCE, TCE, and 1,1-DCE concentrations for RG-8B are followed by several SA events where there is an increase of VC and a decrease in PCE, TCE, and 1,1-DCE in this well.

#### 3.1.1.1.2 Lower HSU

The Lower HSU sampling locations during the fourteenth and fifteenth SA events were primarily non-detect with the occasional detection of VOCs and SVOCs and five exceedances of the MCL/PRGs in piezometer RGPZ-13C. Piezometer RGPZ-13C had an exceedance of n-nitrosodipropylamine at a concentration of 19 µg/L during the fourteenth SA event and exceedances of PCE, TCE, 1,2,3,4,6,7,8-heptachlorinated dibenzo-*p*-dioxin (HpCDD), and octachlorinated dibenzo-*p*-dioxin (OCDD) at concentrations of 0.35 µg/L, 0.34 µg/L, 3.77 picograms per liter (pg/L), and 32.9 pg/L, respectively, during the fifteenth SA event. During the Fall 1999 and Summer 2000 SA events RP-95D and RP-96C-2 were primarily non-detect with the occasional detection of VOCs and SVOCs, and three exceedances in RP-96C-2. Well RP-96C-2 had exceedances of PCE, TCE, and OCDD at concentrations of 0.4 µg/L, 1.1 µg/L, 71.5 pg/L, respectively, during the Summer 2000 SA event. Well RP-98C had fourteen organic chemicals that exceeded their MCLs/PRGs during the Fall 1999 SA event and fifteen exceedances during the Summer 2000 SA event, with 1,1-DCA as the chemical with the highest concentration during both events at concentrations of 840 µg/L and 1,200 µg/L, respectively.

The majority of the exceedances detected in the Lower HSU were for VOCs. Well RP-98C is the well associated with highest concentrations for the majority of the chemicals that were detected in this area, which is located at the southwest edge and downgradient of the Acids Landfill. As shown on Figures G-29 through G-34, the Lower HSU in the area of the Metals and Caustic\Cyanide Landfills has not been significantly impacted by the Upper HSU; however, there are elevated concentrations of VOCs at the downgradient/southwest corner of the Acids Landfills in well RP-98C. The wells and piezometer in the Lower HSU have maintained stable concentrations of chlorinated VOCs over time, which are presented in Attachment G-1.

#### 3.1.1.2 Inorganic Results

##### 3.1.1.2.1 Upper HSU

During the fourteenth (Fall 2004) SA event:

- RG-8B had exceedances of the MCL/PRG for dissolved and total arsenic, cadmium, manganese, nickel, selenium, and vanadium and total aluminum, chromium, and iron;
- RG-9B had exceedances of the MCL/PRG for dissolved and total arsenic, cadmium, iron, manganese, nickel, selenium, and vanadium;
- SW-31 had exceedances for dissolved and total arsenic, cadmium, manganese, nickel, selenium, and vanadium; and
- WP-8S had exceedances for dissolved and total arsenic, cadmium, nickel, iron, selenium, and vanadium.

During the fifteenth (Spring 2005) SA event:

- RG-8B had exceedances of the MCL/PRG for dissolved and total arsenic, cadmium, manganese, nickel, selenium, and vanadium and total iron;
- RG-9B had exceedances of the MCL/PRG for dissolved and total arsenic, cadmium, manganese, nickel, selenium, and vanadium and total iron;
- SW-31 had exceedances for dissolved and total arsenic, cadmium, manganese, nickel, and selenium and total vanadium; and
- WP-8S had exceedances for dissolved and total arsenic, cadmium, nickel, selenium, and vanadium and total iron.

During the Pre-RI SA events:

- LCW-1 was not sampled for metals during any Pre-RI SA events; and
- TP-4 had exceedances of the MCLs/PRGs during the Fall 1999 SA event for dissolved and total cadmium and nickel and Summer 2000 SA event for dissolved cadmium, dissolved and total nickel, and total thallium.

Cyanide was analyzed in all wells, but was detected only twice in two Upper HSU locations (RG-9B and SW-31). Both concentrations were estimated. Well RG-8B is the well associated with the highest concentrations of the metals that were detected in this area, which is located at the southwest edge and downgradient of the Acids Landfill. The dissolved and total metal concentrations are similar with the exception for arsenic, barium, iron, and selenium. The dissolved concentrations for arsenic, barium, and selenium were typically double the total concentrations for these metals during the fourteenth and fifteenth SA events. The dissolved iron concentrations were either not detected or were one to three orders of magnitude lower than the total iron concentrations for wells RG-8B, RG-9B, and WP-8S. As shown in Figures G-35 through G-38, the arsenic, cadmium, nickel, and selenium isopleths, respectively, are similar to the organic isopleths. The concentrations that exceed the MCLs are located in the landfills, which then flow toward the Central Drainage Area.

#### 3.1.1.2.2 Lower HSU

During the fourteenth (Fall 2004) SA event:

- RGPZ-13C had an exceedance of the MCL/PRG for dissolved and total arsenic, and total aluminum, iron, and vanadium; and
- WP-8D had an exceedance for dissolved arsenic.

During the fifteenth (Spring 2005) SA event:

- RGPZ-13C had exceedances of the MCLs/PRGs for dissolved and total arsenic and vanadium; and
- WP-8D had an exceedance for dissolved and total iron.

During the Pre-RI SA events:

- RP-95D had an exceedance of the MCL/PRG for dissolved and total arsenic during the Summer 2000 SA event;
- RP-96C-2 did not have any exceedances during the Fall 1999 and Summer 2000 SA events; and
- RP-98C had exceedances for dissolved and total arsenic and nickel and total cadmium, chromium, and lead during the Fall 1999 SA event and exceedances for total arsenic and dissolved and total cadmium and nickel during the Summer 2000 SA event.

Cyanide was analyzed for in all wells, and only detected twice in well RP-98C. Both detected concentrations were estimated. Well RP-98C is the well associated with the highest concentrations of the metals that were detected in this area, which is located at the southwest edge and downgradient of the Acids Landfill. Dissolved and total metal concentrations are similar. As shown in Figures G-39 and G-41, arsenic has an exceedance in this area at RP-95D, and nickel has an exceedance at RP-98C, which is also consistent with the area impacted by organic contaminants, respectively. As shown in Figures G-40 and G-42, cadmium and selenium do not have any exceedances in this area, respectively.

#### 3.1.1.2.3 *General Mineral and pH*

The cation and anion analytical data reveal a general difference between the groundwater chemistry in the Upper and Lower HSU. Groundwater in the Upper HSU in this area is characterized as a sodium-chloride type, whereas the groundwater sample in the Lower HSU is generally characterized as sodium-sulfate type water (Figures G-14 through G-17). The general mineral concentrations for both the Upper HSU and Lower HSU have remained stable over time, which are presented in Attachment G-2. The pH values were generally neutral, ranging from 6.3 to 7.28 in the Upper HSU and 7.56 to 8.06 in the Lower HSU.

### 3.1.2 **Pesticide/Solvent Landfill Area**

This sampling location group included nine Upper HSU wells and three Lower HSU wells adjacent to, or near the Pesticide/Solvent (P/S) Landfill. The data for the fourteenth and fifteenth SA event are presented in Tables G-6a and G-7 through G-9, and Table G-6b presents data for the twenty-first SA event.

#### 3.1.2.1 Organics Results

##### 3.1.2.1.1 *Upper HSU*

During the fourteenth SA event:

- Gallery Well was analyzed twice during this event. During the first sampling, 64 organic chemicals exceeded the MCL/PRG with methyl ethyl ketone (MEK) as the chemical with the highest concentration at 340,000 µg/L, excluding chemicals with suspect detections,.

During the second sampling, 50 chemicals exceeded with MEK as the chemical with the highest concentration at 1,400,000 µg/L;

- RG-3B had 52 exceedances with acetone as the chemical with the highest concentration at 110,000 µg/L;
- RGPZ-5B had 72 exceedances with methylene chloride as the chemical with the highest concentration at 650,000 µg/L;
- RGPZ-6B had 78 exceedances with MEK as the chemical with the highest concentration at 93,000 µg/L;
- RIMW-3 had 57 exceedances with methylene chloride as the chemical with the highest concentration at 15,000 µg/L;
- RIPZ-8 had 44 exceedances with methylene chloride as the chemical with the highest concentration at 68,000 µg/L;
- RP-20B had 4 exceedances with n-nitrosopyrrolidine as the chemical with the highest concentration at 1.3 µg/L;
- Sump 9B had 63 exceedances with tetrahydrofuran as the chemical with the highest concentration at 69,000 µg/L; and
- SW-44 had 15 exceedances with 1,1-DCA as the chemical with the highest concentration at 350 µg/L.

During the fifteenth SA event:

- Gallery Well had 86 exceedances of the MCL/PRG with MEK as the chemical with the highest concentration at 1,100,000 µg/L;
- RG-3B had 51 exceedances with acetone as the chemical with the highest concentration at 150,000 µg/L;
- RGPZ-5B had 73 exceedances with methylene chloride as the chemical with the highest concentration at 500,000 µg/L;
- RGPZ-6B had 58 exceedances with MEK as the chemical with the highest concentration at 76,000 µg/L;
- RIMW-3 had 57 exceedances with xylenes as the chemical with the highest concentration at 14,000 µg/L;
- RIPZ-8 had 44 exceedances with methylene chloride as the chemical with the highest concentration at 54,000 µg/L;
- RP-20B had 5 exceedances with PCE as the chemical with the highest concentration at 0.76 µg/L;
- Sump 9B had 81 exceedances with methylene chloride as the chemical with the highest concentration at 220,000 µg/L; and
- SW-44 had 15 exceedances with 1,1-DCA as the chemical with the highest concentration at 470 µg/L.

During the Pre-RI SA event:

- Rd Sump had 32 exceedances of the MCL/PRG during the Fall 1999 SA event and had 20 exceedances during the Summer 2000 SA event with acetone as the chemical with the highest concentration during both SA events at 25,000 µg/L and 8,700 µg/L, respectively. The concentrations for acetone were estimated due to miscellaneous lab errors.

The Upper HSU sampling locations that were analyzed for herbicides, pesticides, and PCBs were mostly non-detect with an occasional detection and exceedance. Gallery Well, RG-3B, Sump-9B, and SW-44 were also sampled for explosives. Well SW-44 was the only location that was non-detect for explosives. Gallery Well, RG-3B, and Sump-9B had detections and exceedances of explosives with cyclonite (RDX) as the most prevalent explosive. Many of the detections and exceedances of the MCL/PRG were for VOCs, SVOCs, and PAHs. Many of the detections and exceedances for SVOCs and several of the VOCs and PAHs are considered suspect concentrations because they were either found in an associated field blank or were identified as a tentatively identified compound. The Gallery Well contained the highest concentrations for the majority of the chemicals that were detected in this area, which is located at the south end of the P/S Landfill. The P/S Landfill Area is a known area impacted with NAPL. The NAPL in this area extends from the Gallery Well to PSCT-1. The NAPL is further discussed in Section G3.3. As shown on Figures G-22 through G-28, the extent of contamination in this area begins at the northern portion of the P/S Landfill and from the Metals, Caustic/Cyanide, and Acids Landfills. Contaminants from these landfills flow to the Central Drainage Area on through to PSCT-1. The area impacted by organic contaminants illustrated on these isopleths is similar to the area impacted by NAPL. The concentrations of chlorinated VOCs over time in the Upper HSU P/S Landfill Area are high and have remained relatively consistent, as shown on the time vs. concentration graphs in Attachment G-1.

#### 3.1.2.1.2 Lower HSU

During the fourteenth SA event:

- RGPZ-6C had 3 exceedances of the MCL/PRG with PCE as the chemicals with the highest concentration at 1.3 µg/L;
- RGPZ-6D had 42 exceedances, with PCE and xylenes as the chemicals with the highest concentration at 1,100 µg/L; and
- RP-94D had 3 exceedances, with 1,2,4-trimethylbenzene (1,2,4-TMB) as the chemical with the highest concentration at 19 µg/L. Chemicals 1,2,4-TMB and naphthalene are suspect detections. Chemical 1,2,4-TMB was qualified as a tentatively identified compound, and naphthalene was detected in the associated blank sample.

During the fifteenth SA event:

- RGPZ-6C had 5 exceedances, with PCE as the chemical with the highest concentration at 2.3 µg/L;
- RGPZ-6D had 41 exceedances, with PCE as the chemical with the highest concentration at 1,600 µg/L; and
- RP-94D had 4 exceedances, with bis(2-ethylhexyl)phthalate as the chemical with the highest concentration at 6 µg/L. The bis(2-ethylhexyl)phthalate detection is considered suspect because it was found in an associated blank sample.

Many of the detections and exceedances during the fourteenth and fifteenth SA events were for VOCs and PAHs. Several VOCs and many of the SVOCs were considered suspect concentrations because they were either found in an associated blank sample or qualified as a tentatively identified compound. Piezometer RGPZ-6D contained the highest concentrations for the majority of the chemicals that were detected in the Lower HSU of the P/S Landfill, which is located south and downgradient of the P/S Landfill and north of the PSCT. Piezometers RGPZ-6C and RGPZ-6D are located upgradient and adjacent to piezometers RGPZ-7C and

RGPZ-7D. Piezometers RGPZ-7C and RGPZ-7D both have DNAPL present, which is discussed further in Section G3.3. This area of the Lower HSU is the only known area with DNAPL. As shown on Figures G-29 through G-34, the contamination in this area is in the exact location of the DNAPL. The concentration of chlorinated VOCs over time in the Lower HSU are low in RGPZ-6C and RP-94D and are high in RGPZ-6D, and have remained stable over time in well RP-94D, as shown in Attachment G-1.

### 3.1.2.2 Inorganic Results

#### 3.1.2.2.1 *Upper HSU*

During the fourteenth SA event:

- Gallery Well had exceedances of the MCL/PRG for dissolved and total arsenic, cadmium, chromium, cobalt, iron, manganese, nickel, selenium, and vanadium and dissolved zinc;
- RG-3B had exceedances for dissolved and total arsenic, iron, manganese, nickel, and selenium;
- RGPZ-5B had exceedances for dissolved and total arsenic, iron, manganese, nickel, and selenium and dissolved chromium;
- RGPZ-6B had exceedances for dissolved and total arsenic, iron, manganese, nickel, and selenium and total aluminum, beryllium, cadmium, chromium, lead, and vanadium;
- RIMW-3 had exceedances for dissolved and total arsenic, iron, manganese, and selenium and dissolved nickel;
- RIPZ-8 had exceedances for dissolved and total arsenic, iron, manganese, nickel, and selenium;
- Sump 9B had exceedances for dissolved and total arsenic, iron, manganese, nickel, selenium, and vanadium and dissolved cadmium; and
- SW-44 had exceedances for dissolved and total arsenic, cadmium, manganese, nickel, selenium, and vanadium.

During the fifteenth SA event:

- Gallery Well had exceedances of the MCL/PRG for dissolved and total arsenic, cadmium, iron, manganese, nickel, and selenium and dissolved chromium and zinc;
- RG-3B had exceedances for dissolved and total arsenic, iron, manganese, nickel, and selenium and dissolved vanadium;
- RGPZ-5B had exceedances for dissolved and total arsenic, iron, manganese, nickel, and selenium and dissolved vanadium;
- RGPZ-6B had exceedances for dissolved and total arsenic, iron, manganese, nickel, selenium, and vanadium and total aluminum and chromium;
- RIMW-3 had exceedances for dissolved and total arsenic, iron, manganese, nickel, and selenium;
- RIPZ-8 had exceedances for dissolved and total arsenic, iron, manganese, nickel, and selenium and dissolved vanadium;
- Sump 9B had exceedances for dissolved and total arsenic, iron, manganese, and nickel and total selenium and vanadium; and
- SW-44 had exceedances for dissolved and total arsenic, cadmium, manganese, nickel, and selenium.

During the Pre-RI SA event:

- The Road Sump had exceedances of the MCL/PRG for dissolved and total arsenic, and nickel during the Spring and Fall 1999 SA events.

Cyanide was analyzed for in all wells, but was detected only four times as cyanide (free) and once as cyanide amenable to chlorination. Gallery Well was the sampling location associated with highest concentration of cyanide (free) and the one detection of cyanide amenable to chlorination. The concentrations of cyanide in this sampling location were not estimated, as were the concentrations from the other sampling locations. The Gallery Well also had many other metals and inorganics that had higher dissolved concentrations than total during the fifteenth SA event, which include beryllium, cadmium, calcium, cobalt, lead, magnesium, nickel, potassium, selenium, and sodium. In contrast to the Gallery Well, piezometer RGPZ-6B had total concentrations that exceeded dissolved of aluminum, barium, beryllium, chromium, cobalt, copper, nickel silver, thallium, vanadium, and zinc. However, the Upper HSU P/S Landfill area typically has concentrations of dissolved and total metals that are similar, which indicates that very little solid material was collected in the unfiltered samples. However, several metals have different concentrations of dissolved and total. Arsenic, barium, and zinc typically have higher concentrations of dissolved than total. The concentration difference between dissolved and total ranged from double the concentration to greater than one order of magnitude greater. Lead typically had higher concentrations of total than dissolved. The concentration difference between total and dissolved ranged from double the concentration to greater than one order of magnitude greater. The arsenic and selenium concentrations that exceeded the MCL/PRGs are similar to those in other areas of the site in the Upper HSU. As shown in Figures G-35 through G-38, the area where the exceedances of arsenic, cadmium, nickel, and selenium, respectively, begin is similar to where the contamination of the VOCs are located. The higher concentrations of arsenic, cadmium, nickel, and selenium are located south of the P/S Landfill and in the Central Drainage Area as are the VOCs. The two differences are arsenic and cadmium are lower in concentration around the PSCT-2.

#### 3.1.2.2.2 Lower HSU

During the fourteenth SA event:

- RGPZ-6C had exceedances of the MCL/PRG for dissolved and total arsenic and iron;
- RGPZ-6D had exceedances for dissolved and total arsenic and total iron; and
- RP-94D had exceedances for dissolved and total arsenic and copper and total chromium, lead, and iron.

During the fifteenth SA event:

- RGPZ-6C had exceedances of the MCL/PRG for dissolved and total arsenic and iron;
- RGPZ-6D had exceedances for dissolved and total aluminum, arsenic, and iron and total vanadium; and
- RP-94D had exceedances for dissolved and total arsenic and total iron and vanadium.

Cyanide was analyzed for in all wells, but was not detected. The Lower HSU P/S Landfill Area has concentrations of dissolved and total metals that are similar, which indicates that very little solid material was collected in the unfiltered samples. However, several metals typically have different concentrations of dissolved and total. Arsenic, barium, selenium, and zinc typically

have higher concentrations of dissolved than total. The concentration difference between dissolved and total ranged from double the concentration to one order of magnitude greater. Lead and occasionally iron typically had higher concentrations of total than dissolved. The concentration difference between total and dissolved ranged from double the concentration to greater than one order of magnitude. The arsenic concentrations that exceeded the MCL/PRGs are similar to those in other areas of the site in the Lower HSU. As shown in Figures G-39 and G-41, the arsenic and nickel detections and exceedances are similar to the VOCs detections, respectively. As shown in Figures G-40 and G-42, cadmium and selenium did not have exceedances in this area, respectively.

#### 3.1.2.2.3 *General Minerals and pH*

The cation and anion data reveal a general difference between the groundwater chemistry in the Upper and Lower HSU. Groundwater in the Upper HSU in the area near the Gallery Well is characterized as a magnesium-chloride type and the groundwater near Sump 9B is characterized as sodium-chloride type, whereas the groundwater sample in the Lower HSU is generally characterized as sodium-sulfate type water (Figures G-14 through G-17). The general mineral concentrations for the Upper and Lower HSU are presented in Attachment G-2. The pH values were generally neutral, ranging from 5.98 to 7.62 in the Upper HSU and 7.68 to 8.41 in the Lower HSU, while pH values in the Gallery Well were more acidic (4.9 to 4.93).

### 3.1.3 Burial Trench Area (BTA) and PSCT

This sampling location group included eleven Upper HSU sampling locations along the BTA and PSCT area and two Lower HSU sampling locations in the BTA. The data for the fourteenth and fifteenth SA event are presented in Table G-10a, and the data for the twenty-first SA event is presented on Table G-10b.

#### 3.1.3.1 Organic Results

##### 3.1.3.1.1 *Upper HSU*

During the fourteenth SA event:

- PSCT-1 had 38 exceedances of the MCL/PRG with cis-1,2-dichloroethene as the chemical with the highest concentration at 2,300 µg/L;
- PSCT-2 had 15 exceedances with TCE as the chemical with the highest concentration at 1,200 µg/L;
- PSCT-3 had 15 exceedances with TCE as the chemical with the highest concentration at 2,000 µg/L;
- PSCT-4 had 14 exceedances with cis-1,2-dichloroethene as the chemical with the highest concentration at 5,200 µg/L;
- RIMW-6 was not sampled due to insufficient water;
- RIMW-7 had 37 exceedances with TCE as the chemical with the highest concentration at 19,000 µg/L;
- RIMW-8 had 19 exceedances with Freon 113 as the chemical with the highest concentration at 11,000 µg/L; and
- SW-17 had 25 exceedances with cis-1,2-DCE as the chemical with the highest concentration at 30,000 µg/L.

During the fifteenth SA event:

- PSCT-1 had 44 exceedances of the MCL/PRG with cis-1,2-DCE as the chemical with the highest concentration at 2,500 µg/L;
- PSCT-2 had 19 exceedances with TCE as the chemical with the highest concentration at 1,900 µg/L;
- PSCT-3 had 21 exceedances with TCE as the chemical with the highest concentration at 1,700 µg/L;
- PSCT-4 had 21 exceedances with cis-1,2-DCE as the chemical with the highest concentration at 5,900 µg/L;
- RIMW-6 had 2 exceedances with TCE as the chemical with the highest concentration at 3.0 µg/L;
- RIMW-7 had 47 exceedances with TCE as the chemical with the highest concentration at 25,000 µg/L;
- RIMW-8 had 29 exceedances with acetone as the chemical with the highest concentration at 480,000 µg/L; and
- SW-17 had 35 exceedances with naphthalene as the chemical with the highest concentration at 150,000 µg/L.

During the Post RI SA events:

- RIMW-10 and RIMW-11 did not have any exceedances of the MCL/PRG during the eighteenth (Fall 2006) SA event.

Many of the detections and exceedances during the fourteenth and fifteenth SA events were for VOCs and PAHs. Several VOCs and many of the SVOCs were considered suspect concentrations because they were either found in an associated blank sample or qualified as a tentatively identified compound. Well RIMW-7 contained the highest concentrations for the majority of the chemicals that were detected in the BTA, which is located south and downgradient of the PCB Landfill and west of the P/S Landfill. Wells RIMW-7 and SW-17 were the only two wells with multiple detections of dioxins/furans in this area. The BTA is another known area impacted with NAPL. As shown on Figures G-22 through G-28, the extent of contamination in this area appears to flow towards PSCT-4 parallel to the P/S Landfill, and does not appear to extend west beyond the PSCT, which is bounded by RIMW-10 and RIMW-11. Extraction point PSCT-1 contained the highest concentrations for the majority of the chemicals, including dioxins/furans, that were detected in the PSCT, which is located south and downgradient of the P/S Landfill. Wells that are located south-southeast of the PSCT are typically non-detect. Chlorinated VOCs have been moderate to high over time in PSCT-1, PSCT-2, PSCT-3, PSCT-4, RIMW-7, RIMW-8, and SW-17, but were low to non-detect in RIMW-6, RIMW-10, and RIMW-11, as shown in the graphs in Attachment G-1.

#### 3.1.3.1.2 Lower HSU

During the Post RI SA events:

- RIPZ-15 did not have exceedances of the MCL/PRG during the seventeenth (Spring 2006) SA event, but one exceedance for bis(2-chloroethyl)ether at a concentration of 0.013 µg/L during the eighteenth (Fall 2006) SA event; and
- RIPZ-16 had 14 exceedances with cis-1,2-DCE as the chemical with the highest concentration at 6,800 µg/L during the seventeenth (Spring 2006) SA event and

12 exceedances with cis-1,2-DCE as the chemical with the highest concentration at 8,600 µg/L during the eighteenth (Fall 2006) SA event.

The Lower HSU sampling location RIPZ-15 was mainly non-detect with some detections and one exceedance of MCLs/PRGs. Many of the detections at RIPZ-15 were positively identified but the concentrations were estimated. Piezometer RIPZ-16 is screened in the Lower HSU directly below where well SW-17 is located in the Upper HSU, and contains the highest concentrations in this area of the Site. A few of the detections and one exceedance for VOCs and SVOCs are considered suspect concentrations because they were identified as a tentatively identified compound. As shown in Figures G-29 through G-34, the extent of contamination in this area of the Lower HSU is located around RIPZ-16 and bounded by RIPZ-15 to the north and RGPZ-3C and RGPZ-3D to the south. The concentration of chlorinated VOCs over time in the Lower HSU of this area has not been established. Chlorinated VOCs were non-detect in RIPZ-15, but moderate to high RIPZ-16, as shown in the graphs in Attachment G-1.

### 3.1.3.2 Inorganic Results

#### 3.1.3.2.1 *Upper HSU*

During the fourteenth SA event:

- PSCT-1 had exceedances of the MCL/PRG for dissolved and total arsenic, manganese, nickel, selenium, and vanadium and total cadmium;
- PSCT-2 had exceedances for dissolved and total arsenic, cadmium, nickel, selenium, and vanadium;
- PSCT-3 had exceedances for dissolved and total arsenic, cadmium, nickel, selenium, and vanadium;
- PSCT-4 had exceedances for dissolved and total arsenic, cadmium, nickel, selenium, and vanadium;
- RIMW-6 was not sampled due to insufficient water;
- RIMW-7 had exceedances for dissolved and total arsenic, manganese, and nickel and dissolved vanadium;
- RIMW-8 had exceedances for dissolved and total arsenic and manganese; and
- SW-17 had exceedances for dissolved and total arsenic, chromium, iron, manganese, and nickel and dissolved selenium.

During the fifteenth SA event:

- PSCT-1 had exceedances of the MCL/PRG for dissolved and total arsenic, cadmium, manganese, nickel, and selenium;
- PSCT-2 had exceedances for dissolved and total arsenic, cadmium, nickel, selenium, and vanadium;
- PSCT-3 had exceedances for dissolved and total arsenic, cadmium, nickel, and selenium and total vanadium;
- PSCT-4 had exceedances for dissolved and total arsenic, cadmium, nickel, and selenium and total vanadium;
- RIMW-6 was not sampled for inorganics due to insufficient water;

- RIMW-7 had exceedances for dissolved and total arsenic, manganese, and nickel, total cadmium, and dissolved selenium;
- RIMW-8 had exceedances for dissolved and total arsenic, selenium, and manganese and total vanadium; and
- SW-17 had exceedances for dissolved and total arsenic, manganese, nickel, and selenium and total aluminum and iron.

During the Post RI SA events:

- RIMW-10 and RIMW-11 did not have any exceedances of the MCL/PRG during the eighteenth (Fall 2006) SA event.

Cyanide was analyzed in all wells, but was detected only six times as cyanide (free) and once as cyanide amenable to chlorination. Well SW-17 contained the highest concentration of cyanide (free) and the one detection of cyanide amenable to chlorination. The concentrations of cyanide in this sampling location were not estimated concentrations as were the concentrations from the other sampling locations. The Upper HSU in the BTA has concentrations of dissolved and total metals that are similar, which indicates that very little solid material was collected in the unfiltered samples. However, several metals have different concentrations of dissolved and total. Arsenic, barium, cadmium, selenium, and zinc typically have higher concentrations of dissolved than total. The concentration difference between dissolved and total ranged from double the concentration to greater than one order of magnitude greater. Iron and lead typically had higher concentrations of total than dissolved. The concentration difference between total and dissolved ranged from double the concentration to greater than one order of magnitude greater. The arsenic and selenium concentrations that exceeded the MCL/PRGs are similar to those in other areas of the Site in the Upper HSU. As shown in Figures G-35 through G-38, the areas impacted by metals are similar to those impacted by VOCs.

#### 3.1.3.2.2 Lower HSU

During the Post RI SA events:

- RIPZ-15 had exceedances of the MCL/PRG for dissolved and total manganese and dissolved arsenic during the seventeenth (Spring 2006) SA event and exceedances for dissolved and total arsenic and manganese during the eighteenth (Fall 2006) SA event; and
- RIPZ-16 had exceedances of the MCL/PRG for dissolved arsenic during the seventeenth (Spring 2006) SA event and exceedances for dissolved and total arsenic during the eighteenth (Fall 2006) SA event.

Cyanide was analyzed in both wells, but was not detected. The Lower HSU BTA Area has concentrations of dissolved and total metals that are similar, which indicates that very little solid material was collected in the unfiltered samples. However, several metals in RIPZ-15 and RIPZ-16 have different concentrations of dissolved and total. Arsenic and selenium typically have higher concentrations of dissolved than total. During the Spring 2006 SA event, RIPZ-15 had higher concentrations of dissolved cadmium, silver, and thallium than total cadmium, silver, and thallium. The concentration difference between dissolved and total ranged from double the concentration to five times the concentration. Iron and occasionally lead typically had higher concentrations of total than dissolved. The concentration difference between total and dissolved ranged from double the concentration to five times the concentration. The arsenic

concentrations that exceeded the MCL/PRGs are similar to those in other areas of the site in the Lower HSU. The arsenic exceedance location is similar to where VOCs were detected in RIPZ-16 (Figure G-39); however, cadmium, nickel, selenium did not exceed in this area (Figures G-40 through G-42, respectively).

#### 3.1.3.2.3 General Minerals and pH

The cation and anion data reveal a general difference between the groundwater chemistry down the PSCT trench. Groundwater at the BTA is characterized as predominantly magnesium-sulfate type with RIMW-8 as calcium-carbonate type during the fourteenth event and calcium-chloride type during the fifteenth event; PSCT-4 as magnesium-sulfate type during the fourteenth event and magnesium-chloride type during the fifteenth event; PSCT-3 is characterized as a sodium-chloride type; PSCT-2 is characterized as a magnesium-chloride type; and PSCT-1 is characterized as a sodium-chloride type (Figures G-14 and G-16). The groundwater in the Lower HSU at the BTA is characterized as predominantly sodium-sulfate type (Figures G-15 and G-17). The general mineral concentrations in the Upper HSU have remained stable over time. The Lower HSU has been sampled twice and the concentrations are similar. The general mineral concentrations for the Upper and Lower HSU are presented in Attachment G-2. The pH values were generally neutral, ranging from 6.58 to 7.6.

### 3.1.4 PSCT Evaluation Wells

This group included eighteen Upper HSU sampling locations, including five hydropunch locations, and twelve Lower HSU sampling locations adjacent to and downgradient of the PSCT trench. The PSCT evaluation wells are primarily used to assess whether contaminants are migrating under or across the PSCT. The data for the fourteenth and fifteenth SA events are presented in Tables G-11a and G-12a, and the data for the twenty-first SA event is presented on Tables G-11b and G-12b.

#### 3.1.4.1 Organic Results

##### 3.1.4.1.1 Upper HSU

During the fourteenth SA event:

- PZ-P18-5 had 10 exceedances of the MCL/PRG with TCE as the chemical with the highest concentration at 3.9 µg/L;
- RG-1B had 14 exceedances with 1,1-DCA as the chemical with the highest concentration at 84 µg/L;
- RG-2B was not sampled due to insufficient water;
- RG-4B had 14 exceedances with TCE as the chemical with the highest concentration at 3,700 µg/L;
- RG-5B had no exceedances, but 3 detections;
- RG-6B had 15 exceedances with cis-1,2-DCE as the chemical with the highest concentration at 260 µg/L;
- RG-7B had 13 exceedances with 1,1-DCA as the chemical with the highest concentration at 59 µg/L;
- RIMW-1 had 3 exceedances with 1,2-DCA as the chemical with the highest concentration at 0.66 µg/L;

- RIMW-2 had 20 exceedances with TCE as the chemical with the highest concentration at 97 µg/L;
- RIMW-5 had no exceedances, but 5 detections;
- SW-29 had an exceedance for OCDD at a concentration of 33.2 µg/L; and
- WP-3S had an exceedance for bis(2-ethylhexyl)phthalate at a concentration of 48 µg/L.

During the fifteenth SA event:

- PZ-P18-5 had 9 exceedances of the MCL/PRG with TCE as the chemical with the highest concentration at 4.8 µg/L;
- RG-1B had 16 exceedances with 1,1-DCA as the chemical with the highest concentration at 51 µg/L;
- RG-2B had 13 exceedances with TCE as the chemical with the highest concentration at 2,300 µg/L;
- RG-4B had 19 exceedances with TCE as the chemical with the highest concentration at 3,100 µg/L;
- RG-5B had 4 exceedances with bis(2-ethylhexyl)phthalate as the chemical with the highest concentration at 4.2 µg/L. The bis(2-ethylhexyl)phthalate detection is considered suspect because it was found in an associated blank sample;
- RG-6B had 11 exceedances with cis-1,2-DCE as the chemical with the highest concentration at 140 µg/L;
- RG-7B had 17 exceedances with 1,1-DCA as the chemical with the highest concentration at 67 µg/L;
- RIMW-1 had 4 exceedances with bis(2-ethylhexyl)phthalate as the chemical with the highest concentration at 4.2 µg/L. The bis(2-ethylhexyl)phthalate detection is considered suspect because it was found in an associated blank sample;
- RIMW-2 had 19 exceedances with TCE as the chemical with the highest concentration at 150 µg/L;
- RIMW-5 had 2 exceedance with bis(2-ethylhexyl)phthalate as the chemical with the highest concentration at 7.3 µg/L. The bis(2-ethylhexyl)phthalate detection is considered suspect because it was found in an associated blank sample;
- SW-29 had 3 exceedances with bis(2-ethylhexyl)phthalate as the chemical with the highest concentration at 4.2 µg/L. The bis(2-ethylhexyl)phthalate detection is considered suspect because it was found in an associated blank sample; and
- WP-3S had 4 exceedance with bis(2-ethylhexyl)phthalate as the chemical with the highest concentration at 7.3 µg/L. The bis(2-ethylhexyl)phthalate detection is considered suspect because it was found in an associated blank sample.

During the Post RI SA events:

- RIHP-1 had 9 exceedances with acetone as the chemical with the highest concentration at 70 µg/L;
- RIHP-2 had 4 exceedances with chloroform as the chemical with the highest concentration at 4.2 µg/L;
- RIHP-3 had 1 exceedance for 1,1-DCA at a concentration of 4.8 µg/L;
- RIHP-4 had no exceedances, but 2 detections during the Spring 2007;
- RIHP-5 had 7 exceedances with benzene as the chemical with the highest concentration at 78 µg/L;
- RIHP-6 had no detections during the Spring 2007;

- RIHP-7 had no exceedances, but 3 detections during the Spring 2007; and
- RIPZ-37 had no exceedances during the eighteenth (Fall 2006) SA event.

Concentrations of herbicides, pesticides, and explosives that were analyzed for in the Upper HSU sampling locations were predominantly non-detect. There was only one exceedance of these compounds, which was beta-benzenehexachloride (beta-BHC) in RG-1B at 0.078 µg/L. Many of the detections and exceedances of the MCL/PRG were for VOCs, SVOCs, and PAHs, and many of these are considered suspect concentrations because they were either found in an associated field blank or were identified as a tentatively identified compound. Other detections for VOCs and PAHs in the Upper HSU were positively identified but the associated numerical value is an estimated value. Wells RG-2B and RG-4B contained the highest number of detections, exceedances of MCLs/PRGs, and concentrations of detected compounds for VOCs and SVOCs. These wells are located immediately south of PSCT-4. The concentrations in these two wells are typically one to two orders of magnitude higher than the other Upper HSU wells south of the PSCT. The hydropunch samples RIHP-1 through RIHP-3 and RIHP-5 also had exceedances, with RIHP-1 and RIHP-5 having the majority of the exceedances, which are also typically one to two orders of magnitudes lower than RG-2B and RG-4B concentrations.

As illustrated in Figures G-22 through G-28, this is the largest area of the site. The majority of the contamination is located south of PSCT-1 and PSCT-4. The contamination south of PSCT-1 that exceeds the MCL/PRGs, extends from northwest of PSCT-2, to southeast of PSCT-1, and is bounded to the south by RIHP-2, RIHP-3, and the RCF Pond. The contamination south of PSCT-4 that exceeds the MCL/PRGs, extends from slightly southeast of RIMW-5 to the northwest, to northwest of the PSCT-3 to the southeast, and is bounded by RIHP-4 and RG-5B to the south. The area south of PSCT-3 is typically non-detect; however, there are scattered detections throughout this area that include Pond 18, RIHP-7, RIPZ-37, RAP-3A, and a portion of the RCF Pond.

The area downgradient of the PSCT was formerly used to store liquids in ponds, and Site-related impacts to this area have been reported in previous documents (Woodward-Clyde Consultants [WCC] and Canonie Environmental Services, Inc. [CE], 1989). Samples from wells in this area, collected prior to construction of the PSCT, detected concentrations of organic compounds ranging up to thousands of micrograms per liter. These historical detections of organic compounds suggest that groundwater south of the PSCT was impacted by organic contaminants before construction of the PSCT. Although the data are limited, pond closure and the subsequent construction of the PSCT appear to have resulted in stable or declining concentrations of organic compounds in the area downgradient of the PSCT. Therefore, detection of organic compounds downgradient of the PSCT likely reflects pre-existing contamination rather than contamination due to plume migration.

The concentration of chlorinated VOCs over time in the Upper HSU in this area of the site varies widely depending on the location of the well as shown in Attachment G-1. The wells that are located on the eastern edge of the PSCT south of the Acids Landfill had non-detect to low concentrations of chlorinated VOCs. The wells located south of PSCT-1 had more moderate levels of chlorinated VOCs. The concentrations of the chlorinated VOCs in wells RG-6B, RG-7B, and RIMW-2 have remained constant over time, with the exception of cis-1,2-DCE in RG-6B which has fluctuated significantly. The concentrations in well RG-1B appear to have a decreasing trend. Well WP-3S, which is located south of PSCT-3, has been non-detect with the exception of a low detection of PCE during the Spring 1999 SA event. The concentration of the

chlorinated VOCs immediately south of PSCT-4 in wells RG-2B and RG-4B are high and have fluctuated over time. However, concentrations in RG-5B and RIMW-5 have been non-detect to low. Concentrations of chlorinated VOCs over time near the ponds have been low to moderate and have remained constant.

#### 3.1.4.1.2 Lower HSU

During the fourteenth SA event:

- RGPZ-3C did not have any exceedances of the MCL/PRG, but did have 2 detections;
- RGPZ-3D had 1 exceedance for bis(2-chloroethyl)ether at a concentration of 0.037 µg/L;
- RGPZ-4C had 2 exceedances with acetonitrile as the chemical with the highest concentration at 120 µg/L;
- RGPZ-8D had 6 exceedances with bis(2-ethylhexyl)phthalate as the chemical with the highest concentration at 7.3 µg/L;
- RGPZ-14D had 6 exceedances with 1,2,4-TMB as the chemical with the highest concentration at 16 µg/L. Chemical 1,2,4-TMB is a suspect detection which was qualified as a tentatively identified compound;
- RGPZ-15B had 3 exceedances with crotonaldehyde as the chemical with the highest concentration at 810 µg/L;
- RGPZ-16D had 4 exceedances with 1,3,5-trimethylbenzene (1,3,5-TMB) as the chemical with the highest concentration at 16 µg/L. Chemical 1,3,5-TMB is a suspect detection which was qualified as a tentatively identified compound;
- RP-4D had 1 exceedance of the MCL/PRG for n-nitrosodipropylamine at a concentration of 0.47 µg/L. N-nitrosodipropylamine detection is considered suspect because it was found in an associated blank sample;
- RP-53C had 2 exceedances with 1,3,5-TMB as the chemical with the highest concentration at 13 µg/L. Chemical 1,3,5-TMB is a suspect detection which was qualified as a tentatively identified compound;
- RP-54C did not have any detections of organic compounds;
- RP-107D did not have any exceedances, but did have 2 detections; and
- WP-3D did not have any exceedances, but did have 8 detections.

During the fifteenth SA event:

- RGPZ-3C had 3 exceedances of the MCL/PRG with bis(2-ethylhexyl)phthalate as the chemical with the highest concentration at 6.3 µg/L. Bis(2-ethylhexyl)phthalate detection is considered suspect because it was found in an associated blank sample;
- RGPZ-3D had 4 exceedances with bis(2-ethylhexyl)phthalate as the chemical with the highest concentration at 4.9 µg/L. The bis(2-ethylhexyl)phthalate detection is considered suspect because it was found in an associated blank sample;
- RGPZ-4C had 3 exceedances with n-nitrosodiethylamine as the chemical with the highest concentration at 0.81 µg/L. The n-nitrosodiethylamine detection is considered suspect because it was found in an associated blank sample;
- RGPZ-8D had 5 exceedances with bis(2-ethylhexyl)phthalate as the chemical with the highest concentration at 17 µg/L. The bis(2-ethylhexyl)phthalate detection is considered suspect because it was found in an associated blank sample;

- RGPZ-14D had 8 exceedances with bis(2-ethylhexyl)phthalate as the chemical with the highest concentration at 5.3 µg/L. The bis(2-ethylhexyl)phthalate detection is considered suspect because it was found in an associated blank sample;
- RGPZ-15B had 4 exceedances with bis(2-ethylhexyl)phthalate as the chemical with the highest concentration at 7.2 µg/L. The bis(2-ethylhexyl)phthalate detection is considered suspect because it was found in an associated blank sample;
- RGPZ-16D had 7 exceedances with bis(2-ethylhexyl)phthalate as the chemical with the highest concentration at 8,300 µg/L. The bis(2-ethylhexyl)phthalate detection is considered suspect because it was found in an associated blank sample;
- RP-4D had 3 exceedances with bis(2-ethylhexyl)phthalate as the chemical with the highest concentration at 6.0 µg/L. The bis(2-ethylhexyl)phthalate detection is considered suspect because it was found in an associated blank sample;
- RP-53C had 2 exceedances with bis(2-ethylhexyl)phthalate as the chemical with the highest concentration at 5.9 µg/L. The bis(2-ethylhexyl)phthalate detection is considered suspect because it was found in an associated blank sample;
- RP-54C had 2 exceedances with bis(2-ethylhexyl)phthalate as the chemical with the highest concentration at 4.5 µg/L. The bis(2-ethylhexyl)phthalate detection is considered suspect because it was found in an associated blank sample;
- RP-107D had 2 exceedances with bis(2-ethylhexyl)phthalate as the chemical with the highest concentration at 4.1 µg/L. The bis(2-ethylhexyl)phthalate detection is considered suspect because it was found in an associated blank sample; and
- WP-3D had 1 exceedance of the MCL/PRG for n-nitrosodipropylamine at a concentration of 0.18 µg/L.

During the Pre-RI SA event:

- RG-1C had 1 exceedance of the MCL/PRG for OCDD at a concentration of 34 pg/L during the Spring 1999 SA event, but did not have any exceedances during the Summer 2000 SA event; and
- RP-55C-2 did not have any exceedances during the Fall 1999 or Summer 2000 SA events.

The Lower HSU sampling locations were mainly non-detect with some detections and very few exceedances of MCLs/PRGs. Some of the detections and exceedances for VOCs, SVOCs, and PAHs are considered suspect concentrations because they were either found in an associated field blank or were identified as a tentatively identified compound. Other detections for VOCs, SVOCs, and PAHs in the Upper HSU were positively identified but the associated numerical value is an estimated value. Piezometers RGPZ-14D and RGPZ-16D contained with the highest number of detections, exceedances of MCLs/PRGs, and concentrations of detected compounds. These piezometers are located beneath PSCT-3. Although piezometer RGPZ-8D is located downgradient of piezometers RGPZ-7C and RGPZ-7D, which contain NAPL, it is primarily non-detect with a few detections and very few exceedances of MCL/PRGs, which are significantly lower than the detections in the Lower HSU P/S Landfill sampling locations. As shown in Figures G-29 through G-34, the contamination in this area is located directly below the PSCT in the area of PSCT-1, PSCT-3, and PSCT-4. The concentration of chlorinated VOCs in the Lower HSU, in this area of the site, has been predominantly non-detect with an occasional low detection over time, with the exception of RGPZ-14D and RGPZ-16D, which had moderate detections, as shown in Attachment G-1.

### 3.1.4.2 Inorganic Results

#### 3.1.4.2.1 *Upper HSU*

During the fourteenth SA event:

- PZ-P18-5 had exceedances of the MCL/PRG for dissolved and total arsenic, cadmium, manganese, nickel, selenium, and vanadium and total iron;
- RG-1B had exceedances for dissolved and total arsenic, iron, manganese, selenium, and vanadium and total aluminum, cadmium, and chromium;
- RG-2B was not sampled due to insufficient water;
- RG-4B, RIMW-5, and WP-3S were not analyzed for inorganic compounds;
- RG-5B had exceedances for dissolved arsenic, total iron, dissolved and total vanadium;
- RG-6B had exceedances for dissolved and total arsenic, selenium, and vanadium, total manganese, and dissolved nickel;
- RG-7B had exceedances for dissolved and total arsenic, cadmium, manganese, nickel, selenium, and vanadium and total iron;
- RIMW-1 had exceedances for dissolved and total arsenic and selenium, dissolved nickel, and total vanadium; and
- RIMW-2 had exceedances for dissolved and total arsenic, cadmium, manganese, nickel, and selenium and total lead and iron.

During the fifteenth SA event:

- PZ-P18-5 had exceedances of the MCL/PRG for dissolved and total arsenic, cadmium, manganese, nickel, selenium, and vanadium and dissolved beryllium;
- RG-1B had exceedances for dissolved and total arsenic, manganese, selenium, and vanadium;
- RG-2B and RIMW-5 were not analyzed for inorganic compounds;
- RG-4B had exceedances for dissolved and total arsenic, cadmium, nickel, selenium, and vanadium, dissolved beryllium, and total manganese;
- RG-5B had exceedances for dissolved and total arsenic and nickel and total iron;
- RG-6B had exceedances for dissolved and total arsenic, nickel, and selenium and dissolved cadmium;
- RG-7B had exceedances for dissolved and total arsenic, cadmium, nickel, manganese, and selenium;
- RIMW-1 had exceedances for dissolved and total arsenic, nickel, and selenium;
- RIMW-2 had exceedances for dissolved and total arsenic, cadmium, manganese, nickel, and selenium; and
- RIMW-5 had an exceedance for dissolved arsenic.

During the Post RI SA events:

- RIHP-1 through RIHP-7 were not analyzed during the Spring 2007 for metals due to insufficient water; and
- RIPZ-37 did not have any exceedances during the eighteenth (Fall 2006) SA event.

The Upper HSU in the area south of the PSCT has concentrations of dissolved and total metals that are similar, which indicates that very little solid material was collected in the unfiltered

samples. However, several metals in different sampling locations have different concentrations of dissolved and total. Arsenic, barium, selenium, and zinc typically have higher concentrations of dissolved than total. The concentration difference between dissolved and total ranged from double the concentration to greater than one order of magnitude greater. Iron and lead typically have higher concentrations of total than dissolved. The concentration difference between total and dissolved ranged from three times the concentration to greater than one order of magnitude greater. The arsenic, nickel, selenium, and vanadium concentrations that exceeded the MCL/PRGs are similar to those in other areas of the site. As shown in Figures G-35, G-37 and G-38, the arsenic, nickel, and selenium exceedances extend past PCT-A, PCT-B, and PCT-C to the south and the east, and to the boarder of Zone 1 in the west. There is an area south of PSCT-4 on the arsenic isopleth map (Figure G-35) that is below the MCL, which encompasses RG-5B, RIHP-4, RIHP-5, RIMW-5, and WP-3S. The nickel and selenium isopleth maps (Figures G-37 and G-38) have small areas south of PSCT-3 that are below the MCL, which encompasses WP-3S.

#### 3.1.4.2.2 Lower HSU

During the fourteenth SA event:

- RGPZ-3C had exceedances of the MCL/PRG for total aluminum, arsenic, iron, and vanadium;
- RGPZ-3D had exceedances for dissolved and total arsenic and total iron;
- RGPZ-4C had exceedances for dissolved arsenic and total iron;
- RGPZ-8D was not analyzed for metals;
- RGPZ-14D had exceedances for dissolved and total arsenic, total iron, and dissolved vanadium;
- RGPZ-15B had exceedances for dissolved and total arsenic and vanadium and total iron;
- RGPZ-16D had exceedances for dissolved and total arsenic and total iron;
- RP-4D had exceedances for dissolved and total iron and vanadium and dissolved arsenic;
- RP-53C exceedances for dissolved and total iron and vanadium and dissolved arsenic;
- RP-54C was not analyzed for metals;
- RP-107D was not analyzed for metals; and
- WP-3D was not analyzed for metals.

During the fifteenth SA event:

- RGPZ-3C had exceedances of the MCL/PRG for total aluminum, iron, and vanadium and dissolved arsenic;
- RGPZ-3D had exceedances for dissolved arsenic and total iron and vanadium;
- RGPZ-4C had exceedances for dissolved arsenic and selenium;
- RGPZ-8D was not analyzed for metals;
- RGPZ-14D had exceedances for total iron and vanadium;
- RGPZ-15B had exceedances for dissolved and total arsenic and vanadium and total aluminum and iron;
- RGPZ-16D had exceedances for dissolved and total arsenic and total iron;
- RP-4D had exceedances for dissolved and total arsenic and total iron;

- RP-53C exceedances for dissolved and total iron and vanadium and dissolved arsenic and beryllium;
- RP-54C was not analyzed for metals;
- RP-107D was not analyzed for metals; and
- WP-3D was not analyzed for metals.

During the Pre-RI SA event:

- RG-1C had exceedance of the MCL/PRG for dissolved and total arsenic during the Spring 1999 and Summer 2000 SA events;
- RP-54C had exceedances for dissolved and total arsenic, total beryllium, and dissolved thallium during the Fall 1999 SA event and did not have any exceedances during the Summer 2000 SA event;
- RP-55C-2 had exceedances for dissolved and total arsenic during the Fall 1999 and Summer 2000 SA events;
- RP-107D had exceedances for dissolved and total arsenic and dissolved cadmium and thallium during the Fall 1999 SA event and did not have any exceedances during the Summer 2000 SA event; and
- WP-3D had exceedances for dissolved and total arsenic and total antimony during the Fall 1999 SA event and for dissolved and total arsenic during the Summer 2000 SA event.

The Lower HSU in the area south of the PSCT have concentrations of dissolved and total metals that are similar, which indicates that very little solid material was collected in the unfiltered samples. However, several metals in different sampling locations have different concentrations of dissolved and total. Arsenic, barium, selenium, and zinc typically have higher concentrations of dissolved than total. The concentration difference between dissolved and total ranged from double the concentration to greater than one order of magnitude greater. Iron and occasionally lead typically had higher concentrations of total than dissolved. The concentration difference between total and dissolved ranged from three times the concentration to greater than one order of magnitude greater. The arsenic, nickel, selenium, and vanadium concentrations that exceeded the MCL/PRGs are similar to those in other areas of the site in the Lower HSU. The distribution of arsenic, cadmium, nickel, and selenium are similar to the distribution of the VOCs, as shown on Figures G-39 through G-42.

#### *3.1.4.2.3 General Minerals and pH*

The cation and anion data reveal a general difference between the groundwater chemistry in the Upper and Lower HSU. Groundwater in the Upper HSU in the area is characterized as a magnesium-sulfate and sodium-chloride type, with RG-5B as sodium-sulfate type during the fourteenth event and RG-6B as magnesium-chloride type during the fifteenth event, whereas the groundwater sample in the Lower HSU is generally characterized as sodium-sulfate type water (Figures G-14 through G-17). The general mineral concentrations for both the Upper HSU and Lower HSU have remained stable over time, which are presented in Attachment G-2. The pH values were generally neutral, ranging from 6.82 to 7.52 in the Upper HSU and 7.2 to 8.1 in the Lower HSU.

### **3.1.5 Ponds**

Samples were collected and analyzed from all five pond locations. Table G-13a presents the analytical data for the five locations during the fourteenth and fifteenth SA events, and Table G-13b presents the data for the twenty-first SA event.

#### 3.1.5.1 Organic Results

During the fourteenth (Fall 2004) SA event:

- A-Series Pond had 3 organic chemicals that exceeded their MCLs/PRGs, with n-nitrosopyrrolidine as the chemical with the highest concentration at 0.36 µg/L;
- Pond 13 had 4 exceedances, with 1,2,4-TMB as the chemical with the highest concentration at 17 µg/L. Chemical 1,2,4-TMB is a suspect detection which was qualified as a tentatively identified compound;
- Pond 18 did not have any exceedances;
- Pond A-5 had 3 exceedances, with n-nitrosopyrrolidine as the chemical with the highest concentration at 1.5 µg/L; and
- RCF Pond had 3 exceedances, with n-nitrosopyrrolidine as the chemical with the highest concentration at 0.035 µg/L.

During the fifteenth (Spring 2005) SA event:

- A-Series Pond had 2 organic chemicals that exceeded their MCLs/PRGs, with n-nitrosopyrrolidine as the chemical with the highest concentration at 0.14 µg/L;
- Pond 13 had 4 exceedances, with bis(2-ethylhexyl)phthalate as the chemical with the highest concentration at 5.6 µg/L. The bis(2-ethylhexyl)phthalate detection is considered suspect because it was found in an associated blank sample;
- Pond 18 had 5 exceedances, with MTBE as the chemical with the highest concentration at 13 µg/L;
- Pond A-5 had 4 exceedances, with bis(2-ethylhexyl)phthalate as the chemical with the highest concentration at 51 µg/L. The bis(2-ethylhexyl)phthalate detection is considered suspect because it was found in an associated blank sample; and
- RCF Pond had 4 exceedances, with methylene chloride as the chemical with the highest concentration at 7 µg/L.

Many of the detections and exceedances during the fourteenth and fifteenth SA events were for VOCs, SVOCs, and PAHs. All five ponds have relatively low levels of organic compounds. The ponds have maintained low to non-detect concentrations of chlorinated VOCs over time, which are presented in Attachment G-1 and as shown on Figures G-22 through G-28. However, pond A-5 is the pond with historically the highest chlorinated VOC concentrations.

#### 3.1.5.2 Inorganic Results

During the fourteenth (Fall 2004) SA event:

- A-Series Pond had exceedances of the MCL/PRG for arsenic, nickel, selenium, and vanadium at concentrations of 190 µg/L, 440 µg/L, 690 µg/L, and 63 µg/L, respectively;
- Pond 13 had exceedances for arsenic, chromium, nickel, and selenium at concentrations of 710 µg/L, 92 µg/L, 2,000 µg/L, and 2,900 µg/L, respectively;

- Pond 18 had exceedances for arsenic, nickel, and selenium at concentrations of 78 µg/L, 330 µg/L, and 300 µg/L, respectively;
- Pond A-5 had exceedances for arsenic, chromium, nickel, selenium, and vanadium at concentrations of 250 µg/L, 97 µg/L, 170 µg/L, 950 µg/L, and 62 µg/L, respectively; and
- RCF Pond had exceedances for arsenic, chromium, nickel, and selenium at concentrations of 400 µg/L, 60 µg/L, 460 µg/L, and 1,600 µg/L, respectively.

During the fifteenth (Spring 2005) SA event:

- A-Series Pond had exceedances of the MCL/PRG for arsenic, nickel, and selenium at concentrations of 290 µg/L, 300 µg/L, and 820 µg/L, respectively;
- Pond 13 had exceedances for arsenic, nickel, and selenium at concentrations of 200 µg/L, 410 µg/L, and 720 µg/L, respectively;
- Pond 18 had exceedances for arsenic, nickel, and selenium at concentrations of 78 µg/L, 160 µg/L, and 320 µg/L, respectively;
- Pond A-5 had exceedances for arsenic, nickel, and selenium at concentrations of 220 µg/L, 200 µg/L, and 770 µg/L, respectively; and
- RCF Pond had exceedances for arsenic, nickel, and selenium at concentrations of 110 µg/L, 120 µg/L, and 380 µg/L, respectively.

Cyanide was analyzed in all of the ponds, but was not detected. Pond 13 is the pond that contained the highest concentrations of the metals that were detected in this area, which is located south and downgradient of the RCF Pond and north and upgradient of the PCT-B Trench and as shown on Figures G-35 through G-38.

#### *3.1.5.2.1 General Mineral and pH*

The pond waters are characterized as sodium-chloride type (Figures G-14 and G-16). The general mineral concentrations for the Ponds have remained stable over time, with the exception of chloride, sodium, sulfate, and total dissolved solids. These four general minerals have gradually increased over time until the Fall 2005 sampling event. The events following the Fall 2005 SA event have fluctuated. The general mineral concentrations over time for each pond are presented in Attachment G-2. The pH values were generally neutral to slightly basic, ranging from 7.39 to 9.02.

### **3.1.6 PCT-A and A-Drainage Wells**

This sampling location group included six Upper HSU and two Lower HSU sampling locations in PCT-A and the A-drainage wells. The data for the fourteenth and fifteenth SA events are presented in Table G-14a, and the data for the twenty-first SA event is presented on Table G-14b.

#### **3.1.6.1 Organic Results**

##### *3.1.6.1.1 Upper HSU*

During the fourteenth SA event:

- MW-18C did not have any detection of VOCs. MW-18C was not analyzed for any other organic compounds due to insufficient water;

- RAP-1A did not have any detection of organic compounds;
- RAP-3A had 2 exceedances of the MCL/PRG with PCE as the chemical having the highest concentration at 1.5 µg/L;
- RP-100A did not have any exceedances, but had a detection of phenols at a concentration of 3.8 µg/L;
- RP-103B did not have any detection of VOCs. RP-103B was not analyzed for any other organic compounds; and
- RP-65B did not have any detection of VOCs. RP-65B was not analyzed for any other organic compounds.

During the fifteenth SA event:

- MW-18C had an exceedance of the MCL/PRG for bis(2-ethylhexyl)phthalate at a concentration of 6.3 µg/L. The bis(2-ethylhexyl)phthalate detection is considered suspect because it was found in an associated blank sample;
- RAP-1A had an exceedance n-nitrosodipropylamine at a concentration of 0.031 µg/L. The n-nitrosodipropylamine detection is considered suspect because it was found in an associated blank sample;
- RAP-3A had five organic chemicals that exceeded, with bis(2-ethylhexyl)phthalate as the chemical having the highest concentration at 5.5 µg/L. The bis(2-ethylhexyl)phthalate detection is considered suspect because it was found in an associated blank sample;
- RP-100A had 2 exceedances for bis(2-ethylhexyl)phthalate as the chemical having the highest concentration at 5.0 µg/L. The bis(2-ethylhexyl)phthalate detection is considered suspect because it was found in an associated blank sample;
- RP-103B did not have any detection of VOCs. RP-103B was not analyzed for any other organic compounds; and
- RP-65B did not have any detection of VOCs. RP-65B was not analyzed for any other organic compounds.

The Upper HSU in the PCT-A area is associated with minor detections of organic compounds. Many of the detections and exceedances in the Upper HSU were in RAP-3A which is located in the PCT-A Trench. All of the detections and exceedances for SVOCs, with the exception of phenols, during the fourteenth and fifteenth SA event in the Upper HSU are considered suspect concentrations because they were either found in an associated field blank or were identified as a tentatively identified compound. Many of the detections for VOCs and PAHs in the Upper HSU were positively identified but the associated numerical value is an estimated value. Concentrations of chlorinated VOCs in the Upper HSU have been low to non-detect over time as shown in Attachment G-1. The concentrations of chlorinated VOCs in RAP-3A have been declining over time, however, during the two most recent sampling events cis-1,2-DCE have increased slightly. The detections in the PCT-A area appear to be residual contamination from before the PCT was installed.

#### 3.1.6.1.2 Lower HSU

During the fourteenth SA event, A2B had an exceedance of the MCL/PRG for n-nitrosodiethylamine at a concentration of 0.014 µg/L. During the fifteenth SA event, A2B had exceedances for bis(2-ethylhexyl)phthalate and n-nitrosodipropylamine at concentrations of 5.0 µg/L and 0.063 µg/L, respectively. The bis(2-ethylhexyl)phthalate detection is considered suspect because it was found in an associated blank sample. During the Pre-RI SA events RP-101C had several detections of VOCs and SVOCs during the Fall 1999 and Summer 2000

SA events but no exceedances. During the Fall 1999 SA event RP-101C had exceedances for 1,2,3,4,6,7,8-heptachlorinated dibenzofuran (HpCDF), 1,2,3,4,7,8-hexachlorinated dibenzofuran (HxCDF), and octachlorinated dibenzofuran (OCDF) at concentrations of 100 pg/L, 22 pg/L, and 160 pg/L, respectively. During the Summer 2000 SA event dioxins and furans were not detected in RP-101C. Several of the detections in RP-101C are considered suspect concentrations because they were identified as a tentatively identified compound.

### 3.1.6.2 Inorganic Results

#### 3.1.6.2.1 *Upper HSU*

During the fourteenth SA event:

- Wells MW-18C, RP-100A, RP-103B, and RP-65B were not analyzed for inorganic compounds;
- RAP-1A had exceedances of the MCL/PRG for dissolved and total arsenic, cadmium, nickel, selenium, and vanadium; and
- RAP-3A had exceedances for dissolved arsenic, nickel, selenium, and vanadium.

During the fifteenth SA event:

- MW-18C had exceedances of the MCL/PRG for dissolved and total arsenic and cadmium, dissolved nickel, and total iron and selenium;
- RAP-1A had exceedances for dissolved and total arsenic and selenium, dissolved cadmium, and total vanadium;
- RAP-3A had exceedances for dissolved arsenic, nickel, and selenium; and
- Wells RP-100A, RP-103B, and RP-65B were not analyzed for inorganic compounds.

During Pre-RI SA events:

- RP-100A had exceedances of the MCL/PRG for dissolved and total arsenic and selenium and dissolved nickel during the Fall 1999 SA event and exceedances for dissolved and total nickel and selenium during the Summer 2000 SA event;
- RP-103B had exceedances for dissolved arsenic and dissolved and total selenium during the Fall 1999 SA event and exceedances for dissolved and total selenium during the Summer SA event; and
- RP-65B had exceedances for dissolved and total selenium during the Fall 1999 and Summer 2000 SA events.

Concentrations of dissolved and total metals are similar in the Upper HSU in the PCT-A area, which indicates that very little solid material was collected in the unfiltered samples. However, during the fifteenth SA event, MW-18C had dissolved barium over two times greater than total barium and had total iron nearly one order of magnitude greater than dissolved iron. During the fourteenth and fifteenth SA events, RAP-1A and RAP-3A had dissolved arsenic ranging from double the concentration to nearly four times greater than total arsenic, total lead in RAP-1A during the fourteenth SA event greater than one order of magnitude dissolved lead, dissolved selenium ranging slightly greater in concentration to over times greater than total selenium, and dissolved zinc ranging from nearly three times the concentration to nearly six times greater than total zinc, however, during the fourteenth SA event in RAP-1A total zinc was three times greater

than dissolved zinc. The arsenic, nickel, selenium, and vanadium concentrations that exceeded the MCL/PRGs are similar to those in other areas of Zone 2.

#### 3.1.6.2.2 Lower HSU

During the fourteenth and fifteenth SA events inorganics were not analyzed for in the Lower HSU well A2B. During the Fall 1999 SA event A2B did not have any exceedances of the MCL/PRG for inorganics, but Well RP-101C had exceedances for dissolved and total arsenic. During the Summer 2000 SA event wells A2B and RP-101C had exceedances for dissolved and total arsenic and even though barium was not an exceedance in these wells, the detection of dissolved barium was nearly one order of magnitude greater than total barium.

#### 3.1.6.2.3 General Minerals and pH

The cation and anion data reveal a general difference between the groundwater chemistry in the Upper and Lower HSUs. Groundwater in the Upper HSU in the area of RAP-1A is characterized as a magnesium-sulfate and sodium-sulfate type, with RAB-3A as sodium-chloride type, whereas the groundwater sample from the Lower HSU is generally characterized as sodium-sulfate type water (Figures G-14 through G-17). The general mineral concentrations for both the Upper HSU and Lower HSU have remained stable over time, as presented in Attachment G-2. The pH values were generally neutral in the Upper HSU, ranging from 6.68 to 7.63. The pH in the Lower HSU was not measured.

### 3.1.7 PCT-B and B-Drainage Wells

This sampling location group included six Upper HSU and two Lower HSU sampling locations in PCT-B and the B-drainage wells. The data for the fourteenth and fifteenth SA events are presented in Table G-15a, and the data for the twenty-first SA event is presented on Table G-15b.

#### 3.1.7.1 Organic Results

##### 3.1.7.1.1 Upper HSU

During the fourteenth SA event:

- B3M had 2 exceedances of the MCL/PRG with tetrahydrofuran as the chemical having the highest concentration at 5.0 µg/L;
- RAP-1B had an exceedance n-nitrosopyrrolidine at a concentration of 0.12 µg/L;
- RP-59B did not have any detection of VOCs. RP-59B was not analyzed for any other organic compounds;
- RP-75A did not have any detection of VOCs. RP-75A was not analyzed for any other organic compounds; and
- RP-75B did not have any detection of VOCs. RP-75B was not analyzed for any other organic compounds.

During the fifteenth SA event:

- B3M did not have any detection of VOCs. B3M was not analyzed for any other organic compounds;

- RAP-1B had 3 exceedances with bis(2-ethylhexyl)phthalates the chemical having the highest concentration at 5.5 µg/L. The bis(2-ethylhexyl)phthalate detection is considered suspect because it was found in an associated blank sample;
- RP-59B did not have any detection of VOCs. RP-59B was not analyzed for any other organic compounds;
- RP-75A did not have any detection of VOCs. RP-75A was not analyzed for any other organic compounds; and
- RP-75B did not have any detection of VOCs. RP-75B was not analyzed for any other organic compounds.

During the Pre-RI SA events:

- B-5 did not have any exceedances of the MCL/PRG, but had a detection of bis(2-ethylhexyl)phthalate at a concentration of 0.39 µg/L during the Fall 1999 SA event and an exceedance for OCDF at a concentration of 7.62 pg/L during the Summer 2000 SA event.

Sampling locations in the Upper HSU in the PCT-B contained minor detections of organic compounds. Many of the detections and exceedances in the Upper HSU were in RAP-1B which is located in the PCT-B Trench. All of the detections and exceedances for SVOCs during the fourteenth and fifteenth SA event in the Upper HSU are considered suspect concentrations because they were either found in an associated field blank or were identified as a tentatively identified compound. The two detections of SVOCs in B-5 during the Fall 1999 and Summer 2000 SA events were positively identified but the associated numerical value is an estimated value. Many of the detections for VOCs and PAHs in the Upper HSU were positively identified but the associated numerical value is an approximate value. Concentrations of chlorinated VOCs over time in the Upper HSU have been low to non-detect as shown in Attachment G-1. The detections in the PCT-B Area appear to be residual contamination from before the PCT was installed in this area.

#### 3.1.7.1.2 Lower HSU

During the fourteenth SA event RP-75C had an exceedance of the MCL/PRG for bis(2-chloroethyl)ether at a concentration of 0.059 µg/L. During the fifteenth SA event had exceedances for bis(2-ethylhexyl)phthalate and n-nitrosodipropylamine at concentrations of 4.9 µg/L and 0.048 µg/L, respectively. All of the detections and exceedances for SVOCs during the fourteenth and fifteenth SA event in RP-75C are considered suspect concentrations because they were either found in an associated field blank or were identified as a tentatively identified compound. All of the detections for PAHs in RP-75C were positively identified but the concentrations are estimated. During the Fall 1999 and Summer 2000 SA events, B3B did not have any detections of any organic compounds.

#### 3.1.7.2 Inorganic Results

##### 3.1.7.2.1 Upper HSU

During the fourteenth SA event:

- B3M, RP-59B, RP-75A, and RP-75B were not analyzed for inorganic compounds; and

- RAP-1B had exceedances of the MCL/PRG for dissolved and total arsenic, manganese, nickel, selenium, and vanadium.

During the fifteenth SA event:

- B3M, RP-59B, RP-75A, and RP-75B were not analyzed for inorganic compounds; and
- RAP-1B had exceedances of the MCL/PRG for dissolved and total arsenic, nickel, selenium and total iron and vanadium.

During the Pre-RI SA events:

- B3M had exceedances of the MCL/PRG for dissolved and total arsenic during the Fall 1999 and Summer 2000 SA events;
- B-5 had exceedances of the MCL/PRG for dissolved and total arsenic and nickel during the Fall 1999 and Summer 2000 SA events;
- RP-59B had exceedances for dissolved and total arsenic during the Fall 1999 and Summer 2000 SA events;
- RP-75A had exceedances for dissolved and total arsenic during the Fall 1999 SA event and dissolved and total arsenic and thallium during the Summer 2000 SA event; and
- RP-75B had exceedances for dissolved and total arsenic during the Fall 1999 SA event and dissolved and total arsenic and thallium during the Summer 2000 SA event.

Concentrations of dissolved and total metals in the Upper HSU in the PCT-B area are similar, which indicates that very little solid material was collected in the unfiltered samples. During the fourteenth SA event, sampling location RAP-1B had dissolved arsenic nearly 3 times greater than total arsenic, dissolved barium nearly 4 times greater than total barium, dissolved selenium nearly 2.5 times greater than total selenium, and dissolved zinc greater than one order of magnitude greater than total zinc. However, during the fifteenth SA event, sampling location had dissolved barium 3 times greater than total barium and dissolved zinc 6 times greater than total zinc. The arsenic, nickel, selenium, and vanadium concentrations that exceeded the MCL/PRGs are similar to those in other areas of Zone 2.

#### *3.1.7.2.2 Lower HSU*

RP-75C had exceedances of the MCL/PRG for dissolved arsenic, and dissolved and total iron during the fourteenth SA event, and dissolved and total arsenic and iron during the fifteenth SA event. B3B had exceedances for dissolved and total arsenic and lead and total copper During the Spring 1999 SA event, and exceedances for dissolved and total arsenic and dissolved thallium during the Summer 2000 SA event. The Lower HSU concentrations of the dissolved and total metals are similar. Dissolved zinc was detected over one magnitude higher than total zinc in Well RP-75C during the fifteenth SA event. During the Summer 2000 SA event, dissolved barium was detected over one magnitude higher than total barium and dissolved zinc nearly three times greater than total zinc in Well B3B.

#### *3.1.7.2.3 General Mineral and pH*

The cation and anion data indicate a general difference between the groundwater chemistry in the Upper and Lower HSU. Groundwater in the Upper HSU in the area is characterized as a sodium-chloride type, whereas the groundwater sample in the Lower HSU is generally characterized as sodium-sulfate type water (Figures G-14 through G-17). The general mineral

concentrations for both the Upper HSU and Lower HSU have remained stable over time, as presented in Attachment G-2. The pH values were generally neutral, ranging from 7.38 to 7.4 in the Upper HSU and ranging from 7.6 to 7.68 in the Lower HSU.

### 3.1.8 PCT-C and C-Drainage Wells

This sampling location group included nine Upper HSU and two Lower HSU sampling locations in PCT-C and the C-drainage wells. The data for the fourteenth and fifteenth SA events are presented in Table G-16a, and the data for the twenty-first SA event is presented on Table G-16b..

#### 3.1.8.1 Organic Results

##### 3.1.8.1.1 *Upper HSU*

During the fourteenth SA event:

- C3M did not have any detection of organic compounds;
- C-5 had several detections of VOCs and SVOCs, but did not have any exceedances of the MCL/PRG;
- MW-7C had 2 exceedances of the MCL/PRG with bis(2-chloroethyl)ether as the chemical having the highest concentration at 0.024 µg/L;
- RAP-1C had several detections of VOCs and SVOCs, but did not have any exceedances;
- RIMW-9 had 2 exceedances with bis(2-chloroethyl)ether as the chemical having the highest concentration at 0.06 µg/L;
- RP-28B had 3 exceedances with n-nitrosodipropylamine as the chemical having the highest concentration at 0.46 µg/L. The n-nitrosodipropylamine detection is considered suspect because it was found in an associated blank sample;
- RP-72A did not have any detection of organic compounds; and
- RP-76A did not have any detection of organic compounds.

During the fifteenth SA event:

- C3M did not have any detection of organic compounds;
- C-5 had 5 exceedances of the MCL/PRG with bis(2-ethylhexyl)phthalate as the chemical having the highest concentration at 5.5 µg/L. The bis(2-ethylhexyl)phthalate detection is considered suspect because it was found in an associated blank sample;
- MW-7C had 2 exceedances with bis(2-ethylhexyl)phthalate as the chemical having the highest concentration at 5.1 µg/L. The bis(2-ethylhexyl)phthalate detection is considered suspect because it was found in an associated blank sample;
- RAP-1C had an exceedance for bis(2-ethylhexyl)phthalate at a concentration of 6.0 µg/L. The bis(2-ethylhexyl)phthalate detection is considered suspect because it was found in an associated blank sample;
- RIMW-9 had 2 exceedances with bis(2-ethylhexyl)phthalate as the chemical having the highest concentration at 4.9 µg/L. The bis(2-ethylhexyl)phthalate detection is considered suspect because it was found in an associated blank sample;
- RP-28B had an exceedance for bis(2-ethylhexyl)phthalate at a concentration of 5.1 µg/L. The bis(2-ethylhexyl)phthalate detection is considered suspect because it was found in an associated blank sample;

- RP-72A did not have any detection of organic compounds; and
- RP-76A did not have any detection of organic compounds.

During Pre-RI SA events:

- RP-13B did not have any exceedances during the Spring 1999 SA event and did not have any detections during the Summer 2000 SA event.

The Upper HSU in the PCT-C Area is associated with minor detections of organic compounds. Typically the chemical with highest concentration in the wells were also found in the associated trip blank sample. Concentrations of chlorinated VOCs over time in the Upper HSU have been low to non-detect as shown in Attachment G-1. The detections in the PCT-C Area appear to be residual contamination from before the PCT was installed in this area.

#### 3.1.8.1.2 Lower HSU

During the fourteenth SA event RP-72D had a few detections of VOCs, SVOCs, and PAHs, but no exceedances. During the fifteenth SA event RP-72D had exceedances for bis(2-ethylhexyl)phthalate and n-nitrosodipropylamine at concentrations of 5.4 µg/L and 0.035 µg/L, respectively. The bis(2-ethylhexyl)phthalate and n-nitrosodipropylamine detections are considered suspect because they were found in an associated blank sample. During Pre-RI SA events MW-7D did not have any detections of organic compounds during the Fall 1999 SA event, and had a few detections but no exceedances during the Summer 2000 SA event.

#### 3.1.8.2 Inorganic Results

##### 3.1.8.2.1 Upper HSU

During the fourteenth SA event:

- C3M was not analyzed for inorganics;
- C-5 had exceedances of the MCL/PRGs for total and dissolved arsenic, cadmium, iron, manganese, nickel, selenium, and vanadium;
- MW-7C was not analyzed for inorganics;
- RAP-1C had exceedances for total and dissolved arsenic, nickel, selenium, and vanadium;
- RIMW-9 had exceedances for total aluminum, iron, and vanadium and total and dissolved arsenic and chromium;
- RP-28B was not analyzed for inorganics;
- RP-72A was not analyzed for inorganics; and
- RP-76A was not analyzed for inorganics.

During the fifteenth SA event:

- C3M was not analyzed for inorganics;
- C-5 had exceedances of the MCL/PRGs for total and dissolved arsenic, iron, manganese, nickel, and selenium;
- MW-7C was not analyzed for inorganics;
- RAP-1C had exceedances for total and dissolved arsenic, nickel, and selenium;

- RIMW-9 had exceedances for total aluminum and iron and total and dissolved arsenic;
- RP-28B was not analyzed for inorganics;
- RP-72A was not analyzed for inorganics; and
- RP-76A was not analyzed for inorganics.

During Pre-RI SA events:

- RP-13B had an exceedance of dissolved lead during the Spring 1999 SA event and an exceedance of total beryllium during the Summer 2000 SA event.

Concentrations of dissolved and total metals in the Upper HSU in the PCT-C area are similar, which indicates that very little solid material was collected in the unfiltered samples. Iron is the only metal in the Upper HSU with a significant difference between dissolved and total at concentrations of 1,100 µg/L and 12,000 µg/L, respectively, for the fourteenth SA event and 2,100 µg/L and 20,000 µg/L, respectively, for the fifteenth SA event in Well C-5. Dissolved iron in Well RIMW-9 was non-detect during the fourteenth and fifteenth SA event while total iron was detected at 21,000 µg/L and 12,000 µg/L, respectively. The arsenic, nickel, selenium, and vanadium concentrations that exceeded the MCL/PRGs are similar to those in other areas of Zone 2.

#### *3.1.8.2.2 Lower HSU*

During the fourteenth and fifteenth SA events dissolved and total arsenic and iron exceeded the MCL/PRGs. During Pre-RI SA events MW-7D had exceedances for dissolved and total arsenic during the Fall 1999 and Summer 2000 SA events and total beryllium during the Summer 2000 SA event. The Lower HSU concentrations of the dissolved and total metals are similar. The dissolved arsenic was detected at a higher concentration than the total arsenic in Well RP-72D, where as the total iron was detected at a higher concentration than the dissolved iron in the same well.

#### *3.1.8.2.3 General Minerals and pH*

The cation and anion data indicate a similarity between the groundwater chemistry in the Upper and Lower HSU. Groundwater in both the Upper and Lower HSU in the area is characterized as a sodium-chloride type, with RAP-1C as sodium-sulfate type during the fifteenth event (Figures G-14 through G-17). The general mineral concentrations for both the Upper HSU and Lower HSU have remained stable over time, which are presented in Attachment G-2. The pH values were generally neutral, ranging from 6.5 to 8.86 in the Upper HSU and ranging from 7.81 to 8.1 in the Lower HSU.

### **3.1.9 North Perimeter and North Drainage Wells**

This sampling location group included seven Upper HSU sampling locations and eighteen Lower HSU sampling locations in the North Perimeter and North Drainage wells. The data for the fourteenth and fifteenth SA events are presented in Tables G-17a and G-18a, and the data for the twenty-first SA event is presented on Tables G-17b and G-18b.

#### **3.1.9.1 Organic Results**

##### *3.1.9.1.1 Upper HSU*

During the fourteenth SA event:

- RG-11B had 7 detections of VOCs and SVOCs, but none of the chemicals exceeded the MCL/PRG;
- RP-109B did not have any detection of organic compounds;
- RP-17B did not have any detection of organic compounds;
- SW-47 had 9 detections of VOCs and SVOCs, but none of the chemicals exceeded the MCL/PRG; and
- WP-7S did not have any detection of organic compounds.

During the fifteenth SA event:

- RG-11B had 1 exceedance of the MCL/PRG for bis(2-ethylhexyl)phthalate at a concentration of 6.3 µg/L. The bis(2-ethylhexyl)phthalate detection is considered suspect because it was found in an associated blank sample;
- RG-11B-2 had 3 exceedances for with n-nitrosodipropylamine as the chemical having the highest concentration at 0.28 µg/L. The benzo(a)anthracene detection is considered suspect because it was found in an associated blank sample;
- RP-109B did not have any detection of organic compounds;
- RP-17B did not have any detection of organic compounds;
- SW-47 had 5 exceedances with bis(2-ethylhexyl)phthalate as the chemical having the highest concentration at 8.2 µg/L. The bis(2-ethylhexyl)phthalate detection is considered suspect because it was found in an associated blank sample; and
- WP-7S had 3 exceedances, two of which were bis(2-ethylhexyl)phthalate at concentrations of 7.7 µg/L and 6.5 µg/L. The bis(2-ethylhexyl)phthalate detections are considered suspect because it was found in an associated blank sample.

During Pre-RI SA events:

- MW-7BU did not have any exceedances of the MCL/PRG during the Fall 1999 SA event, but 1 detection of bis(2-ethylhexyl)phthalate at a concentration of 0.27 µg/L, and no detections during the Summer 2000 SA event.

Many of the detections and exceedances in the Upper HSU in the North Perimeter and North Drainage areas were located along the North Perimeter adjacent to, and north of the P/S Landfill, with the exception of WP-7S, which is located along the North Perimeter but between the Metals and Caustic/Cyanide Landfills. The detection and exceedances were predominantly for VOCs, SVOCs, and PAHs. The groundwater in wells RG-11B, RG-11B-2, SW-47, and WP-7S flow towards the landfills. The wells in the Upper HSU have maintained non-detect to low concentrations of chlorinated VOCs over time, which are presented in Attachment G-1. Beginning in the fifteenth (Spring 2005) SA event there was detectable concentrations of 1,1-DCE and VC. It appears that natural degradation is taking place in this well due to higher concentration of VC in comparison to 1,1-DCE. The North Drainage wells did not have detections of organics during the fourteenth and fifteenth SA events, and the detection in MW-7BU during the Fall 1999 was an estimated value.

#### 3.1.9.1.2 Lower HSU

During the fourteenth SA event:

- RGPZ-2B had an exceedance of the MCL/PRG for bis(2-ethylhexyl)phthalate at a concentration of 6.3 µg/L;
- RGPZ-2C had an exceedance for bis(2-chloroethyl)ether at a concentration of 6.3 µg/L;
- RGPZ-2D had 10 exceedances, with 1,2,4-TMB as the chemical having the highest concentration at 67 µg/L;
- RGPZ-9B had 2 exceedances with bis(2-chloroethyl)ether as the chemical having the highest concentration at 6.9 µg/L;
- RGPZ-10B did not have any detection of organic compounds;
- RGPZ-11C had 8 exceedances with bis(2-ethylhexyl)phthalate as the chemical having the highest concentration at 6.5 µg/L;
- RGPZ-12C had 5 exceedances, with vinyl chloride as the chemical having the highest concentration at 1.1 µg/L;
- RGPZ-12D had 5 exceedances, with bis(2-ethylhexyl)phthalate as the chemical having the highest concentration at 15 µg/L;
- RP-1D had an exceedance for n-nitrosodipropylamine at a concentration of 0.04 µg/L. The n-nitrosodipropylamine detection is considered suspect because it was found in an associated blank sample;
- RP-62B-1 had 4 exceedances, with bis(2-chloroethyl)ether as the chemical having the highest concentration at 2.3 µg/L. The n-nitrosodipropylamine detection is considered suspect because it was found in an associated blank sample;
- RP-62D had 3 exceedances with n-nitrosodipropylamine as the chemical having the highest concentration at 0.11 µg/L. The n-nitrosodipropylamine detection is considered suspect because it was found in an associated blank sample;
- RP-63C had 3 exceedances with bis(2-chloroethyl)ether as the chemical having the highest concentration at 1.4 µg/L;
- RP-109D had 2 exceedances with n-nitrosodipropylamine as the chemical having the highest concentration at 0.36 µg/L. The n-nitrosodipropylamine detection is considered suspect because it was found in an associated blank sample; and
- WP-7D had 3 exceedances with 1,2,4-TMB as the chemical having the highest concentration at 19 µg/L. Chemical 1,2,4-TMB is a suspect detection which was qualified as a tentatively identified compound.

During the fifteenth SA event:

- RGPZ-2B had 3 exceedances with bis(2-ethylhexyl)phthalate as the chemical having the highest concentration at 6.0 µg/L. The bis(2-ethylhexyl)phthalate detection is considered suspect because it was found in an associated blank sample;
- RGPZ-2C had 2 exceedances with bis(2-chloroethyl)ether as the chemical having the highest concentration at 6.3 µg/L. The bis(2-ethylhexyl)phthalate detection is considered suspect because it was found in an associated blank sample;
- RGPZ-2D had 6 exceedances, with bis(2-chloroethyl)ether as the chemical having the highest concentration at 7.7 µg/L. The bis(2-ethylhexyl)phthalate detection is considered suspect because it was found in an associated blank sample;
- RGPZ-9B had 5 exceedances, with bis(2-chloroethyl)ether as the chemical having the highest concentration at 6.9 µg/L. The bis(2-ethylhexyl)phthalate detection is considered suspect because it was found in an associated blank sample;

- RGPZ-11C had 4 exceedances with bis(2-ethylhexyl)phthalate as the chemical having the highest concentration at 6.3 µg/L. The bis(2-ethylhexyl)phthalate detection is considered suspect because it was found in an associated blank sample;
- RGPZ-12C had 5 exceedances, with bis(2-ethylhexyl)phthalate as the chemical having the highest concentration at 5.6 µg/L. The bis(2-ethylhexyl)phthalate detection is considered suspect because it was found in an associated blank sample;
- RGPZ-12D had 7 exceedances, with bis(2-ethylhexyl)phthalate as the chemical having the highest concentration at 5.6 µg/L. The bis(2-ethylhexyl)phthalate detection is considered suspect because it was found in an associated blank sample;
- RP-1D had 2 exceedances with bis(2-ethylhexyl)phthalate as the chemical having the highest concentration at 4.2 µg/L. Both exceedances are considered suspect because they were found in an associated blank sample;
- RP-62B-1 had 3 exceedances with bis(2-ethylhexyl)phthalate as the chemical having the highest concentration at 6.3 µg/L. The bis(2-ethylhexyl)phthalate detection is considered suspect because it was found in an associated blank sample;
- RP-62D had 3 exceedances for bis(2-ethylhexyl)phthalate as the chemical having the highest concentration at 5.4 µg/L. The bis(2-ethylhexyl)phthalate detection is considered suspect because it was found in an associated blank sample;
- RP-63C had 2 exceedances with 1,1,2-trichloroethane (1,1,2-TCA) as the chemical having the highest concentration at 1.9 µg/L;
- RP-109D had an exceedance for n-nitrosodipropylamine at a concentration of 0.095 µg/L; and
- WP-7D had 3 exceedances with bis(2-ethylhexyl)phthalate as the chemical having the highest concentration at 6.2 µg/L. The bis(2-ethylhexyl)phthalate detection is considered suspect because it was found in an associated blank sample.

During Pre-RI SA events:

- MW-25D had an exceedance of the MCL/PRG for OCDD at a concentration of 24.7 pg/L during the Summer 2000 SA event;
- MW-27D had 3 exceedances of dioxins and furans with OCDD as having the highest concentration at 111 pg/L, during the Summer 2000 SA event;
- RP-41B did not have any exceedances of the MCL/PRG during the Fall 1999 and Summer 2000 SA events; and
- RP-61B did not have any exceedances of the MCL/PRG during the Fall 1999 SA event, and did not have any exceedances during the Summer SA event.

Many of the detections and exceedances in the Lower HSU in the North Perimeter and North Drainage areas are located along the length of the North Perimeter. The detection and exceedances were predominantly for VOCs, SVOCs, PAHs, and dioxins/furans. Many of the detections and exceedances are considered suspect concentrations because they were either found in an associated field blank or were identified as a tentatively identified compound. Other detections were positively identified but the concentrations were estimated. Piezometers RGPZ-11C, RGPZ-12C, and RGPZ-12D are associated with the greatest number of detections and exceedances. Piezometer RGPZ-11C is located along the North Ridge between the P/S Landfill and the Metals Landfill, while piezometers RGPZ-12C and RGPZ-12D are located along the North Ridge between the Metals Landfill and Cyanide/Caustic Landfill. The wells in the Lower HSU have maintained non-detect to low concentrations of chlorinated VOCs over time, which are presented in Attachment G-1.

### 3.1.9.2 Inorganic Results

#### 3.1.9.2.1 *Upper HSU*

During the fourteenth SA event:

- Wells RG-11B, RG-11B-2, RP-109B, RP-17B, and WP-7S were not analyzed for inorganic compounds; and
- SW-47 had exceedances of the MCL/PRG for dissolved and total arsenic, iron, manganese, and molybdenum, dissolved selenium, and total chromium and nickel.

During the fifteenth SA event:

- Wells RG-11B, RG-11B-2, RP-109B, and RP-17B were not analyzed for inorganic compounds;
- SW-47 had exceedances of the MCL/PRG for dissolved and total arsenic, iron, manganese, molybdenum, nickel, and selenium and total chromium and vanadium; and
- WP-7S had exceedances for dissolved and total arsenic and selenium, total iron, and dissolved nickel.

During Pre-RI SA events:

- MW-7BU had exceedances of the MCL/PRG for dissolved and total arsenic and nickel, and total chromium during the Summer 2000 SA event;
- RG-11B had exceedances for dissolved and total arsenic and selenium, dissolved copper, and total nickel during the Spring 2001 SA event;
- RP-17 had exceedances for dissolved and total arsenic and selenium during the Fall 1999 SA event, and dissolved and total arsenic during the Summer 2000 SA event; and
- RP-109B had exceedances for dissolved and total arsenic and total chromium during the Fall 1999 SA event and dissolved and total arsenic during the Summer 2000 SA event.

Cyanide was analyzed not detected in wells SW-47 and WP-7S during the fourteenth and fifteenth SA events. Cyanide was sampled for during the Pre-RI SA events listed above and was detected once in RG-11B at an estimated concentration of 0.008 mg/L. Well SW-47 is the well that contained the highest concentrations of the metals that were detected in this area, which is located along the North Ridge and between the P/S Landfill and Metals Landfill. The dissolved and total metal concentrations are similar with the exception for iron. Dissolved iron was either not detected or was one order of magnitude lower than the total iron concentrations for wells SW-47 and WP-7S.

#### 3.1.9.2.2 *Lower HSU*

During the fourteenth SA event:

- RGPZ-2B was not analyzed for inorganic compounds;
- RGPZ-2C had exceedances of the MCL/PRG for dissolved and total arsenic and vanadium;

- RGPZ-2D had exceedances for dissolved and total iron and total aluminum, chromium, lead, and vanadium;
- RGPZ-9B had exceedances for dissolved and total arsenic and vanadium and total aluminum, chromium, iron, lead, and manganese;
- RGPZ-10B was not analyzed for inorganic compounds;
- RGPZ-11C had exceedances for dissolved and total iron and total aluminum, arsenic, chromium, and lead;
- RGPZ-12C had exceedances for dissolved and total arsenic and dissolved selenium and vanadium;
- RP-1D had exceedances for dissolved and total arsenic and vanadium;
- RP-62B-1 had exceedances for dissolved and total iron, dissolved arsenic and selenium, and total lead;
- RP-62D had exceedances for dissolved arsenic and dissolved and total vanadium;
- RP-63C had exceedances for dissolved and total iron, dissolved arsenic, and total vanadium;
- RP-109D had exceedances for dissolved and total arsenic, iron, and vanadium and dissolved selenium; and
- WP-7D had exceedances for dissolved and total iron, dissolved arsenic, and total vanadium.

During the fifteenth SA event:

- RGPZ-2B had exceedances of the MCL/PRG for dissolved and total arsenic and total iron;
- RGPZ-2C had exceedances for dissolved and total arsenic and total iron;
- RGPZ-2D had exceedances for total aluminum, iron, lead, and vanadium;
- RGPZ-9B had exceedances for dissolved and total arsenic and total aluminum, chromium, iron, lead, and vanadium;
- RGPZ-11C had exceedances for dissolved and total arsenic and iron and total aluminum, chromium, lead, and vanadium;
- RGPZ-12C had exceedances for dissolved and total arsenic and vanadium and dissolved beryllium;
- RGPZ-12D had exceedances for dissolved and total arsenic and total aluminum, iron, and vanadium;
- RP-1D had exceedances for dissolved and total arsenic;
- RP-62B-1 had exceedances for dissolved and total arsenic and total iron and vanadium;
- RP-62D had exceedances for dissolved and total arsenic;
- RP-63C had exceedances for dissolved and total iron, dissolved arsenic, and total vanadium;
- RP-109D had exceedances for dissolved and total arsenic, dissolved selenium, and total iron and vanadium; and
- WP-7D had exceedances for dissolved and total iron and total vanadium.

During Pre-RI SA events:

- MW-25D had exceedances of the MCL/PRG for dissolved and total arsenic during the Summer 2000 SA event;
- MW-27D had exceedances for dissolved and total arsenic during the Summer 2000 SA event;

- RP-41B had exceedances for dissolved and total arsenic and dissolved thallium during the Fall 1999 SA event, and for dissolved and total arsenic during the Summer 2000 SA event; and
- RP-61B did not have any exceedances during the Fall 1999 SA event, but did have exceedances for dissolved and total arsenic during the Summer 2000 SA event.

Cyanide was analyzed in all wells and piezometers during the fourteenth and fifteenth SA events and was detected in RGPZ-9B during the fifteenth SA event at a concentration of 0.0075 mg/L, which was an estimated value. Piezometers RGPZ-2D, RGPZ-9B, and RGPZ-11C contained the highest concentrations of the metals that were detected in this area. Piezometer RGPZ-2D is located in along the North Ridge north of the PCB Landfill, Piezometer RGPZ-9B is located along the North Ridge east of the P/S Landfill, and Piezometer RGPZ-11C is located along the North Ridge between the P/S Landfill and the Metals Landfill south of RGPZ-9B. The dissolved and total metal concentrations are similar with the exception for barium, iron, lead, selenium, and zinc. The dissolved concentrations for barium, selenium, and barium were typically double the total concentrations for these metals during the fourteenth and fifteenth SA events. The dissolved iron and lead concentrations were either not detected or were one to three orders of magnitude lower than the total iron concentrations in several of the sampling locations in the Lower HSU.

#### 3.1.9.2.3 General Minerals and pH

The cation and anion data indicate a general difference between the groundwater chemistry in the Upper and Lower HSU. Groundwater in the Upper HSU along the north perimeter is characterized as a magnesium-sulfate type, while the north drainage is characterized as sodium-chloride type, whereas the Lower HSU is primarily characterized as sodium-sulfate type with areas of sodium-chloride type (Figures G-14 through G-17). The general mineral concentrations for both the Upper HSU and Lower HSU have remained stable over time, which are presented in Attachment G-2. The pH values were generally neutral, ranging from 7.2 to 7.3 in the Upper HSU and ranging from 7.03 to 8.59 in the Lower HSU.

### 3.1.10 Former RCRA Landfill

The former Resource Conservation and Recovery Act (RCRA) Landfill is monitored with two Upper HSU wells and one Lower HSU well. The data for the fourteenth and fifteenth SA events are presented in Table G-19a, and the data for the twenty-first SA event is presented on Table G-19b.

#### 3.1.10.1 Organic Results

##### 3.1.10.1.1 Upper HSU

During the fourteenth SA event:

- RG-10B had an exceedance of the MCL/PRG for 1,2,4-TMB at concentrations of 15.8 µg/L, respectively. Chemical 1,2,4-TMB is a suspect detection which was qualified as a tentatively identified compound; and
- SW-46 had exceedances for bis(2-chloroethyl)ether and n-nitrosopyrrolidine at concentrations of 0.15 µg/L and 0.048 µg/L, respectively.

During the fifteenth SA event:

- RG-10B had exceedances of the MCL/PRG for benzo(a)pyrene, bis(2-ethylhexyl)phthalate, n-nitrosodipropylamine, and OCDD at concentrations of 0.016 µg/L, 5.7 µg/L, 0.18 µg/L, and 9.71 pg/L, respectively. The bis(2-ethylhexyl)phthalate detection is considered suspect because it was found in an associated blank sample; and
- SW-46 had exceedances for n-nitrosodipropylamine and n-nitrosopyrrolidine at concentrations of 0.11 µg/L and 0.049 µg/L, respectively.

Many of the detections and exceedances during the fourteenth and fifteenth SA events were for SVOCs and PAHs. The two Upper HSU RCRA wells have relatively low concentrations of organics. The Upper HSU RCRA wells have maintained low to non-detect concentrations of chlorinated VOCs over time, which are presented in Attachment G-1.

#### 3.1.10.1.2 Lower HSU

During the fourteenth SA event, DB-1 did not have any exceedances. However, during the fifteenth SA event bis(2-ethylhexyl)phthalate, n-nitrosodiethylamine, and n-nitrosodipropylamine exceeded the MCL/PRG at concentrations of 5.1 µg/L, 0.24 µg/L, and 0.21 µg/L, respectively. Bis(2-ethylhexyl)phthalate was found in an associated blank sample and the detection is considered suspect. Many of the detections and exceedances during the fourteenth and fifteenth SA events were for SVOCs and PAHs. Well DB-1 has maintained low to non-detect concentrations of chlorinated VOCs over time, which is presented in Attachment G-1.

#### 3.1.10.2 Inorganic Results

##### 3.1.10.2.1 Upper HSU

During the fourteenth SA event:

- RG-10B had exceedances of the MCL/PRG for dissolved and total arsenic, selenium, and vanadium, and total aluminum, chromium, iron, and nickel. Cyanide (free) was detected during this event but was not an exceedance; and
- SW-46 had exceedances for dissolved and total arsenic, iron, manganese, nickel, selenium, and vanadium.

During the fifteenth SA event:

- RG-10B had exceedances of the MCL/PRG for dissolved and total arsenic and selenium, and total aluminum, chromium, iron, and nickel. Cyanide (free) was analyzed for but was not detected during this event; and
- SW-46 had exceedances for dissolved and total arsenic, iron, manganese, and nickel, selenium, and total vanadium.

The concentrations for both dissolved and total metals were very similar in both wells, with the exceptions of chromium, iron, nickel and selenium in well RG-10B. The dissolved chromium, iron, and nickel were either relatively low concentrations or were not detected compared to the

exceedances for total chromium, iron, and nickel. The dissolved selenium in well RG-10B was higher in concentration than the total selenium,

#### 3.1.10.2.2 Lower HSU

During the both the fourteenth and fifteenth SA event, DB-1 had exceedances of the MCL/PRG for dissolved and total arsenic and total iron. Cyanide was not analyzed for in DB-1.

#### 3.1.10.2.3 General Minerals and pH

The cation and anion data indicate a similarity between the groundwater chemistry in the Upper and Lower HSU in the southern area of the Former RCRA Landfill. Groundwater in both the Upper and Lower HSU in the southern area is characterized as a sodium-chloride type, and RG-10B is characterized as magnesium-sulfate type (Figures G-14 through G-17). The general mineral concentrations for both the Upper HSU and Lower HSU have remained stable over time, which are presented in Attachment G-2. The pH values were generally neutral, ranging from 6.9 to 7.47 in the Upper HSU and ranging from 7.54 to 7.6 in the Lower HSU.

### 3.1.11 Ranch Wells

Ranch Wells WS-1 through WS-4 are located in the Upper HSU. The data for the fourteenth and fifteenth SA events are presented in Table G-20a, and the data for the twenty-first SA event is presented on Table G-20b.

#### 3.1.11.1 Organic Results

During the fourteenth SA event;

- WS-1 had exceedances of the MCL/PRG for 1,2,4-TMB, bis(2-chloroethyl)ether and OCDD at concentrations of 13 µg/L, 0.043 µg/L, and 8.06 pg/L, respectively. Chemical 1,2,4-TMB is a suspect detection which was qualified as a tentatively identified compound;
- WS-2 did not have any exceedances;
- WS-3 had exceedances for 1,2,4-TMB and bis(2-chloroethyl)ether at concentrations of 21 µg/L and 0.032 µg/L; and
- WS-4 had exceedances for bis(2-chloroethyl)ether, PCE, and tetrahydrofuran at concentrations of 0.46 µg/L, 8 µg/L, and 0.021 µg/L, respectively.

During the fifteenth SA event;

- WS-1 had exceedances of the MCL/PRG for bis(2-ethylhexyl)phthalate and n-nitrosodipropylamine at concentrations of 4.8 µg/L and 0.042 µg/L, respectively. The bis(2-ethylhexyl)phthalate detection is considered suspect because it was found in an associated blank sample;
- WS-2 had exceedances for bis(2-ethylhexyl)phthalate and n-nitrosodipropylamine at concentrations of 4.9 µg/L and 0.075 µg/L, respectively. The bis(2-ethylhexyl)phthalate detection is considered suspect because it was found in an associated blank sample;
- WS-3 had an exceedance for OCDD at a concentration of 19.9 pg/L; and
- WS-4 had exceedances for benzo(a)pyrene, bis(2-ethylhexyl)phthalate, and n-nitrosodipropylamine at concentrations of 0.015 µg/L, 5.1 µg/L, and 0.027 µg/L,

respectively. The bis(2-ethylhexyl)phthalate detection is considered suspect because it was found in an associated blank sample.

The Ranch wells are associated with relatively low levels of organics.

### 3.1.11.2 Inorganic Results

During the fourteenth SA event:

- WS-1 had exceedances of the MCL/PRG for dissolved and total arsenic and total iron;
- WS-2 had exceedances for dissolved and total arsenic; and
- WS-3 and WS-4 had exceedances for dissolved arsenic and dissolved and total iron and manganese.

During the fifteenth SA event:

- WS-1 and WS-2 had an exceedance of the MCL/PRG for total arsenic;
- WS-3 had exceedances for dissolved and total arsenic, iron and manganese; and
- WS-4 had exceedances for dissolved and total iron and manganese.

Cyanide was analyzed for, but not detected in any of the Ranch Wells. Groundwater in the Ranch Wells is characterized as a sodium-chloride type, but WS-2 is characterized as calcium-chloride (Figures G-14 and G-16). The pH values were generally neutral, ranging from 6.3 to 7.72.

## **3.2 Radionuclide and Stable Isotope Sampling**

### **3.2.1 Historical Studies**

The age of groundwater is defined as the length of time the water has been isolated from the atmosphere. Measurement of  $^3\text{H}$  and  $^{14}\text{C}$  activity of carbon dissolved in groundwater provides a means of estimating groundwater ages. The relative age of groundwater in the Upper and Lower HSU was previously estimated using  $^3\text{H}$  and  $^{14}\text{C}$  dating techniques. Detailed descriptions of the studies are presented in the Hydrogeologic Site Characterization and Evaluation Report (HSCER; WCC, 1988). These discussions can be found in the HSCER in Section 9.3.3 (pages 9-33 through 9-39). Groundwater velocity calculations, based on the groundwater age dating, are presented in the HSCER in Appendix C.8. A summary of the data presented in the HSCER is included in Figure G-43. Information included on this figure include wells sampled, screen depth, water levels, TDS data and the results of the  $^{14}\text{C}$  and  $^3\text{H}$  testing that was conducted (this data is also presented graphically on Figure G-44).

$^{14}\text{C}$  analysis was completed to provide better resolution of the groundwater age, particularly for the Lower HSU (WCC, 1988). The maximum age estimates range from 2,700 to 5,200 years before present (ybp, "present" equals 1950 A.D), for the Upper HSU and 24,900 to 42,300 ybp for the Lower HSU. Measurements of  $^{14}\text{C}$  indicate that most of the carbon in groundwater was derived from dissolution of carbonate minerals, resulting in an over estimate of the ages. Three models were applied to correct the ages, resulting in values ranging from 0 to 2,700 ybp for the Upper HSU, and 1,670 to 39,600 ybp for the Lower HSU. The range of ages calculated for the Lower HSU suggests that the groundwater in the deepest screened portion of the Lower HSU is not ancient connate seawater, but may be up to 39,600 years old.

Order of magnitude estimates of groundwater velocity were calculated between well pairs in the Lower HSU using the  $^{14}\text{C}$  data. The first pair included RP-1D on the North Ridge above the former RCRA Landfill and RP-4D to the south-southeast, generally between Pond 18 and RCF Pond. The second pair included RP-4D and RP-6D to the south-southeast, south of the PCT-B trench. The groundwater velocity between RP-1D and RP-4D was calculated to be 0.9 feet per year (ft/yr) and the groundwater velocity between RP-4D and RP-6D was calculated to be 0.2 ft/yr (WCC, 1988). Groundwater velocity is discussed in greater detail in Section 2.3.3 of the RI/FS Work Plan.

The  $^3\text{H}$  dating method identifies the presence of  $^3\text{H}$  present in the groundwater as being “pre-bomb,” or “post-bomb,” depending on whether groundwater was isolated before or after 1953 nuclear bomb testing. The Upper HSU results indicate the presence of younger “post-bomb” water. Concentrations of  $^3\text{H}$  precipitation have decreased since the mid-1960s bomb peak, except for some small increases from French and Chinese tests in the late 1970s. The Lower HSU results were near or below the detection limit for  $^3\text{H}$  activity, demonstrating the water in the lower zone is older than 1953 and is “pre-bomb.” Figure G-44 presents existing Site  $^3\text{H}$  data plotted versus depth. This analysis reveals a distinct trend of decreasing  $^3\text{H}$  with depth and demonstrates that deeper groundwater within the Lower HSU may have likely received more recent “post-bomb” source recharge from precipitation. This interpretation seems inconsistent with the results of the  $^{14}\text{C}$  analysis above due to the dilution effect that results from the mixing of a small amount of recharge water with the greater amount older water in the Lower HSU, making it difficult to measure the younger carbons. This interpretation is consistent with the CSC’s analysis of general chemistry presented in semiannual groundwater monitoring reports prepared as part of the RGMEW, beginning with the Groundwater Data Summary Report 1992-2000 where it is discussed that the presence of sulfate suggests that the Lower HSU has likely been affected by the overlying former landfill units and ponds, and as groundwater moves farther downgradient from the facility, it is returning to the sodium-chloride type.

The research and consulting community clearly recognize that  $^{14}\text{C}$  age dating techniques for groundwater produce estimated results that include a certain degree of uncertainty. The following quote from the text book *Physical and Chemical Hydrogeology* (Domenico and Schwartz, 1990) illustrates this point: “In spite of a long history of development,  $^{14}\text{C}$  age dating method is at best a semi-quantitative tool. Confident predictions can be made only when processes affecting the carbon chemistry are absolutely defined - the exception rather than the rule. The hope of collecting a single sample of water and extracting a date seems to have faded in light of the effort required for process identification.” The work summarized in the HSCER text indicates that the data was modeled using three different methods to correct the estimated age. The multiple model corrected age dating approach conducted in 1988 was done using standard accepted practices. The CSC believes that the spatial coverage, and the methods used, associated with work presented in the HSCER is sufficient and appropriate.

### 3.2.2 Current Studies

#### 3.2.2.1 Carbon and Tritium Age Dating

In order to compare the existing data collected during the HSCER scope of work, and as discussed with the EPA, the CSC collected eight groundwater samples (including one duplicate) during the fourteenth SA sampling event, and three samples during the fifteenth SA sampling

event for,  $^{14}\text{C}$ ,  $^{13}\text{C}/^{12}\text{C}$ ,  $^3\text{H}$  analyses. The samples were collected from wells and piezometers RGPZ-2C, RGPZ-2D, RGPZ-15B, RGPZ-16D, RP-62B-1, RP-62D-2, RP-65B, RP-76A, RP-107D, and SW-31. The duplicate sample was collected from Well SW-31. Figure G-45 illustrates the current and historical  $^{14}\text{C}$ ,  $^{13}\text{C}/^{12}\text{C}$ , and  $^3\text{H}$  results collected at the Site dating from the HSCER. Additional information associated with the wells that were sampled is also provided on Figure G-45. Laboratory results are included in Attachment G-4.

Naturally occurring radioactive isotopes provide information on the age of groundwater. The first step in determining this groundwater age is to establish the recharge area using these isotopic fingerprinting methods, and then estimate how long it took for that body of groundwater to travel to its recharge area to the point of measurement. For younger groundwater, the most widely used and reliable method of dating is one that measures the abundance of  $^3\text{H}$  and helium-3 ( $^3\text{He}$ ).  $^3\text{H}$  is a radioactive isotope of hydrogen that decays to  $^3\text{He}$  with a half-life of 12.32 years. It is produced in the upper atmosphere by cosmic radiation, and can replace hydrogen in  $\text{H}^2$ -gas, forming hydrogen ( $^3\text{H}$ ) gas (HT), and in water, forming tritiated water vapor (HTO). The release of excess  $^3\text{H}$  into the atmosphere from nuclear weapons tests conducted between 1952 and 1963 'tagged' rain water, and thereby all surface waters with HTO. This tracer perfectly follows the water in atmospheric, oceanic and hydrological transport and mixing processes. Atmospheric  $^3\text{H}$  concentrations peaked between 1962 and 1965 and most of this excess (i.e., bomb produced)  $^3\text{H}$  was precipitated during the same time period and a few years afterward. Since then the deposition rate has tapered off sharply. Thus the presence of excess  $^3\text{H}$  in the water of an aquifer unequivocally proves that recharge occurs on a time scale of years to decades. The actual  $^3\text{H}$  level, combined with approximate local  $^3\text{H}$  history of precipitation may give more specific information about the make-up of the aquifer. The amount of  $^3\text{He}$  from the decay of  $^3\text{H}$  is then measured along with the amount of  $^3\text{H}$  that still remains in the water. That sum is then equal to the amount of  $^3\text{H}$  that was present at the time of recharge. This method of dating is very accurate for dating groundwater up to forty years old with an accuracy resolution of plus or minus only one year.

The site  $^3\text{H}$  samples were submitted to the Rosenstiel School of Marine and Atmospheric Science, Tritium Laboratory, University of Miami, Miami, Florida.

Well	HSU	Sampling Event	$^3\text{H}$ Units
SW-31 (original)	Fill/Lower	Fourteenth SA/RI	2.80
SW-31 (duplicate)	Fill/Lower	Fourteenth SA/RI	2.73
RP-76A	Alluvium	Fourteenth SA/RI	0.32 (average of duplicate runs)
RGPZ-15B	Lower	Fourteenth SA/RI	0.09
RP-107D	Lower	Fourteenth SA/RI	0.00
RGPZ-2C	Lower	Fourteenth SA/RI	0.01
RGPZ-16D	Lower	Fourteenth SA/RI	0.05
RP-65B	Upper/Lower	Fourteenth SA/RI	0.29 (average of duplicate runs)
RGPZ-2D	Lower	Fifteenth SA/RI	-0.03
RP-62B-1	Lower	Fifteenth SA/RI	0.06
RP-62D-2	Lower	Fifteenth SA/RI	-0.11
Gallery Well	Upper/Lower	Nineteenth SA	226

According to these results, Well SW-31 is producing water most likely formed within the last 35 years, possibly during the late 1960s, whereas all other wells, with the exception of the Gallery Well, produced groundwater samples that predate the atomic bomb, and are therefore considered "old" waters. Previous studies (WCC, 1988) determined that groundwater extracted from wells developed in fill resulted in the largest  $^3\text{H}$  content and that concentrations decreased

with depth. Values for  $^3\text{H}$  in the Upper HSU indicate the presence of some “post-bomb” water, while values from the Lower HSU are an order of magnitude lower than those from the Upper HSU. The samples collected from RGPZ-2D and RP-62D have negative  $^3\text{H}$  unit (TU) values. Per the University of Miami laboratory report, included in Attachment G-4, negative values can occur because the net  $^3\text{H}$  count rate is, in principle, the difference between the count rate of the sample and that of a  $^3\text{H}$ -free sample (background count or blank sample). Given a set of “unknown” samples with no  $^3\text{H}$ , the distribution of net results should become symmetrical around 0 TU. The negative values are reported as such for the benefit of allowing an unbiased statistical treatment of sets of data. This implies that if there is any “post-bomb” water present in the Lower HSU, it has been diluted to the point of being immeasurable.  $^3\text{H}$  levels are commonly elevated in landfill leachate (Hackley et.al, 1996), and therefore, the high  $^3\text{H}$  value observed for the Gallery Well is not unusual. Elevated  $^3\text{H}$  levels in leachate are generally attributed to the disposal of luminescent paints or of self-luminescent exit signs, or dials and gauges within the landfill (Hackley et.al, 1996).

The ages of older groundwater can be determined by measuring the amount of dissolved  $^{14}\text{C}$  in the water.  $^{14}\text{C}$  decays at a rate with a half-life of 5,730 years, considerably larger than that of  $^3\text{H}$ , and provides a useful method of dating water less than 40,000 years old.

The  $^{14}\text{C}$  samples were collected from the same wells/piezometers as the  $^3\text{H}$  samples, and sent to Beta Analytical, Inc. in Miami Florida for analysis. The following are the radiocarbon results for the eleven samples, each of which provided adequate amounts of carbon for accurate measurements:

Well	HSU	Sampling Event	Apparent $^{14}\text{C}$ Age (years BP)	Conventional $^{14}\text{C}$ Age (years BP)	$^{13}\text{C}/^{12}\text{C}$ Ratio (o/oo)
SW-31 (original)	Fill/Lower	Fourteenth SA/RI	9,690 +/- 60	4,800	-11.7
SW-31 (duplicate)	Fill/Lower	Fourteenth SA/RI	9,560 +/- 70	4,700	-11.6
RP-76A	Alluvium	Fourteenth SA/RI	3,850 +/- 40	0	-12.9
RGPZ-15B	Lower	Fourteenth SA/RI	22,510 +/- 160	18,600	-3.2
RP-107D	Lower	Fourteenth SA/RI	33,740 +/- 580	28,300	+2.4
RGPZ-2C	Lower	Fourteenth SA/RI	28,480 +/- 300	23,300	+1.3
RGPZ-16D	Lower	Fourteenth SA/RI	32,150 +/- 460	26,000	-1.4
RP-65B	Upper/Lower	Fourteenth SA/RI	10,930 +/- 60	7,300	-3.2
RGPZ-2D	Lower	Fifteenth SA/RI	32,400 +/- 390	27,300	-0.10
RP-62B-1	Lower	Fifteenth SA/RI	23,650 +/- 240	19,500	2.8
RP-62D	Lower	Fifteenth SA/RI	28,510 +/- 130	23,600	0.20
Gallery Well	Upper/Lower	Nineteenth SA	354.8 +/- 1.3	128	+7.48

Note: Before Present (BP); o/oo is per mil or parts per thousand

These analyses were performed on the dissolved inorganic carbon (DIC) within the submitted waters, with results reported Apparent Radiocarbon Age and corrected to the Conventional Radiocarbon Age using the chemistry-based Tamer's model. According to these  $^{14}\text{C}$  results, all groundwater samples considerably predate the atomic bomb. The results are consistent with the previous studies (WCC, 1988) which measured some  $^{14}\text{C}$  activity in all groundwater samples collected and determined that groundwater in the Lower HSU beneath the Site is most likely thousands of years old, but less than 40,000 years old, with ages ranging from 0 to 36,000 years BP.

In addition, the  $^{13}\text{C}/^{12}\text{C}$  results are consistent with previous results indicating that much of the carbon present in groundwater beneath the site is derived from dissolution of aquifer minerals, with the exception of the anomalous results from the Gallery Well. Like the  $^3\text{H}$  results discussed above, landfill leachate typically has a unique isotopic signature relative to nearby groundwater. Leachate from a mature landfill is typically enriched in the heavier  $^{13}\text{C}$  isotope as a result of biodegradation and the process of methanogenesis.  $^{14}\text{C}$  activity is also frequently elevated in landfill leachate, and the younger calculated age is likely a result of the decomposition of modern (synthetic) organic matter disposed of within the landfill.

### 3.2.2.2 Nitrate Isotope Analyses

$^{15}\text{N}/^{14}\text{N}$  and oxygen-18/oxygen-16 ( $^{18}\text{O}/^{16}\text{O}$ ) ratios of dissolved nitrate were analyzed in an attempt to identify the recharge area(s) of groundwater in the Gallery Well. Samples were collected from SW-44 in the Upper HSU of the BTA, RP-68C-2 in the Lower HSU between the PCB and P/S Landfills, and the Gallery Well. In theory, groundwater from different areas should contain unique isotopic signatures as a result of fractionation due to local microbial activity and other factors. The signature observed in the Gallery Well could then be compared to the potential source areas. However, the isotopic ratios within the sample collected from the Gallery Well could not be determined due to a low nitrate concentration and, therefore, comparisons to other samples could not be made. Laboratory results are included in Attachment G-4. The isotope results for SW-44 and RP-68C-2 were as follows:

Well	Sampling Event	$^{15}\text{N}/^{14}\text{N}$ Results
SW-44	Nineteenth SA	Delta N-15 of dissolved nitrate: 24.5
SW-44	Nineteenth SA	Delta O-18 of dissolved nitrate: 22.5
RP-68C-2	Nineteenth SA	Delta N-15 of dissolved nitrate: 12.9
RP-68C-2	Nineteenth SA	Delta O-18 of dissolved nitrate: 31.5
Gallery Well	Nineteenth SA	Delta N-15 of dissolved nitrate: NA
Gallery Well	Nineteenth SA	Delta O-18 of dissolved nitrate: NA

### 3.3 NAPL Evaluation

Contaminants have been observed at the Site as a separate phase (NAPL) as well as in the dissolved phase. The NAPL contaminants occur as fluids that are more dense than water (DNAPL) which sink in groundwater, or fluids that are less dense than water (LNAPL) which float on groundwater. The historical presence of NAPL was documented and evaluated as a part of the RI/FS Work Plan (CSC, 2004b) and additional NAPL investigations were performed as a part of 2004 RI activities as summarized in the Interim Progress Report (IPR; CSC, 2005) and during the Fall 2006. NAPL is presently known to occur in the area from the middle of the P/S Landfill to extraction sump PSCT-1. Table F-6 lists NAPL and water level data from October 1997 through March 2009.

During the Summer 2001, a CPT investigation was conducted within the P/S Landfill and near the P/S Landfill Clay Barrier. The objective of this investigation was to evaluate the potential presence of a "low area" within the base of the landfill and to monitor for the presence of DNAPL within that "low area". A "low area" was not identified during the investigation. Piezometer PZ-LA-01 was installed to the base of the P/S Landfill; no DNAPL was observed in the piezometer. The results of this investigation were presented in the *Report of Findings, Pesticide/Solvent*

*Landfill Low Area and Gallery Well/Clay Barrier Investigation (Harding ESE, 2001b)*. In addition, during these activities, a well was installed next to Sump 9B to monitor for DNAPL. This well was screened down to the weathered/unweathered claystone contact. This investigation was discussed in the report titled *Summary Report for Sump 9B Work Plan* dated October 4, 2001 (*Harding ESE, 2001a*). Piezometer installation activities conducted during the Summer of 2000 included installation of nested piezometers between Sump 9B and the Road Sump. NAPL was subsequently observed in Lower HSU Piezometers RGPZ-7C and RGPZ-7D.

During Fall 2006, an additional CPT investigation was conducted within the P/S Landfill and within the BTA. The objective of this investigation was to evaluate liquid levels within the P/S Landfill and to delineate the contamination in the BTA Area. One additional piezometer was installed in the middle of the P/S Landfill, two piezometers were installed in the BTA Area in the Lower HSU, and two monitoring wells were installed in the Upper HSU adjacent to the BTA Area. The results of the investigation are discussed in Section G3.1 and discussed below.

During the Summer of 2007, four additional piezometers were installed within the P/S Landfill. The objective of this investigation was to evaluate liquid levels and the presence of DNAPL within the P/S Landfill.

### 3.3.1 NAPL Chemistry and Physical Properties

During the RI groundwater chemistry investigation, the CSC collected and analyzed samples of LNAPL and DNAPL present in site wells for chemical composition and physical properties. LNAPL samples were collected from three locations: the Gallery Well, Gallery Well piezometer GW-PZ-W, and Sump 9B piezometer Sump 9B-PB. DNAPL samples were collected from three locations: the Gallery Well, Piezometer RGPZ-7C, and Piezometer RGPZ-7D. The NAPL samples were analyzed for physical properties including density, viscosity, and LNAPL/DNAPL-water interfacial tension. The physical properties of these samples are documented in Appendix F. The NAPL samples were also analyzed for VOCs, SVOCs, PCBs, PAHs, herbicides, pesticides, metals, and cyanide. Table G-21 presents the detected concentrations of compounds in the Appendix IX list for LNAPL and DNAPL samples collected during December 2004. The NAPL results for physical testing, including density, flash point, and specific gravity are also presented. Due to the high numbers of Appendix IX compounds detected during this phase of sampling, only the most prevalent ones will be discussed in the text of this report; however, all detections are presented in Table G-21. Figures G-46 through G-57 show the LNAPL and DNAPL chemistry of each location. Figures G-58 through G-63 compares the Gallery Well, GW-PZ-W, and SUMP 9B-PZ-B LNAPL concentrations, and Figures G-64 through G-69 compares the Gallery Well, RGPZ-7C, and RGPZ-7D DNAPL concentrations.

Elevated concentrations of many Appendix IX compounds were detected during discreet interval NAPL sampling conducted on December 15 and 16, 2004. The composition of each LNAPL and DNAPL sample is a mixture of cosolvated, primarily organic compounds including VOCs, with lesser concentrations of SVOCs, PAHs, herbicides, and a few metals. On a mass basis, the Gallery Well LNAPL composition is approximately 44 percent VOCs, 5.5 percent SVOCs, and 0.5 percent PAHs, herbicides, and metals, while the Gallery Well DNAPL composition is approximately 38 percent VOCs, 5 percent SVOCs, and 0.5 percent PAHs, herbicides, and metals.

The total concentration of nine VOCs, consisting of total xylenes, PCE, toluene, methylene chloride, ethylbenzene, 1,1,1-trichloroethane (1,1,1-TCA), Freon 113, and TCE, were present in LNAPL samples collected from the Gallery Well and piezometers GW-PZ-W and 9B-PZ-B at approximately 34 percent, 22.3 percent, and 25.6 percent, respectively. The total concentration of the nine VOCs present in DNAPL samples collected from the Gallery well and piezometers RGPZ-7C and RGPZ-7D at approximately 40 percent, 27.46 percent, and 1.05 percent, respectively.

The percentage of the above mentioned nine compounds detected within the LNAPL samples collected from the Gallery Well, and piezometers GW-PZ-W and 9B-PZ-B, during December 2004 are as follows:

- Total xylenes were present at percentages of 9.1, 6.1, and 7.7 percent, respectively;
- PCE was present at percentages of 6.8, 3.9, and 5.3 percent, respectively;
- Toluene was present at percentages of 3.8, 3.8, and 4.2 percent, respectively;
- Methylene chloride was present at percentages of 2.5, 1.9, and 0.6 percent, respectively;
- Ethylbenzene was present at percentages of 2.5, 1.7, and 2 percent, respectively;
- 1,1,1-TCA was present at percentages of 4.4, 2.6, and 2.5 percent, respectively;
- Freon 113 was present at percentages of 3, 1.5, and 2.1 percent, respectively;
- TCE was present at percentages of 1, 0.4, and 0.9 percent, respectively; and
- Chloroform was present at percentages of 0.9, 0.4, and 0.3 percent, respectively.

The percentage of the above mentioned nine compounds detected within the DNAPL samples collected from the Gallery Well, and piezometers RGPZ-7C and RGPZ-7D, during December 2004 are as follows:

- Total xylenes were present at percentages of 6.6, 9.4, and 0.5 percent, respectively;
- PCE was present at percentages of 12, 12, and 0.4 percent, respectively;
- Toluene was present at percentages of 4.7, 1.8, and 0.005 percent, respectively;
- Methylene chloride was present at percentages of 3.4, 0.02, and 0.002 percent, respectively;
- Ethylbenzene was present at percentages of 3.1, 2.1, and 0.1 percent, respectively;
- 1,1,1-TCA was present at percentages of 4.3 and 0.004 percent for the Gallery Well and piezometer RGPZ-7C; 1,1,1-TCA was below the reporting limit in piezometer RGPZ-7D;
- Freon 113 was present at percentages of 2.4 and 1.8 percent for the Gallery Well and piezometer RGPZ-7C; Freon 113 was below the reporting limit in piezometer RGPZ-7D;
- TCE was present at percentages of 2.1 and 0.3 percent for the Gallery Well and piezometer RGPZ-7C; TCE was below the reporting limit in piezometer RGPZ-7D; and
- Chloroform was present at percentage of 1.4 percent in the Gallery Well. Chloroform was below the reporting limit for piezometers RGPZ-7C and RGPZ-7D.

Both the LNAPL and DNAPL present in wells contain numerous VOCs and SVOCs. The DNAPL samples collected from the Gallery Well and RGPZ-7C and RGPZ-7D appear to contain similar ratios of PCE, TCE, xylenes, and toluene, but have different concentrations of other marker constituents. It is reasonable to assume that the DNAPL in the Gallery Well is a mixture of DNAPL chemicals that were disposed of directly into the P/S Landfill. The wastes placed in drums in the P/S Landfill reportedly contained chemical mixtures in addition to single-compound spent solvents or other wastes.

The DNAPL found in RGPZ-7C/D may have migrated from the P/S Landfill wastes or from wastes placed in ponds and pads in the Central Drainage Area. The relative “age” of the DNAPL in the three locations must also be considered in comparing the chemical fingerprints. While the DNAPL in the Gallery Well may be a blend of historically released chemicals and newly released chemicals, the depths at which DNAPL was found in RGPZ-7C/D might suggest that the DNAPL is associated with an older release. Further, the chemical composition of the DNAPL found at depth may have been altered or degraded during migration. Based on these analyses, the CSC cannot comment with any certainty about the exact location of source material for the DNAPL found in RGPZ-7C/D.

### 3.3.1.1 Physical Testing

Physical testing, consisting of density, using test method D4052, flash point, using method D93, and specific gravity, using method D-4052, was performed for DNAPL and LNAPL samples collected from the Gallery Well, and DNAPL collected from piezometer RGPZ-7C. The results for physical testing for LNAPL and DNAPL collected from the Gallery Well, and DNAPL collected from piezometer RGPZ-7C were as follows:

- Density was detected at 0.9905, 1.0851, and 1.0184 grams per cubic centimeter, respectively;
- Specific gravity was detected at 0.9914, 1.0863, and 1.0194, respectively; and
- Flash point was detected at 38, 31, and 27 degrees Fahrenheit (°F), respectively.

### 3.3.2 **Groundwater Concentrations**

Between 1997 and 2007, the CSC collected extensive groundwater chemistry data as a part of the RGMEW and RI. The CSC used the RGMEW and RI groundwater chemistry data to assess areas of the site that have the potential to contain NAPL. The CSC developed isoconcentration contour maps for several key site COCs to illustrate the distribution of COCs in groundwater and NAPL-related compounds. The CSC also compared dissolved concentrations of the COCs with aqueous solubilities of the chemicals to identify areas potentially impacted by LNAPL and DNAPL. The CSC prepared isoconcentration maps for the following COCs:

- PCE;
- TCE;
- cis-1,2-DCE;
- VC;
- Benzene;
- Total Volatile Organics;
- Arsenic; and
- Nickel.

Although the site NAPLs and groundwater contain many different chemicals, the CSC selected the above COCs for mapping as these compounds are present as both NAPL and dissolved compounds within groundwater, have been detected in the greatest number of wells at relatively high concentrations, and have relatively low drinking water standards (such as MCLs). The chlorinated hydrocarbons PCE, TCE, cis-1,2-DCE, and VC also represent a reductive dechlorination degradation chain. The CSC is currently evaluating the spatial and temporal trends of these chlorinated solvents to further assess natural attenuation processes at the site

as discussed in Appendix O. The isoconcentration maps are part of the developing conceptual site model needed to assess data adequacy and to plan site groundwater remediation.

The following sections of the text discuss the distributions of COCs in Upper and Lower HSU, and the results of the CSC's NAPL solubility analyses.

### 3.3.2.1 Upper HSU Groundwater Concentrations

The concentration contour maps for the five COCs listed above and total VOCs are included as Figures G-22 through G-28 and include side-by-side results of the two RI sampling events, along with the most recent two previous sampling results of other site wells not sampled as a part of the RI. Concentration contour values include a non-detect contour, the MCL concentration, and 1 percent of the solubility concentration, taken to be an indicator of potential NAPL presence in the area of a monitoring point. Where applicable, the figures also show 10 percent of solubility concentration contours (note that for the chemicals shown, PCE is the only chemical exceeding 10 percent of its solubility concentration). A concentration contour map for total VOCs is included as Figures G-27 and G-28 and includes side-by-side results of the two RI sampling events, along with the most recent two previous sampling results of other Site wells not sampled as a part of the RI. The total VOCs Figures G-27 and G-28 also include time concentration graphs for each well.

#### 3.3.2.1.1 *Upper HSU – NAPL Area*

As illustrated on Figures G-22 through G-28, Upper HSU groundwater concentrations in the Central Drainage Area are high in the areas known to contain NAPLs. Dissolved concentrations of PCE greater than 10,000 µg/L were detected in the area between the Gallery Well and RG-3B, just north of PSCT-1 (see Figure G-23). PCE concentrations greater than 1 percent of aqueous solubility (or 2,060 µg/L) were detected in six of these wells. PCE concentrations greater than 10 percent of aqueous solubility (or 20,600 µg/L) were detected in four of these wells. TCE in the Central Drainage Area of the Upper HSU (see Figure G-24) was present at slightly lower concentrations, although TCE concentrations exceeded 1 percent of aqueous solubility (12,800 µg/L) in three Central Drainage Area wells. Cis-1,2-DCE in the Upper HSU Central Drainage Area (see Figure G-25) was detected at lower concentrations, although the highest concentration (14,000 µg/L) was detected in well RG-3B north of PSCT-1. Cis-1,2-DCE was not detected in the Central Drainage Area exceeding its 1 percent of aqueous solubility. VC concentrations in the Central Drainage Area of the Upper HSU (see Figure G-26) also did not exceed 1 percent of aqueous solubility, and the highest VC concentration (7,200 µg/L) was detected in Well RG-3B north of PSCT-1.

In the BTA, high concentrations of several COCs were detected in wells RIMW-7, RIMW-8, SW-17, and in PSCT-4. Aqueous concentrations of PCE and TCE exceeding 1 percent of solubility were detected in wells RIMW-7 and RIMW-8. However, concentrations of PCE and TCE were much lower in RIMW-8 as compared with RIMW-7, and VC was not detected in the samples from RIMW-8.

#### 3.3.2.1.2 *Upper HSU – Dissolved-phase Plume*

Upper HSU concentrations are generally much lower in areas south of the PSCT than north of the PSCT. As illustrated on Figures G-22 through G-26, concentrations of each of the five COCs mapped exceed MCLs in the Upper HSU south of PSCT-1 and PSCT-4. South of

PSCT-1, PCE and TCE concentrations of around 100 µg/L were detected in RIMW-2, while TCE concentrations exceeded 1,000 µg/L in Well RG-3B south of PSCT-4. The maximum concentration of cis-1,2-DCE south of the PSCT was 260 µg/L in Well RG-6B. VC concentrations south of the PSCT were lower; the maximum VC concentration in this area was 41 µg/L in Well RG-6B. Benzene concentrations were relatively low south of the PSCT, and samples from only a few wells in this area exceeded the MCL for benzene. No dissolved concentrations exceeding 1 percent of solubility were detected south of the PSCT.

As shown in Figures G-27 and G-28, concentration contours for total VOCs in the Upper HSU follow the same pattern as the individual chemical isoconcentration maps, with the highest concentration within the Central Drainage Area and generally much lower concentrations in areas south of the PSCT.

### 3.3.2.2 Lower HSU Groundwater Concentrations

As illustrated on Figures G-29 through G-34, dissolved COCs were detected in the Lower HSU in four localized areas: in the Central Drainage Area at piezometer RGPZ-6D; at the toe of the Acids Landfill in Well RP-98C (pre-RI sample); in the BTA in piezometer RIPZ-16; and at low concentrations in Lower HSU piezometers RGPZ-14D and RGPZ-16D, near PSCT-3.

The highest chemical concentrations in the Lower HSU were detected in the Central Drainage Area at well RGPZ-6D, where both PCE and TCE concentrations exceeded 1,000 µg/L. However, RIPZ-16, which is located in the BTA, has cis-1,2-DCE concentrations exceeding 1,000 µg/L. PCE concentrations in RGPZ-6D approached but did not exceed 1 percent of aqueous solubility. Concentrations of xylene, present in both the LNAPL and DNAPL samples, exceeded 1 percent of aqueous solubility in RGPZ-6D. Because DNAPL has been gauged in nearby piezometers RGPZ-7C and RGPZ-7D, it is likely that the Lower HSU area between RGPZ-6D and RGPZ-7D is impacted by DNAPL.

COCs have also been detected in Lower HSU well RP-98C, near the Acids Landfill. This well was sampled four times as a part of the RGMEW between 1997 and 2000, and was subsequently dropped from the sampling program. As illustrated on Figures G-29 through G-33, COC concentrations in this well ranged from 5.2 to 63 µg/L. Chemicals were not detected in a sample from Lower HSU well RP-95D, located north of the Acids Landfill, or in Lower HSU wells south of the PSCT. Well RP-98C is completed in the Lower HSU but is essentially a water table well screened between 50 and 60 feet bgs. Depth to the HSU contact in this well is 38 feet bgs, while depth to water in the well during 2005 was around 53 feet bgs. Thus chemicals detected in this well are not considered indicative of either NAPL presence or deep dissolved Lower HSU contamination.

Near PSCT-3, Lower HSU piezometers RGPZ-14D and RGPZ-16D, sampled as a part of the RI, contained very low VOC concentrations (Figures G-29 through G-33). VC was the only VOC detected in RGPZ-16D (at 4.3 and 3.0 µg/L), PCE was not detected in either well, and TCE, cis-1,2-DCE, and VC were detected in RGPZ-14 at a maximum concentration of 5.5 µg/L. These low concentrations are not considered indicative of DNAPL presence in this area.

As shown in Figure G-34, concentration contours for total VOCs in the Lower HSU follow the same pattern as the individual chemical isoconcentration maps, with the highest concentration within the Central Drainage Area. However, high concentrations of total VOCs were also

detected in piezometer RGPZ-2D in the North Drainage north of the PCB Landfill and in RGPZ-12C along the North Drainage north of the Caustic/Cyanide Landfill.

### 3.3.2.3 Groundwater Concentrations Relative to Aqueous Solubility

The CSC compared concentrations of known site NAPL COCs with each chemical's aqueous solubility to determine if dissolved chemical concentrations greater than 1 percent and 10 percent of their solubility concentration are present in site groundwater. Dissolved concentrations greater than 1 percent or 10 percent of NAPL compounds solubilities are often an indicator of NAPL presence (USEPA, 2004). The solubilities used in this analysis were compiled from the Risk Assessment Information System ([www.risk.lsd.ornl.gov](http://www.risk.lsd.ornl.gov)) (United States Department of Energy [USDOE], 2006).

As described in an EPA publication (USEPA, 1992), for DNAPLs comprising a mixture of chemicals, the "effective solubility" should be calculated for comparison to groundwater concentrations. The effective solubility is the theoretical aqueous solubility of an organic constituent in groundwater that is in chemical equilibrium with a mixed DNAPL (a DNAPL containing several organic chemicals). The effective solubility of a particular organic chemical can be estimated by multiplying its mole fraction in the DNAPL mixture (obtained via analysis of the DNAPL sample or estimated from waste characterization data) by its pure-phase solubility. For example, if a laboratory analysis indicates that the mole fraction of TCE in DNAPL is 10 percent, then the effective solubility would be 110 milligrams per liter (mg/L) [pure-phase solubility of TCE, multiplied by the mole fraction of TCE  $(1,100 \text{ mg/L}) \times (0.10) = 110 \text{ mg/L}$ ].

The use of this approach at the Site is problematic because the number of chemicals detected in site DNAPL is large (the Gallery Well DNAPL contained over 40 different VOCs). Using this approach, the calculated effective solubilities of any individual constituent are significantly lower than the pure-phase aqueous solubilities. For example, the mole fraction of TCE in the Gallery Well DNAPL was approximately 3 percent, which results in an effective solubility of 31 mg/L [ $(1,100 \text{ mg/L}) \times (0.03) = 31 \text{ mg/L}$ ]. As discussed below, it is likely not appropriate to employ the 1 percent "rule of thumb" for inferring the presence of a DNAPL phase based on this calculated effective solubility. The CSC has documented that numerous wells at the site containing concentrations of constituents greater than 1 percent of these calculated effective solubilities do not contain DNAPLs. Feenstra and Cherry (1996) noted that use of a 1 percent "rule of thumb" in any assessment of the spatial distribution of DNAPL zones must be performed cautiously, particularly in the downgradient direction, as the dissolved plume emitted by the DNAPL could migrate a substantial distance from the source zone. The CSC has found that the 1 percent "rule of thumb" is generally consistent when comparing dissolved-phase chemical concentrations with pure-phase aqueous solubilities, rather than effective solubilities (i.e., DNAPL observations in wells are generally found in locations where the dissolved chemistry exhibits concentrations greater than 1 percent of the pure-phase solubilities).

The CSC compared COC concentrations to aqueous solubilities of the following chemicals: 1,1-DCA, 1,1,1-TCA, 1,2-dichlorobenzene (1,2-DCB), 1,2,4-TMB, benzene, carbon tetrachloride, chloroform, ethylbenzene, Freon 113, methylene chloride, MEK, methyl isobutyl ketone (MIBK), n-Nitrosopyrrolidine, PCE, toluene, TCE, VC, and xylenes (see Table G-22). These chemicals were chosen because they were detected at the highest concentrations in the speciation analysis of the NAPL collected from Gallery Well, GW-P(W), SUMP 9B-PB, RGPZ-7C, and RGPZ-7D. The aromatics (i.e., BETX) were evaluated as LNAPLs, while the chlorinated solvents were considered DNAPL, although both types of organic compounds were

detected in the LNAPL and DNAPL samples (see Section 2.4). The site wells and piezometers that are known to contain NAPL or are potentially impacted by NAPL (based on dissolved chemical concentrations) are listed in Table G-22 and shown on Figures G-70 through G-72.

For the Fall 2004 and Spring 2005 RI sampling events, ethylbenzene, toluene, and xylenes were detected in the groundwater samples at concentrations greater than 1 percent and 10 percent of their aqueous solubilities (see Table G-22). The dissolved concentrations greater than 1 percent and 10 percent of the aqueous solubility for the Upper HSU are primarily located in the Central Drainage Area between the Gallery Well and PSCT-1 (see Figure G-70). However, dissolved concentrations of LNAPL greater than 1 percent and 10 percent of the aqueous solubility for these two sampling events have not been detected in PSCT-1 or in any sampling locations south of the PSCT. In the BTA, RIMW-7 had dissolved concentrations of xylenes greater than 1 percent of the aqueous solubility (see Figure G-70). Lower HSU Piezometer RGPZ-6D, had dissolved concentrations of xylenes greater than 1 percent of the aqueous solubility (see Figure G-72).

For the chlorinated VOCs, 1,1,1-TCA, 1,2-DCB, 1,2,4-TMB, Freon 113, methylene chloride, MIBK, PCE, and TCE were detected at dissolved concentrations greater than 1 percent of the aqueous solubility, and 1,2-DCB, 1,2,4-TMB, and PCE were detected at dissolved concentrations greater than 10 percent of the aqueous solubility (see Table 2.3-1). Dissolved concentrations greater than 1 percent of the aqueous solubility in the Upper HSU were primarily located in the Central Drainage Area. One well at the toe of the Metals Landfill (WP-8S) and one at the toe of the Caustic/Cyanide Landfill (RG-9B) had detections of Freon 113 greater than 1 percent of the aqueous solubility, although concentrations of other COCs including PCE, TCE, cis-1,2-DCE, and VC were much lower in these wells. Wells RIMW-7 and RIMW-8, which are located downgradient of the burial trenches, have detections of Freon 113, PCE, and TCE greater than 1 percent solubility (see Figure G-71). RIMW-8 had dissolved concentrations of Freon 113 greater than 10 percent of the aqueous solubility.

### **3.3.3 NAPL Presence**

The CSC has detected LNAPL and DNAPL in the Central Drainage Area of the site. Currently, LNAPL is present as a separate phase in 16 Upper HSU wells and piezometers in an area from the Gallery Well at the toe of the P/S Landfill to just north of PSCT-1. DNAPL is present in P/S Landfill piezometer RIPZ-13, installed in August 2007, the Upper HSU Gallery Well, and in two Lower HSU piezometers between the P/S Landfill and PSCT-1. LNAPL and DNAPL depths and thicknesses are routinely measured in these wells and piezometers, and a summary of historical NAPL levels is presented in Appendix F.

To date, neither LNAPL nor DNAPL has been measured as a separate phase in any other site wells or piezometers, with the exception of well RG-3B, and piezometers RIPZ-27 and RIPZ-39, which have intermittently contained LNAPL. NAPL has not been detected in the recently installed RI wells and piezometers in the BTA (although observations during drilling may suggest NAPL in this area), or in other site wells and piezometers near and downgradient of the other site landfills. As described in Section G3.3.2.3, groundwater samples from some monitoring wells in the Central Drainage Area that do contain separate-phase NAPL also have relatively high concentrations of dissolved LNAPL and DNAPL constituents. Relatively high concentrations may indicate the presence of LNAPL or DNAPL near these wells, and the CSC reviewed the aqueous groundwater chemistry as evidence of NAPL presence (see Section G3.3.2.3). The CSC also reviewed the RI drilling investigation data with respect to

NAPL observations in core samples. All of these lines of evidence were evaluated to delineate the likely lateral and vertical extent of NAPL. Table G-23 summarizes this information with respect to potential NAPL locations at the site. Figures G-70 through G-72 show the locations of known or inferred NAPLs in the Upper and Lower HSU, respectively. Based on these data, discrete site areas potentially impacted by NAPL have been identified, as discussed below.

### 3.3.3.1 Central Drainage Area

The Upper HSU locations in the Central Drainage Area where LNAPL and DNAPL have been observed or inferred generally coincide with a historical site drainage that ran along the length of the P/S Landfill and continued into the area that is now the RCF Pond (see Figure G-70). A brief discussion of potential NAPL sources (based on information contained in the *RI/FS Work Plan* – specifically Sections 2.4 through 2.8, Tables 2-14 through 2-18, and Figure 2-48) follows.

The potential source(s) of NAPLs in the Central Drainage Area include:

- The P/S Landfill, where large quantities of pesticides and solvents were disposed of from 1979 through 1989. As described in Section 2.4 of the *RI/FS Work Plan*, waste disposal in the P/S Landfill began at the toe of an existing canyon (or surface drainage), and waste placement continued to the north. The landfill is unlined and the landfill operators excavated Upper HSU and alluvial deposits to the approximate contact with the Lower HSU claystone to create landfill volume. As shown on Figure G-71, a former surface water drainage feature ran the entire length of the P/S Landfill;
- Former ponds and pads in the NAPL area downgradient of the P/S Landfill. These include Pond R and Pads 9A and 9B, which were all designated as “Landfill Runoff/Leachate Control” units. Pond R held liquids from 1977 through 1987 and Pads 9A and 9B contained liquids from 1985 through 1987. Note that Pond 7 (which held waste liquids from 1979 through 1984) was converted into Pads 9A and 9B in 1985. Neither Pond R nor Pads 9A and 9B were completely closed during pond closure activities and these three units were recommended for landfill closure; and
- Former ponds (Ponds 6 and 19) just west of the NAPL area, which held site runoff and other liquids from about 1980 through 1987. These ponds are considered possible NAPL sources because (1) they were designated to receive landfill runoff or leachate, (2) they are located along former site drainages where NAPL may more easily migrate, and (3) they were not completely closed during pond closure activities. Notations made during closure of Pond 6 indicated that the western third of the pond was possibly impacted by leachate from the P/S Landfill. Pond 19 was recommended for closure, with the exception of the south dike and adjacent fill materials. The western third of Pond 6 and the southern portion of Pond 19 were recommended for closure as landfills.

#### 3.3.3.1.1 *Central Drainage Area LNAPL*

LNAPL is currently detected in the following Upper HSU Central Drainage Area wells:

- P/S Landfill piezometers RIPZ-13 and RIPZ-14;
- Gallery Well, and adjacent piezometers GW-PZ-W, GWPZ-E1, GW-PZ-E2, GW-PZ-E3, RIPZ-23, and RIPZ-24 (these wells are all located at the toe of the P/S Landfill); and
- Sump 9B piezometers Sump 9B-PB, Sump 9B-PC, Sump 9B-CW, and RIPZ-25 (all located in the former Pad 9B area).
- RGPZ-5B, RIMW-3, RIPZ-8, and RIPZ-31.

The locations of these wells and piezometers are identified on Appendix F Figure F-33. Historically, small amounts (less than 0.1 foot) of LNAPL were observed in RG-3B (in the former Pad 9A area), but LNAPL is currently not observed in this well. Note that LNAPL has not been observed in piezometer RIPZ-26 (former Pad 9A). The CSC identified possible LNAPL in soil core samples obtained from RIPZ-26 and from groundwater samples collected from RGPZ-6B.

Based on the LNAPL elevation monitoring, dissolved chemistry analyses, and sample observations, the LNAPL zone in the Central Drainage Area likely extends from the Gallery Well to a location near RG-3B, approximately 200 feet north of PSCT-1 (Figure G-70). The extent of the LNAPL zone does not imply that the LNAPL is contiguous throughout this area; LNAPL is probably located in discrete zones as influenced by available flow paths and soil properties. The lateral extent of the LNAPL zone may be 300 to 400 feet wide from near piezometer RIPZ-8 to near RIPZ-5B (Figure G-70) and possibly narrows to the south.

#### 3.3.3.1.2 Central Drainage Area DNAPL

DNAPL is currently detected in the following Central Drainage Area wells:

- P/S Landfill piezometer RIPZ-13;
- Gallery Well (Upper HSU);
- RG-PZ-7C (Lower HSU); and
- RG-PZ-7D (Lower HSU).

The thickness of DNAPL in the Gallery Well was monitored during a series of four “recovery tests” performed between August 2004 and October 2005. These data were documented in a series of memoranda provided to EPA (MACTEC, 2003, 2004a,b,c,d, and 2005b). Thickness of DNAPL during pumping and non-pumping conditions ranged from less than 1 foot to around 3 feet. Note that during 2004 and 2005, the CSC extracted DNAPL from the Gallery Well at an estimated rate of around 10 gallons per day.

In the Lower HSU, the CSC measured DNAPL thickness in RGPZ-7C and RGPZ-7D during 2005 of approximately 10 feet and 1 foot, respectively. Based on the dissolved chemistry analyses presented in Section 2.3, the extent of the Lower HSU DNAPL zone in the Central Drainage Area may include the area around piezometer RGPZ-6D (see Figure G-72). As with the Upper HSU, additional Lower HSU DNAPL is possible, considering the fractured nature of the claystone matrix.

#### 3.3.3.2 BTA

Neither LNAPL nor DNAPL have been directly measured in the BTA, but NAPL may be present based on observations made during drilling and groundwater sampling, and the dissolved chemistry analyses. At RIMW-7, LNAPL was inferred during drilling and DNAPL could be present based on the dissolved-phase chemistry analysis. Only one DNAPL compound (Freon 113) was noted as a possible DNAPL indicator in the Upper HSU at RIMW-8. Because only one compound exceeded 10 percent of its solubility at that location, the likelihood of DNAPL there is low (the CSC would expect more chemicals indicating DNAPL). As described in Section 4, the CSC collected additional data in the Lower HSU (at RIPZ-15 and -16) to assess the presence of NAPLs in this area.

The former burial trenches themselves are the most likely source of any potential NAPLs in this area. Seven trenches (approximately 15 feet deep) were sequentially excavated into the subsurface and wastes were placed in the trenches from 1974 to 1979 before the landfills were constructed. Waste disposal in that area also included disposal into 11 injection wells (approximately 30 to 40 feet deep) that operated from 1978 to 1982 (records indicate that one well was reportedly never placed into service). The trenches reportedly received between 6,000 and 80,000 pounds of waste and approximately 1.3 million pounds of waste were disposed via injection wells.

Pond 23 (located over the former burial trenches) was constructed in 1984 to provide runoff control in the area and the pond held liquids until 1987. Although the pond was designated as an alternate alkaline pond (or designated to receive bulk liquid wastes), it is uncertain if the pond was used for those purposes. Based on the waste disposal history, it appears that the most significant sources of potential NAPLs in the BTA are the trenches and injection wells.

### 3.3.3.3 Other Site Areas

NAPLs have not been detected in any site wells or piezometers beyond those noted in the Central Drainage Area. Also, the results of the UVIF/MIP work completed across the site (targeted at former ponds where NAPL constituents may have been disposed of, and along the former site drainages) indicated only one potential NAPL location at the southern perimeter of the site. The CSC completed additional investigations in this RISBON-59 area including installation and sampling of RIPZ-37 and RIHP-7.

Although Figure G-71 indicates potential DNAPL (based on dissolved concentrations) at the toe of the Metals and Caustics/Cyanides Landfills, the CSC does not consider these locations to contain potential NAPL. Only one chemical (Freon 113) exceeded 1 percent solubility in both of these locations and dissolved concentrations of other NAPL-indicator VOCs were much lower.

## **3.4 Groundwater Chemistry Summary**

Groundwater contamination is predominantly located within the Zone 1 Site boundary; sporadic, low level contamination occurs within Zone 2. In the Upper HSU, VOC contamination zones are separated by the PSCT. The Zone 1 area north of the PSCT contains the majority of the dissolved phased VOC contamination and all of the NAPL contamination. The northern extent of the Upper HSU contamination from east to west occurs in the western portion of the Caustic/Cyanide Landfill, the western half of the Acids Landfill, the southern portion of the Metals Landfill, the northern portion the P/S Landfill and at the BTA south of the PCB Landfill (Figures G-22 through G-26). The eastern extent of VOC contamination is delineated by several monitoring wells near the eastern extent of the PSCT and North Ridge wells, while the western extent of the VOC contamination is delineated by RI monitoring wells on the North ridge and west of the PSCT. The VOC plumes in the Upper HSU beneath the Landfills converge and flow into the Central Drainage Area and into the PSCT in the PSCT-1 area. The VOC plume in the Upper HSU in the BTA flows south into the PSCT in the PSCT-4 area. The distribution of VOC contamination in the Upper HSU is consistent with groundwater flow directions (Appendix F).

The P/S Landfill and Central Drainage Area are the only areas of the site where both DNAPL and LNAPL in the Upper HSU were observed during drilling, gauged in routine liquid level

monitoring, and inferred based on the concentrations of dissolved compounds. The Central Drainage Area is the only area of the site where DNAPL was gauged in routine liquid level sampling and inferred based on the concentrations of dissolved compounds. There is also a significant area of contamination located in the BTA that extends to the southern portion of the PCB Landfill, which flows into the PSCT. The BTA was investigated for the presence of DNAPL and LNAPL, and although dissolved VOC concentrations are relatively high, no wells or piezometers were observed to contain NAPL during liquid level monitoring.

Based on the distribution and concentrations north and south of the PSCT, the PSCT appears to contain the VOC contamination in the northern areas. The PSCT acts to prevent contaminant movement to areas south of the trenches.

Upper HSU VOC contamination in groundwater south of the PSCT is the highest south of PSCT-1 and PSCT-4. The contamination in these two areas is typically one to two orders of magnitude lower in concentration than the concentrations observed in the BTA and the Central Drainage Area. The VOC contamination in the area south of PSCT-1 and PSCT-4 was likely present before the PSCT was installed and within the former ponds. The VOC contamination sharply declines north of the current Ponds and generally not detected south of the five Ponds.

The majority of the sampling locations in Lower HSU did not indicate the presence of VOCs. However, VOC are detected within four areas of the Lower HSU: the BTA; Central Drainage Area; southern edge of the Acids Landfill; and PSCT-3. The area associated with the least amount of contamination of the four areas in the Lower HSU is PSCT-3, which has concentrations typically below the MCL/PRG. The Central Drainage Area exhibits the highest levels of VOC contamination in the Lower HSU, and is the only area in the Lower HSU where DNAPL is present. The Lower HSU VOC contamination in the Central Drainage Area appears related to overlying Upper HSU VOC contamination present between the P/S Landfill and PSCT.

Dissolved concentrations of Arsenic and other metals may be elevated within the Zone 1 boundary but are generally not elevated in Zone 2. The higher concentrations of metals in the Upper HSU are located within the Central Drainage Area and also in the Ponds. Pond 13 has the highest concentrations of dissolved metals of the surface water features sampled. Metals concentrations in the Lower HSU are generally lower than in the Upper HSU; the highest dissolved metals concentrations in the Lower HSU are predominantly located along the North Ridge on the border of Zone 1 and Zone 2. The metal concentrations in the Lower HSU do not appear to coincide with the potentially elevated Upper HSU concentrations.

## 4.0 EVALUATION OF ADDITIONAL DATA NEEDS

The groundwater quality data obtained during the RI Phase I and Phase II investigations, along with historical data, were evaluated with respect to the groundwater Data Quality Objectives (DQOs) identified in the RI/FS Work Plan.

RI/FS Work Plan Sections 4.3 through 4.6 identify specific decisions and decision rules for issues related to this Task, including those related to contaminant extent, fate and transport, TI and Feasibility Study (FS) evaluations. Table 5.1 of the IPR identifies all of the RI/FS DQO decisions and provides an evaluation of additional data needs associated with each, and the decisions specific to well and piezometer drilling are listed below. Note some of these groundwater decisions are also addressed in Appendix E (Well and Piezometer Drilling), Appendix F (Groundwater Levels), Appendix L (Geophysics), Appendix M (NAPL Surveys) and Appendix O (Monitored Natural Attenuation Evaluation).

### 4.1 *DQO Decisions Related to Groundwater Contaminant Fate and Transport*

The specific decisions and decision rules for issues related to groundwater contaminant fate extent and transport that were included in the DQOs of the RI/FS Work Plan are as follows:

- What is the nature and extent of NAPL in the Capped Landfills Area?
- Are there NAPLs present in other areas of the site and what is the character of these NAPLs?
- What is the extent(s) of site-related groundwater impacts?
- How have concentrations of different water quality parameters changed over time?
- Based on the observed water quality trends, what are the anticipated future concentration trends?

The CSC believes that the groundwater data collected as a part of the RI are adequate for evaluating the contaminant fate and transport DQO Decisions noted above.

Sufficient data have been collected to evaluate presence, nature, and extent of NAPL. NAPL distribution has been characterized on the basis of measurements in the existing and new wells and piezometers, and the NAPL extent is delineated via the Site's monitoring network. The chemical composition of both LNAPL and DNAPL has been determined and discussed above in Section G3.3.

Similarly, the extent of and trends in groundwater impacts have been characterized. The RGMEW groundwater sampling program has provided extensive historical information on COC distribution and temporal variability; thus enabling CSC to discern seasonal patterns and trend in COC distribution. These data are sufficient to evaluate anomalies in future water quality measurements. The additional groundwater sampling conducted as a part of the RI and Phase II investigation provided characterization to the presence and distribution of additional potential COCs.

#### **4.2 DQO Decisions Related to TI Evaluations for Groundwater**

The specific decisions and decision rules for issues related to the TI Waiver for groundwater that were included in the DQOs of the RI/FS Work Plan are as follows:

- What is the nature and extent of groundwater contamination?
- Is DNAPL or LNAPL present or likely to be present?
- What are the site hydrogeologic properties and will these properties preclude effective removal of contamination?

The groundwater data collected as a part of these RI investigations was adequate for evaluating the TI for groundwater. As described above, the nature and extent of groundwater contamination and NAPL has been characterized on the basis of water quality and liquid level data from existing and new wells.

#### **4.3 DQO Decisions Related to FS Evaluations for Groundwater**

The specific decisions and decision rules for issues related to the FS evaluations for groundwater that were included in the DQOs of the RI/FS Work Plan are as follows:

- What is the chemical nature and physical extent of the contaminated area requiring remediation?
- What are the relevant physical properties of the subsurface vadose zone and/or saturated zone where contamination is present?

Groundwater data collected as a part of these RI investigations are adequate for conducting FS evaluations for groundwater. The nature and extent of groundwater contamination and NAPL has been characterized on the basis of water quality and liquid level data from existing and new wells.

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