Fox Avenue Site

Enhanced Reductive Dechlorination
Performance Monitoring and Remedial Optimization Report
First Half 2013

Prepared for
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This report describes remedial actions conducted at the Fox Avenue Site (Site). The remedial actions described in this report have been conducted in substantial compliance with the Site Cleanup Action Plan (Ecology 2012) and the Engineering Design Report (Floyd|Snider 2012) for the remedial action project.

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List of Abbreviations and Acronyms

Acronym/Abbreviation	Definition
bgs	Below ground surface
°Bx	Degrees Brix
cis-1,2-DCE	cis-1,2-Dichloroethene
CAP	Cleanup Action Plan
COC	Contaminant of concern
CPOC	Conditional Points of Compliance
CVOC	Chlorinated volatile organic compound
DO	Dissolved oxygen
Ecology	Washington State Department of Ecology
ERD	Enhanced reductive dechlorination
FS	Feasibility Study
GWCC	Great Western Chemical Company
HCl	Hydrochloric acid
IDW	Investigation-derived Waste
IA	Interim Action
ISCO	In-situ chemical oxidation
MTCA	Model Toxics Control Act
ORP	Oxidation-reduction potential
PCE	Tetrachloroethene
PCR	Polymerase chain reaction
ppb	Parts per billion
POC	Points of Compliance
ppt	Parts per thousand
PVC	Polyvinyl chloride
RA	Remedial Action
RI	Remedial Investigation
SBW	Seattle Boiler Works
scfm	Standard cubic feet per minute
TCE	Trichloroethene
TOC	Total organic carbon
trans-1,2-DCE	trans-1,2-Dichloroethene
VC	Vinyl chloride
VFA	Volatile fatty acid
VOC	Volatile organic compound
WBZ	Water bearing zone

1.0 Introduction

This report summarizes the groundwater monitoring and a portion of the remedial actions completed in the first half of 2013 at the Fox Avenue Site (Site). The Site is located at 6900 Fox Avenue in the Duwamish industrial corridor of South Seattle (see Figure 1.1). The work summarized in this report started as part of the Interim Actions (IA) initiated per the terms of the 2009 Agreed Order between the Washington State Department of Ecology (Ecology) and Fox Avenue Building LLC and continuing under the terms of the Agreed Order to implement the Fox Ave final Cleanup Action Plan (CAP) dated June 2012. Elevated levels of chlorinated volatile organic compounds (CVOCs) were first identified in soil and groundwater at the Site in the early 1990s. The CVOC plume is related to solvent spills associated with operations at the now defunct Great Western Chemical Company (GWCC, the prior owner of the Fox Ave property). The GWCC filed for bankruptcy in 2001 and the present owner, Fox Avenue Building LLC, acquired the property in 2003. The Fox Avenue Trust is responsible for implementation of the cleanup action.

The initial purpose of the IA was to mitigate the risk presented by VOCs in Site groundwater as the final groundwater remedy was developed and implemented. The Site-wide remedial action (RA) was selected in a Cleanup Action Plan (Ecology 2012). The Site-wide RAs are underway and have been implemented in accordance with the Engineering Design Report for cleanup of the Fox Ave Site (Floyd|Snider 2012). This report focuses on one element of the Site-wide RA: Biological treatment of groundwater using Enhanced Reductive Dechlorination (ERD) including associated performance monitoring of groundwater. Groundwater transport of VOCs from the Site and their discharge to the Duwamish Waterway is a primary exposure/risk pathway and ERD treatment of groundwater started in 2009 as an IA phase of the RA.

The VOC plume at the Site has migrated down gradient within the 1st and 2nd Water Bearing Zones (1st WBZ and 2nd WBZ) towards the Duwamish Waterway located approximately 400 feet southwest of the Fox Ave property (Figure 1.2). The primary contaminants of concern (COCs) identified in the VOC plume are tetrachloroethene (PCE), trichloroethene (TCE), cis-1,2-dichloroethene (cis-1,2-DCE), and vinyl chloride (VC); collectively referred to as CVOCs. All of these CVOCs are related: The parent compound, PCE, was accidentally spilled at the Site (by prior property owner, GWCC) and the daughter products (TCE, cis-1,2-DCE and VC) are derived from dechlorination of PCE (see Figure 1.3).

Enhanced reductive dechlorination is an in-situ treatment technology that promotes accelerated degradation of CVOCs. Figure 1.3 presents the dechlorination pathways that CVOCs undergo in an ERD process and the corresponding geochemical conditions required to promote rapid dechlorination. The groundwater monitoring presented in this report covers actions completed to date in 2013 including several sampling events in February, May, and July 2013. The remedial actions implemented in this period have included biological treatment of the groundwater plume using ERD and soil vapor extraction (SVE) treatment of soil in the Northwest (NW) Corner area and thermal treatment of the source area soils, which lasted from January thru May of 2013.

1.1 Purpose of Report

The purpose of this report is to summarize field activities conducted and performance monitoring data collected during the first half of 2013 at the Fox Avenue Site (monitoring in February through July 2013 and related ongoing remediation actions). As noted previously, this report focuses on one element of the Site-wide RA: Biological treatment of groundwater using Enhanced Reductive Dechlorination.

Field activities completed in this period included:

1. Performance/remedial optimization monitoring including several rounds of sampling from monitoring wells and seeps;
2. Substrate injections to promote ERD;
3. Expansion of the ERD injection well (IW) network (four new IWs installed in February 2013 on Seattle Boiler Works [SBW] Property);
4. Well development for the new IWs; and
5. Post thermal treatment temperature monitoring in the down-gradient plume area.

Expansion of the ERD system in the SBW property was completed to supplement ongoing degradation processes in the down-gradient areas, including the seeps to the Waterway.

1.2 Performance Criteria from Cleanup Action Plan

The CAP for the Fox Ave Site includes cleanup levels, points of compliance, conditional points of compliance, and remediation levels applicable for the different restoration timeframes. This section provides a brief summary of those CAP elements as a benchmark for evaluating the performance data for the groundwater remedial actions. The MTCA cleanup levels for all media at the Fox Ave Site are set in the CAP. Specifically related to groundwater, the Site cleanup levels from the CAP are summarized below:

Fox Ave Site Groundwater Cleanup Levels

Chemical of Concern	Groundwater Cleanup Level—Protection of Surface Water (µg/L)
Benzene	51
1,1- Dichloroethene	3.2
Pentachlorophenol	3.0
Tetrachloroethene	3.3
Trichloroethene	30
Total petroleum hydrocarbons	500
Vinyl chloride	2.4

Points of Compliance

The Points of Compliance (POCs) where the cleanup levels are to be achieved for groundwater at the Site are based on the following. Based on the Site conditions and technical feasibility, the RI/FS and CAP for the Fox Ave Site demonstrated that it is not practicable to meet the cleanup levels throughout the Site in a reasonable restoration time frame (per MTCA (WAC 173-340-720(8))) and a conditional POC (CPOC) is used in the CAP. The CPOC for groundwater at the Fox Avenue Site (specified in the CAP) is along the down-gradient property boundary of both the Fox Ave. LLC property and the Whitehead Property encompassing the full width of the groundwater plume (and the owner of the Whitehead Property has agreed to the use of a CPOC).

The POC for the groundwater seeps discharging to surface water is the seeps along the S. Myrtle Street Embayment. The seeps are to be sampled and the concentrations directly compared to the groundwater cleanup standards (listed above).

Remediation Levels

Within the CAP (and pursuant to MTCA WAC 173-340-200) Remediation Levels are set at concentrations above which specific components of the cleanup action will be implemented (as part of the overall cleanup action). By definition, Remediation Levels are concentrations that exceed cleanup standards and are used when a combination of cleanup action components are necessary to achieve cleanup levels at the POC. The Fox Ave CAP uses Remediation Levels to meet the cleanup standards at the CPOC and are also established to allow one cleanup technology to transition to another. The Remediation Levels for groundwater (from the CAP) are summarized below:

Groundwater Remediation Level	Basis
250 µg/L total CVOCs (as measured in the designated monitoring well network)	1. Use of thermal treatment and ERD to achieve 250 µg/L total CVOCs; predicted to result in achieving cleanup levels at the seeps in reasonable restoration time frame. 2. Concentration will not present a vapor intrusion risk in down-gradient properties. 3. Cleanup levels will be attained at the CPOC over an extended restoration time frame via natural attenuation.

Restoration Time Frame

The projected time frame (used in the CAP) for ERD treatment to achieve groundwater Remediation Levels at the CPOC is anticipated to be approximately 5 years (post-thermal treatment of soil), and compliance with cleanup levels at the point of discharge to surface water at the S. Myrtle Street Embayment is expected within approximately 10 to 15 years through a combination of ERD and MNA.

When achieved, these CAP elements eliminate all existing ecological risk from the migration of Site contaminants. Attainment of cleanup levels throughout the entire groundwater plume will take considerably longer, potentially up to 50 years.

2.0 Remedial Actions Implementation

The RAs have been implemented in accordance with the initial project Work Plan for the IA (Floyd|Snider and CALIBRE 2008) and the Engineering Design Report (Floyd|Snider 2012). Implementation of ERD was planned in two phases with both Phase 1 and 2 continuing during this monitoring period.

- **Phase 1** Install injection wells along two transect lines and test the effectiveness of ERD to treat the central area of the main VOC plume (i.e., groundwater with CVOCs greater than 1,000 µg/L). This IA activity was implemented under the terms of the 2009 Agreed Order.
- **Phase 2** Implement ERD by adding injection wells along wider transects of the main VOC plume and also in the smaller NW Corner area and down gradient on Seattle Boiler Works. This RA activity was implemented under the terms of the Final Cleanup Action Plan.

A key part of the ERD remedial action is substrate injection (Bio-stimulation) to create in-situ conditions conducive to, and accelerate, the biological degradation processes. The IA/RA implementation has included several substrate injection events (starting as a demonstration in the IA Phase). The last two substrate injection events (implemented in different areas) are summarized in this report. The plume areas where substrate injection was implemented in this period include:

Event Sequence	Date of Substrate Injection Event
a	*February/March 2013 (SBW [2 old and 4 new wells] and NW Corner area) (4 new wells on SBW property were installed, developed, and sampled in February 2013)*
b	*June 2013 (Row 2 [6 old and 4 new wells on SBW property], NW Corner area, and Row 1 [2 shallow wells])*

Substrate injection has been completed utilizing sucrose (and other carbohydrates) derived from off specification food-grade products that are available locally. Permitting to complete all ERD substrate injection work has included an Underground Injection Control (UIC) permit/registration with Ecology (for each substrate injection well).

2.1 Performance Monitoring

Sampling of both injection wells and down-gradient monitoring wells has been completed following the procedures presented in the project Work Plan. Performance sampling completed within this period of the project was implemented at selected injection and monitoring wells on 20 February 2013, 9 May 2013 (temperature monitoring), 23 May 2013 (temperature monitoring), 29 May 2013, 14 June 2013 (temperature monitoring), 10 July 2013 (temperature monitoring), and 22-24 July 2013 (groundwater sampling and including seep sampling).

The sampling events were completed to:

1) Collect performance data to evaluate current VOC concentrations along the Row 1 and 2 ERD transects (including down-gradient wells) to identify the conditions at the end of thermal heating.
2) Collect baseline data in the recently installed Phase 2 expansion ERD injection wells.
3) Evaluate current VOC concentrations at seep locations (in the embayment below the Myrtle street cul-de-sac).
4) Monitor temperature influence at down-gradient injection and monitoring wells following the completion of source-area thermal treatment.

Selected wells were also sampled for TOC, dissolved gases, and bacterial count analysis. The data from the sampling listed above has also been used for remedial optimization of the remedial action.

Temperature monitoring was added to the ERD performance monitoring and optimization in this sampling period. Temperature monitoring is important for the ERD optimization for the following reasons:

1) Soil heating releases the organic carbon contained in the soil (potentially most of it) and bio-stimulation through substrate addition is necessary after heating.
2) Soil heating reduces microbial community composition (methanogens) and dechlorination capability. At high temperatures (above 55°C) most relevant microbes are killed and bio-augmentation is necessary to restart dechlorination processes (after temperatures decline). After microbes have been killed, bio-augmentation can quickly re-establish the targeted microbial community because there is little competition.
3) At moderate temperatures (e.g., 40°C) dechlorination may cease but the microbes are still present. At the 35°C to 45°C range, dechlorination of parent products PCE and TCE may still continue but the *Dehalococcoides* spp. bacteria (responsible for the cis-1,2-DCE and VC conversion) are no longer active. The optimal dechlorination rate for *Dehalococcoides* spp. is thought to occur at 30° to 35°C.

The temperature monitoring described in this report is focused on the down-gradient plume areas where the heat has been transported (via groundwater flow from thermal treatment of the source area). Items 1 and 2 (listed above) are expected to be important for the source area where thermal treatment was implemented; as temperatures decline in that area both bio-stimulation and bio-augmentation to promote ERD may be necessary. In the down-gradient plume area, the current monitoring data indicate that item 2 (listed above) will be important in a limited area of the plume (the central plume area down gradient from the thermal treatment zone) and item 3 will be important for the larger plume area.

2.2 Substrate Injection

Substrate injections were completed following procedures described in the IA Work Plan and in the same manner as the prior injections. A detailed description of injection procedures is presented in the IA Work Plan (Floyd|Snider and CALIBRE 2008).

Two substrate injection events were completed since the last performance report; these events took place on 25 February 2013 – 4 March 2013 and 3 – 14 June 2013. These two events addressed separate areas of the project as follows:

- In the February/March 2013 event, four recently installed and two existing IWs located on SBW Property were injected. Well logs for the new injection wells are provided in Appendix D and all injection well locations are shown on Figure 2. Additionally, seven injection wells in the NW Corner area were injected. The injection event took place after the well development and baseline sampling of the four new IWs on SBW property.

- In the June 2013 event, twelve Row 2 injection wells (including the four recently installed SBW wells) and eight injection wells in the NW corner area were injected. Six up-gradient thermal electrodes slotted for vapor recovery purposes were tested for substrate addition (a test to determine what volume and flow rate these wells would accept if they were used for post thermal bio-polish purposes). Approximately 30 gallons of substrate was applied to three of the six wells at a maximum rate of 1.5 gpm, while the other three wells immediately pressurized and would not accept any flow. The test indicated that these electrodes are not suitable for substrate injection purposes.

The installation of the Phase 2 ERD expansion wells are discussed in Section 2.3. Table 2.1 provides a summary of volumes and total mass of substrate applied to each injection well during the 2013 events. Additional details are presented in Appendix A.

Sodium bicarbonate (baking soda) was mixed into the substrate at approximately 50 pounds per 5,000-gallon batch (~860 ppm alkalinity as carbonate) to provide increased buffering capacity for pH control. Approximately 500 gallons of chase water mixed with baking soda (~2,150 ppm alkalinity as carbonate) were injected into each well after the substrate solution was injected. The chase water was added to push the substrate out of the immediate area at the well screen and filter pack in order to reduce the potential for bio-fouling.

During the June 2013 injection event, a representative from the City of Seattle Public Utilities was on Site and indicated concern over the potential for spills as a result of the ongoing substrate injections. One area was the pavement around the holding tank along Fox Avenue. The injection process includes filtering substrate and transfer to separate 250 gallon totes. Small quantities of liquid (trace quantities that had stained the pavement) were present on the pavement and had migrated in the direction towards a nearby catch basin. The second area (a minor spill in a dirt area) was the result of a well seal coming off an injection well near the Myrtle St. cul-de-sac while pumping substrate into the well. The substrate pooled in the nearby dirt/gravel parking area adjacent to the cul-de-sac. Vehicle traffic in and around the cul-de-sac subsequently drove through the puddle and the tires tracked substrate onto the pavement. The City notified the Department of Ecology; an Ecology staff inspected the Site and deferred oversight to the City of Seattle. The property owner (Cascade Columbia Distribution) and the Ecology project manager were notified by CALIBRE that day. The City of Seattle requested CALIBRE empty the catch basin near the substrate holding tank, pressure wash the catch basin and pavement around the holding tank and an area of pavement in Myrtle St. cul-de-sac. Substrate injections were halted and Bravo Environmental was scheduled to clean the areas of concern. Bravo Environmental arrived on-Site the following morning and performed the requested cleanup. Photos were taken of the two areas and sent to the City of Seattle point of contact. Expanded containment was setup in the immediate area of the holding tank as well as under the flatbed used to deliver the filtered sugar to each specific injection area.

2.3 Phase 2 ERD Expansion Wells

Four injection wells were installed, developed, and sampled in February 2013 as part of the Phase 2 RA implementation. The four new wells are located within Seattle Boiler Works Property (R2-IW8, R2-IW9, R2-IW10, R2-IW11 [1st and 2nd WBZ]) down gradient of the Row 1 transect. These wells complete the row 2 injection transect.

Figure 1.2 shows the locations of the recently installed wells.

2.4 Investigation-Derived Waste

All investigation-derived waste (IDW) was stored in containers for subsequent characterization and treatment/disposal following regulatory guidelines by Cascade Columbia personnel. The IDW generated during the past period of performance consisted of purge water generated during the sampling events and well development water.

3.0 Remedial Action Performance Monitoring

This section describes sampling performed in the reporting period (multiple sampling events were completed through July 2013). Sampling results and other groundwater quality parameters collected during this period are presented in Tables 3.2 through 3.38.

3.1 Sampling Procedures

The groundwater sampling conducted during this period was performed using two different sampling procedures; low-flow sampling (from most wells) and passive diffusion bag (PDB) sampling (from selected wells with multiple screen intervals). Analytes included in the monitoring events were VOCs, TOC, dissolved gases (methane, ethane, ethene), and bacterial census in selected wells. Groundwater quality parameters (pH, conductivity, dissolved oxygen [DO], oxidation-reduction potential [ORP], and temperature) were measured in the field using a flow-through cell and Horiba multi-parameter water quality meter or a temperature meter. The Horiba water quality meter and temperature meter were calibrated each day.

All samples were collected following the procedures/guidelines in the project Work Plan (Floyd|Snider and CALIBRE 2008).

3.2 Summary of Data from Groundwater Sampling

Table 3.2 summarizes past and current water quality parameters (field measured parameters) that were collected at the time of sampling. A summary of the laboratory analytical results (along with some relevant historical CVOC data) are presented in Tables 3.3 through 3.38.

3.3 Quality Assurance Review

Samples were collected following the quality assurance procedures and guidelines in the project Work Plan including the following:

- Sampling Standard Operating Procedures (SOPs) from the QAPP were followed.
- Field sample forms were filled out to record sampling data.
- Samples were preserved (where appropriate), placed in a cooler with ice, and maintained under chain-of-custody for each delivery.
- Samples were delivered to the laboratory at the completion of the sampling event.
- Duplicate samples were taken at a rate of 1 duplicate per 10 samples.

A Level 1 data review of the laboratory results was completed by Floyd|Snider, Inc. personnel to evaluate data quality for the intended use. Sample collection, recording, preservation and analysis met the requirements in the Work Plan and QAPP. All chain-of-custody forms were completed. All samples were delivered within the temperature criteria and analyzed within required holding times. Analyses for all samples were completed using approved analytical methods identified in the Work Plan/QAPP. The lab performed method-specific standard calibrations and checks to ensure laboratory equipment was operating in specified parameters as part of the sample analysis.

All laboratory data obtained from the sampling are considered suitable for the intended use based on the project QAPP and the documentation/SOPs/data review noted above.

4.0 Summary of Current Conditions Relevant to the ERD Remedial Action

The following sections summarize key conditions relevant to the performance monitoring of the ERD remedial action.

4.1 Water Quality Parameters

The up-gradient source area thermal treatment was completed in May 2013 and water temperatures have increased substantially (in the immediately down-gradient plume area). The temperature rise is expected to influence/change groundwater conditions in the area and future sampling events will be used to monitor these changes. Water quality parameters recorded during this monitoring period are presented in Table 3.2. In general, the field water quality parameters measured are similar to recent historical data; reducing conditions are noted at most wells, dissolved oxygen is generally low, and pH is generally in a neutral range (although some ERD injection wells are reduced below a pH of 5). These conditions are conducive to ERD implementation.

4.2 Volatile Organic Compounds – February 2013

Baseline VOC levels were measured in the four (4) new injection wells (installed in February 2013 as part of the Phase 2 ERD expansion). Sampling was completed following well development. Results from this sampling event show concentrations of CVOCs with the degradation daughter products cis-1,2-DCE and VC making up the bulk of CVOCs observed at these new wells (well R2-IW9 showed PCE and TCE at non-detect in the 1st and 2nd WBZ). These wells are installed down gradient of Row 1 wells where several years of ERD injections have continued and existing performance monitoring data demonstrate that the dechlorination processes are continuing as the plume migrates to these down-gradient locations.

4.3 Volatile Organic Compounds – May and July 2013

A small subset of the wells were sampled in May 2013 (R1-IW3A, R1-IW4A, R1-IW4B, B-58, B-59, B-60, B-61, and R2-IW1) and a larger Site-wide sampling event was completed in July 2013.

4.3.1 Wells Near and Along Fox Avenue

Wells sampled along Fox Ave included R1-IW2, R1-IW3A, R1-IW4A, R1-IW4B, R1-IW7, R1-IW15, R1-IW18, R1-IW20, B-58, B-59, B-60, and B-61. The analytical results are presented in Tables 3.3 through 3.14 and Figures 4.1 through 4.7.

In this area, wells with CVOCs below the 250 ug/L (total CVOCs) Remediation Level included R1-IW2, R1-IW4B, R1-IW7, B-59, and B-61. For the remaining wells (above the 250 ug/L Remediation Level) several are approaching the Remediation Level and have only recently begun ERD injections (wells R1-IW15, R1-IW18, and R1-IW20).

Some of the wells in this area are still above the Remediation Level, but concentrations of both parent and daughter products are declining with the ERD treatment (e.g., wells R1-IW4A, B-58 and B-60, see Figures 4.1, 4.4, and 4.6). Monitoring well B-60, for example, showed a PCE reduction from 114 ug/L (Aug 2012) to 1.6 ug/L (Jul 2013) and TCE from 323 ug/L (Aug 2012)

1.5 ug/L TCE (July 2013). ERD treatment well R1-IW4A has shown 99.9% reductions in both PCE and TCE from prior high CVOC levels.

The remaining wells above the 250 ug/L Remediation Level; R1-IW3A, R1-IW4A, B-58 and B-60) are shallow and in a zone that appears to be increasing in temperature above 40 ºC. At this temperature (above 40 ºC), dechlorination rates will be reduced (or cease) and renewed ERD efforts (including both bio-stimulation and bio-augmentation) will be implemented as temperatures decline.

4.3.2 Wells in Myrtle Street and in Seattle Boiler Works

Wells sampled in Myrtle Street and in Seattle Boiler Works property included; R2-IW1, R2-IW8, R2-IW9, R2-IW10, R2-IW11, MW-5, MW-6, B-64, B-65, B-33a, and B-34. The analytical results are presented in Tables 3.15 through 3.25 and Figures 4.8 through 4.10. For the injection wells in this area (R2-IW1, R2-IW8, R2-IW9, R2-IW10, and R2-IW11, the last 4 of which are new) the current sampling represents a baseline sampling before the start of ERD (or a restart after a long interruption from ERD treatment) and the analytical results from these treatment wells exceed the Remediation Level of 250 ug/L (total CVOCs). Well MW-6 is also above the 250 ug/L Remediation Level (presently at 301 ug/L total CVOCs). For the remainder of the wells in this area (MW-5, B-64, B-65, B-33a, and B-34), the present levels detected are below the 250 ug/L Remediation Level. Of particular note is well B-33a which is below the final cleanup level of 2.4 ug/L for vinyl chloride. Measured CVOCs were also non-detect for PCE and TCE. The performance monitoring data from this well, located just up-gradient of the discharge zone to the waterway, has demonstrated a 99.9%+ reduction from prior peak CVOC concentrations (see Table 3.24 and Figure 4.9).

4.3.3 Seep Sampling

In addition to groundwater sampling at the above mentioned wells, four seeps located in the embayment below the Myrtle Street cul-de-sac (see Figure 4.17) were sampled for VOCs at a low tide on 23 July 2013. Each of the four seep areas have been sampled previously as part of the Fox Ave project beginning in 2009.

Table 3.26 presents the seep results from July 2013 along with the prior sampling results.
All four seeps had non-detect levels (<1 ug/L) for PCE and TCE. Two seep locations, SP-01 and SP-02, were also non detect (<1 ug/L) for the other CVOC degradation/daughter products (cis1,2-DCE and VC). The other two seep locations, SP-03 and SP-04, had detectable levels of cis-1,2-DCE and VC but the concentrations are significantly reduced from prior sampling (a 98% reduction in CVOCs).

The locations of seeps SP-01 and SP-02 (presently at non-detect levels) are down gradient from the Row 2 injection wells which have undergone regular ERD treatment since the start of the Interim Actions at the Fox Ave Site (started in February of 2009). The ERD treatment wells located up gradient of SP-03 and SP-04 have not been used consistently as access to these areas has been limited. The CVOC levels in seeps SP-01, SP-02 and SP-04 are below the Site cleanup goals (set in the CAP). The CVOC levels detected in SP-03 are still above the Site cleanup goals but concentrations are declining (see Figure 4.16) and the impacts from the up-gradient remedial actions are evident.

4.3.4 Wells in NW Corner Area

Wells in the NW Corner area were sampled in March and July 2013. The wells sampled in the NW Corner area included R1-IW8, R1-IW9, R1-IW10, R1-IW11, R1-IW13, NW1-1, NW2-1, and B-56. In addition, two up-gradient MWs (near the NW Corner within the Cascade Columbia Warehouse) were also sampled (B-66 and B-71). The analytical results for CVOCs are summarized in Tables 3.27 through 3.36 and presented in Figures 4.11 through 4.15.

Bio-augmentation was implemented in the NW Corner area in mid-2012 and the monitoring results demonstrate that it has been effective (the VC daughter product is apparent and no stall/excess accumulation of cis-12 DCE is noted). The CVOC concentrations observed at monitoring wells NW1-1 and NW1-2 show clear progression of dechlorination steps/daughter products within this area (see Figures 4.14 and 4.15).

The performance monitoring results looks good. The analytical results from R1-IW8, R1-IW9, R1-IW10, R1-IW11, R1-IW13, NW1-1, and NW2-1 are all less than the Remediation Level (250 ug/L total CVOCs) and multiple wells show CVOC reductions of 90% to 98%. B-56 is still above the Remediation Level at 297 ug/L CVOCs. .

4.4 Other Analytes

Samples from selected wells were tested for two other analytes for the purpose of remedial optimization; total organic carbon (TOC) and dissolved gasses (methane, ethane, ethene). The TOC data are variable across the treatment areas based on the timing/residues from the most recent injection events. In general, the TOC data is used to assess when additional substrate injection is necessary. The dissolved gasses data (methane, ethane, ethene) indicate low levels of ethene and ethane in selected wells, many of the samples are below the detection limits.

4.5 Bacterial Count

Samples were collected for bacterial count in July 2013. The wells sampled included R1-IW8 (in the NW Corner area), R1-IW7 (at 45 ft bgs), R1-IW4b (at 50 ft bgs), B-59 (on the west side of Fox Ave.), and R1-IW2 (at 17 ft bgs). The laboratory results are presented in Table 3.37. The bacterial count uses quantitative polymerase chain reaction (qPCR) for enumeration of *Dehalococcoides* spp. organisms and the related vinyl chloride reductase gene.

The laboratory results indicate abundant dechlorinating bacteria in all areas sampled. The first census count is for *Dehalococcoides* spp., a specific bacterial group known to be capable of full reductive dechlorination of PCE to ethene. The levels detected, typically in the 10^3 to 10^4 cells/ml range, is sufficient for effective plume treatment with ERD.

None of the sample locations tested (for bacterial census) are yet hot enough to kill the bacteria. The cell counts listed in Table 3.37 are based on counts of DNA strands which would include both live bacterial cells (dechlorinating bacteria) and any dead cells that had not yet degraded.

The laboratory results also provide positive counts for VC Reductase (bvc A gene encode from VC reductase enzyme of *Dehalococcoides* sp. strain BAV1, and vcr A gene encode from cis-1,2 DCE and VC reductase enzyme of *Dehalococcoides* sp. strain VS).

The bacterial count results are consistent with the other performance monitoring data (i.e., CVOC concentrations which demonstrate that significant reductive dechlorination is occurring).

4.7 Post-Thermal Temperature Monitoring

Monitoring the temperature change (from the thermal treatment in the source area) at down-gradient Row 1 injection and monitoring wells was started in May 2013. Data has been collected each month since with the most recent data collected in conjunction with the Site-wide monitoring on 22 – 24 July 2013. The temperature data are presented as cross sections in Figures 4.18 through 4.23. Elevated temperatures were first recorded at wells in the center of the plume (wells R1-IW3A/B, R1-IW4A/B and R1-IW5) from a depth of ~10 to 45 ft bgs with temperatures ranging from 19 to 45 ºC. The existing monitoring data indicate temperatures have increased at each location monitored (well R1-IW4 last measured at >55 ºC) and spread horizontally (from R1-IW13 to R1-IW7) and vertically (from 10 – 65 ft bgs). The average pre-thermal baseline temperature for Row 1 wells is ~ 14 ºC. The sequence of cross-section data plots presents a clear picture of the heat plume migrating across the monitoring transects.

As discussed in Section 2, increased temperatures will impact the ERD biological treatment processes. The optimal dechlorination rate for *Dehalococcoides* spp. is thought to occur at 30° to 35°C. In the 35° to 40°C range, dechlorination of parent products PCE and TCE may still continue but the *Dehalococcoides* spp. bacteria (responsible for the cis-1,2-DCE and VC conversion) are no longer active. At high temperatures (above 55°C, most relevant microbes are killed.

In the Row 1 ERD transect area along Fox Ave, the present temperature profile data (as of late July 2013) indicate an area roughly 100 ft wide (transverse to the groundwater flow direction) and 10 ft deep (below the water table) has reached temperatures above 40°C. In this area (from R1-IW2 south to R1-IW5), bio-augmentation is planned to rapidly restart dechlorination processes (after temperatures decline below 40°C).

Continued monitoring will be used to identify suitable groundwater temperatures for the installation of replacement injection well R1-IW16. This well will be installed and bio-augmented in conjunction with the other injection wells in this immediate down-gradient area.

5.0 Conclusions/Recommendations

The performance monitoring results (VOC sampling data) presented in this report were collected from down-gradient plume areas at a time near the end of thermal treatment in source area. Based on the locations and typical groundwater travel times, the bulk of the locations sampled have not yet been impacted by thermal treatment at the source areas. The data presented in this report serve as a baseline to gauge the future impacts of thermal treatment in the down-gradient plume. The data also provide a progress update of the ERD performance within the areas treated (Phase 1 and Phase 2 of the ERD implementation).

The performance monitoring results indicate that ERD has accelerated the full dechlorination of contaminants at the Site. The last monitoring well before the Waterway (well B-33A, a key point of compliance) has demonstrated a 99.9+% reduction in CVOCs and currently meets the Site cleanup levels set in the CAP; <3.3 ug/L for PCE, <30 ug/L for TCE and <2.4 ug/L for VC. The CVOC levels detected in seeps SP-01, SP-02 and SP-04 are also below the Site cleanup levels. The CVOC levels detected in seep SP-03 are still above the Site cleanup goals but performance monitoring data indicate that concentrations are declining rapidly (see Figure 4.16).

Other wells with similar CVOC reductions (greater than 99+%) include R1-IW7, B-59, B-61, and B-65; these other wells meet the Site Remediation Level (250 ug/L total CVOCs) but have not yet achieved the Site cleanup levels (see Figures 4.2 through 4.10). Further reductions are anticipated following recently completed source control via thermal treatment.

In the NW Corner area, the results from R1-IW8, R1-IW9, R1-IW10, R1-IW11, R1-IW13, NW1-1, and NW2-1 are all less than the Remediation Level (250 ug/L total CVOCs) and multiple wells show CVOC reductions of 90% to 98%,(see Figures 4.11 through 4.15). One location in the NW Corner area, B-56, is still above the Remediation Level at 297 ug/L CVOCs.

Laboratory results for the bacterial count indicate abundant dechlorinating bacteria in all areas sampled. The *Dehalococcoides* spp levels detected, typically in the 10^3 to 10^4 cells/ml range, is sufficient for effective plume treatment with ERD. The bacterial count results are consistent with the other ERD performance monitoring data.

Since the completion of source-area thermal treatment in May 2013, groundwater temperatures have increased significantly in a limited area of the down-gradient Row 1 wells, specifically in the 1st WBZ near the center of the plume. Temperatures recorded to date are high enough to impact the ERD biological treatment processes in this area. As temperatures in this area decline to a range suitable for bacterial growth (<40 ºC; [104º F]), specific wells will be targeted for bio-augmentation to renew the dechlorination process in the central plume area.

The current performance monitoring data demonstrate that ERD has made significant progress to meet the Site-wide cleanup objectives from the CAP (most wells in the NW Corner area and many wells along Fox Ave meet the Remediation Level, and 3 of the 4 seeps meet the cleanup levels). Coupled with the recently completed thermal treatment in the source area, the data demonstrate substantial progress towards Site restoration and meeting the CAP objectives.

Future monitoring events will be required to verify these trends continue. It is anticipated that continued substrate injections will be required to ensure that conditions to promote accelerated degradation processes are maintained.

6.0 References

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Tables

Table 2.1
Substrate Injection Records
Feb-13, Jun-13

Well ID	Substrate Volume (gallons)	Substrate Mass (tons sugar)
R1-IW3A	268	0.19
R1-IW4A	255	0.18
R1-IW8	1,549	0.76
R1-IW9	1,585	0.81
R1-IW10	1,617	0.80
R1-IW11	250	0.48
R1-IW12	1,248	0.82
R1-IW13	1,237	0.79
R1-IW14	1,255	0.83
R1-IW15	3,700	2.43
R2-IW1	4,972	2.00
R2-IW2	5,000	2.00
R2-IW3	832	1.61
R2-IW4	832	1.61
R2-IW5	832	1.61
R2-IW6	832	1.61
R2-IW7	832	1.61
R2-IW8	5,006	2.12
R2-IW9	5,000	1.99
R2-IW10	2,491	1.79
R2-IW11	2,474	1.78
Total	**42,067**	**27.82**

Table 3.1

Wells Sampled (February 2013)

Well - Row 2	Sample Date	WBZ	Sample Depth	Analytes Sampled
R2-IW8	2/20/2013	1	12	VOCs
R2-IW8	2/20/2013	2	40	VOCs
R2-IW8	2/20/2013	2	63	VOCs
R2-IW9	2/20/2013	1	12	VOCs
R2-IW9	2/20/2013	2	40	VOCs
R2-IW9	2/20/2013	2	63	VOCs
R2-IW10	2/20/2013	1	12	VOCs
R2-IW10	2/20/2013	2	37	VOCs
R2-IW10	2/20/2013	2	60	VOCs
R2-IW11	2/20/2013	1	12	VOCs
R2-IW11	2/20/2013	2	37	VOCs
R2-IW11	2/20/2013	2	60	VOCs

Wells Sampled (May 2013)

Well - Row 1	Sample Date	WBZ	Sample Depth	Analytes Sampled
R1-IW3a	5/29/2013	1	12	VOCs
R1-IW4a	5/29/2013	1	11	VOCs
R1-IW4b	5/29/2013	2	50	VOC, Dissolved Gases
B-58	5/29/2013	1	11	VOCs
B-59	5/29/2013	2	27	VOCs
B-60	5/29/2013	1	11	VOC, Dissolved Gases
B-61	5/29/2013	2	42	VOCs
Well - Row 2	**Sample Date**	**WBZ**	**Sample Depth**	**Analytes Sampled**
R2-IW-1	5/29/2013	1	17	VOCs
R2-IW-1	5/29/2013	2	45	VOCs

Wells Sampled (July 2013)

Well - Row 1	Sample Date	WBZ	Sample Depth	Analytes Sampled
R1-IW8	7/24/2013	1	11	VOCs, TOC, Dissolved Gases, Census
R1-IW9	7/23/2013	1	11	VOCs, TOC, Dissolved Gases
R1-IW10	7/23/2013	1	11	VOCs, TOC, Dissolved Gases
R1-IW11	7/23/2013	1	12	VOCs
R1-IW13	7/23/2013	1	12	VOCs, TOC, Dissolved Gases
R1-IW15	7/24/2013	1	12	VOCs, TOC
R1-IW15	7/24/2013	2	55	VOCs, TOC
NW1-1	7/23/2013	1	11	VOCs
NW1-2	7/23/2013	1	11	VOCs
R1-IW2	7/24/2013	1	17	VOCs, TOC, Census
R1-IW2	7/24/2013	2	60	VOCs, TOC
R1-IW3a	7/24/2013	1	12	VOCs
R1-IW4a	7/24/2013	1	11	VOCs, TOC, Dissolved Gases
R1-IW4b	7/24/2013	2	50	VOCs, TOC, Census
R1-IW7	7/24/2013	1	17	VOCs, TOC
R1-IW7	7/24/2013	2	45	VOCs, TOC, Census
R1-IW18	7/24/2013	1	12	VOCs, TOC
R1-IW18	7/24/2013	2	55	VOCs, TOC
R1-IW20	7/24/2013	1	12	VOCs, TOC
R1-IW20	7/24/2013	2	55	VOCs, TOC
B-58	7/22/2013	1	11	VOCs
B-59	7/24/2013	2	27	VOCs, Census

Table 3.1

B-60	7/22/2013	1	11	VOC, Dissolved Gases
B-61	7/22/2013	2	42	VOCs
B-56	7/25/2013	1	11	VOCs
B-66	7/25/2013	1	11	VOCs
B-71	7/25/2013	1	11	VOCs
Well - Row 2	**Sample Date**	**WBZ**	**Sample Depth**	**Analytes Sampled**
SP-01	7/23/2013	Seep	Surface	VOCs
SP-02	7/23/2013	Seep	Surface	VOCs
SP-03	7/23/2013	Seep	Surface	VOCs
SP-04	7/23/2013	Seep	Surface	VOCs
MW-5	7/22/2013	1	10	VOCs
MW-6	7/22/2013	2	40	VOCs
B-34	7/22/2013	1	11	VOCs
B-33a	7/22/2013	2	32	VOC, Dissolved Gases
B-64	7/22/2013	1	11	VOCs
B-65	7/22/2013	2	32	VOCs

Table 3.2
Field Water Quality Parameters

Well ID	Sample Date	WBZ	Sample Depth (ft bgs)	pH	Conduc-tivity (mS/m)	Turbidity (NTU)	DO (mg/L)	Temper. (°C)	ORP (mV)
NW Corner Injection Wells									
R1-IW8	3/31/2011	1	11	4.45	351	305	0.4	12	92
	5/18/2011	1	11	5.1	360	990	0.5	14.4	56
	11/30/2011	1	11	5.12	236	116	0.41	13.7	-24
	8/21/2012	1	11	4.73	253	409	3.1	17.12	6
	7/22/2013	1	11	4.21	399	0	0.75	18.23	136
R1-IW9	3/31/2011	1	11	4.39	173	297	0.7	11.6	112
	5/18/2011	1	11	6.8	198	990	1.4	12.7	-37
	11/30/2011	1	11	4.34	124	125	0	12.3	91
	8/21/2012	1	11	4.99	91.4	918	0.77	14.66	-31
	7/22/2013	1	11	4.18	201	0	0.95	15.58	201
R1-IW10	3/30/2011	1	11	4.47	330	399	0.5	11.9	75
	5/18/2011	1	11	5	220	990	0.5	14	47
	11/30/2011	1	11	4.58	183	56	0.78	11.8	69
	8/21/2012	1	11	4.84	104	405	0.54	15.51	-30
	7/22/2013	1	11	5.5	613	0	0.4	17.41	-41
Row 1 Injection Wells									
R1-IW1	11/29/2011	1	15	4.37	332	63.4	0	13.6	15
R1-IW2	1/14/2010	1	17	4.50	160	390	1.7	13.6	-89
	1/29/2010	1	17	4.60	140	370	2.1	14.3	-73
	2/16/2010	1	17	4.68	130	990	1.2	14	-11
	8/20/2012	1	17	4.43	212	202	1.74	15.1	59
	7/22/2013	1	17	6.05	135	349	0.52	31.68	-29
R1-IW3A	11/29/2011	1	12	5.94	426	194	0	9.9	-140
	8/20/2012	1	12	6.78	18	90.5	1	19.52	-299
	5/29/2013	1	12	5.96	775	574	0.79	43.69	-51
	7/22/2013	1	12	Sampled with PDB, no parameters collected.					
R1-IW4A	4/29/2009	1	11	5.72	56	9	0.7	12.6	-128
	6/23/2009	1	11	5.86	53	94	0.6	15.7	-90
	7/23/2009	1	11	5.78	67	220	2.3	15.4	-49
	9/16/2009	1	11	5.29	57	16	2.3	18.7	-107
	10/27/2009	1	11	5.82	63	350	5.4	13.3	-113
	1/14/2010	1	11	5.42	86	310	2.7	13.4	-129
	1/29/2010	1	11	5.76	90	310	2.3	13.3	-164
	2/16/2010	1	11	5.81	78	990	1.8	13.3	-74
	4/14/2010	1	11	4.45	140	680	4.1	13.3	-21
	3/31/2011	1	11	4.75	55.3	21.3	1	12.5	-19
	11/29/2011	1	11	4.36	306	953	0	12.8	-49
	8/20/2012	1	11	5.02	175	292	0.79	17.09	-108
	5/29/2013	1	11	5.60	93.1	0	0.35	50.25	-45
	7/22/2013	1	11	6.24	135	675	0.99	>55.00	-62

Table 3.2
Field Water Quality Parameters

Well ID	Sample Date	WBZ	Sample Depth (ft bgs)	pH	Conduc-tivity (mS/m)	Turbidity (NTU)	DO (mg/L)	Temper. (°C)	ORP (mV)
R1-IW5	12/14/2012	1	10	4.93	266	908	0.92	9.89	55
R1-IW6	5/19/2010	1	15	6.05	90	680	1.8	20.8	-149
	12/14/2012	1	17	4.54	154	364	0.41	11.67	79
R1-IW7	1/15/2010	1	17	6.14	16	580	9.6	9.7	-31
	1/29/2010	1	17	6.14	97	260	2	12.8	-160
	2/16/2010	1	17	5.90	110	990	3.4	12.8	-74
	7/22/2013	1	17	Sampled with PDB, no parameters collected.					
R1-IW11	10/9/2012	1	12	5.73	39.7	107	2.47	14.72	211
	7/22/2013	1	12	4.47	45.5	189	0.49	16.24	22
R1-IW12	10/9/2012	1	12	5.89	118	87.3	1.11	15.22	-33
R1-IW13	10/9/2012	1	12	5.91	106	106	1.11	16	-18
	7/22/2013	1	12	4.41	25.9	428	0.64	26.76	103
R1-IW14	10/9/2012	1	12	5.59	47.4	45.8	1.1	16.99	83
R1-IW15	10/11/2012	1	12	6.63	46.9	5.4	1.43	14.2	-18
	7/22/2013	1	12	4.89	79.7	190	0.37	34.8	29
R1-IW-17	10/11/2012	1	12	6.23	53.1	36.7	0.51	13.19	-1
R1-IW-18	10/11/2012	1	12	6.00	55.1	120	1.02	13.54	41
	7/22/2013	1	12	Sampled with PDB, no parameters collected.					
R1-IW-19	10/11/2012	1	12	6.04	48.5	149	3.48	13.95	35
R1-IW-20	10/11/2012	1	12	5.89	39.7	193	0.8	13.36	35
	7/22/2013	1	12	Sampled with PDB, no parameters collected.					
R1-IW1	6/23/2009	2	60	4.61	190	120	0.4	15.6	-45
	7/23/2009	2	60	4.68	130	120	1.4	15.2	-77
	10/26/2009	2	60	4.49	200	380	3.1	14.9	4
	1/15/2010	2	45	4.61	170	350	0.8	13.9	-102
	1/15/2010	2	60	4.61	170	630	1.2	14.2	-114
	4/14/2010	2	60	3.85	280	990	3.9	14.8	15
	4/14/2010	2	60	3.99	180	480	1.6	14.6	-7
	11/29/2011	2	60	4.33	338	107	0	13.5	-21
R1-IW2	1/27/2009	2	30	6.25	60.2	11.3	2.34	13.9	96
	1/27/2009	2	45	6.29	60	41.5	4.07	12.6	74
	1/27/2009	2	65	6.26	59.2	35.2	2.46	13.6	34
	4/17/2009	2	45	4.23	180	630	0.3	14.5	-72
	4/29/2009	2	30	4.55	150	35	1.3	14.4	-103
	4/29/2009	2	60	4.40	200	90	0.5	14.4	-93
	7/23/2009	2	60	4.68	110	160	0.8	14.8	-82
	9/16/2009	2	60	4.53	160	150	1.7	17.2	-77
	10/27/2009	2	60	4.70	170	320	3.3	14.9	-22
	1/14/2010	2	60	4.46	180	360	0.8	13	-100
	1/29/2010	2	60	4.58	150	380	1.9	14.1	-84
	2/16/2010	2	60	4.59	130	990	2.3	14.3	0
	3/31/2011	2	60	4.47	333	95	0.6	13.7	104

Table 3.2
Field Water Quality Parameters

Well ID	Sample Date	WBZ	Sample Depth (ft bgs)	pH	Conduc-tivity (mS/m)	Turbidity (NTU)	DO (mg/L)	Temper. (°C)	ORP (mV)
	11/29/2011	2	60	4.36	266	688	0	12.8	-13
	8/20/2012	2	60	4.47	216	178	0.74	16.84	12
	7/22/2013	2	60	5.92	131	377	0.38	25.03	-36
R1-IW4B	1/27/2009	2	30	6.54	70.6	4.3	3.11	10	71
	1/27/2009	2	40	6.52	69.1	48.2	2.34	13.2	-1
	1/27/2009	2	65	6.47	69.7	41.9	2.68	14.2	71
	4/17/2009	2	45	5.20	84	180	1.6	14.3	-112
	4/29/2009	2	50	5.60	74	30	0.7	13.7	-207
	7/23/2009	2	50	6.01	73	15	0.4	14.8	-199
	9/16/2009	2	50	5.07	150	61	2.2	16.9	-119
	10/27/2009	2	50	5.55	86	61	2.8	14.2	-142
	1/14/2010	2	50	4.88	120	350	1.2	13.8	-110
	1/29/2010	2	50	5.32	110	330	1.1	13.6	-160
	2/16/2010	2	50	5.38	100	990	1.3	13.8	-88
	4/14/2010	2	50	4.13	170	290	2	14.7	-38
	3/31/2011	2	50	4.45	174	181	0.5	13.7	86
	11/29/2011	2	50	4.39	209	380	0	13.2	-19
	8/20/2012	2	50	4.94	213	141	0.3	16.62	-125
	5/29/2013	2	50	5.08	75.6	64.1	0.2	35.21	-2
	7/22/2013	2	50	6.09	138	432	0.77	32.56	9
R1-IW5	5/19/2010	2	50	4.40	160	990	0.9	18.1	-57
	12/14/2012	2	50	4.93	337	4.52	0.25	11.35	44
R1-IW6	5/19/2010	2	50	6.03	100	460	1	18.4	-178
	12/14/2012	2	60	4.57	167	326	0.28	11.23	65
R1-IW7	6/23/2009	2	45	6.23	110	27	0.9	14.2	-145
	7/23/2009	2	45	6.29	92	64	0.5	14.1	-134
	9/16/2009	2	45	6.07	94	13	3.4	15.9	-118
	10/26/2009	2	45	6.19	100	33	2.9	13.4	-144
	1/15/2010	2	45	6.13	95	280	3.1	10.7	-153
	1/29/2010	2	45	6.17	100	270	2.3	13	-160
	2/16/2010	2	45	6.01	110	990	2.5	12.8	-92
	4/14/2010	2	45	5.35	120	360	4.5	13.6	-90
	3/31/2011	2	45	4.64	110	240	0.8	13	-12
	11/29/2011	2	45	5.24	123	612	0	12.1	-58
	8/20/2012	2	45	5.05	156	142	0.5	16.32	-166
	7/22/2013	2	45	5.89	80.1	114	1.28	23.44	47
R1-IW15	10/11/2012	2	55	7.00	112	32.7	2.97	14.87	-48
	7/22/2013	2	55	4.46	93.8	551	0.31	25.98	44
R1-IW17	10/11/2012	2	55	6.43	49	267	0.39	13.94	-21
R1-IW-18	10/11/2012	2	55	6.09	58	186	0.38	13.06	13
	7/22/2013	2	55	Sampled with PDB, no parameters collected.					
R1-IW-19	10/11/2012	2	55	6.54	126	730	0.38	13.24	-53

Table 3.2
Field Water Quality Parameters

Well ID	Sample Date	WBZ	Sample Depth (ft bgs)	pH	Conduc-tivity (mS/m)	Turbidity (NTU)	DO (mg/L)	Temper. (°C)	ORP (mV)
R1-IW-20	10/11/2012	2	55	6.03	55.1	463	0.52	12.7	9
	7/22/2013	2	55	Sampled with PDB, no parameters collected.					
Row 2 Injection Wells									
R2-IW1	10/27/2009	1	17	5.83	24	990	3.7	14.7	23
	1/15/2010	1	17	4.50	280	370	1.9	11.6	-103
	6/28/2010	1	17	4.67	58	450	2.8	19.4	-9
	12/13/2012	1	17	6.40	77.9	14.1	0.6	11.58	109
	5/29/2013	1	17	4.87	119	68.7	1.29	12.9	22
R2-IW2	10/28/2009	1	17	5.58	34	540	6.4	10.4	16
	6/28/2010	1	17	4.27	160	740	2.6	18.9	-8
	12/13/2012	1	17	6.20	104	34.6	0.56	11.7	28
R2-IW3	1/14/2010	1	17	4.72	320	660	0.6	11.6	-135
R2-IW4	4/29/2009	1	17	5.21	90	120	0.5	13	-234
R2-IW6	1/15/2010	1	17	4.85	300	480	2.4	10.8	-100
R2-IW7	10/11/2012	1	12	6.02	51.4	360	2.39	13	68
R2-IW8	2/20/2013	1	12	6.37	58.8	8.6	2.39	11.03	133
R2-IW9	2/20/2013	1	12	6.48	106	15.9	1.72	11.11	168
R2-IW10	2/20/2013	1	12	6.67	87.3	23.3	0.84	11.45	195
R2-IW11	2/20/2013	1	12	6.02	57	91.5	1.38	11.48	253
R2-IW1	10/27/2009	2	30	6.31	56	980	2.6	12.9	-110
	10/27/2009	2	45	6.54	64	990	2	13.6	-120
	10/27/2009	2	65	6.52	62	990	2.3	13.8	-99
	1/15/2010	2	45	4.52	280	490	0.7	12.3	-121
	2/16/2010	2	45	4.20	110	990	3	12.9	52
	4/22/2010	2	45	3.81	110	340	2.6	13	75
	6/28/2010	2	45	4.56	68	450	3.1	16.8	12
	12/13/2012	2	45	6.63	83.3	14.5	0.26	12.18	41
	5/29/2013	2	45	4.67	123	70.2	0.47	12.67	19
R2-IW2	10/28/2009	2	30	6.10	81	990	4.6	12.4	-85
	10/28/2009	2	45	6.18	86	810	39	12.1	-97
	10/28/2009	2	65	6.19	100	990	3.2	13.3	-106
	4/22/2010	2	45	3.81	210	420	3.2	13.5	64
	6/28/2010	2	45	4.34	170	550	2.7	17	-10
	12/13/2012	2	45	6.07	103	43.2	0.39	12.05	4
R2-IW3	4/17/2009	2	45	4.42	130	410	0.2	13.6	-50
	4/29/2009	2	30	4.52	120	230	0.7	12.9	-67
	4/29/2009	2	60	4.50	310	380	0.5	13	-32
	6/23/2009	2	30	5.59	90	60	2.4	15	-125
	7/23/2009	2	30	5.79	81	72	1	13.8	-153
	10/27/2009	2	30	5.10	94	79	3.5	14.4	-65
	1/14/2010	2	30	4.63	320	690	0.4	12	-153

Table 3.2
Field Water Quality Parameters

Well ID	Sample Date	WBZ	Sample Depth (ft bgs)	pH	Conduc-tivity (mS/m)	Turbidity (NTU)	DO (mg/L)	Temper. (°C)	ORP (mV)
	1/29/2010	2	30	4.37	270	440	1	12.9	-49
	2/16/2010	2	30	4.27	230	990	2.2	13.3	26
	4/14/2010	2	30	3.85	230	350	3.9	14.8	14
	4/1/2011	2	30	4.82	313	181	0.6	12.6	70
	11/28/2011	2	30	4.36	383	533	0	13.3	-39
	8/17/2012	2	30	5.08	297	132	3.26	16.22	-32
R2-IW4	1/26/2009	2	30	6.13	NA*	97.4	8.89	11.5	295
	1/26/2009	2	45	6.22	NA*	95.8	8.75	11.9	297
	1/26/2009	2	65	6.42	NA*	93.2	8.5	13.2	294
	1/28/2009	2	30	6.99	51.9	3	2.46	12.6	98
	1/28/2009	2	65	6.90	52	55.1	3.36	12.7	-5
	4/17/2009	2	45	4.50	170	990	0.3	13.9	-91
	4/29/2009	2	45	4.53	190	130	0.3	13.4	-171
	7/23/2009	2	45	4.77	220	75	0.6	14.5	-134
	10/29/2009	2	45	4.47	180	500	3.2	13.7	-23
R2-IW5	5/19/2010	2	45	3.77	150	990	1.6	16.1	41
R2-IW6	6/23/2009	2	45	5.42	80	70	0.9	14.2	-95
	10/29/2009	2	45	4.82	120	190	3.6	13.6	-39
	1/15/2010	2	45	4.90	290	490	1.1	12.6	-123
	1/29/2010	2	45	4.10	160	390	1.6	12.8	-24
	2/16/2010	2	45	4.21	130	990	3.1	12.6	24
	4/15/2010	2	45	3.58	160	350	1.9	12.7	39
	4/1/2011	2	45	4.63	273	109	0.6	12.3	102
	11/28/2011	2	45	4.16	302	455	0	11.9	-74
	8/17/2012	2	45	4.79	356	84.7	5.62	16.29	-4
R2-IW7	10/11/2012	2	55	6.23	52.6	70	0.6	12.7	5
R2-IW8	2/20/2013	2	40	6.50	77.2	192	0.22	11.84	72
R2-IW9	2/20/2013	2	40	6.71	111	42.9	0.3	11.71	100
R2-IW10	2/20/2013	2	37	7.53	106	150	0.75	11.4	150
R2-IW-11	2/20/2013	2	37	6.76	96	28.9	1.04	11.41	226
R2-IW8	2/20/2013	2	63	6.56	79.3	72.2	0.28	11.69	54
R2-IW9	2/20/2013	2	63	6.36	118	207	2.55	11.91	81
R2-IW10	2/20/2013	2	60	7.49	103	124	0.73	11.64	123
R2-IW-11	2/20/2013	2	60	7.58	114	176	0.34	11.8	178
Row 1 Performance Wells									
B-10A	5/19/2010	1	12	5.69	74	470	1.4	14.6	-123
B-58	1/27/2009	1	10	6.04	13.2	65.4	6.57	11.1	194
	4/28/2009	1	10	5.58	26	14	3.1	10.6	127
	10/26/2009	1	10	5.54	22	20	5.6	14.9	123
	1/20/2010	1	10	5.64	25	250	4.2	13	172
	7/30/2010	1	10	5.22	30	990	7	14	154

Table 3.2
Field Water Quality Parameters

Well ID	Sample Date	WBZ	Sample Depth (ft bgs)	pH	Conduc-tivity (mS/m)	Turbidity (NTU)	DO (mg/L)	Temper. (°C)	ORP (mV)
	3/30/2011	1	10	4.35	32.3	8.8	0.9	10.8	141
	11/29/2011	1	10	6.39	86.8	619	4.58	14.2	25
	8/20/2012	1	10	Pumped well dry, no water quality measurements recorded.					
	5/29/2013	1	10	5.99	69.4	250	5.19	24.88	-18
	7/22/2013	1	10	6.28	83.7	78.5	0.27	32.34	-73
B-60	1/27/2009	1	10	6.43	12	19.9	10	9	209
	4/28/2009	1	10	5.43	11	7	9.3	9.3	147
	9/16/2009	1	10	5.62	12	0	5.1	20.3	56
	10/26/2009	1	10	5.57	15	14	7.1	14.9	98
	1/14/2010	1	10	5.56	10	240	2.1	7.7	-1
	2/16/2010	1	10	5.65	12	990	2.6	8.5	-52
	4/14/2010	1	10	5.23	14	240	4.2	9.1	-14
	7/30/2010	1	10	4.84	19	990	4.9	13.5	124
	3/30/2011	1	10	4.42	35.3	10	2	11	109
	11/29/2011	1	10	6.13	89.2	0	0	13.2	-49
	8/20/2012	1	10	6.36	57.6	0	0.59	14.73	-30
	5/29/2013	1	10	5.68	79.4	17.9	0.39	20.07	14
	7/22/2013	1	10	5.74	108	77.7	0.85	35.53	-5
B-59	1/27/2009	2	25	6.91	55.1	-5*	4.14	12.8	103
	4/28/2009	2	27	5.84	550	51	0.4	12.1	-209
	10/26/2009	2	25	6.05	360	470	3.3	14	-129
	1/21/2010	2	25	6.38	250	990	1.5	13	-143
	7/30/2010	2	27	5.61	310	990	2.3	14.2	-72
	3/30/2011	2	27	4.87	411	176	1.2	12.9	28
	11/29/2011	2	27	6.08	502	288	0	11.8	-74
	8/20/2012	2	27	5.57	423	251	0.22	14.89	-37
	5/29/2013	2	27	5.78	78	99.3	0.4	20.33	0
	7/22/2013	2	27	5.32	75.4	555	0.97	32.61	50
B-61	1/27/2009	2	40	6.37	60.2	93.4	3.93	11.6	187
	4/28/2009	2	40	5.95	69	14	0.4	12.8	-91
	6/23/2009	2	40	6.19	75	75	1.3	14.4	-101
	7/23/2009	2	40	6.25	77	14	2.1	14.4	-100
	9/16/2009	2	40	6.16	73	31	2.4	16.1	-117
	10/26/2009	2	40	6.10	74	25	3.6	14.6	-124
	1/14/2010	2	40	6.05	60	440	5	9.8	-82
	2/16/2010	2	40	6.03	58	990	2.4	11.1	-80
	4/14/2010	2	40	5.94	73	290	4.8	12.2	-68
	7/30/2010	2	40	5.65	67	990	3.2	14.7	-64
	3/30/2011	2	40	4.74	57.2	30.6	1.1	12.7	17
	11/29/2011	2	40	6.33	81.5	251	0	13.2	-90
	8/20/2012	2	40	6.46	71.8	54.2	0.65	14.7	-116
	5/29/2013	2	40	6.13	72	44	5.36	14.51	14

Table 3.2
Field Water Quality Parameters

Well ID	Sample Date	WBZ	Sample Depth (ft bgs)	pH	Conduc-tivity (mS/m)	Turbidity (NTU)	DO (mg/L)	Temper. (°C)	ORP (mV)
	7/22/2013	2	40	6.04	69	42.2	1.64	23.57	1
Row 2 Performance Wells									
B-64	1/26/2009	1	10	5.99	NA*	94.1	8.71	13.1	295
	4/28/2009	1	10	5.12	20	86	6.5	11.7	139
	10/29/2009	1	10	5.50	23	530	6.2	14.9	122
	1/14/2010	1	10	5.48	20	990	5.6	12.7	9
	2/16/2010	1	10	5.37	22	990	5.4	12.5	-16
	3/30/2011	1	10	4.41	22.3	79.9	1.7	11.2	106
	11/28/2011	1	10	5.58	28.5	40.8	1.76	12.9	71
	8/17/2012	1	10	5.58	27.9	0	1.03	17.95	171
	7/22/2013	1	10	5.37	30.6	15.1	0.55	16.12	55
B-34	1/26/2009	1	10.5	6.13	NA*	109	10	8.4	338
	4/28/2009	1	10.5	7.13	870	120	7.2	10.3	16
	10/29/2009	1	10.5	7.09	4	240	3.6	15	-37
	1/15/2010	1	10.5	7.37	2	260	7.8	8.4	-10
	4/15/2010	1	10.5	7.35	2.5	340	3.2	10.1	-88
	3/30/2011	1	10.5	5.32	1.73	510	1.2	8.9	-54
	11/28/2011	1	10.5	6.73	20	125	0	12.3	85
	8/17/2012	1	10.5	6.68	667	17	3.36	18.65	86
	7/22/2013	1	10.5	6.47	1,260	31.5	1.32	16.84	21
MW-3	10/28/2009	1	10	5.86	25	400	5.1	14.2	74
	1/15/2010	1	10	6.01	34	250	3.6	14.1	-30
	4/22/2010	1	10	5.60	23	270	2.5	13.4	-27
	12/13/2012	1	10	5.85	56.3	46.6	3.42	13.62	53
MW-5	10/27/2009	1	10	6.30	150	240	5.2	16.3	-3
	12/13/2012	1	10	6.36	776	8.3	5.72	10.16	201
	7/22/2013	1	10	5.85	546	1.7	3.66	13.92	191
B-15	1/29/2010	1	18	6.17	140	990	4.3	12.5	62
B-30	1/29/2010	1	15	6.42	170	990	5.2	12.9	9
B-47	1/29/2010	1	13	5.77	190	990	5.2	12.8	96
B-35	8/17/2012	2	27	6.10	54.4	44.9	0.76	15.03	-49
B-65	1/26/2009	2	29	6.58	NA*	116	8.88	12.1	323
	4/28/2009	2	29	5.94	61	2	1.2	12.9	-106
	10/29/2009	2	29	6.19	65	150	5.6	13.4	-121
	1/14/2010	2	29	6.06	84	210	2	12.3	-146
	2/16/2010	2	29	6.02	74	990	2.7	12.3	-129
	3/30/2011	2	29	4.67	82.3	18.1	2.9	12.4	29
	11/28/2011	2	29	6.18	94.3	30.2	0	12.5	-57
	8/17/2012	2	29	6.14	93.2	0	1.06	15.77	-43
	7/22/2013	2	29	5.48	105	89.4	0.71	15.77	25
B-33A	1/26/2009	2	30	6.00	NA*	97.8	9.55	11	342

Table 3.2
Field Water Quality Parameters

Well ID	Sample Date	WBZ	Sample Depth (ft bgs)	pH	Conduc-tivity (mS/m)	Turbidity (NTU)	DO (mg/L)	Temper. (°C)	ORP (mV)
	4/28/2009	2	30	5.79	250	51	0.6	11.8	-42
	6/23/2009	2	30	5.95	400	140	0.7	14.7	-82
	6/23/2009	2	30	6.18	450	45	1.2	14	-81
	7/23/2009	2	30	6.27	370	43	1.4	15.1	-81
	10/29/2009	2	30	6.09	250	140	4.4	13.1	-91
	1/15/2010	2	30	6.25	600	320	10.5	8.2	19
	2/16/2010	2	30	4.96	50	990	2.8	10.2	54
	4/15/2010	2	30	6.14	390	370	1.8	12.7	-93
	3/30/2011	2	30	5.05	106	151	0.5	11.4	-21
	11/28/2011	2	30	6.23	111	289	0	12.3	-141
	8/17/2012	2	30	5.79	116	27.9	1.33	14.37	-71
	7/22/2013	2	30	5.77	79.9	30.5	0.41	14.43	20
MW-4	10/28/2009	2	40	6.27	100	400	3.4	13.5	-110
	1/15/2010	2	40	6.37	96	230	2.4	13.8	-109
	4/22/2010	2	40	6.12	88	340	3.9	14.3	-72
	12/13/2012	2	40	6.13	90.9	48.1	0.43	12.73	35
MW-6	10/27/2009	2	40	6.19	710	990	4.1	13.9	-12
	12/13/2012	2	40	5.82	173	181	0.74	11.5	238
	7/22/2013	2	40	5.87	269	194	0.68	13.93	174
Phase 2 Performance Wells									
B-56	1/20/2010	1	13	5.57	43	290	2.8	13	114
	5/18/2011	1	13	6.70	42	365	2	12.2	168
B-57	1/21/2010	1	14	5.76	35	380	4.1	11.7	119
NW1-1	1/20/2010	1	12	5.53	44	220	4	13.6	82
	3/30/2011	1	12	4.43	46.5	24.3	1.8	11.8	82
	5/18/2011	1	12	6.20	55.3	305	1.8	13.5	69
	11/30/2011	1	12	5.98	66.2	0	2.29	13.5	62
	8/21/2012	1	12	5.90	75.8	8.9	0.99	15.48	-52
	7/22/2013	1	12	5.25	75.3	15.5	0.56	19.1	53
NW1-2	1/20/2010	1	12	5.53	46	230	2.8	13.2	89
	3/30/2011	1	12	4.52	48.3	10.3	1.9	12	65
	5/18/2011	1	12	6.00	59.1	175	1.6	13.5	62
	11/30/2011	1	12	5.71	98	11.5	0.69	13.1	-90
	8/21/2012	1	12	5.77	52.3	9.4	0.8	14.95	-67
	7/22/2013	1	12	4.33	89.5	210	0.53	16.55	94
B-13	1/20/2010	1	12	5.68	60	270	2.5	13.6	59
B-22	1/20/2010	1	10	5.88	55	370	1.7	11.2	-86
	11/30/2011	1	10	6.16	35.3	49	2.95	12.8	80
	8/21/2012	1	10	6.02	67	9.5	2.96	17.4	133
B-62	1/21/2010	1	12	5.94	43	370	4.4	13.2	77
B-18	1/21/2010	1	15	6.11	62	990	1.2	13	-78

Table 3.2
Field Water Quality Parameters

Well ID	Sample Date	WBZ	Sample Depth (ft bgs)	pH	Conduc-tivity (mS/m)	Turbidity (NTU)	DO (mg/L)	Temper. (°C)	ORP (mV)
B-36	1/21/2010	1	10	5.95	21	990	5.3	12.7	67
NW2-1	1/20/2010	2	29	6.35	57	320	3	13.9	-110
	10/11/2012	2	29	6.90	59.1	18.5	0.83	14.04	-56
NW2-2	1/20/2010	2	29	6.54	60	330	2.2	13.4	-130
B-23	1/20/2010	2	29	5.96	51	990	3	13.4	-63
B-63	1/21/2010	2	43	6.02	97	990	2.4	13.5	-71
B-19	1/21/2010	2	46	6.11	48	840	1.4	13.1	-77
B-35	1/21/2010	2	27	6.04	33	990	3.1	13.3	-81

Notes:

January 2009 data represents pre-ERD Baseline results.

* Recorded value of turbidity indicates Horiba malfunction for Well B-59 on 1/27/2009.

NA* Indicates an error reading on conductivity and temp, Horiba was recalibrated after the error was found.

Abbreviations:

bgs Below ground surface
C Celsius
DO Dissolved oxygen
ft Feet
mS/m Millisiemens per meter
mV Millivolt
NTU Nephelometric turbidity units
ORP Oxidation-reduction potential

Table 3.3a
R1-IW2 Water Quality CVOC Data (Row 1 Injection Well, 1st and 2nd WBZ)

Sample Date	PCE (µg/L)	TCE (µg/L)	cis-1,2-DCE (µg/L)	trans-1,2-DCE (µg/L)	VC (µg/L)	Total CVOCs (µg/L)
R1-IW2-17						
1/14/2010	20 U	20 U	92	20 U	110	202
1/14/2010-D	1 U	3.8	33	1.4	110	148
1/29/2010	3.1	5.5	36	3 U	88	133
2/16/2010	13	8.4	37	5 U	76	134
8/20/2012	1	1.35	1 U	1 U	11.5	14
7/24/2013	1 U	1 U	46.6	2.79	43.1	92.5
R1-IW2-60						
1/26/2009	20 U	140	610	20 U	220	970
4/29/2009	5.6	17	250	3.4	190	466
7/23/2009	1.3	1.8	180	2.4	140	326
9/16/2009	1 U	3	75	2.1	62	142
10/27/2009	3.9	3.1	86	1.4	50	144
10/27/2009-D	2.8	3.2	78	2.2	45	131
1/14/2010	20 U	20 U	35	20 U	90	125
1/29/2010	3 U	4	32	3 U	85	121
2/16/2010	4.5 J	6.5	45	5 U	71	127
3/31/2011	1.2	1.6	4.1	1 U	33.4	40
3/31/2011-D	1 U	1.5	3.8	1 U	30.7	36
11/29/2011	1 U	1.3	21.1	1 U	17.1	39
8/20/2012	1 U	1.3	1 U	1 U	14.6	16
7/24/2013	1 U	1 U	103 D	4.1	62 D	169

Abbreviations:

CVOC Chlorinated volatile organic compound
DCE Dichloroethene
PCE Tetrachloroethene
TCE Trichloroethene
VC Vinyl chloride

Qualifiers:

U Non-detect
J Estimated
E Estimated concentration exceeded calibration range
D Dilution was required

Table 3.3b

R1-IW2 Other Water Quality Parameters (Row 1 Injection Well, 1st and 2nd WBZ)

Parameter Group	Parameters	Units	Dates					
			1/29/2010	2/16/2010	3/31/2011	11/29/2011	8/20/2012	7/24/2013
R1-IW2-17								
Total Organic Carbon	TOC	mg/L					4,810 D	100 D
R1-IW2-60								
Dissolved Gases	Ethane	mg/L						
	Ethene	mg/L						
	Methane	mg/L						
Anions	Bromide	mg/L						
	Nitrate	mg/L						
	Nitrite	mg/L						
	Sulfate	mg/L						
	Chloride	mg/L						
	Phosphate	mg/L						
Total Organic Carbon	TOC	mg/L	1,700	1,100	3,280	3,390 D	4,960 D	126 D

Qualifiers:

U Non-detect
J Estimated
E Estimated concentration exceeded calibration range
D Dilution was required

Table 3.4
R1-IW3A Water Quality CVOC Data (Row 1 Injection Well, 1st WBZ)

Sample Date	PCE (µg/L)	TCE (µg/L)	cis-1,2-DCE (µg/L)	trans-1,2-DCE (µg/L)	VC (µg/L)	Total CVOCs (µg/L)
R1-IW3A-12						
11/29/2011	6.4	8.9	7.4	1 U	0.85	16.2
8/20/2012	1 U	6.0	11.6	1 U	15.7	33.3
5/29/2013	6	17.7	46.6	13.8	3.59	87.7
7/24/2013	7.2	52.2	793 D	47.1	24.4	924

Abbreviations:

CVOC Chlorinated volatile organic compound
DCE Dichloroethene
PCE Tetrachloroethene
TCE Trichloroethene
VC Vinyl chloride

Qualifiers:

U Non-detect
J Estimated
E Estimated concentration exceeded calibration range
D Dilution was required

Table 3.5a

R1-IW4A Water Quality CVOC Data (Row 1 Injection Well, 1st WBZ)

Sample Date	PCE (µg/L)	TCE (µg/L)	cis-1,2-DCE (µg/L)	trans-1,2-DCE (µg/L)	VC (µg/L)	Total CVOCs (µg/L)
R1-IW4A-11						
1/26/2009	3,100	1,100	1,300	23	290	5,813
4/29/2009	250	88	440	11	370	1,159
4/29/2009	260	89	450	11	400	1,210
6/23/2009	9.6	1.4	2,500	1 U	0.2 U	2,511
7/23/2009	1,700	380	1,300	35	1,500	4,915
9/16/2009	2.9	7.3	1,200	11	260	1,481
10/27/2009	18	13	4,200	39	370	4,640
1/14/2010	10 U	13	3,600	28	350	3,991
1/29/2010	140	550	4,300	46	420	5,456
2/16/2010	1,700	3,600	6,100	52	170	11,622
2/16/2010-D	2,000	4,100	6,700	60	190	13,050
4/14/2010	7.8 J	14 J	2,500	24	210	2,756
3/31/2011	1 U	1 U	619	18.8	907	1,545
11/29/2011	20 U	20 U	2,600 D	20 D	242 D	2,842
8/20/2012	1.57	3.75	1,450 D	16	504 D	1,975
5/29/2013	8.84	36	2,030 D	123 D	130 D	2,328
5/29/2013-D	8.75	35.2	1,990 D	116 D	123 D	2,273
7/24/2013	1 U	5.4	1,540 D	23.4	106 D	1,675

Abbreviations:

CVOC Chlorinated volatile organic compound
DCE Dichloroethene
PCE Tetrachloroethene
TCE Trichloroethene
VC Vinyl chloride

Qualifiers:

U Non-detect
J Estimated
E Estimated concentration exceeded calibration range
D Dilution was required

Table 3.5b

R1-IW4A Other Water Quality Parameters (Row 1 Injection Well, 1st WBZ)

Parameter Group	Parameters	Units	Date						
			2/16/2010	4/14/2010	3/31/2011	11/29/2011	8/20/2012	5/29/2013	7/24/2013
R1-IW4A-11									
Dissolved Gases	Ethane	mg/L		0.005 U				0.005 U	0.005 U
	Ethene	mg/L		0.005 U				0.00881	0.005 U
	Methane	mg/L		3.8				1.21 D	2.66 D
Total Organic Carbon	TOC	mg/L	18	550	12.2	3,780	15,800 D		

Qualifiers:

U Non-detect
J Estimated
D Dilution was required
E Estimated concentration exceeded calibration range

Table 3.6a

R1-IW4B Water Quality CVOC Data (Row 1 Injection Well, 2nd WBZ)

Sample Date	PCE (µg/L)	TCE (µg/L)	cis-1,2-DCE (µg/L)	trans-1,2-DCE (µg/L)	VC (µg/L)	Total CVOCs (µg/L)
R1-IW4B-50						
1/26/2009	360	200	570	20 U	1,100	2,230
4/29/2009	5.6	2.9	35	1.4	350	395
7/23/2009	1 U	1 U	14	2.5	270	287
9/16/2009	1 U	1.4	34	1 U	92	127
10/27/2009	1.5	1 U	3.1	1 U	77	82
1/14/2010	1 U	1 U	2.1	1 U	98	100
1/29/2010	3.3	7.5	25	3 U	62	98
2/16/2010	32	37	32	5 U	84	185
4/14/2010	1.1	2	16	1.3	130	150
3/31/2011	1.2	1.8	57.4	1 U	64.9	125
11/29/2011	1.3	3.0	26.1	1 U	124	154
8/20/2012	1 U	2.2	17.2	1 U	100 D	119
5/29/2013	1 U	1.0	498 D	21.4	108 D	628
7/24/2013	1 U	1 U	138 D	1.6	55.1 D	195
7/24/2013-D	1 U	1 U	140 D	1.5	52.1	194

Abbreviations:

CVOC Chlorinated volatile organic compound
DCE Dichloroethene
PCE Tetrachloroethene
TCE Trichloroethene
VC Vinyl chloride

Qualifiers:

U Non-detect
J Estimated
D Dilution was required
E Estimated concentration exceeded calibration range

Table 3.6b

R1-IW4B Other Water Quality Parameters (Row 1 Injection Well, 2nd WBZ)

Parameter Group	Parameters	Units	Dates					
			2/16/2010	4/14/2010	3/31/2011	11/29/2011	8/20/2012	7/24/2013
R1-IW4B-50								
Dissolved Gases	Ethane	mg/L	0.005 U	0.005 U				
	Ethene	mg/L	0.41	0.005 U				
	Methane	mg/L	5.0	7.6				
Total Organic Carbon	TOC	mg/L	410	1,800	1,640	2,550	3,420 D	135 D

Qualifiers:

U Non-detect
J Estimated
D Dilution was required
E Estimated concentration exceeded calibration range

Table 3.7a

R1-IW7 Water Quality CVOC Data (Row 1 Injection Well, 1st and 2nd WBZ)

Sample Date	PCE (µg/L)	TCE (µg/L)	cis-1,2-DCE (µg/L)	trans-1,2-DCE (µg/L)	VC (µg/L)	Total CVOCs (µg/L)
R1-IW7-17						
1/15/2010	10 U	13	52	10 U	2 U	65
1/29/2010	77	170	360	22	7,500	8,129
2/16/2010	280	350	700	21	4,200	5,551
7/24/2013	1 U	1 U	9.03	1 U	59.6 D	69
R1-IW7-45						
1/28/2009	49.6	33.6	1,200	39	13,000	14,322
6/23/2009	660	88	880	17	1,000	2,645
7/23/2009	1 U	11	99	16	5,200	5,326
9/16/2009	1 U	3.7	45	7.7	3,400	3,456
10/26/2009	1 U	1 U	170	1 U	7,300	7,470
1/15/2010	100 U	97 J	380	100 U	6,800	7,277
1/29/2010	45	110	680	29	8,700	9,564
1/29/2010-D	50	120	710	30	8,800	9,710
2/16/2010	90	150	780	26	6,600	7,646
4/14/2010	1.2	3.3	1,000	22	3,500	4,527
3/31/2011	1 U	1 U	18.7	1.88	1,370	1,391
11/29/2011	1 U	1.73	127	2.7	552	683
8/20/2012	1 U	2	13.3	1.1	213 D	229
7/24/2013	1 U	1 U	7.0	1 U	61.6 D	69

Abbreviations:

CVOC Chlorinated volatile organic compound
DCE Dichloroethene
PCE Tetrachloroethene
TCE Trichloroethene
VC Vinyl chloride

Qualifiers:

U Non-detect
J Estimated
D Dilution was required
E Estimated concentration exceeded calibration range

Table 3.7b

R1-IW7 Water Quality CVOC Data (Row 1 Injection Well, 1st and 2nd WBZ)

Parameter Group	Parameters	Units	Dates			
			1/15/2010	1/29/2010	2/16/2010	7/24/2013
R1-IW7-17						
Total Organic Carbo	TOC	mg/L	10	15	9.9	93.9 D

Parameter Group	Parameters	Units	Dates					
			2/16/2010	4/14/2010	3/31/2011	11/29/2011	8/20/2012	7/24/2013
R1-IW7-45								
Dissolved Gases	Ethane	mg/L	0.005 U	0.005 U				
	Ethene	mg/L	0.38	12.6				
	Methane	mg/L	0.26	6.47				
Total Organic Carbo	TOC	mg/L	16	180	183	599 D	1,390 D	96.8 D

Qualifiers:

U Non-detect
J Estimated
E Estimated concentration exceeded calibration range
D Dilution was required

Table 3.8a

R1-IW15 Water Quality CVOC Data (Row 1 Injection Well, 1st and 2nd WBZ

Sample Date	PCE (µg/L)	TCE (µg/L)	cis-1,2-DCE (µg/L)	trans-1,2-DCE (µg/L)	VC (µg/L)	Total CVOCs (µg/L)
R1-IW15-12						
10/11/2012	1 U	1 U	3.1	1 U	13.2	16
7/24/2013	52	72.2 D	394 D	9.5	5.0	533
R1-IW15-55						
10/11/2012	1 U	1 U	70 D	20.8	172 D	263
7/24/2013	37.2	50.8	190 D	4.3	6.6	289

Abbreviations:

CVOC Chlorinated volatile organic compound
DCE Dichloroethene
PCE Tetrachloroethene
TCE Trichloroethene
VC Vinyl chloride

Qualifiers:

U Non-detect
J Estimated
D Dilution was required
E Estimated concentration exceeded calibration range

Table 3.8b

R1-IW15 Water Quality CVOC Data (NW Corner Injection Well, 1st and 2nd WBZ)

Parameter Group	Parameters	Units	Dates 7/24/2013
R1-IW15-12			
Total Organic Carbon	TOC	mg/L	351 D
Parameter Group	**Parameters**	**Units**	**Dates 7/24/2013**
R1-IW15-55			
Total Organic Carbon	TOC	mg/L	759 D

Qualifiers:

U Non-detect
J Estimated
D Dilution was required
E Estimated concentration exceeded calibration range

Table 3.9a

R1-IW18 Water Quality CVOC Data (Row 1 Injection Well, 1st and 2nd WBZ)

Sample Date	PCE (µg/L)	TCE (µg/L)	cis-1,2-DCE (µg/L)	trans-1,2-DCE (µg/L)	VC (µg/L)	Total CVOCs (µg/L)
R1-IW18-12						
10/11/2012	11.6	15.8	103 D	2.1	410 D	542
7/24/2013	1 U	2.5	23.1	1 U	208 D	234
R1-IW18-55						
10/11/2012	4.1	6.7	116 D	2.1	496 D	625
7/24/2013	1 U	1.1	13.3	1.2	262 D	278

Abbreviations:

CVOC Chlorinated volatile organic compound
DCE Dichloroethene
PCE Tetrachloroethene
TCE Trichloroethene
VC Vinyl chloride

Qualifiers:

U Non-detect
J Estimated
D Dilution was required
E Estimated concentration exceeded calibration range

Table 3.9b

R1-IW18 Water Quality CVOC Data (Row 1 Injection Well, 1st and 2nd WBZ)

Parameter Group	Parameters	Units	Dates 7/24/2013
R1-IW18-12			
Total Organic Carbon	TOC	mg/L	7.43

Parameter Group	Parameters	Units	Dates 7/24/2013
R1-IW18-55			
Total Organic Carbon	TOC	mg/L	6.65

Qualifiers:

U Non-detect
J Estimated
D Dilution was required
E Estimated concentration exceeded calibration range

Table 3.10a

R1-IW20 Water Quality CVOC Data (Row 1 Injection Well, 1st and 2nd WBZ)

Sample Date	PCE (µg/L)	TCE (µg/L)	cis-1,2-DCE (µg/L)	trans-1,2-DCE (µg/L)	VC (µg/L)	Total CVOCs (µg/L)
R1-IW20-12						
10/11/2012	2.9	104 D	238 D	1.7	11.1	358
7/24/2013	1 U	1 U	130 D	2.3	280 D	412
R1-IW20-55						
10/11/2012	1.3	21.7	309 D	1.7	19.8	354
7/24/2013	1 U	1 U	140 D	2.4	213 D	355

Abbreviations:

CVOC Chlorinated volatile organic compound
DCE Dichloroethene
PCE Tetrachloroethene
TCE Trichloroethene
VC Vinyl chloride

Qualifiers:

U Non-detect
J Estimated
D Dilution was required
E Estimated concentration exceeded calibration range

Table 3.10b

R1-IW20 Water Quality CVOC Data (Row 1 Injection Well, 1st and 2nd WBZ)

Parameter Group	Parameters	Units	Dates 7/24/2013
R1-IW20-12			
Total Organic Carbon	TOC	mg/L	8.83

Parameter Group	Parameters	Units	Dates 7/24/2013
R1-IW20-55			
Total Organic Carbon	TOC	mg/L	436 D

Qualifiers:

U Non-detect
J Estimated
D Dilution was required
E Estimated concentration exceeded calibration range

Table 3.11

B-58 Water Quality CVOC Data (Row 1 Performance Well, 1st WBZ)

Sample Date	PCE (µg/L)	TCE (µg/L)	cis-1,2-DCE (µg/L)	trans-1,2-DCE (µg/L)	VC (µg/L)	Total CVOCs (µg/L)
B-58						
8/19/2003	4,230	2,820	14,400		238	21,688
11/17/2004	1,310 J	948 J	10,100		869 J	13,227
1/11/2005	5,520	1,810	7,510		1,100	15,940
2/10/2005	5,680	2,120	4,650		597	13,047
3/8/2005	6,940	2,040	5,960		736	15,676
8/16/2005	3,340	683	3,490		993	8,506
12/14/2005	11,700	4,780	4,190		500	21,170
2/16/2006	1,730	341	638		36.4	2,745
12/6/2006	829	14.1	2 U		2 U	843
8/9/2007	2,360	8 U	8 U		8 U	2,360
1/28/2009	190	16	5.8	1 U	0.2 U	212
4/28/2009	690	210	120	1.7	23	1,045
10/26/2009	890	140	60	0.95 J	6.3	1,097
1/21/2010	670	69	32	10 U	5.7	777
7/30/2010	700	100	75	20 U	4 U	875
10/21/2010	430	150	240	2.5	12	835
3/30/2011	446	152	229	2.0	26.2	855
11/29/2011	171	58.9	866	15.5	368	1,479
8/20/2012	34.4	14	146 D	3.1	19.9	217
5/29/2013	14.4	4.38	825 D	61.4 D	181 D	1,086
7/22/2013	16.1	3.3	316 D	30.8	354 D	720

Data before January 2009 represents pre-ERD Baseline results.

Abbreviations:

CVOC Chlorinated volatile organic compound
DCE Dichloroethene
PCE Tetrachloroethene
TCE Trichloroethene
VC Vinyl chloride

Qualifiers:

U Non-detect
J Estimated
D Dilution was required
E Estimated concentration exceeded calibration range

Table 3.12

B-59 Water Quality CVOC Data (Row 1 Performance Well, 2nd WBZ)

Sample Date	PCE (µg/L)	TCE (µg/L)	cis-1,2-DCE (µg/L)	trans-1,2-DCE (µg/L)	VC (µg/L)	Total CVOCs (µg/L)
B-59						
8/19/2003	6.25	5.13	294		67.4	373
12/14/2005	40 U	40 U	462		858	1,320
12/6/2006	9.8	4 U	1,110		1,430	2,550
8/9/2007	0.84	1.92	225		179	407
1/27/2009	23	6.5	48	1 U	2.5	80
4/28/2009	18	22	150	7.7	200	398
10/26/2009	14	1.7	3.8	1.1	7.8	28
1/21/2010	45	2.4	2.8	10 U	1.7	52
7/30/2010	10 U	20 U	9.8 J	20 U	22	32
10/21/2010	1.2	0.54 J	16	1 U	8.7	26
10/21/2010-D	1.1	0.6 J	27	0.55 J	7.9	37
3/30/2011	1.4	1.3	7.8	1 U	5.9	16
11/29/2011	1 U	1 U	1.5	1 U	2.1	3.5
8/20/2012	1 U	2.4	21.2	1.6	58 D	83
5/29/2013	1 U	1 U	2.6	1 U	12	15
7/24/2013	1 U	1 U	2.3	1 U	3.0	5.2

Data before January 2009 represents pre-ERD Baseline results.

Abbreviations:

CVOC Chlorinated volatile organic compound
DCE Dichloroethene
PCE Tetrachloroethene
TCE Trichloroethene
VC Vinyl chloride

Qualifiers:

U Non-detect
J Estimated
D Dilution was required
E Estimated concentration exceeded calibration range

Table 3.13a

B-60 Water Quality CVOC Data (Row 1 Performance Well, 1st WBZ)

Sample Date	PCE (µg/L)	TCE (µg/L)	cis-1,2-DCE (µg/L)	trans-1,2-DCE (µg/L)	VC (µg/L)	Total CVOCs (µg/L)
B-60						
8/19/2003	515	49.7	26.1		1.81	593
12/11/2003	9,100	1,360	2,180		50 U	12,640
1/27/2004	20,700	9,680	7,100		250 U	37,480
2/26/2004	17,300	2,820	3,150		200 U	23,270
3/27/2004	10,400	1,880	2,200		100 U	14,480
4/26/2004	8,970	1,190	1,700		200 U	11,860
1/11/2005	6,160	381	8,030		19,400	33,971
2/10/2005	3,050	1,550	8,080 J		9,660 J	22,340
3/8/2005	1,190	2,350	6,590		4,350	14,480
8/16/2005	91.2	0.8	83.6		847	1,023
12/13/2005	252	202	717		1,310	2,481
2/16/2006	512	3,390	4,160		1,870	9,932
7/13/2006	170	0.2 U	191		1,740	2,101
12/6/2006	254	38.8	345		2,670	3,308
8/6/2007	63.3 J	0.2 UJ	37 J		865 JB	965
1/27/2009	1.7	4 U	1 U	1 U	60	62
4/28/2009	39	1.5	5.4	1 U	0.2 U	46
9/16/2009	24	2.1	9	1 U	29	64
10/26/2009	92	2.6	2.4	1 U	1.4	98
1/14/2010	17	1 U	12	1 U	12	41
2/16/2010	42	23	17	5 U	3.8	86
4/14/2010	25	1.3	9.7	20 U	15	51
4/14/2010-D	28	1.3	7.8	20 U	15	52
7/30/2010	250	20	37	20 U	110	417
7/30/2010-D	210	19 J	30	20 U	99	358
10/21/2010	420	130	370	4.1	38	985
3/30/2011	432	213	584	7.3	106	1,342
11/29/2011	22	12.3	822	12.2	1,680	2,549
8/20/2012	114 D	323 D	2,850 D	53 D	572 D	3,912
5/29/2013	1.2	3.1	50	6.5	637 D	698
7/22/2013	1.6	1.5	936 D	73.7 D	92.6 D	1,105

Data before January 2009 represents pre-ERD Baseline results.

Abbreviations:

CVOC Chlorinated volatile organic compound
DCE Dichloroethene
PCE Tetrachloroethene
TCE Trichloroethene
VC Vinyl chloride

Qualifiers:

U Non-detect
J Estimated
E Estimated concentration exceeded calibration range
D Dilution was required
JB Estimated due to possible blank interference

Table 3.13b

B-60 Other Water Quality Parameters (Row 1 Performance Well, 1st WBZ)

Parameter Group	Parameters	Units	Dates						
			7/30/2010	10/21/2010	3/30/2011	11/29/2011	8/20/2012	5/29/2013	7/22/2013
B-60									
Dissolved Gases	Ethane	mg/L			0.005 U	0.0134	0.00521	0.0112	0.005 U
	Ethene	mg/L			0.109	0.248	0.0283	0.06	0.00801
	Methane	mg/L			2.7	5.7	10.3 D	1.8 D	1.97 D
NWTPH-Gx	Gasoline	ug/L		50 U					
	Gasoline Range Hydrocarbons	ug/L		50 U					
	Mineral Spirits/Stoddard	ug/L		50 U					
NWTPH-Dx/Dx-Ext	Diesel (Fuel Oil)	ug/L		50 U					
	Diesel Range Organics	ug/L		50 U					
	Mineral Oil	ug/L		50 U					
	Heavy Oil	ug/L		100 U					

Qualifiers:

U Non-detect
J Estimated
D Diltuion was required
E Estimated concentration exceeded calibration range

Table 3.14
B-61 Water Quality CVOC (Row 1 Performance Well, 2nd WBZ)

Sample Date	PCE (µg/L)	TCE (µg/L)	cis-1,2-DCE (µg/L)	trans-1,2-DCE (µg/L)	VC (µg/L)	Total CVOCs (µg/L)
B-61						
8/19/2003	1 U	942	14,900		1,630	17,472
12/11/2003	200 U	460	9,580		1,110	11,150
1/27/2004	400 U	972	11,900		1,440	14,312
2/26/2004	250 U	1,700	15,800		1,960	19,460
3/27/2004	200 U	1,110	9,310		538	10,958
4/26/2004	200 U	982	9,740		742	11,464
5/28/2004	460	8.13	1,340		1.75	1,810
1/11/2005	347	2,130	8,140		100 U	10,617
2/10/2005	414	1,520	8,660		200 U	10,594
3/8/2005	248	1,720	7,420		200 U	9,388
12/13/2005	200 U	796	5,830		200 U	6,626
12/6/2006	14.4	1,170	3,630		8 U	4,814
8/9/2007	8 U	1,900	3,210		8.4 JB	5,118
1/27/2009	76	450	870	11	1 U	1,407
4/28/2009	1 U	1.4	1,700	36	1,200	2,937
4/28/2009-D	1 U	1.1	1,600	28	1,800	3,429
6/23/2009	5.7	13	100	1 U	5.2	124
7/23/2009	1 U	1.1	1,700	38	1,600	3,339
9/16/2009	1.7	1 U	1,300	15	1,300	2,617
10/26/2009	1 U	1 U	1,100	14	1,200	2,314
1/14/2010	10 U	10 U	2,300	29	3,900	6,229
2/16/2010	14	16	2,600	24	2,100	4,754
4/14/2010	20 U	20 U	1,300	16 J	950	2,266
7/30/2010	10 U	10 U	2,200	29	2,600	4,829
10/21/2010	0.82 J	1 U	350	5.4	710	1,062
3/30/2011	1 U	1.5	848	12.8	633	1,495
3/30/2011-D	1 U	1.4	861	30.1	632	1,524
11/29/2011	1 U	1.6	1,260	11.6	1,220	2,493
8/20/2012	1 U	1 U	2.2	1 U	9.3	12
8/20/2012-D	1 U	1 U	2.7	1 U	10.6	13
5/29/2013	1 U	1 U	19.8	1 U	172 D	192
7/22/2013	1 U	1 U	4.2	1 U	151 D	155

Data before January 2009 represents pre-ERD Baseline results.
Abbreviations:

CVOC Chlorinated volatile organic compound
DCE Dichloroethene

PCE Tetrachloroethene
TCE Trichloroethene
VC Vinyl chloride

Qualifiers:

U Non-detect
J Estimated
E Estimated concentration exceeded calibration range
JB Estimated due to possible blank interference

Table 3.15

R2-IW1 Water Quality CVOC Data (Row 2 Injection Well, 1st and 2nd WBZ)

Sample Date	PCE (µg/L)	TCE (µg/L)	cis-1,2-DCE (µg/L)	trans-1,2-DCE (µg/L)	VC (µg/L)	Total CVOCs (µg/L)
R2-IW1-17						
10/27/2009	280	160	1,900	44	170	2,554
1/15/2010	35	27	3,000	28	810	3,900
6/28/2010	10 U	20 U	1,200	20 U	250	1,450
12/13/2012	1 U	1 U	11,100 D	76.5	5,740 D	16,840
5/29/2013	1 U	1 U	941 D	3.61	2,160 D	3,105
R2-IW1-45						
10/27/2009	36	1 U	9,100	57	2,700	11,893
1/15/2010	44	28	2,900	28	890	3,890
1/15/2010-D	35	28	3,000	28	940	4,031
2/16/2010	4.5 J	6.5	45	5 U	71	127
4/22/2010	24	24	1,900	27	280	2,255
6/28/2010	10 U	20 U	1,100	110	260	1,470
12/13/2012	1 U	1 U	11,500 D	76	5,800 D	17,376
5/29/2013	1 U	1 U	1,030 D	17.5	2,410 D	3,458

Abbreviations:

CVOC Chlorinated volatile organic compound
DCE Dichloroethene
PCE Tetrachloroethene
TCE Trichloroethene
VC Vinyl chloride

Qualifiers:

U Non-detect
J Estimated
D Dilution was required
E Estimated concentration exceeded calibration range

Table 3.16

R2-IW8 Water Quality CVOC Data (Row 2 Injection Well, 1st and 2nd WBZ)

Sample Date	PCE (µg/L)	TCE (µg/L)	cis-1,2-DCE (µg/L)	trans-1,2-DCE (µg/L)	VC (µg/L)	Total CVOCs (µg/L)
R2-IW8-12						
2/20/2013	16.4	10.1	2,560 D	3.7	2,220 D	4,810
R2-IW8-40						
2/20/2013	2.1	1.5	5,330 D	10.2	6,450 D	11,794
R2-IW8-63						
2/20/2013	5.3	3.3	3,130 D	4.2	5,250 D	8,393

Data in Febr. 2013 represent baseline sampling before start of ERD remedial action in this area.
Abbreviations:

CVOC Chlorinated volatile organic compound
DCE Dichloroethene
PCE Tetrachloroethene
TCE Trichloroethene
VC Vinyl chloride

Qualifiers:

U Non-detect
J Estimated
D Dilution was required
E Estimated concentration exceeded calibration range

Table 3.17

R2-IW9 Water Quality CVOC Data (Row 2 Injection Well, 1st and 2nd WBZ)

Sample Date	PCE (µg/L)	TCE (µg/L)	cis-1,2-DCE (µg/L)	trans-1,2-DCE (µg/L)	VC (µg/L)	Total CVOCs (µg/L)
R2-IW9-12						
2/20/2013	1 U	1 U	407 D	3.3	1,050 D	1,460
R2-IW9-40						
2/20/2013	1 U	1 U	157 D	2.9	651 D	811
R2-IW9-63						
2/20/2013	1 U	1 U	122 D	5.7	1,140 D	1,268

Data in Febr. 2013 represent baseline sampling before start of ERD remedial action in this area.
Abbreviations:

CVOC Chlorinated volatile organic compound
DCE Dichloroethene
PCE Tetrachloroethene
TCE Trichloroethene
VC Vinyl chloride

Qualifiers:

U Non-detect
J Estimated
D Dilution was required
E Estimated concentration exceeded calibration range

Table 3.18

R2-IW10 Water Quality CVOC Data (Row 2 Injection Well, 1st and 2nd WBZ)

Sample Date	PCE (µg/L)	TCE (µg/L)	cis-1,2-DCE (µg/L)	trans-1,2-DCE (µg/L)	VC (µg/L)	Total CVOCs (µg/L)
R2-IW10-12						
2/20/2013	17.2	7.7	732 D	7.8	2,030 D	2,795
2/20/2013-Dup	15.9	7.1	690 D	7.8	2,040 D	2,761
R2-IW10-37						
2/20/2013	1 U	1 U	795 D	9.0	2,410 D	3,214
R2-IW10-60						
2/20/2013	1 U	1 U	1,290 D	14.4	3,520 D	4,824

Data in Febr. 2013 represent baseline sampling before start of ERD remedial action in this area.
Abbreviations:

CVOC Chlorinated volatile organic compound
DCE Dichloroethene
PCE Tetrachloroethene
TCE Trichloroethene
VC Vinyl chloride

Qualifiers:

U Non-detect
J Estimated
D Dilution was required
E Estimated concentration exceeded calibration range

Table 3.19

R2-IW11 Water Quality CVOC Data (Row 2 Injection Well, 1st and 2nd WBZ)

Sample Date	PCE (µg/L)	TCE (µg/L)	cis-1,2-DCE (µg/L)	trans-1,2-DCE (µg/L)	VC (µg/L)	Total CVOCs (µg/L)
R2-IW11-12						
2/20/2013	53.2	69.0 D	214 D	41.3	24.0	402
R2-IW11-37						
2/20/2013	14.2	18.8	49.0	11.4	11.9	105
R2-IW11-60						
2/20/2013	1 U	1 U	1.5	1 U	0.48	2

Data in Febr. 2013 represent baseline sampling before start of ERD remedial action in this area.
Abbreviations:

CVOC Chlorinated volatile organic compound
DCE Dichloroethene
PCE Tetrachloroethene
TCE Trichloroethene
VC Vinyl chloride

Qualifiers:

U Non-detect
J Estimated
D Dilution was required
E Estimated concentration exceeded calibration range

Table 3.20
MW-5 Water Quality CVOC Data (Row 2 Performance Well, 1st WBZ)

Sample Date	PCE (µg/L)	TCE (µg/L)	cis-1,2-DCE (µg/L)	trans-1,2-DCE (µg/L)	VC (µg/L)	Total CVOCs (µg/L)
MW-5						
10/27/2009	4.1	1 U	28	1 U	100	132
12/13/2012	1 U	1 U	1 U	1 U	0.2 U	NA
7/22/2013	8.0	1 U	2.9	1 U	0.2 U	11

Abbreviations:

CVOC Chlorinated volatile organic compound
DCE Dichloroethene
PCE Tetrachloroethene
TCE Trichloroethene
VC Vinyl chloride

Qualifiers:

U Non-detect
J Estimated
E Estimated concentration exceeded calibration range

Table 3.21
MW-6 Water Quality CVOC Data (Row 2 Performance Well, 2nd WBZ)

Sample Date	PCE (µg/L)	TCE (µg/L)	cis-1,2-DCE (µg/L)	trans-1,2-DCE (µg/L)	VC (µg/L)	Total CVOCs (µg/L)
MW-6						
10/27/2009	150	93	120	1 U	28	391
12/13/2012	22.1	9.8	40.7	1.6	0.2 U	74
7/22/2013	140 D	61.9 D	97 D	1.8	0.2 U	301

Abbreviations:

CVOC Chlorinated volatile organic compound
DCE Dichloroethene
PCE Tetrachloroethene
TCE Trichloroethene
VC Vinyl chloride

Qualifiers:

U Non-detect
J Estimated
E Estimated concentration exceeded calibration range

Table 3.22

B-64 Water Quality CVOC Data (Row 2 Performance Well, 1st WBZ)

Sample Date	PCE (µg/L)	TCE (µg/L)	cis-1,2-DCE (µg/L)	trans-1,2-DCE (µg/L)	VC (µg/L)	Total CVOCs (µg/L)
B-64						
8/18/2003	254	125	209		5 U	588
11/16/2004	154	66.8	130		4 U	351
3/7/2005	300	164	401		10 U	865
12/12/2005	348	115	868		10 U	1,331
12/6/2006	49.3 J	9.02 J	18.9 J		1 UJ	77
8/2/2007	143	50.6	78.7		0.22	273
1/26/2009	20 U	48	110	20 U	20	178
4/28/2009	94	20	55	1 U	1.7	171
10/29/2009	150	29	42	1 U	7.8	229
1/14/2010	31	8.3	23	1 U	12	74
2/16/2010	22	11	39	5 U	11	83
3/30/2011	35.1	17.7	23.3	1 U	0.2 U	76
11/28/2011	12.8	4.3	14.5	1 U	1.91	34
8/17/2012	42.8 D	22	99.8 D	2.8	0.2 U	167
7/22/2013	12.4	3.9	60.6 D	1 U	6.4	83

Data before January 2009 represents pre-ERD Baseline results.

Abbreviations:

CVOC Chlorinated volatile organic compound
DCE Dichloroethene
PCE Tetrachloroethene
TCE Trichloroethene
VC Vinyl chloride

Qualifiers:

U Non-detect
J Estimated
D Dilution was required
E Estimated concentration exceeded calibration range

Table 3.23

B-65 Water Quality CVOC Data (Row 2 Performance Well, 2nd WBZ)

Sample Date	PCE (µg/L)	TCE (µg/L)	cis-1,2-DCE (µg/L)	trans-1,2-DCE (µg/L)	VC (µg/L)	Total CVOCs (µg/L)
B-65						
8/18/2003	1 U	1 U	33,400		8,160	41,560
11/16/2004	2.84	1 U	21,600 J		7,570 J	29,173
3/7/2005	100 U	100 U	17,200		6,300	23,500
12/13/2005	200 U	200 U	12,400		6,210	18,610
12/6/2006	400 UJ	400 UJ	18,100 J		8,270 J	26,370
8/2/2007	1.14	0.79	28,200		7,460	35,662
1/26/2009	20 U	20 U	15,000	130	6,500	21,630
1/29/2009	200 U	200 U	23,000	150 J	9,800	32,950
4/28/2009	1 U	1 U	510	1.6	260	772
10/29/2009	1 U	1 U	1,500	1 U	1,800	3,300
1/14/2010	100 U	100 U	5,400	100 U	5,800	11,200
2/16/2010	5 U	4.3 J	5,500	12	3,900	9,416
2/16/2010-D	5 U	4.8 J	5,400	17	3,600	9,022
3/30/2011	1 U	1 U	2,580	17.1	2,270	4,867
11/28/2011	1 U	1 U	2,500 D	10.9	2,010 D	4,521
8/17/2012	1 U	1 U	220 D	6.0	518 D	744
7/22/2013	1 U	1 U	21.1	1 U	105 D	126

Data before January 2009 represents pre-ERD Baseline results.

Abbreviations:

CVOC Chlorinated volatile organic compound
DCE Dichloroethene
PCE Tetrachloroethene
TCE Trichloroethene
VC Vinyl chloride

Qualifiers:

U Non-detect
J Estimated
E Estimated concentration exceeded calibration range
D Dilution was required

Table 3.24a

B-33A Water Quality CVOC Data (Row 2 Performance Well, 2nd WBZ)

Sample Date	PCE (µg/L)	TCE (µg/L)	cis-1,2-DCE (µg/L)	trans-1,2-DCE (µg/L)	VC (µg/L)	Total CVOCs (µg/L)
B-33A						
8/18/2003	6.56	1 U	4,500		11,600	16,107
12/12/2005	200 U	200 U	4,080		6,240	10,320
12/6/2006	100 UJ	100 UJ	3,460 J		12,200 J	15,660
8/2/2007	1.03	0.6	4,040		7,090	11,132
1/26/2009	20 U	20 U	1,100	1.2 J	1,900	3,001
1/29/2009	200 U	200 U	2,100	200 U	5,000	7,100
4/28/2009	1 U	1 U	2,100	1.9	1,200	3,302
6/23/2009 low tide	1 U	1 U	1,300	1 U	1,700	3,000
6/23/2009 high tide	1 U	1 U	1,710	1 U	2,700	4,410
7/23/2009	1 U	1 U	3,200	3	8,100	11,303
10/29/2009	1 U	1 U	3,300	1 U	4,200	7,500
1/15/2010	10 U	10 U	16	10 U	27	43
2/16/2010	5 U	4.4 J	830	5 U	1,800	2,634
4/15/2010	20 U	20 U	1,600	20 U	5,500	7,100
4/15/2010-D	20 U	20 U	1,400	20 U	4,600	6,000
3/30/2011	1 U	1 U	168	1 U	462	630
11/28/2011	1 U	1 U	19	1 U	113	132
8/17/2012	1 U	1 U	3.3	1 U	8.2	11.5
7/22/2013	1 U	1 U	1 U	1 U	2.3	2.3
7/22/2013-D	1 U	1 U	1 U	1 U	2.2	2.2

Data before January 2009 represents pre-ERD Baseline results.

Abbreviations:

CVOC Chlorinated volatile organic compound
DCE Dichloroethene
PCE Tetrachloroethene
TCE Trichloroethene
VC Vinyl chloride

Qualifiers:

U Non-detect
J Estimated
E Estimated concentration exceeded calibration range

Table 3.24b

B-33A Other Water Quality Parameters (Row 2 Performance Well, 2nd WBZ)

Parameter Group	Parameters	Units	Dates					
			2/16/2010	4/15/2010	3/30/2011	11/28/2011	8/17/2012	7/22/2013
B-33A								
Dissolved Gases	Ethane	mg/L	0.005 U	0.08	0.097	0.211	0.114	0.0583
	Ethene	mg/L	0.18	13.7	0.0967	1.08 D	0.173	0.005 U
	Methane	mg/L	0.23	1.9	8.71	12.9 D	9.81 D	4.15 D

Qualifiers:

U Non-detect

J Estimated

E Estimated concentration exceeded calibration range

D Dilution was required

Table 3.25

B-34 Water Quality CVOC Data (Row 2 Performance Well, 1st WBZ)

Sample Date	PCE (µg/L)	TCE (µg/L)	cis-1,2-DCE (µg/L)	trans-1,2-DCE (µg/L)	VC (µg/L)	Total CVOCs (µg/L)
B-34						
8/18/2003	14.6	9.5	45		24.9	94
12/12/2005	36.8	17.5	18.8		0.93	74
12/6/2006	29.7 J	10 J	11.7 J		1 UJ	51
8/2/2007	27.1	9.56	20.4		15.2	72
1/26/2009	20 U	20 U	41	20 U	4 U	41
1/29/2009	11.8	2.8	1.2	1 U	0.2 U	16
4/28/2009	19	5	4.5	1 U	0.2 U	29
10/29/2009	13	3.6	30	1 U	100	147
1/15/2010	8	2.8	2.6	1 U	3.3	17
4/15/2010	11	4.4	3.6	10 U	0.4	19
3/30/2011	5.1	1.7	2.6	1 U	0.5	10
11/28/2011	6.9	4.7	3.3	1 U	0.2 U	15
8/17/2012	4.8	4.3	16.8	1 U	0.2 U	26
7/22/2013	4.4	2.8	5.8	1 U	0.2 U	13

Data before January 2009 represents pre-ERD Baseline results.

Abbreviations:

CVOC Chlorinated volatile organic compound
DCE Dichloroethene
PCE Tetrachloroethene
TCE Trichloroethene
VC Vinyl chloride

Qualifiers:

U Non-detect
J Estimated
E Estimated concentration exceeded calibration range

Table 3.26
Seep Water Quality CVOC Data

Sample Location	Sample ID and Date	PCE (µg/L)	TCE (µg/L)	cis-1,2-DCE (µg/L)	trans-1,2-DCE (µg/L)	VC (µg/L)	Total CVOCs (µg/L)	Total Dissolved Solids (ppt)
S-16	**Seep 1**							
	6/23/2009	1 U	1 U	14	1 U	0.2 U	14	7.7
	10/17/2012	1 U	1 U	1 U	1 U	0.2 U	0	7.8
	7/23/2013	1 U	1 U	1 U	1 U	0.2 U	0	6.3
S-1	**Seep 2**							
	6/23/2009	1 U	1 U	1 U	1 U	0.2 U	0	7.7
	10/17/2012	1 U	1 U	9.4	1 U	20.1	30	6.6
	7/23/2013	1 U	1 U	1 U	1 U	0.2 U	0	10
S-13	**Seep 3**							
	6/23/2009	1 U	1 U	1,800	7	1,400	3,207	3.2
	10/17/2012	2.7	1.5	190 D	2.3	367 D	564	6.2
	7/23/2013	1 U	1 U	19.6	1 U	52.5	75	4.4
S-2	**Seep 4**							
	6/23/2009	55	30	96	1 U	0.2 U	181	6.2
	6/23/2009-D	73	30	120	1 U	0.2 U	223	
	10/17/2012	50 D	52.5 D	338 D	105 D	2.9	548	3.3
	7/23/2013	1 U	1 U	9.5	1 U	0.85	10.3	9.4

Abbreviations:

CVOC	Chlorinated volatile organic compound
DCE	Dichloroethene
PCE	Tetrachloroethene
ppt	Parts per thousand
TCE	Trichloroethene
VC	Vinyl chloride

Qualifier:

U	Non-detect
D	Dilution was required

Table 3.27a
R1-IW8 Water Quality CVOC Data (NW Corner Injection Well, 1st WBZ)

Sample Date	PCE (µg/L)	TCE (µg/L)	cis-1,2-DCE (µg/L)	trans-1,2-DCE (µg/L)	VC (µg/L)	Total CVOCs (µg/L)
R1-IW8-11						
11/1/2010	570	17	4.9	1 U	0.2 U	592
3/31/2011	131	49.6	591	1 U	10.2	782
5/18/2011	17.4	157	943	1.1	1.2	1,119
11/30/2011	8.9	71.1	2,390	4.6	11.8	2,482
8/21/2012	6.1	10.9	512 D	5.5	183 D	717
7/24/2013	3.4	2.1	17	1 U	21.9	44.4

Abbreviations:

CVOC Chlorinated volatile organic compound
DCE Dichloroethene
PCE Tetrachloroethene
TCE Trichloroethene
VC Vinyl chloride

Qualifiers:

U Non-detect
J Estimated
D Dilution was required
E Estimated concentration exceeded calibration range

Table 3.27b
R1-IW8 Water Quality CVOC Data (NW Corner Injection Well, 1st WBZ)

Parameter Group	Parameters	Units	Dates					
			1/3/2011	3/31/2011	5/18/2011	11/30/2011	8/21/2012	7/24/2013
R1-IW8-11								
Dissolved Gases	Ethane	mg/L		0.005 U	0.005 U	0.005 U	0.005 U	0.005 U
	Ethene	mg/L		0.005 U	0.005 U	0.005 U	0.005 U	0.005 U
	Methane	mg/L		0.0393	0.0286	7.6	4.03 D	1.74 D
Total Organic Carbon	TOC	mg/L	2,900	1,840	3,020	1,260	3,050 D	7,040 D

Qualifiers:

U Non-detect
J Estimated
D Dilution was required
E Estimated concentration exceeded calibration range

Table 3.28a

R1-IW9 Water Quality CVOC Data (NW Corner Injection Well, 1st WBZ)

Sample Date	PCE (µg/L)	TCE (µg/L)	cis-1,2-DCE (µg/L)	trans-1,2-DCE (µg/L)	VC (µg/L)	Total CVOCs (µg/L)
R1-IW9-11						
11/1/2010	260	9	5.6	1 U	0.2 U	275
3/31/2011	378	58.2	825	2.1	9.6	1,273
5/18/2011	36	317	539	2.5	1.2	896
11/30/2011	337	131	974	1.0 U	2.4	1,444
8/21/2012	29.1	12.4	2,170 D	15.2	22.6	2,249
7/23/2013	7.6	3.2	65.7 D	1.3	9.7	87

Abbreviations:

CVOC Chlorinated volatile organic compound
DCE Dichloroethene
PCE Tetrachloroethene
TCE Trichloroethene
VC Vinyl chloride

Qualifiers:

U Non-detect
J Estimated
D Dilution was required
E Estimated concentration exceeded calibration range

Table 3.28b

R1-IW9 Water Quality CVOC Data (NW Corner Injection Well, 1st WBZ)

Parameter Group	Parameters	Units	Dates					
			1/3/2011	3/31/2011	5/18/2011	11/29/2011	8/21/2012	7/23/2013
R1-IW9-11								
Dissolved Gases	Ethane	mg/L			0.005 U		0.005 U	0.005 U
	Ethene	mg/L			0.005 U		0.005 U	0.005 U
	Methane	mg/L			0.0517		5.38 D	2.13 D
Total Organic Carbon	TOC	mg/L	6,980	762	257	975	635 D	2,330 D

Qualifiers:

U Non-detect
J Estimated
D Dilution was required
E Estimated concentration exceeded calibration range

Table 3.29a

R1-IW10 Water Quality CVOC Data (NW Corner Injection Well, 1st WBZ)

Sample Date	PCE (µg/L)	TCE (µg/L)	cis-1,2-DCE (µg/L)	trans-1,2-DCE (µg/L)	VC (µg/L)	Total CVOCs (µg/L)
R1-IW10-11						
11/1/2010	710	37	19	1 U	0.2 U	766
11/1/2010-D	710	38	19	1 U	0.2 U	767
3/30/2011	240	76.4	540	20 U	7.8	864
5/18/2011	18.6	9.9	1,330	9.4	3.1	1,371
11/30/2011	407	82.9	1,110	5.4	0.6	1,606
8/21/2012	23.2	8.3	1,110 D	7.8	20.5	1,170
7/23/2013	2.0	3.4	80.3 D	1 U	5.0	90.7

Abbreviations:

CVOC Chlorinated volatile organic compound
DCE Dichloroethene
PCE Tetrachloroethene
TCE Trichloroethene
VC Vinyl chloride

Qualifiers:

U Non-detect
J Estimated
D Dilution was required
E Estimated concentration exceeded calibration range

Table 3.29b

R1-IW10 Water Quality CVOC Data (NW Corner Injection Well, 1st WBZ)

Parameter Group	Parameters	Units	Dates					
			1/3/2011	3/30/2011	5/18/2011	11/30/2011	8/21/2012	7/23/2013
R1-IW10-11								
Dissolved Gases	Ethane	mg/L			0.005 U		0.005 U	0.005 U
	Ethene	mg/L			0.005 U		0.005 U	0.005 U
	Methane	mg/L			0.129		3.92 D	1.51 D
Total Organic Carbon	TOC	mg/L	4,680	1,680	1,300	1,400	720 D	2,220 D

Qualifiers:

U Non-detect

J Estimated

D Dilution was required

E Estimated concentration exceeded calibration range

Table 3.30
R1-IW11 Water Quality CVOC Data (NW Corner Injection Well, 1st WBZ)

Sample Date	PCE (µg/L)	TCE (µg/L)	cis-1,2-DCE (µg/L)	trans-1,2-DCE (µg/L)	VC (µg/L)	Total CVOCs (µg/L)
R1-IW11-12						
10/9/2012	95.5 D	4.0	3.7	1 U	0.2 U	103
7/23/2013	13.7	5.9	28.2	1 U	0.2 U	47.8

Abbreviations:

CVOC Chlorinated volatile organic compound
DCE Dichloroethene
PCE Tetrachloroethene
TCE Trichloroethene
VC Vinyl chloride

Qualifiers:

U Non-detect
J Estimated
D Dilution was required
E Estimated concentration exceeded calibration range

Table 3.31a
R1-IW13 Water Quality CVOC Data (NW Corner Injection Well, 1st WBZ)

Sample Date	PCE (µg/L)	TCE (µg/L)	cis-1,2-DCE (µg/L)	trans-1,2-DCE (µg/L)	VC (µg/L)	Total CVOCs (µg/L)
R1-IW13-12						
10/9/2012	80 D	60 D	196 D	2.0	150 D	488
7/23/2013	4.1	2.4	16.1	1 U	9.5	32

Abbreviations:

CVOC Chlorinated volatile organic compound
DCE Dichloroethene
PCE Tetrachloroethene
TCE Trichloroethene
VC Vinyl chloride

Qualifiers:

U Non-detect
J Estimated
D Dilution was required
E Estimated concentration exceeded calibration range

Table 3.31b

R1-IW13 Water Quality CVOC Data (NW Corner Injection Well, 1st WBZ)

Parameter Group	Parameters	Units	Dates 7/23/2013
R1-IW13-12			
Dissolved Gases	Ethane	mg/L	0.005 U
	Ethene	mg/L	0.005 U
	Methane	mg/L	0.593 D
Total Organic Carbon	TOC	mg/L	732 D

Qualifiers:

U Non-detect
J Estimated
D Dilution was required
E Estimated concentration exceeded calibration range

Table 3.32

NW1-1 Water Quality CVOC Data (NW Corner Performance Well, 1st WBZ)

Sample Date	PCE (µg/L)	TCE (µg/L)	cis-1,2-DCE (µg/L)	trans-1,2-DCE (µg/L)	VC (µg/L)	Total CVOCs (µg/L)
NW1-1						
1/20/10	1,600	60	21	20 U	4 U	1,681
3/30/11	706	40.7	11.6	1 U	0.2 U	758
5/18/11	1,910	58.8	37.8	1 U	0.2 U	2,007
11/30/11	535	33.7	28.1	1 U	0.2 U	597
8/21/12	509 D	68 D	314 D	2.3	126 D	1,019
3/11/13	86.5 D	48.1	243 D	2.0	11.9	391
7/23/13	23.9	16.2	128 D	2.1	16.2	186
7/23/2013-D	19.4	13.9	140 D	1.8	14.1	189

Abbreviations:

CVOC Chlorinated volatile organic compound
DCE Dichloroethene
PCE Tetrachloroethene
TCE Trichloroethene
VC Vinyl chloride

Qualifiers:

U Non-detect
J Estimated
D Dilution was required
E Estimated concentration exceeded calibration range

Table 3.33

NW1-2 Water Quality CVOC Data (NW Corner Performance Well, 1st WBZ)

Sample Date	PCE (µg/L)	TCE (µg/L)	cis-1,2-DCE (µg/L)	trans-1,2-DCE (µg/L)	VC (µg/L)	Total CVOCs (µg/L)
NW1-2						
1/20/10	680	24	40	10 U	5.8	750
3/30/11	561	29	9.2	1 U	0.2 U	599
5/18/11	1,190	39.6	22.2	1 U	0.2 U	1,252
11/30/11	69	40.4	1,110	8.6	0.36	1,228
8/21/12	160 D	79 D	326 D	3.0	0.2 U	568
3/11/13	6.4	25.7	236 D	2.0	1.2	270
7/23/13	51.5	45.8	88.6 D	1.2	5.9	187

Abbreviations:

CVOC Chlorinated volatile organic compound
DCE Dichloroethene
PCE Tetrachloroethene
TCE Trichloroethene
VC Vinyl chloride

Qualifiers:

U Non-detect
J Estimated
D Dilution was required
E Estimated concentration exceeded calibration range

Table 3.34

B-56 Water Quality CVOC Data (1st WBZ, Up gradient of NW Corner Area)

Sample Date	PCE (µg/L)	TCE (µg/L)	cis-1,2-DCE (µg/L)	trans-1,2-DCE (µg/L)	VC (µg/L)	Total CVOCs (µg/L)
B-56						
1/20/2010	180	10 U	8 J	10 U	2 U	188
5/18/2011	234	7.6	7	1 U	0.2 U	249
3/11/2013	106 D	15.3	12	1 U	0.2 U	133
7/25/2013	287	7.9	2.2	1 U	0.2 U	297

Abbreviations:

CVOC Chlorinated volatile organic compound
DCE Dichloroethene
PCE Tetrachloroethene
TCE Trichloroethene
VC Vinyl chloride

Qualifiers:

U Non-detect
D Dilution was required
J Estimated
E Estimated concentration exceeded calibration range

Table 3.35

B-71 Water Quality CVOC Data (1st WBZ, MW in warehouse)

Sample Date	PCE (µg/L)	TCE (µg/L)	cis-1,2-DCE (µg/L)	trans-1,2-DCE (µg/L)	VC (µg/L)	Total CVOCs (µg/L)
B-71						
3/11/2013	85.5 D	11.9	13.8	1 U	0.2 U	111
7/25/2013	266	39.9	19.4	1 U	0.2 U	325

Abbreviations:

CVOC Chlorinated volatile organic compound
DCE Dichloroethene
PCE Tetrachloroethene
TCE Trichloroethene
VC Vinyl chloride

Qualifiers:

U Non-detect
D Dilution was required
J Estimated
E Estimated concentration exceeded calibration range

Table 3.36

B-66 Water Quality CVOC Data (1st WBZ, MW in Warehouse)

Sample Date	PCE (µg/L)	TCE (µg/L)	cis-1,2-DCE (µg/L)	trans-1,2-DCE (µg/L)	VC (µg/L)	Total CVOCs (µg/L)
B-66						
3/11/2013	96 D	6.3	5.9	1 U	0.2 U	108
7/25/2013	109	3.0	1 U	1 U	0.2 U	112

Abbreviations:

CVOC Chlorinated volatile organic compound
DCE Dichloroethene
PCE Tetrachloroethene
TCE Trichloroethene
VC Vinyl chloride

Qualifiers:

U Non-detect
D Dilution was required
J Estimated
E Estimated concentration exceeded calibration range

Table 3.37
Biological Census Sampling

Location/Sample Name	Sample Date	Parameter	Census count	units
R1-IW8-11	7/24/2013	DHC	2,420	cells/mL
		bvc A	2,000	cells/mL
		tce A	4	cells/mL
		vcr A	38	cells/mL
R1-IW7-45	7/24/2013	DHC	53,800	cells/mL
		bvc A	20,900	cells/mL
		tce A	4	cells/mL
		vcr A	3,100	cells/mL
R1-IW4b-50	7/24/2013	DHC	712	cells/mL
		bvc A	699	cells/mL
		tce A	49	cells/mL
		vcr A	110	cells/mL
B-59	7/24/2013	DHC	6,190	cells/mL
		bvc A	1,660	cells/mL
		tce A	4	cells/mL
		vcr A	1,000	cells/mL
R1-IW2-17	7/24/2013	DHC	30,300	cells/mL
		bvc A	20,000	cells/mL
		tce A	12	cells/mL
		vcr A	1,030	cells/mL

DHC *Dehalococcoides* spp. bacterial group known to be capable of full reductive dechlorination of PCE to ethene

bvc A gene encode from vinyl chloride reductase enzyme from *Dehalococcoides* sp. str. BAV1

tceA gene encode from the enzyme responsible for reductive dechlorination of TCE to cis-12DCE in selected strains o*f Dehalococcoides.*

vcr A gene encode from cis 1,2 DCE and vinyl chloride reductase enzyme from *Dehalococcoides* sp. strain VS

Figures

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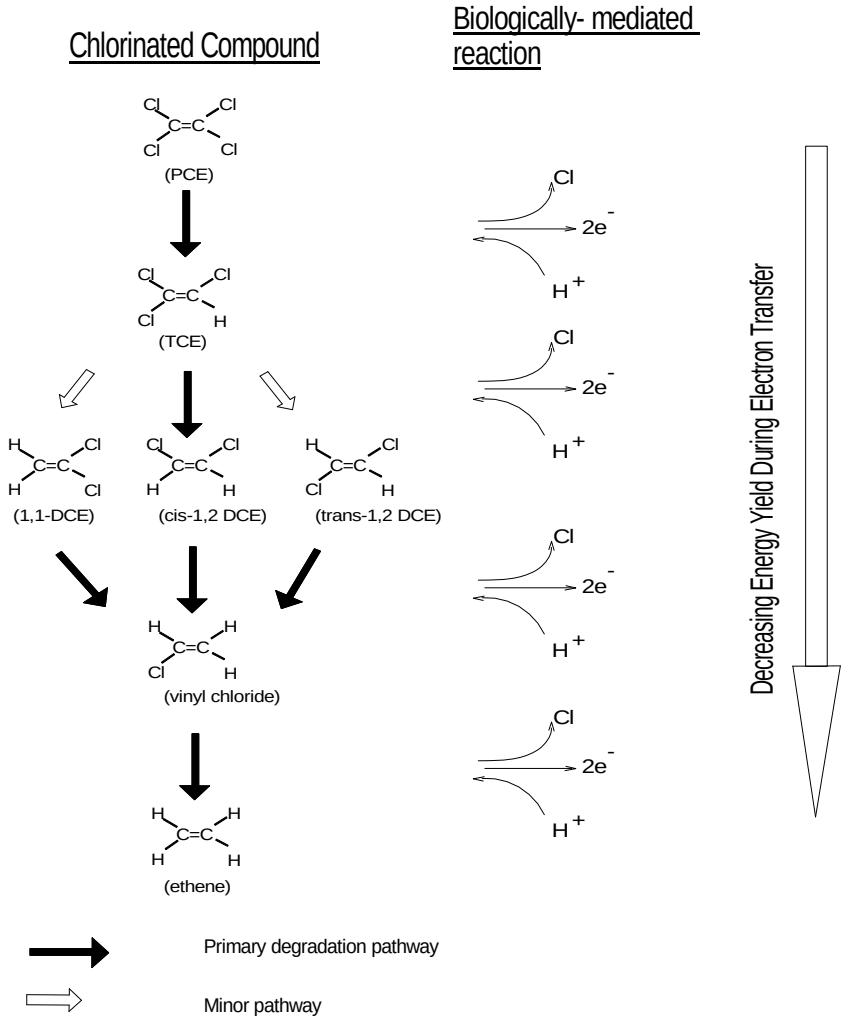
Groundwater Remediation

Fox Avenue Site
Seattle, Washington

Figure 1.1
Vicinity Map

File: F:\projects\FoxAve-RA\GIS\MXD\Figure 1.1 (Calibre Figure - Vicinity Map).mxd
6/3/2009



Enabling Aquifer Condition	Typical Redox Energy Level for Optimum Degradation (see note below)
Anaerobic Denitrification	Redox measures +250 to +100 mV
Anaerobic Iron (III) reduction	Redox measures +100 to 0 mV
Anaerobic Sulfate reduction	Redox measures 0 to -200 mV
Methane fermentation Methanogenesis	Redox measures -200 mV and lower

Note: a wide range of ORP values have been cited in prior studies; values presented here are general ranges from prior work (example reference sources include: Faris and Vlassopoulos [2003] and Wiedemeier et al. [1998]

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Fox Avenue Summary Report
Fox Avenue Site
Seattle, Washington

Figure 1.3
Primary Degradation Pathways of Chlorinated Ethenes by Reductive Dechlorination

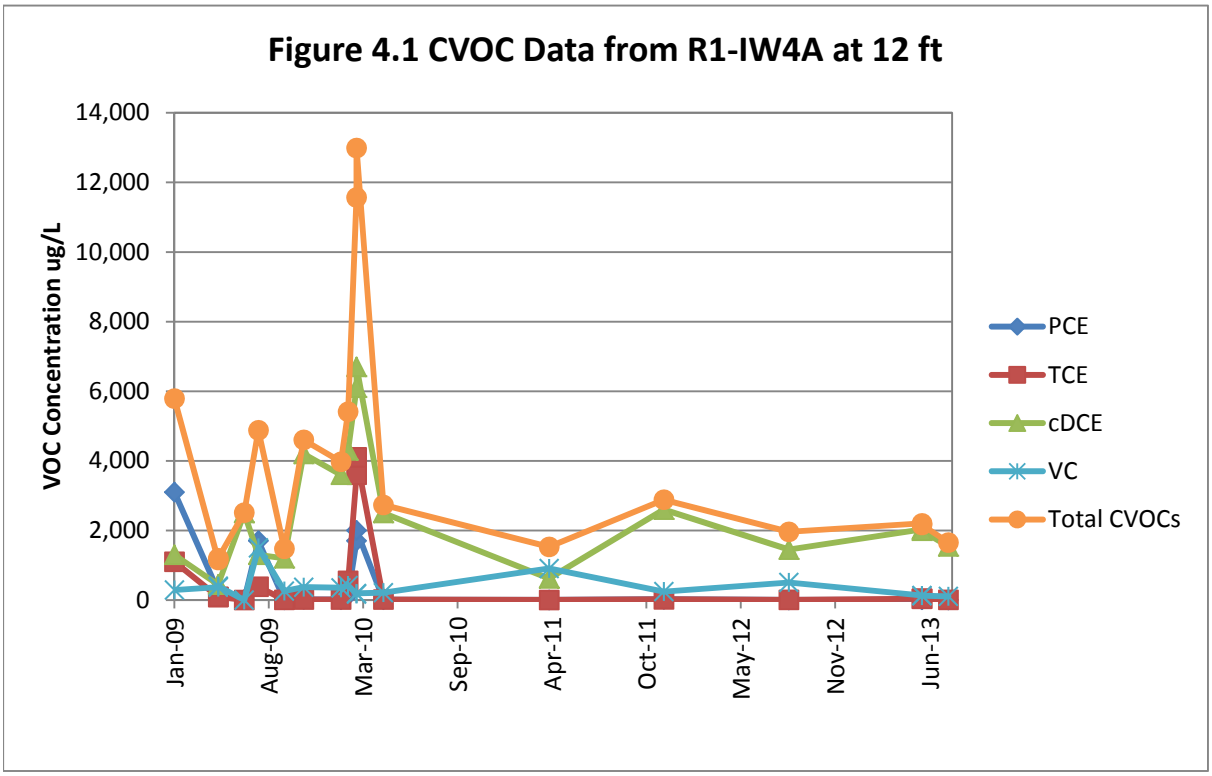


Figure 4.1 CVOC Data from R1-IW4A at 12 ft
VOC Concentration ug/L
14,000
12,000
10,000
8,000
6,000
4,000
2,000
0
Jan-09
Aug-09
Mar-10
Sep-10
Apr-11
Oct-11
May-12
Nov-12
Jun-13
PCE
TCE
cDCE
VC
Total CVOCs

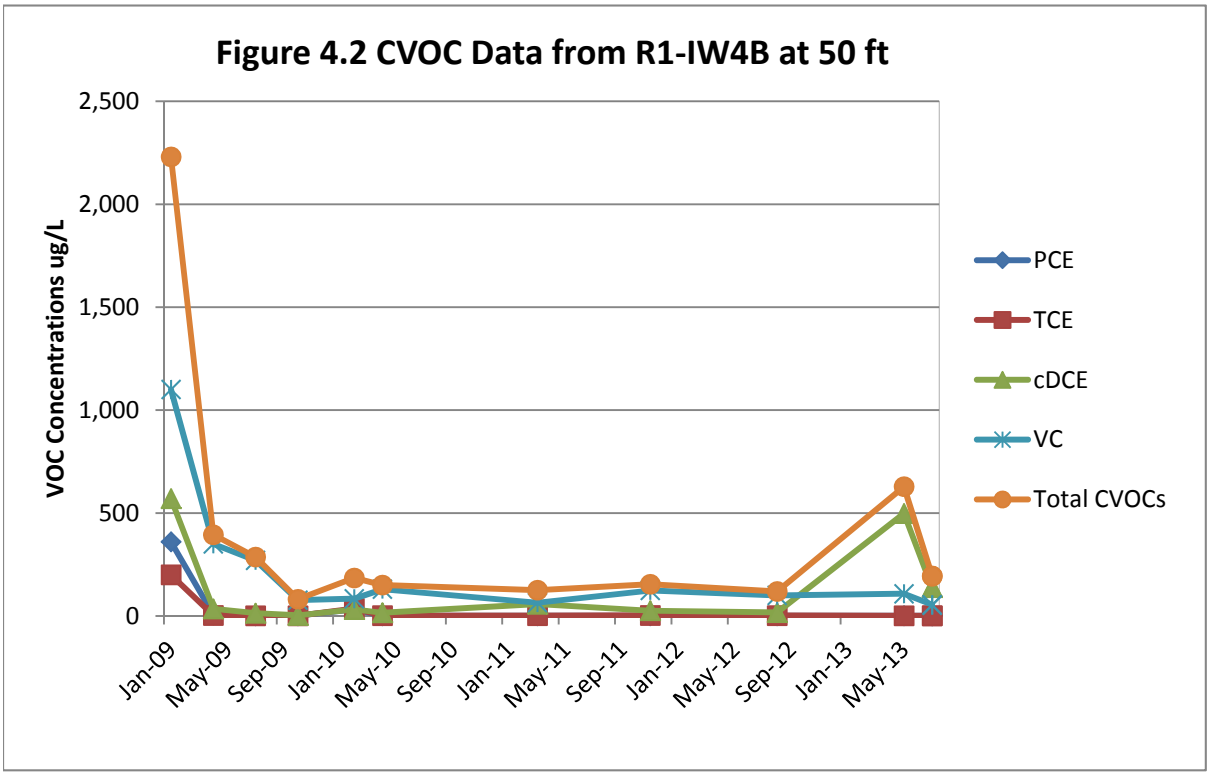


Figure 4.2 CVOC Data from R1-IW4B at 50 ft
VOC Concentrations ug/L
2,500
2,000
1,500
1,000
500
0
Jan-09
May-09
Sep-09
Jan-10
May-10
Sep-10
Jan-11
May-11
Sep-11
Jan-12
May-12
Sep-12
Jan-13
May-13
PCE
TCE
cDCE
VC
Total CVOCs

Figure 4.3 CVOC Data from R1-IW7 at 45 ft

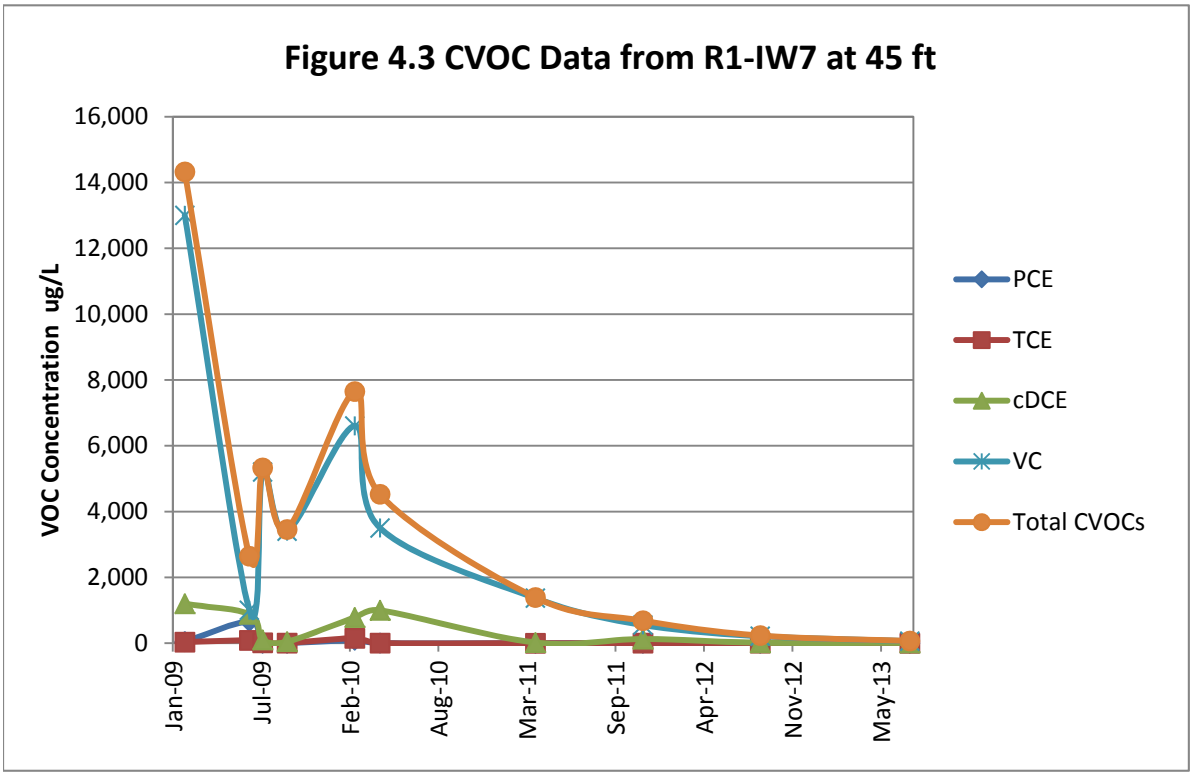
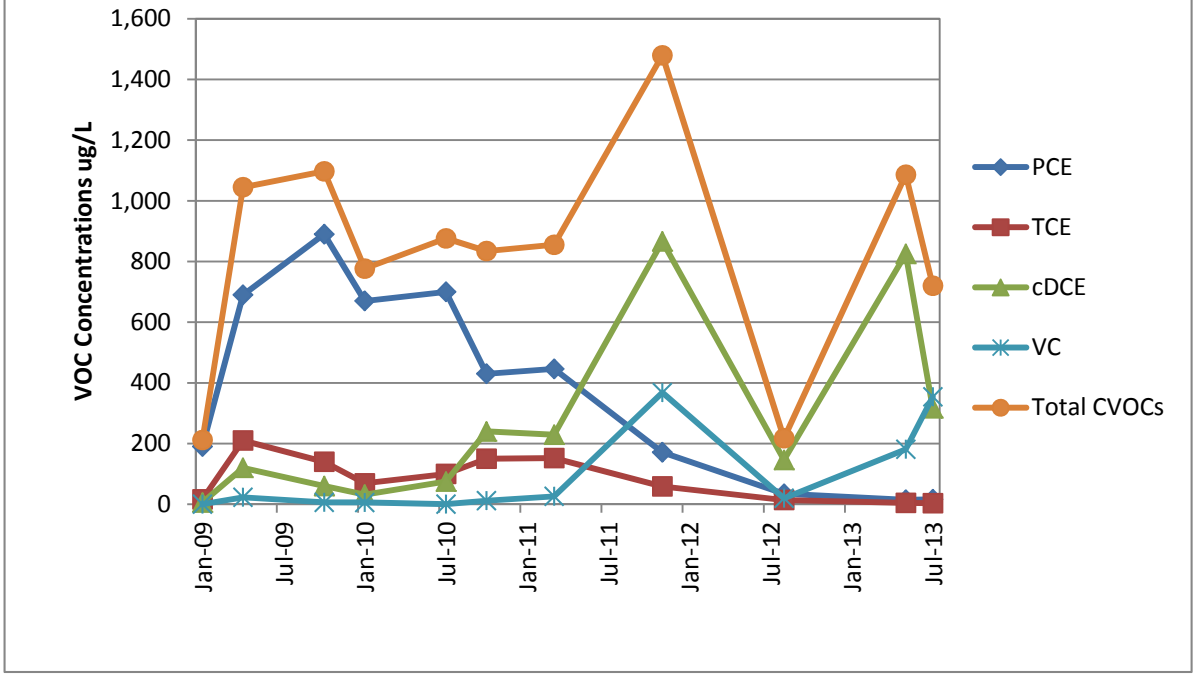


Figure 4.4 CVOC Data from B-58 at 10 ft



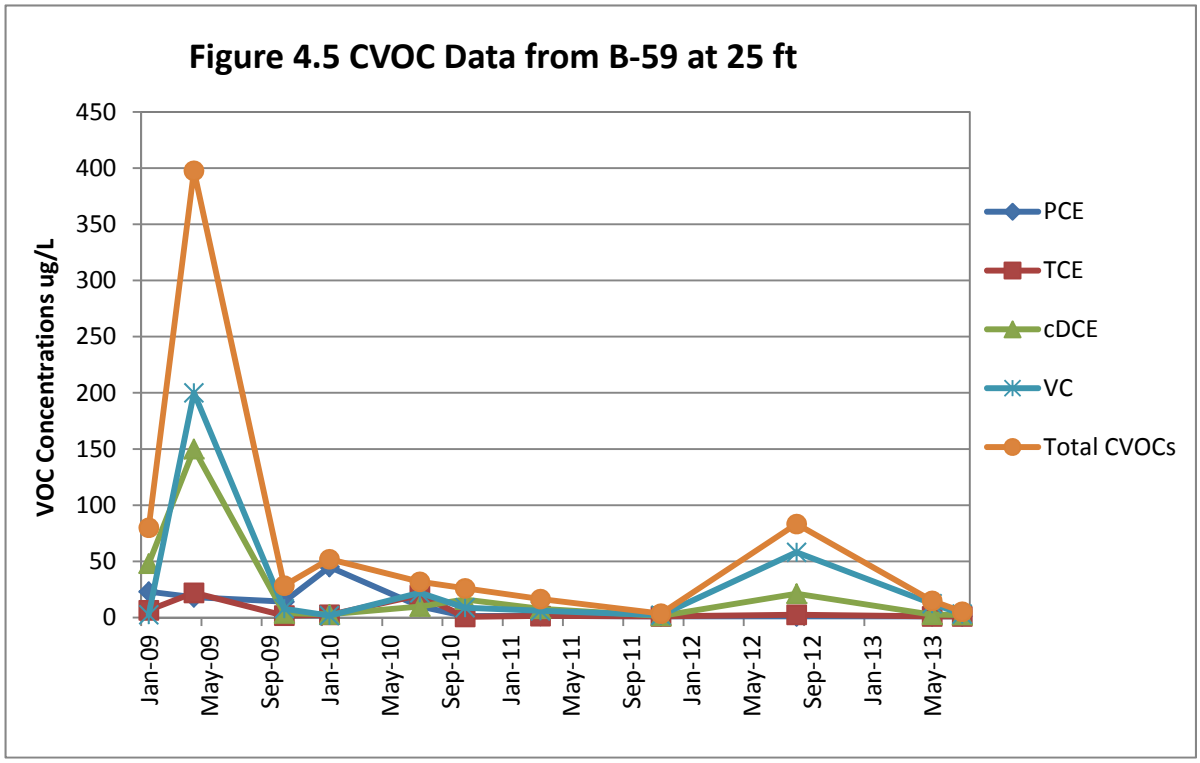


Figure 4.5 CVOC Data from B-59 at 25 ft
VOC Concentrations ug/L
450
400
350
300
250
200
150
100
50
0
Jan-09
May-09
Sep-09
Jan-10
May-10
Sep-10
Jan-11
May-11
Sep-11
Jan-12
May-12
Sep-12
Jan-13
May-13
PCE
TCE
cDCE
VC
Total CVOCs

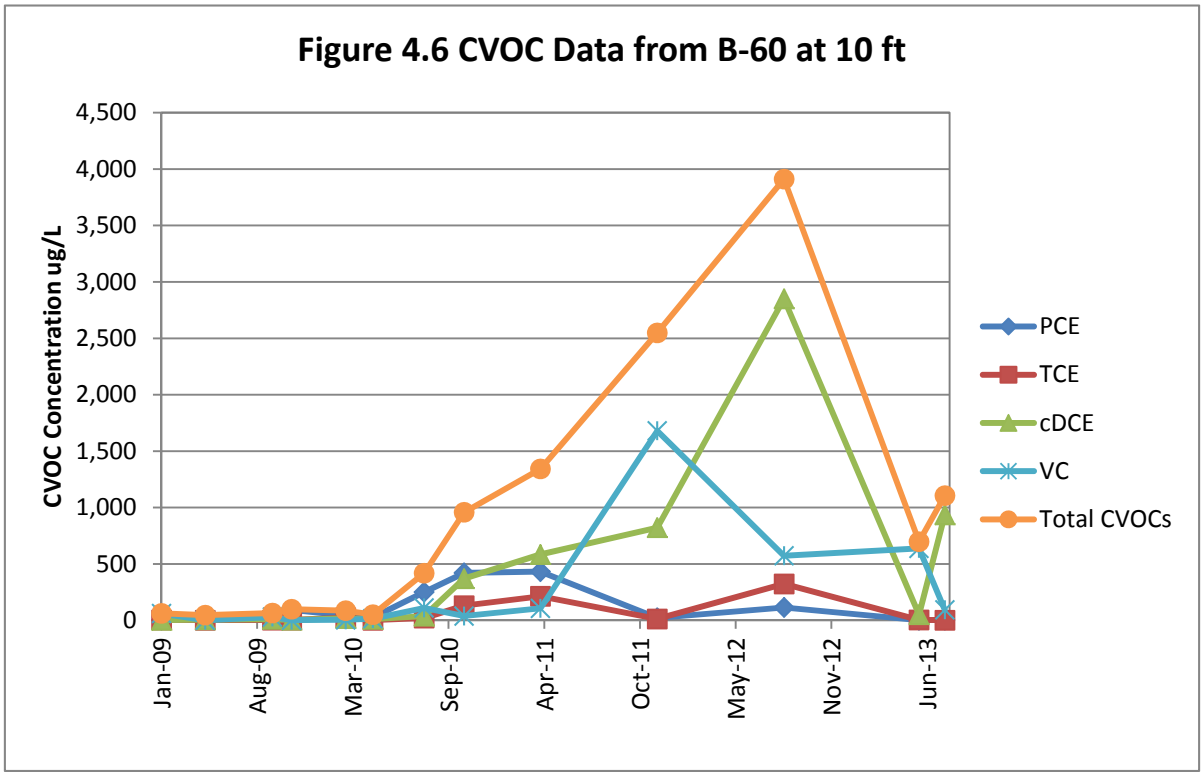


Figure 4.6 CVOC Data from B-60 at 10 ft
CVOC Concentration ug/L
4,500
4,000
3,500
3,000
2,500
2,000
1,500
1,000
500
0
Jan-09
Aug-09
Mar-10
Sep-10
Apr-11
Oct-11
May-12
Nov-12
Jun-13
PCE
TCE
cDCE
VC
Total CVOCs

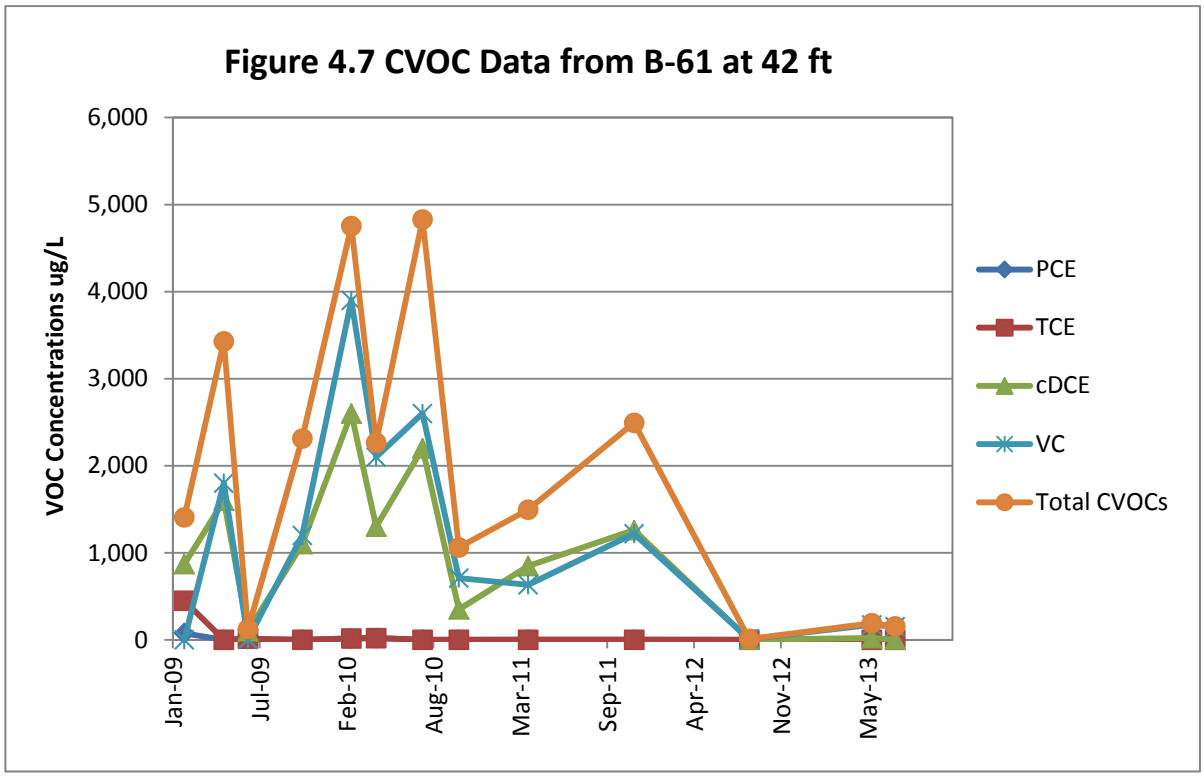


Figure 4.7 CVOC Data from B-61 at 42 ft
VOC Concentrations ug/L
6,000
5,000
4,000
3,000
2,000
1,000
0
Jan-09
Jul-09
Feb-10
Aug-10
Mar-11
Sep-11
Apr-12
Nov-12
May-13
PCE
TCE
cDCE
VC
Total CVOCs

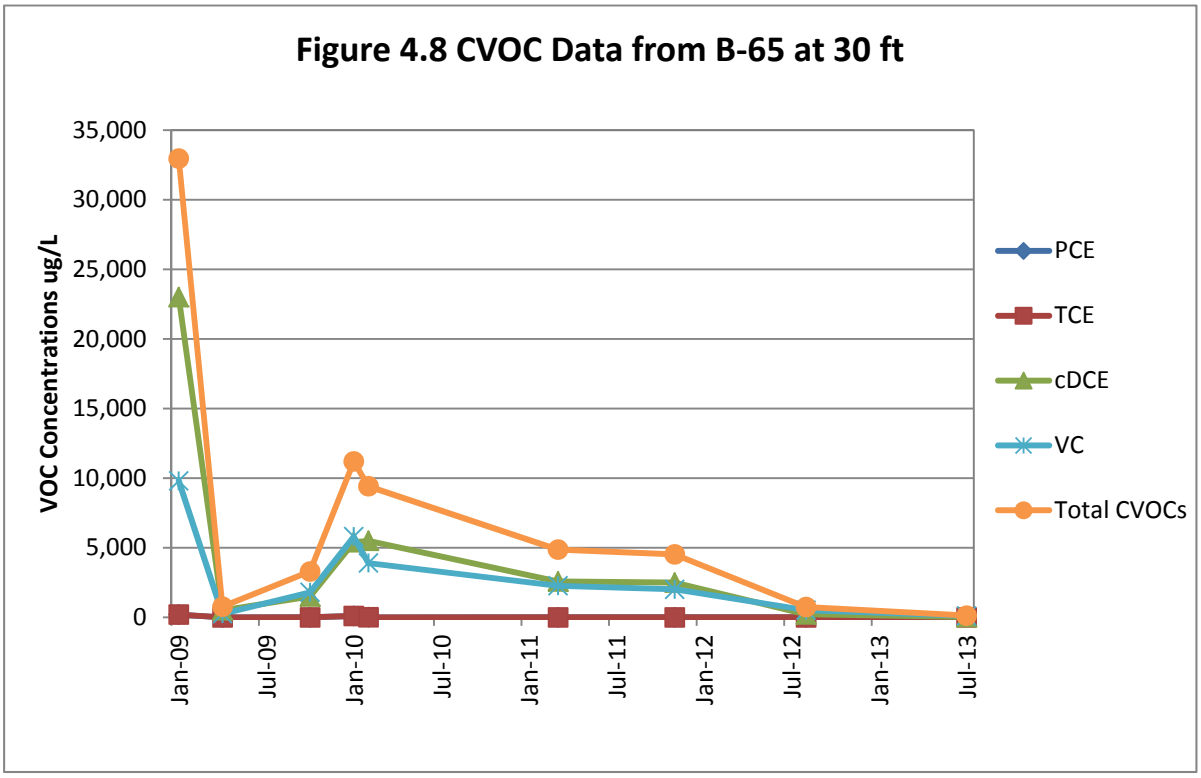


Figure 4.8 CVOC Data from B-65 at 30 ft
VOC Concentrations ug/L
35,000
30,000
25,000
20,000
15,000
10,000
5,000
0
Jan-09
Jul-09
Jan-10
Jul-10
Jan-11
Jul-11
Jan-12
Jul-12
Jan-13
Jul-13
PCE
TCE
cDCE
VC
Total CVOCs

Figure 4.9 CVOC Data from B-33a at 30 ft

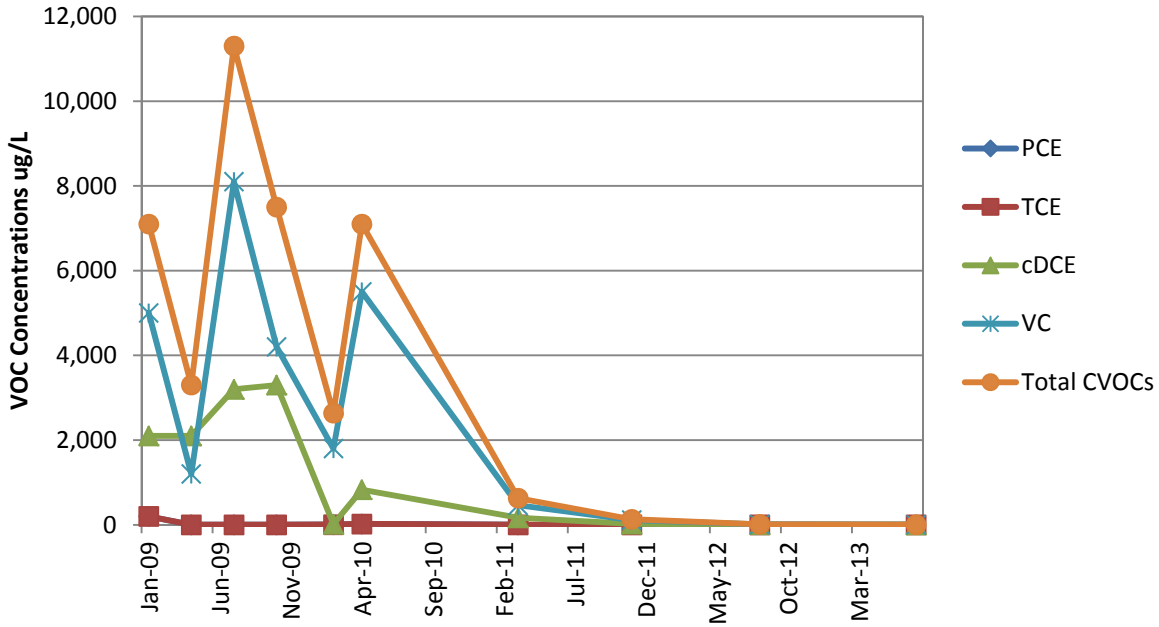
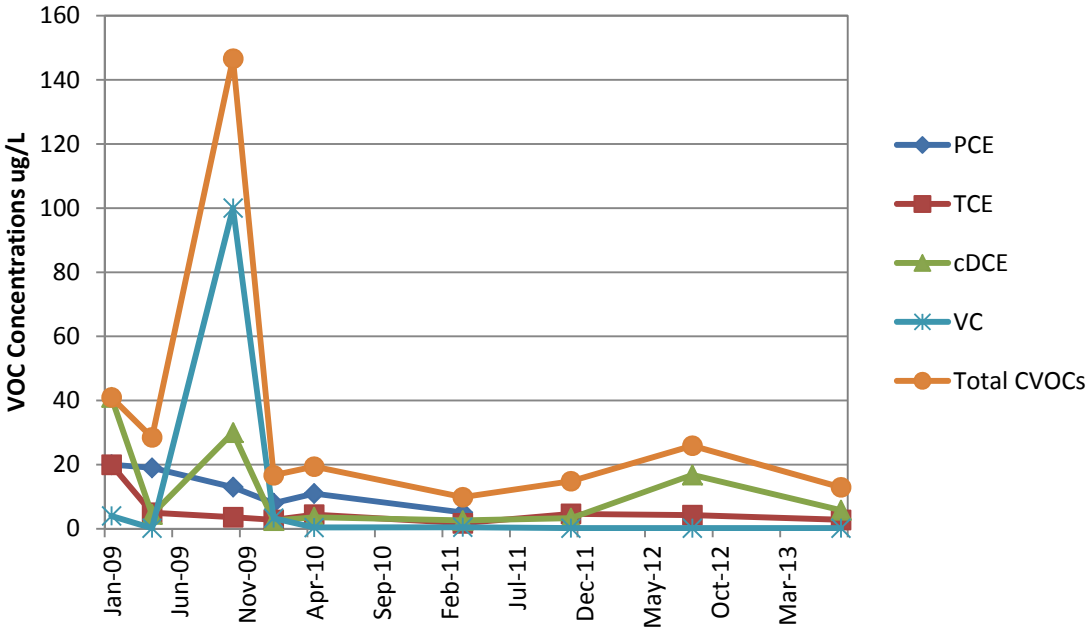


Figure 4.10 CVOC Data from B-34 at 11 ft



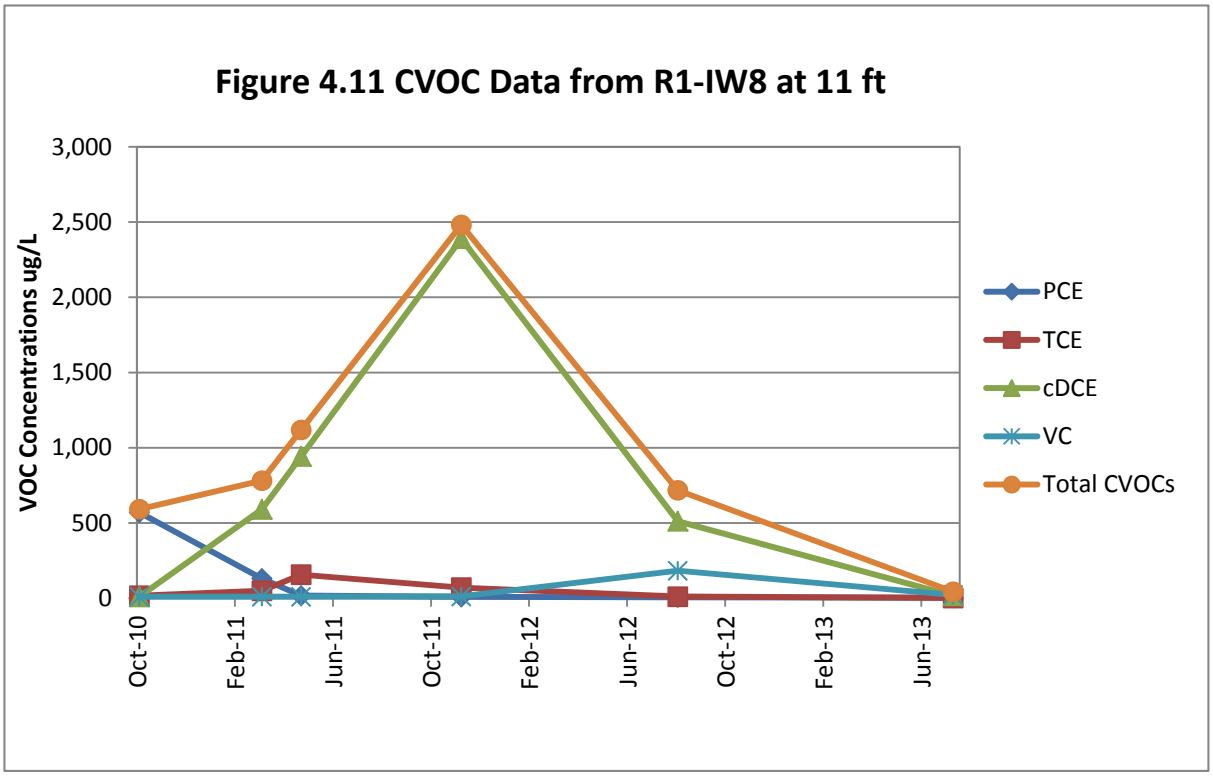


Figure 4.11 CVOC Data from R1-IW8 at 11 ft
VOC Concentrations ug/L
3,000
2,500
2,000
1,500
1,000
500
0
Oct-10
Feb-11
Jun-11
Oct-11
Feb-12
Jun-12
Oct-12
Feb-13
Jun-13
PCE
TCE
cDCE
VC
Total CVOCs

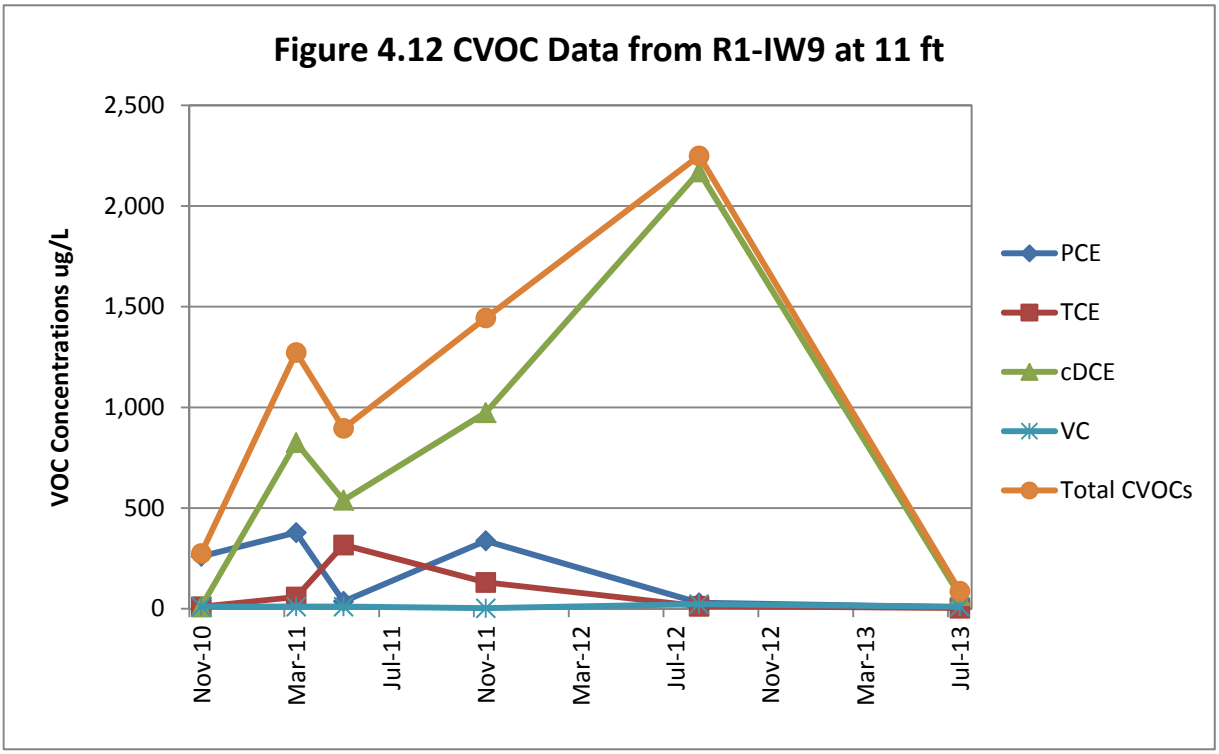


Figure 4.12 CVOC Data from R1-IW9 at 11 ft
VOC Concentrations ug/L
2,500
2,000
1,500
1,000
500
0
Nov-10
Mar-11
Jul-11
Nov-11
Mar-12
Jul-12
Nov-12
Mar-13
Jul-13
PCE
TCE
cDCE
VC
Total CVOCs

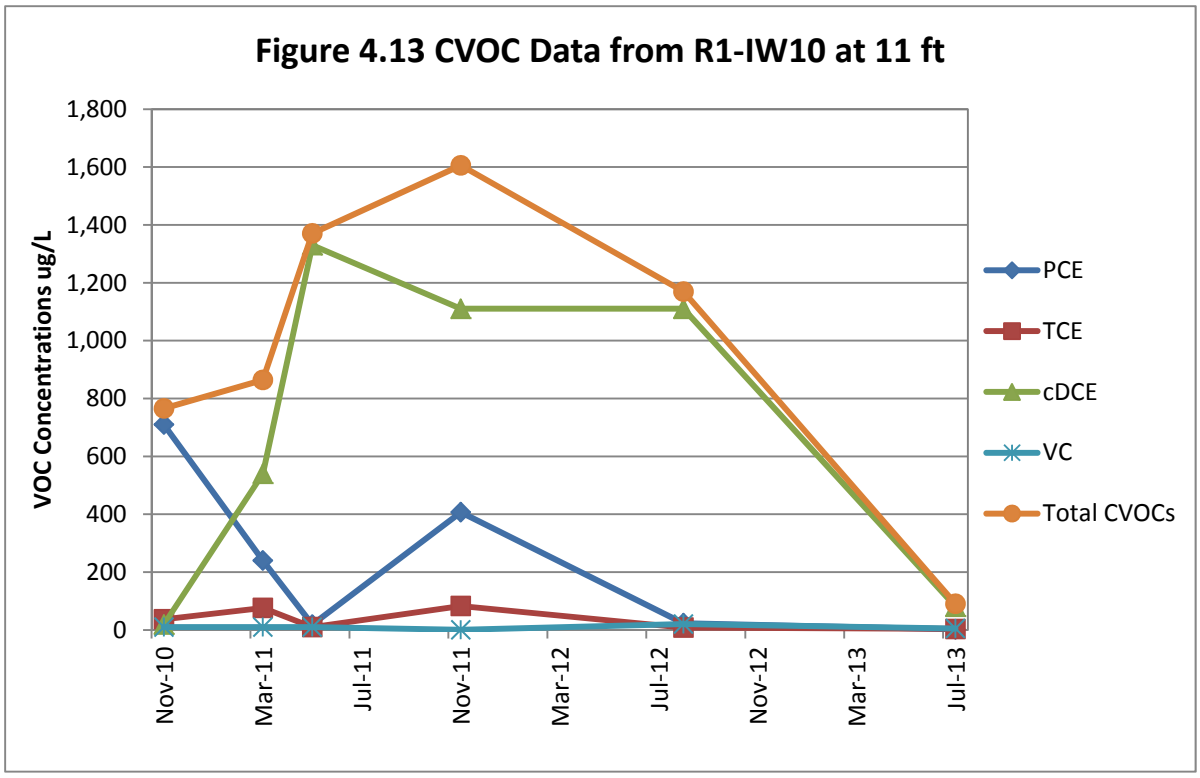


Figure 4.13 CVOC Data from R1-IW10 at 11 ft
VOC Concentrations ug/L
1,800
1,600
1,400
1,200
1,000
800
600
400
200
0
Nov-10
Mar-11
Jul-11
Nov-11
Mar-12
Jul-12
Nov-12
Mar-13
Jul-13
PCE
TCE
cDCE
VC
Total CVOCs

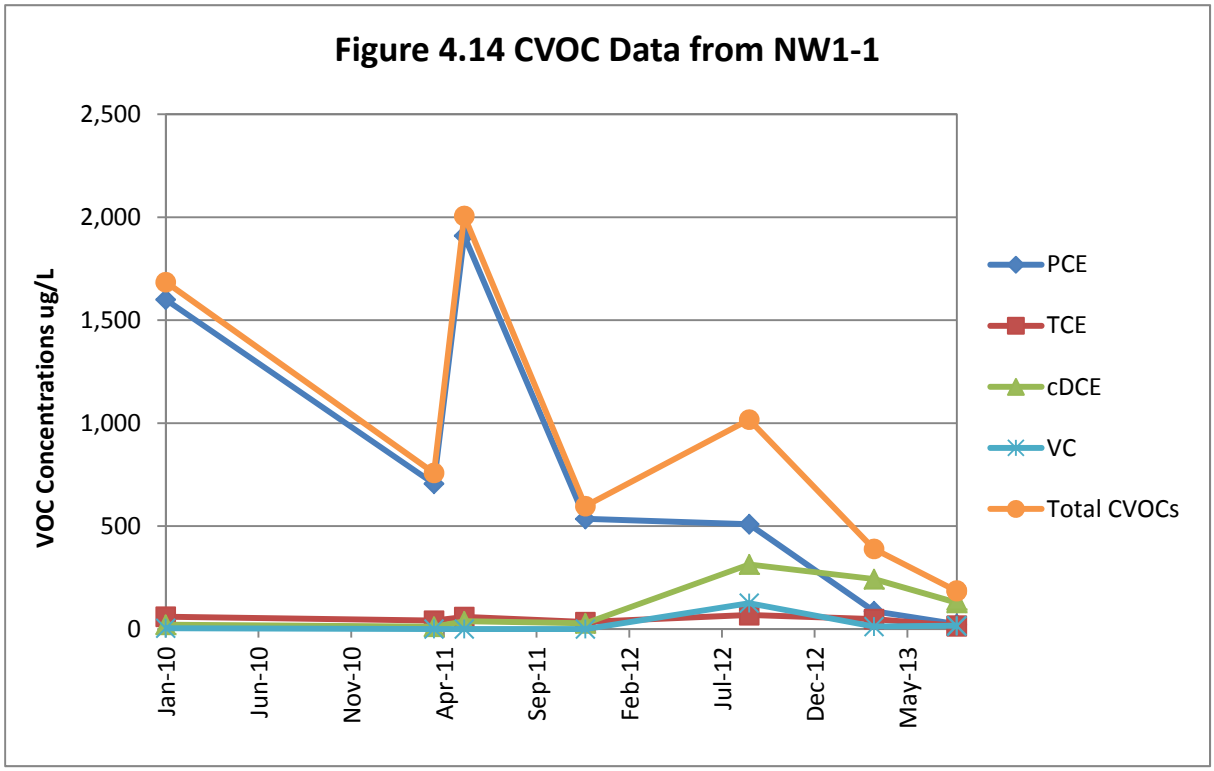


Figure 4.14 CVOC Data from NW1-1
VOC Concentrations ug/L
2,500
2,000
1,500
1,000
500
0
Jan-10
Jun-10
Nov-10
Apr-11
Sep-11
Feb-12
Jul-12
Dec-12
May-13
PCE
TCE
cDCE
VC
Total CVOCs

Figure 4.15 CVOC Data from NW1-2

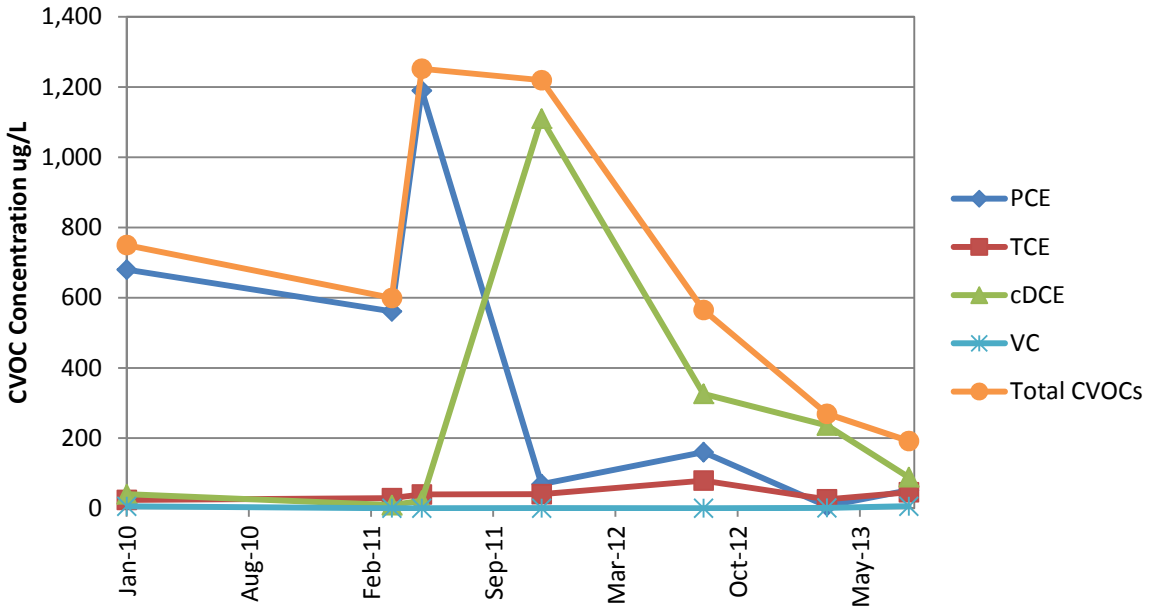
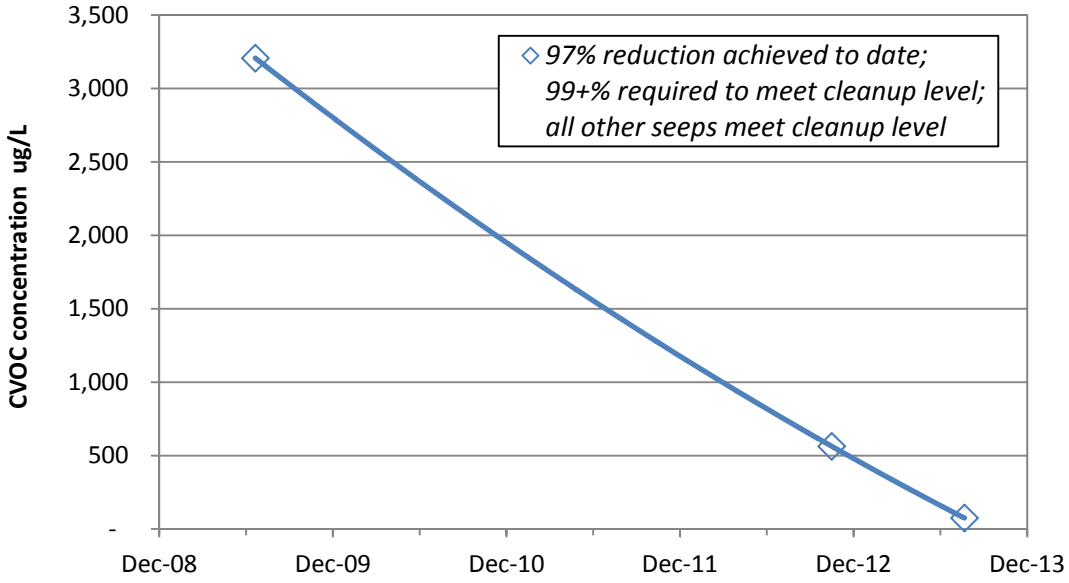
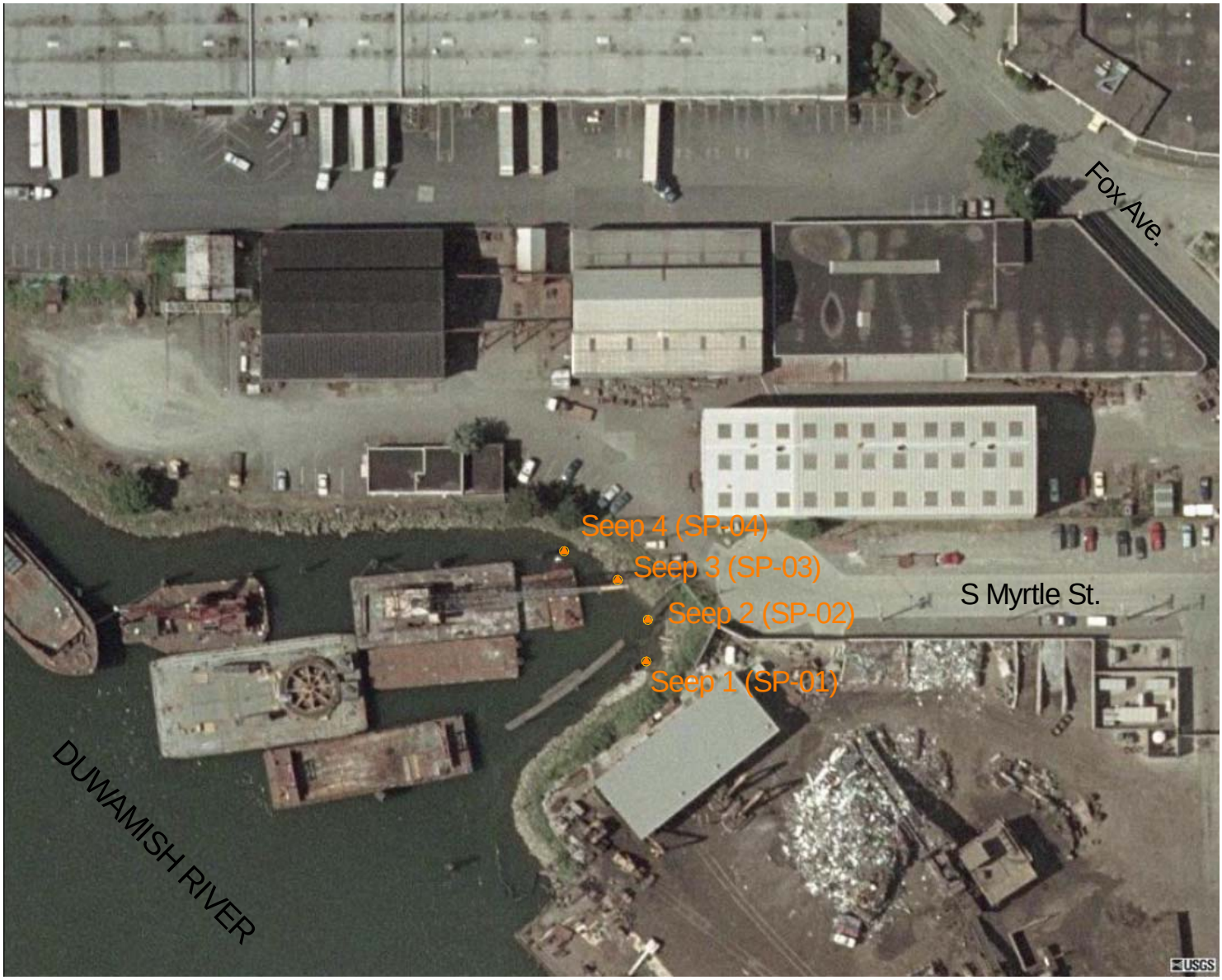


Figure 4.16 CVOC Data from SP-03





Legend

Seep 2 (SP-02) 2013 Seep Sample Name

N

0 30' 60' 120'
SCALE IN FEET

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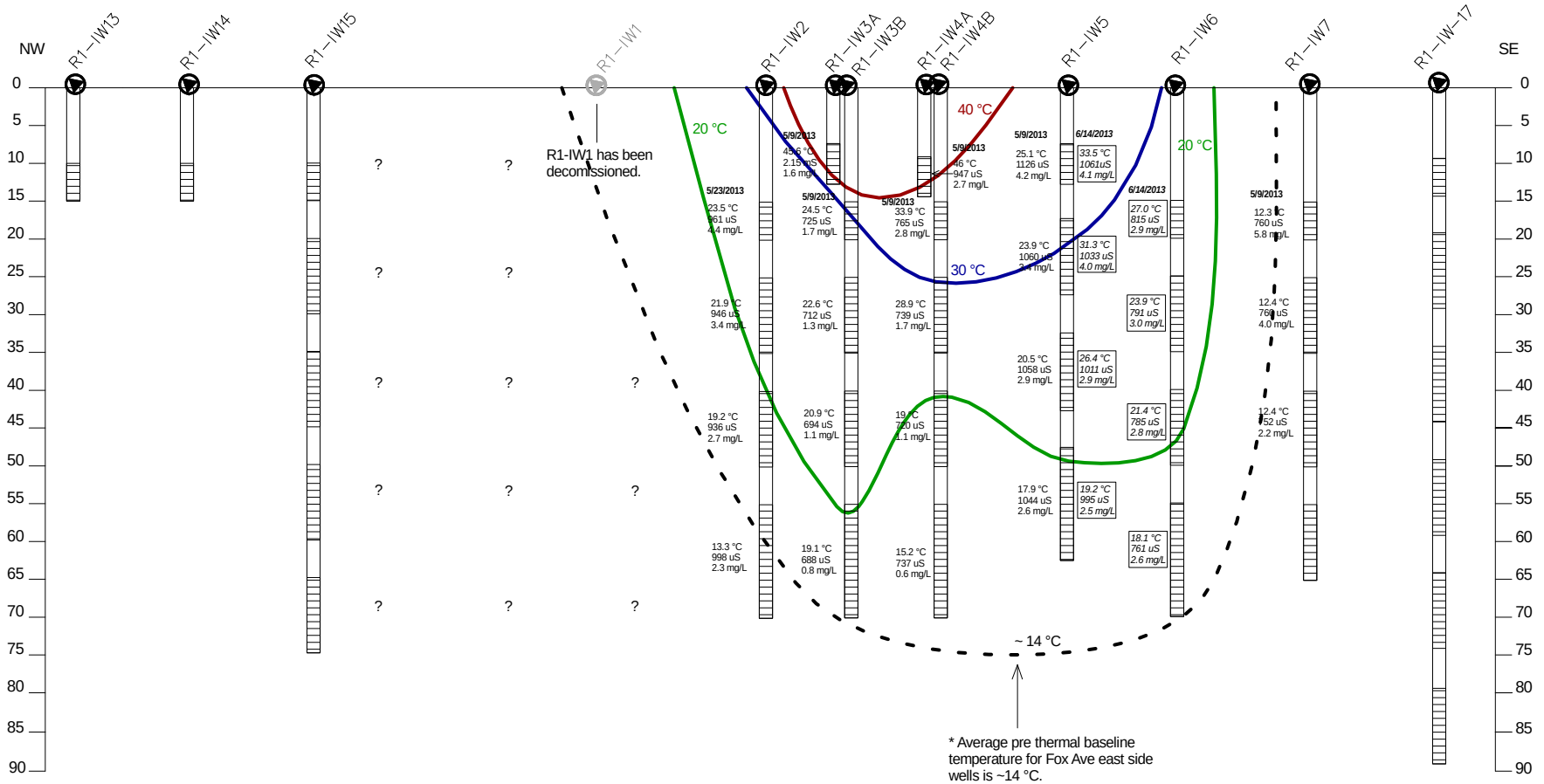
Fox Avenue Site
Seattle, WA

Figure 4.17
Seep Sampling Locations
Fox Ave Site



40 °C Iso Temperature Contour

R1-IW1 Injection Well

B-22 Monitoring Well

20.9 °C Temperature
694 uS Conductivity
1.1 mg/L Dissolved Oxygen

* Field measurements collected on 5-9-13.
R1-IW2 collected on 5-23-13.
R1-IW5 (also 5-9-13) and R1-IW6 data collected on 6-14-13.

(Vertical Exaggeration = 2x)

VERTICAL SCALE IN FEET
1" = 20'

HORIZONTAL SCALE IN FEET
1" = 40'

Fox Ave East Side Wells

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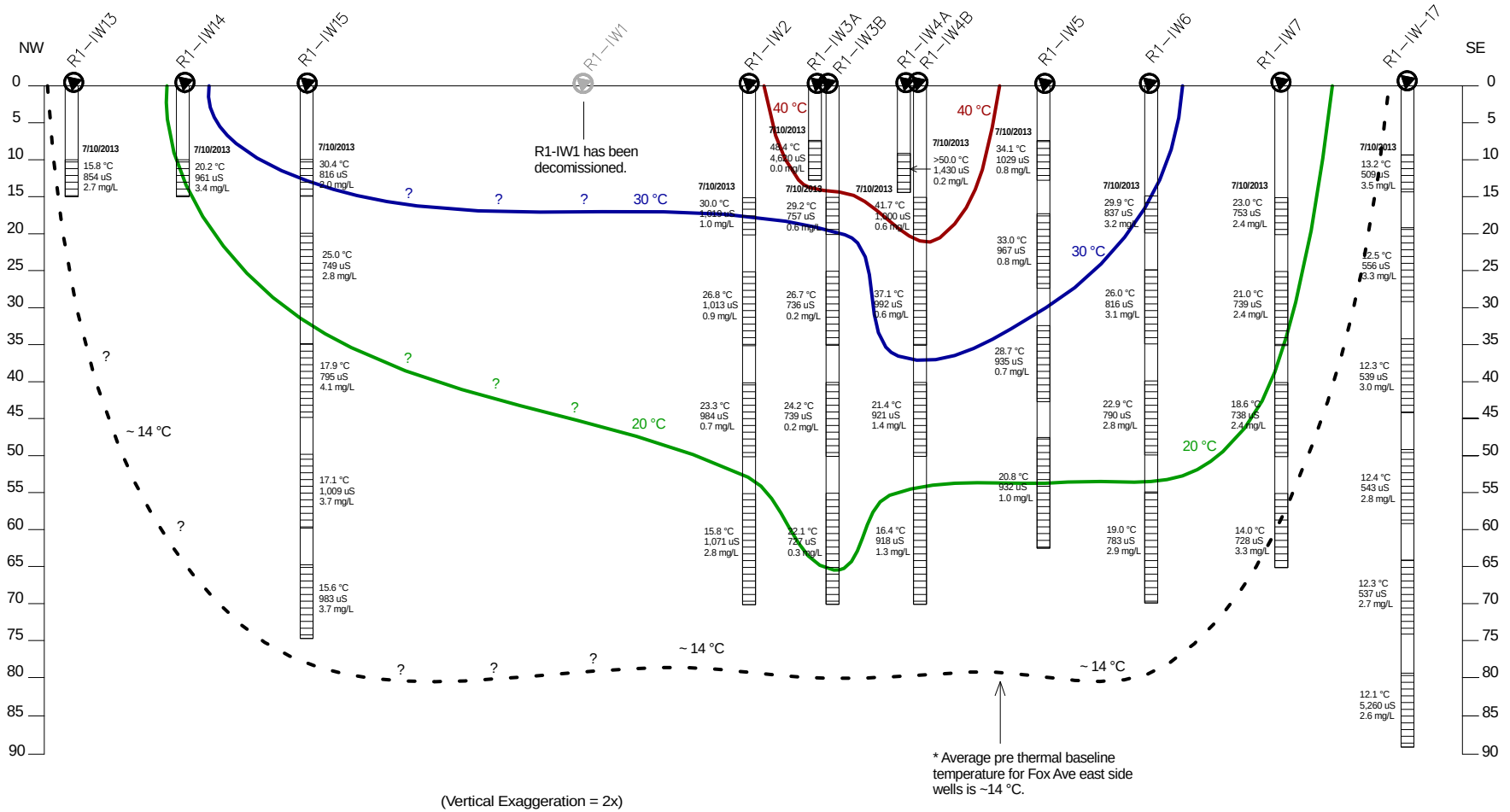
Cross Section Row 1
Fox Avenue Site
Seattle, WA

Figure 4.18
Temperature Monitoring Row 1 Wells
May and June 2013
Fox Ave Site



40 °C Iso Temperature Contour

R1-IW1 Injection Well

B-22 Monitoring Well

20.9 °C Temperature
694 uS Conductivity
1.1 mg/L Dissolved Oxygen

* Field measurements collected on 7-10-2013

(Vertical Exaggeration = 2x)

VERTICAL SCALE IN FEET 1" = 20'

HORIZONTAL SCALE IN FEET 1" = 40'

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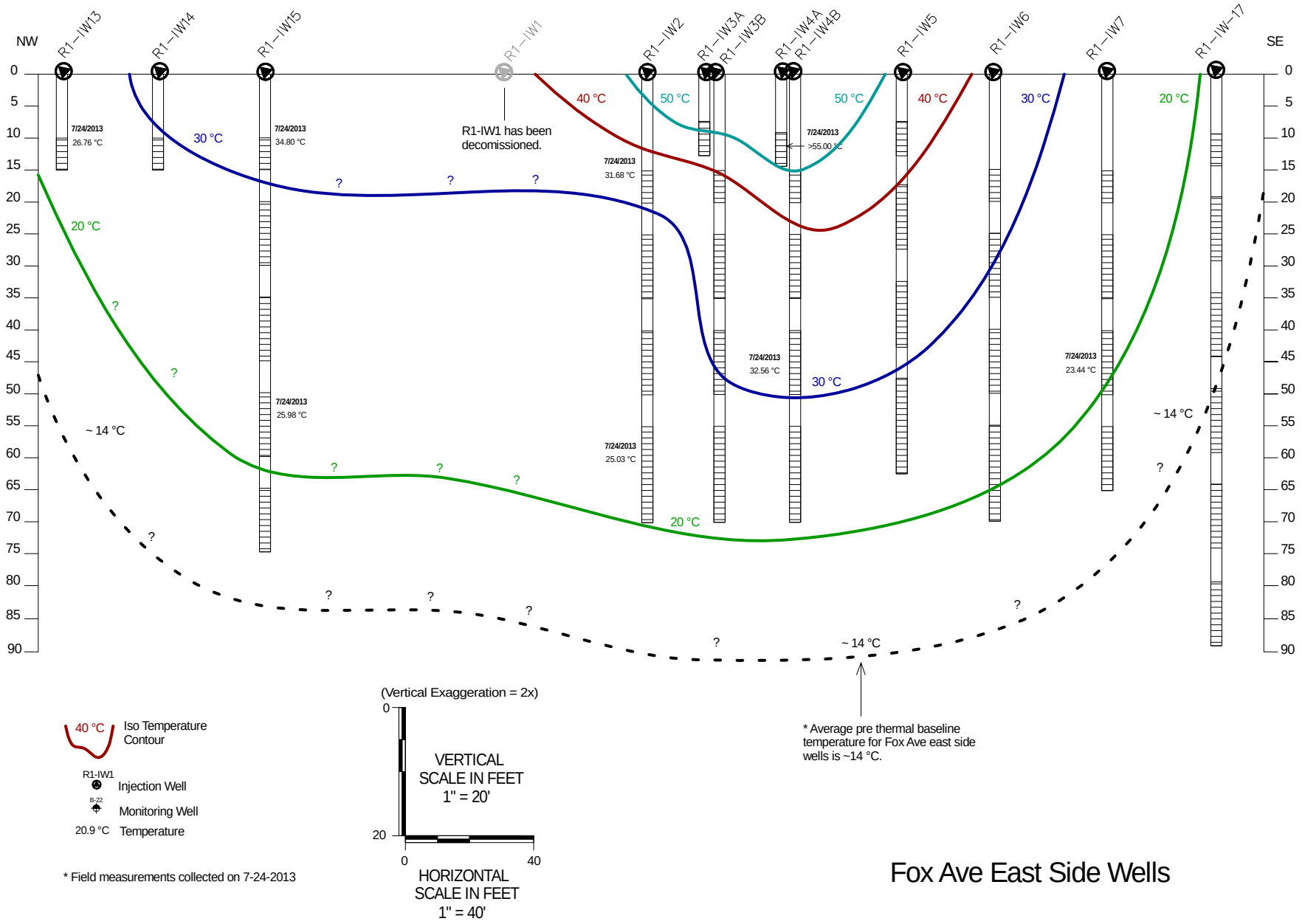
Cross Section Row 1
Fox Avenue Site
Seattle, WA

Figure 4.19
Temperature Monitoring Row 1 Wells
July 10, 2013
Fox Ave Site



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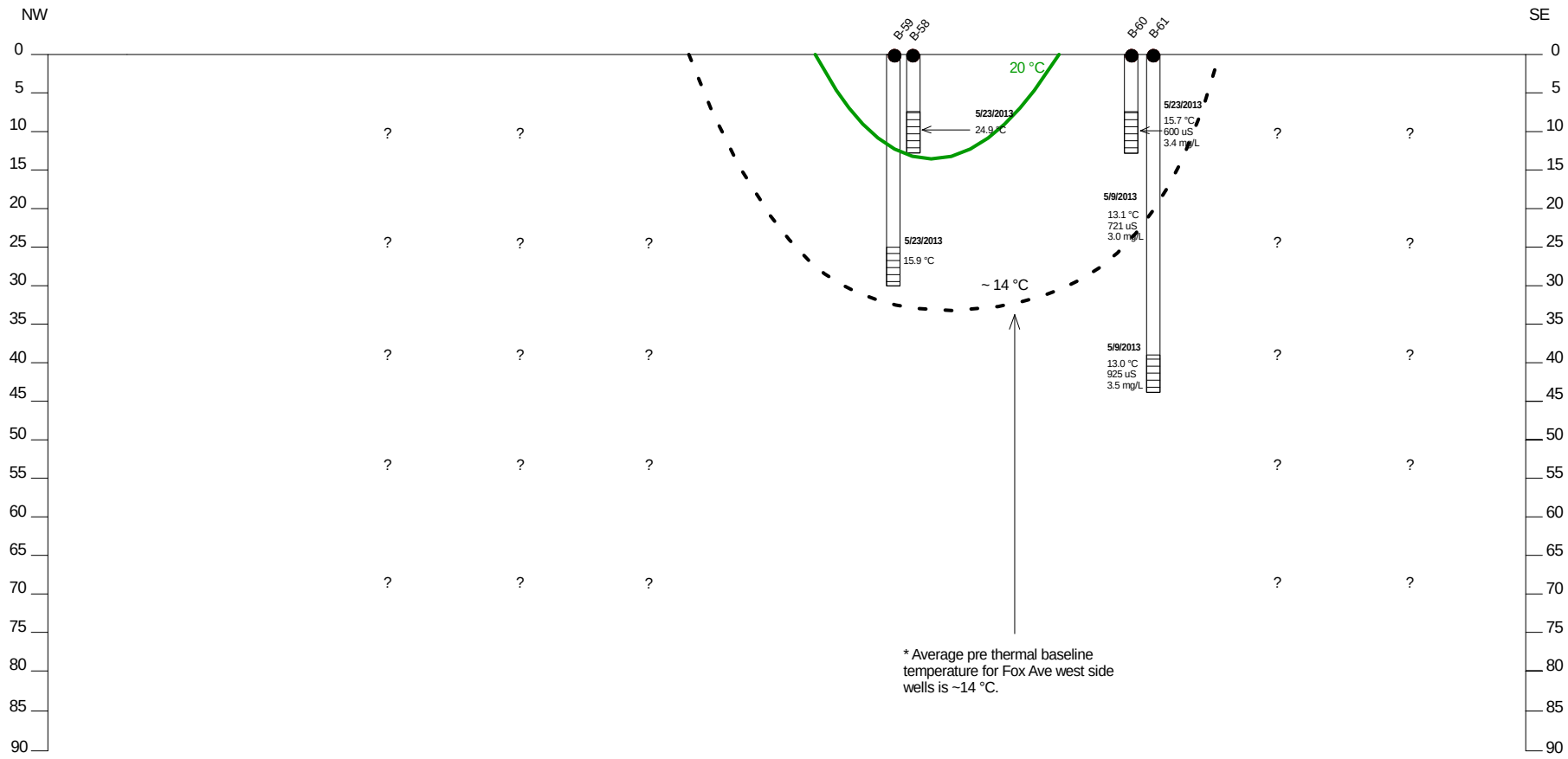
Cross Section Row 1
Fox Avenue Site
Seattle, WA

Figure 4.20
Temperature Monitoring Row 1 Wells
July 24, 2013
Fox Ave Site



20 °C Iso Temperature Contour

R1-IW1 Injection Well

B-22 Monitoring Well

20.9 °C Temperature
694 uS Conductivity
1.1 mg/L Dissolved Oxygen

* Field measurements collected on 5-9-13 and 5-23-13.

(Vertical Exaggeration = 2x)

VERTICAL SCALE IN FEET
1" = 20'

HORIZONTAL SCALE IN FEET
1" = 40'

Fox Ave West Side Wells

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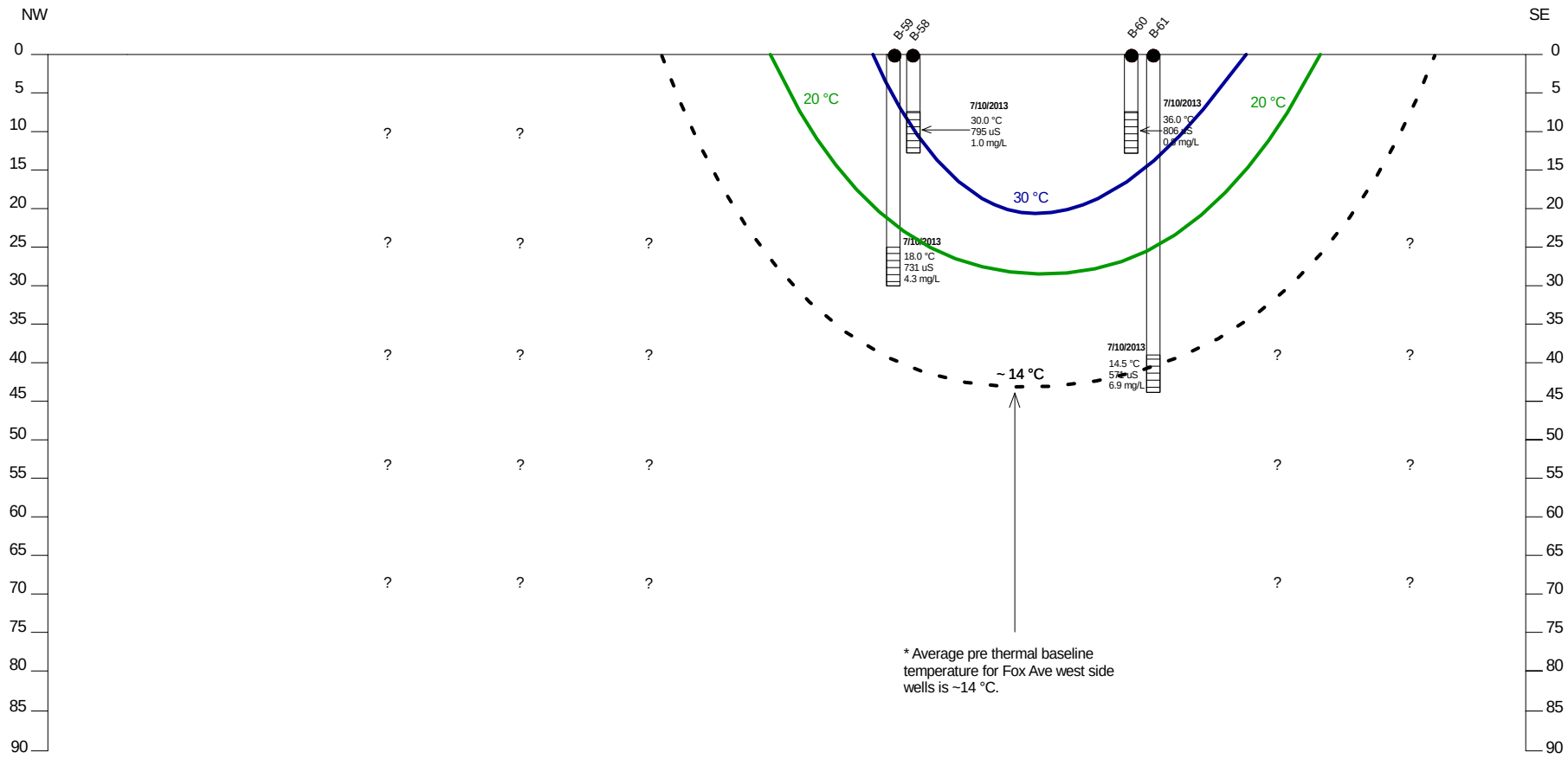
Cross Section Row 1
Fox Avenue Site
Seattle, WA

Figure 4.21
Temperature Monitoring Row 1 Wells
May 2013
Fox Ave Site



30 °C Iso Temperature Contour

R1-IW1 Injection Well

B-22 Monitoring Well

20.9 °C Temperature
694 uS Conductivity
1.1 mg/L Dissolved Oxygen

* Field measurements collected on 7-10-2013

(Vertical Exaggeration = 2x)

VERTICAL SCALE IN FEET
1" = 20'

HORIZONTAL SCALE IN FEET
1" = 40'

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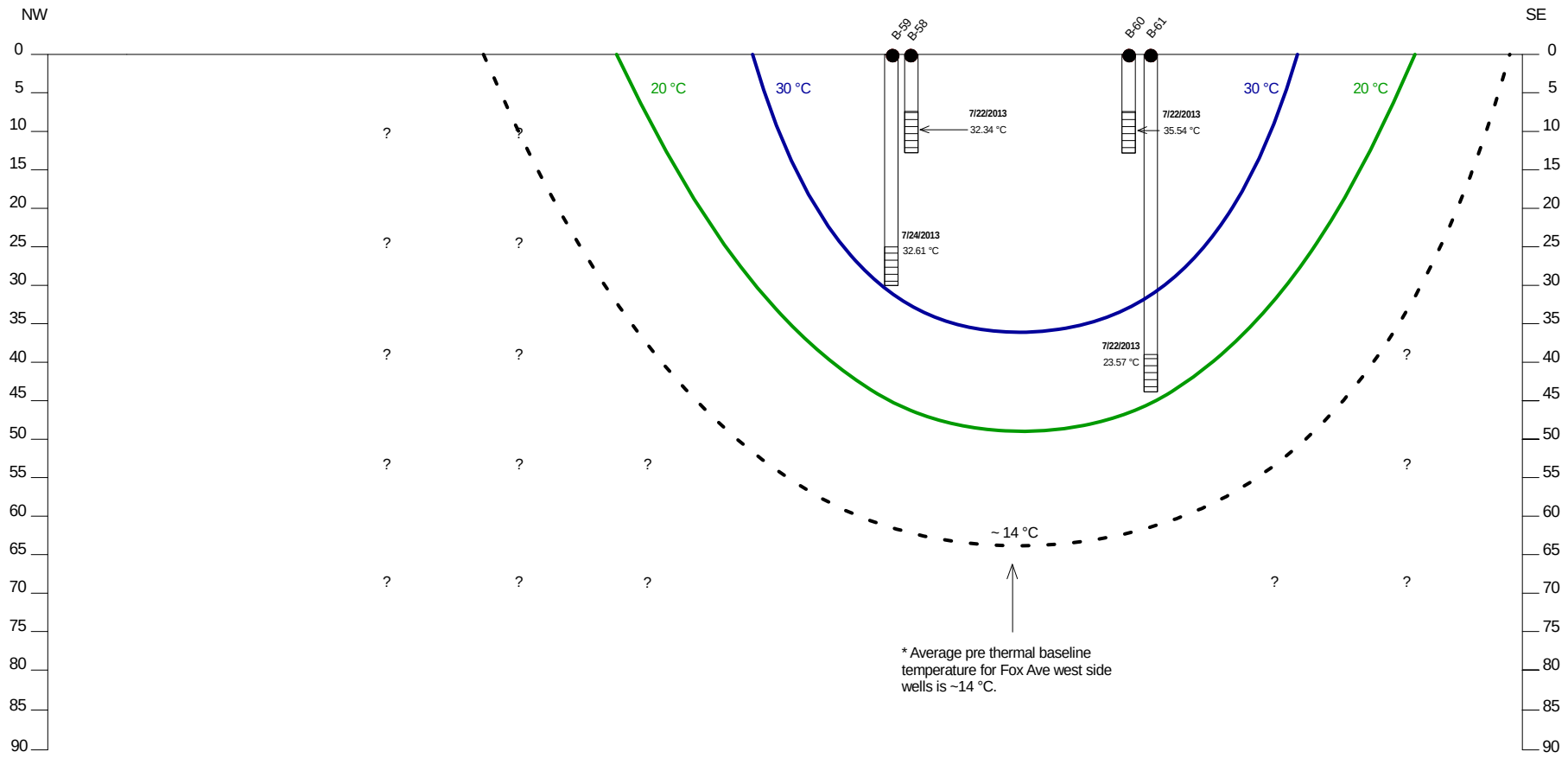
Cross Section Row 1
Fox Avenue Site
Seattle, WA

Figure 4.22
Temperature Monitoring Row 1 Wells
July 10, 2013
Fox Ave Site



30 °C Iso Temperature Contour

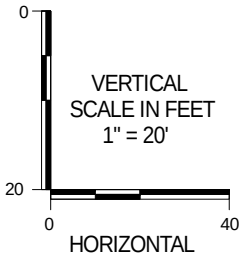
R1-IW1 Injection Well

B-22 Monitoring Well

20.9 °C Temperature

* Field measurements collected on 7-22-2013 and 7-24-2013

(Vertical Exaggeration = 2x)



Fox Ave West Side Wells

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Cross Section Row 1
Fox Avenue Site
Seattle, WA

Figure 4.23
Temperature Monitoring Row 1 Wells
July 22 and July 24, 2013
Fox Ave Site

Appendix A
Substrate Injection Logs

Substrate Injection Mass Feb-13, Jun-13		
Well ID	**Substrate Volume (gallons)**	**Substrate Mass (lbs sugar)**
R1-IW3A	268	380
R1-IW4A	255	362
R1-IW8	1,549	1,513
R1-IW9	1,585	1,615
R1-IW10	1,617	1,608
R1-IW11	250	967
R1-IW12	1,248	1,633
R1-IW13	1,237	1,585
R1-IW14	1,255	1,661
R1-IW15	3,700	4,865
R2-IW1	4,972	4,005
R2-IW2	5,000	4,006
R2-IW3	832	3,218
R2-IW4	832	3,218
R2-IW5	832	3,218
R2-IW6	832	3,218
R2-IW7	832	3,218
R2-IW8	5,006	4,232
R2-IW9	5,000	3,971
R2-IW10	2,491	3,590
R2-IW11	2,474	3,565
Total	**42,067**	**55,649**

Abbreviations:

lbs Pounds

February 2013 Injections

Row 1

Well ID	Interval	Gallons Injec	Brix	lbs Sugar
R1-IW8	8-13	1,000	8.9	739
		1,000		739

Well ID	Interval	Gallons Injec	Brix	lbs Sugar
R1-IW9	8-13	924	8.9	683
		924		683

Well ID	Interval	Gallons Injec	Brix	lbs Sugar
R1-IW10	8-13	1,002	8.9	740
		1,002		740

Well ID	Interval	Gallons Injec	Brix	lbs Sugar
R1-IW12	10-15	1,002	8.2	682
		1,002		682

Well ID	Interval	Gallons Injec	Brix	lbs Sugar
R1-IW13	10-15	1,004	8.2	683
		1,004		683

Well ID	Interval	Gallons Injec	Brix	lbs Sugar
R1-IW14	10-15	1,002	8.2	682
		1,002		682

Well ID	Interval	Gallons Injec	Brix	lbs Sugar
R1-IW15	10-15	1,000	8.9	739
R1-IW15	20-30	500	8.9	369
R1-IW15	35-45	500	8.9	369
R1-IW15	50-60	500	8.2	340
R1-IW15	65-75	500	8.2	340
		3,000		2,158

Row 2

Well ID	Interval	Gallons Injec	Brix	lbs Sugar
R2-IW1	15-20	972	14.6	1,178
R2-IW1	25-35	468	14.6	567
R2-IW1	25-35	32	9.4	25
R2-IW1	40-50	500	9.4	390
R2-IW1	55-70	500	9.4	390
		2,472		2,550

February 2013 Injections

Well ID	Interval	Gallons Injec	Brix	lbs Sugar
R2-IW2	15-20	1,000	14.6	1,212
R2-IW2	25-35	389	14.6	471
R2-IW2	25-35	111	9.4	87
R2-IW2	40-50	500	9.4	390
R2-IW2	55-70	500	9.4	390
		2,500		2,550

Well ID	Interval	Gallons Injec	Brix	lbs Sugar
R2-IW8	10-15	1,006	14.6	1,219
R2-IW8	20-30	500	14.6	606
R2-IW8	35-45	416	14.6	504
R2-IW8	35-45	84	9.4	66
R2-IW8	50-65	500	9.4	390
		2,506		2,785

Well ID	Interval	Gallons Injec	Brix	lbs Sugar
R2-IW9	10-15	1,000	14.6	1,212
R2-IW9	20-30	328	14.6	397
R2-IW9	20-30	172	9.4	134
R2-IW9	35-45	500	9.4	390
R2-IW9	50-65	500	9.4	390
		2,500		2,524

Well ID	Interval	Gallons Injec	Brix	lbs Sugar
R2-IW10	7-12	560	17.6	818
R2-IW10	17-27	250	17.6	365
R2-IW10	32-45	250	17.6	365
R2-IW10	47-62	250	17.6	365
		1,310		1,914

Well ID	Interval	Gallons Injec	Brix	lbs Sugar
R2-IW11	7-12	532	17.6	777
R2-IW11	17-27	250	17.6	365
R2-IW11	32-45	250	17.6	365
R2-IW11	47-62	250	17.6	365
		1,282		1,873

June 2013 Injections

Row 1

Well ID	Interval	Gallons Inje	Brix	lbs Sugar
R1-IW3a	7-12	268	17.1	380
		268		380

Well ID	Interval	Gallons Inje	Brix	lbs Sugar
R1-IW4a	9-14	255	17.1	362
		255		362

Well ID	Interval	Gallons Inje	Brix	lbs Sugar
R1-IW8	10-15	549	17.0	775
		549		775

Well ID	Interval	Gallons Inje	Brix	lbs Sugar
R1-IW9	10-15	661	17.0	933
		661		933

Well ID	Interval	Gallons Inje	Brix	lbs Sugar
R1-IW10	10-15	615	17.0	868
		615		868

Well ID	Interval	Gallons Inje	Brix	lbs Sugar
R1-IW11	10-15	250	46.6	967
		250		967

Well ID	Interval	Gallons Inje	Brix	lbs Sugar
R1-IW12	10-15	246	46.6	951
		246		951

Well ID	Interval	Gallons Inje	Brix	lbs Sugar
R1-IW13	10-15	233	46.6	901
		233		901

Well ID	Interval	Gallons Inje	Brix	lbs Sugar
R1-IW14	10-15	253	46.6	979
		253		979

Well ID	Interval	Gallons Inje	Brix	lbs Sugar
R1-IW15	10-15	225	46.6	870
R1-IW15	20-30	125	46.6	483
R1-IW15	35-45	125	46.6	483
R1-IW15	50-60	125	46.6	483
R1-IW15	65-75	100	46.6	387
		700		2,707

June 2013 Injections
Row 2

Well ID	Interval	Gallons Inje	Brix	lbs Sugar
R2-IW1	15-20	750	6.9	430
R2-IW1	25-35	335	6.9	192
R2-IW1	25-35	290	7.1	171
R2-IW1	40-50	625	7.1	368
R2-IW1	55-70	500	7.1	295
		2,500		1,455

Well ID	Interval	Gallons Inje	Brix	lbs Sugar
R2-IW2	15-20	750	6.9	430
R2-IW2	25-35	302	6.9	173
R2-IW2	25-35	323	7.1	190
R2-IW2	40-50	625	7.1	368
R2-IW2	55-70	500	7.1	295
		2,500		1,456

Well ID	Interval	Gallons Inje	Brix	lbs Sugar
R2-IW3	15-20	250	46.6	967
R2-IW3	25-35	208	46.6	805
R2-IW3	40-50	208	46.6	805
R2-IW3	55-70	166	46.6	642
		832		3,218

Well ID	Interval	Gallons Inje	Brix	lbs Sugar
R2-IW4	15-20	250	46.6	967
R2-IW4	25-35	208	46.6	805
R2-IW4	40-50	208	46.6	805
R2-IW4	55-70	166	46.6	642
		832		3,218

Well ID	Interval	Gallons Inje	Brix	lbs Sugar
R2-IW5	15-20	250	46.6	967
R2-IW5	25-35	208	46.6	805
R2-IW5	40-50	208	46.6	805
R2-IW5	55-70	166	46.6	642
		832		3,218

Well ID	Interval	Gallons Inje	Brix	lbs Sugar
R2-IW6	15-20	250	46.6	967
R2-IW6	25-35	208	46.6	805
R2-IW6	40-50	208	46.6	805
R2-IW6	55-70	166	46.6	642
		832		3,218

June 2013 Injections

Well ID	Interval	Gallons Inje	Brix	lbs Sugar
R2-IW7	10-15	250	46.6	967
R2-IW7	20-30	208	46.6	805
R2-IW7	35-45	208	46.6	805
R2-IW7	50-65	166	46.6	642
		832		3,218

Well ID	Interval	Gallons Inje	Brix	lbs Sugar
R2-IW8	10-15	750	7.1	442
R2-IW8	20-30	625	6.9	358
R2-IW8	35-45	425	6.9	243
R2-IW8	35-45	200	7.1	118
R2-IW8	50-65	500	6.9	286
		2,500		1,448

Well ID	Interval	Gallons Inje	Brix	lbs Sugar
R2-IW9	10-15	750	6.9	430
R2-IW9	20-30	268	6.9	153
R2-IW9	20-30	357	7.1	210
R2-IW9	35-45	625	7.1	368
R2-IW9	50-65	500	7.1	295
		2,500		1,456

Well ID	Interval	Gallons Inje	Brix	lbs Sugar
R2-IW10	7-12	331	17.1	470
R2-IW10	17-27	300	17.1	426
R2-IW10	32-45	300	17.1	426
R2-IW10	47-62	250	17.1	355
		1,181		1,676

Well ID	Interval	Gallons Inje	Brix	lbs Sugar
R2-IW11	7-12	342	17.1	485
R2-IW11	17-27	300	17.1	426
R2-IW11	32-45	300	17.1	426
R2-IW11	47-62	250	17.1	355
		1,192		1,692

Appendix B
Laboratory Data Packages and Sample Sheets

Appendix C
UIC Registration for Expansion Wells

UIC Well Registration for Class V UIC Wells that Automatically Meet the Nonendangerment Standard

Please send completed forms to: UIC Coordinator, Water Quality Program, WA Department of Ecology P.O. Box 47600, Olympia, WA 98504-7600

A. Facility Name and Location

Facility Name: Cascade Columbia Distribution
Address: 6900 Fox Ave S
PO Box:
City: Seattle State: WA ZIP: 98108
Phone at the facility: 206-282-6334
County: King

B. Contact Information

Well Owner

Name: Bob Code
Organization: Cascade Columbia Distribution
Address: 6900 Fox Ave S
PO Box:
City: Seattle
State: WA ZIP: 98108
E-mail: bobc@cascadecolumbia.com
Phone: 206-282-6334

Property Owner

Same as Well Owner ☑ If not:
Name:
Organization:
Address:
PO Box:
City:
State: ZIP:
E-mail:
Phone:

Technical Contact Person

Same as Well Owner ☐ If not:
Name: Tom Colligan
Organization: Floyd Snider
Address: 601 East Union Street
PO Box:
City: Seattle
State: WA ZIP: 98101
E-mail: tom.colligan@floydsnider.com
Phone: 206-292-2078

C. Type of Class V Well that this form may be used for (see WAC 173-218-070 and WAC 173-218-100)

Use the number from the following list to fill in the "Number of UIC Well Type from Section C" in the well table:

1. **Well used for Subsidence Control:** UIC wells which inject fluids that meet chapter 173-200 WAC, Water quality standards for ground waters of the state of Washington, to control subsidence.
2. **Extraction/dewatering well maintenance:** UIC wells that temporarily inject fluids or other material for the purpose of maintaining a properly functioning extraction well or dewatering well.
3. **Receives unpolluted stormwater:** UIC wells receiving stormwater from nonpollutant-generating surfaces. Some examples of a non pollutant generating surface are paved bicycle pathways and sidewalks that are separate from the road and fenced fire lanes. Sidewalks frequently treated with salt or other deicing chemicals are NOT considered a non pollutant generating surface.

4. **Receives Inert roof runoff:** UIC wells that only receive runoff from a roof coated with an inert, nonleachable material and a roof that is not subject to venting of manufacturing, commercial, or other indoor pollutants.
5. **Closed loop heating and cooling water return flow** that have not added any chemical or product to the water. ***If any chemical or product is added to the water, the UIC well is NOT automatically rule-authorized. Fill in information for the chemical or product in the table, and attach Material Safety Data Sheets to this registration. The department will contact you.*
6. **Air conditioning or heat pump return flow** that have not added any chemical or product to the water, and are used to return fluid to the supply aquifer. The fluids must not impair beneficial uses of ground water or surface water.

   If any chemical or product is added to the water, the UIC well is NOT automatically rule-authorized. Fill in information for the chemical or product in the table, and attach Material Safety Data Sheets to this registration. The department will contact you.

For the following UIC well types, please also fill in permit information in the well table:

1. **Aquifer recharge wells** that meet the requirements in chapter 173-157 WAC Underground artificial storage and recovery.
2. **Reclaimed Water:** UIC wells used as part of a reclaimed water project that meet the requirements of the Water reclamation and reuse standards as authorized by RCW 90.46.042.
3. **Septic systems that serve twenty or more people per day** and either receive operating permits, meet the requirements and are permitted in accordance with chapter 246-272B WAC Large on-site sewage system regulations; or meet the requirements of chapter 246-272A WAC On-site sewage systems.
4. **Geothermal:** UIC wells used for geothermal fluid return flow into the same aquifer and that meet chapter 173-200 WAC Water quality standards for ground waters of the state of Washington, chapter 173-216 WAC State waste discharge permit program requirements and RCW 79.76 Geothermal Resources.
5. **NPDES Individual Permit** that covers the UIC wells on-site, except for UIC wells used to manage stormwater.
6. **State Waste Discharge Permit** that covers the UIC wells on-site, except for UIC wells used to manage stormwater.
7. **CERCLA or RCRA cleanup site** – Permit ID is the EPA site ID.
8. **MTCA – Cleanup site under a MTCA order or consent decree** – Permit ID is the state site ID.

   This form does NOT apply to MTCA Voluntary Cleanup Sites. Use the UIC Registration form for Voluntary or Independent Cleanup Sites.

E. UIC Well Information

Well Name	UIC Well Type Number From Section C (1 – 12)	Construction Date	EPA Well Type	Status	Depth of UIC Well (ft.)	Latitude	Longitude
R2-IW10	12	02/14/2013	5X26	Active	62	47.53992	-122.327
R2-IW11	12	02/12/2013	5X26	Active	62	47.540022	-122.327
R2-IW8	12	02/11/2013	5X26	Active	65	47.53961	-122.326
R2-IW9	12	02/11/2013	5X26	Active	65	47.53976	-122.327

Additional Information

Well Name	Permit Type	Permit ID	Permit Issuer
R2-IW10	MTCA	DE 6486	Ecology
R2-IW11	MTCA	DE 6486	Ecology
R2-IW8	MTCA	DE 6486	Ecology
R2-IW9	MTCA	DE 6486	Ecology

If a UIC well is in a Wellhead Protection Area, Critical Aquifer Recharge Area, or other ground water protection area, the local government may have additional ordinances or requirements.

F. Signature of Authorized Representative

I hereby certify that the information contained in this registration is true and correct to the best of my knowledge.

Name of legally authorized representative | Title

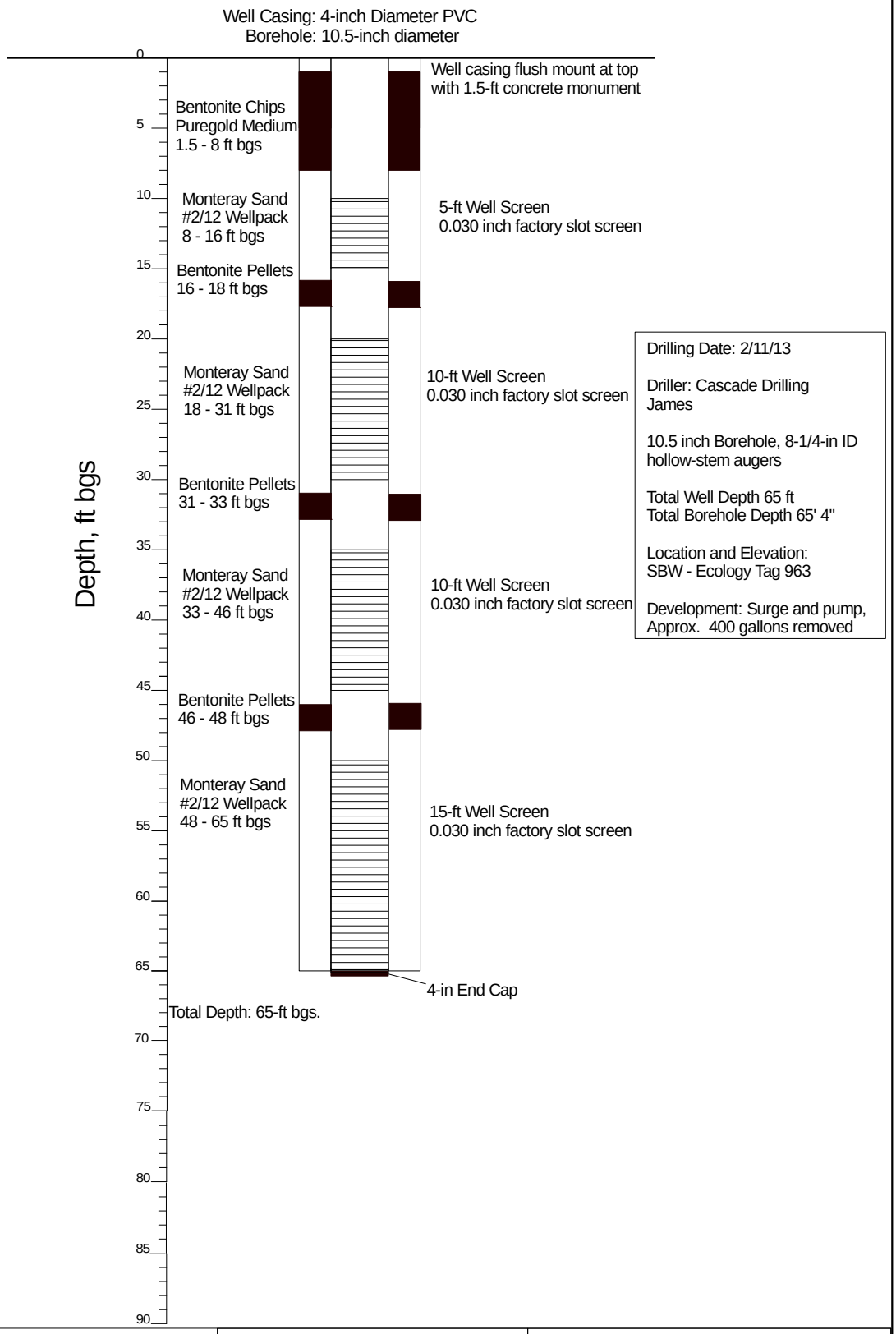
Signature of legally authorized representative | Date

Thank you for filling out your registration.

If you would like to inquire about the registration status, please contact Mary Shaleen-Hansen at (360) 407-6143 or maha461@ecy.wa.gov

For Department Use Only					
Site ID	Date Submitted	Date Received	Date Acknowledged	Date Entered	Final Disposition
32095	02/15/2013				Pending

Appendix D
Well Completion Diagrams



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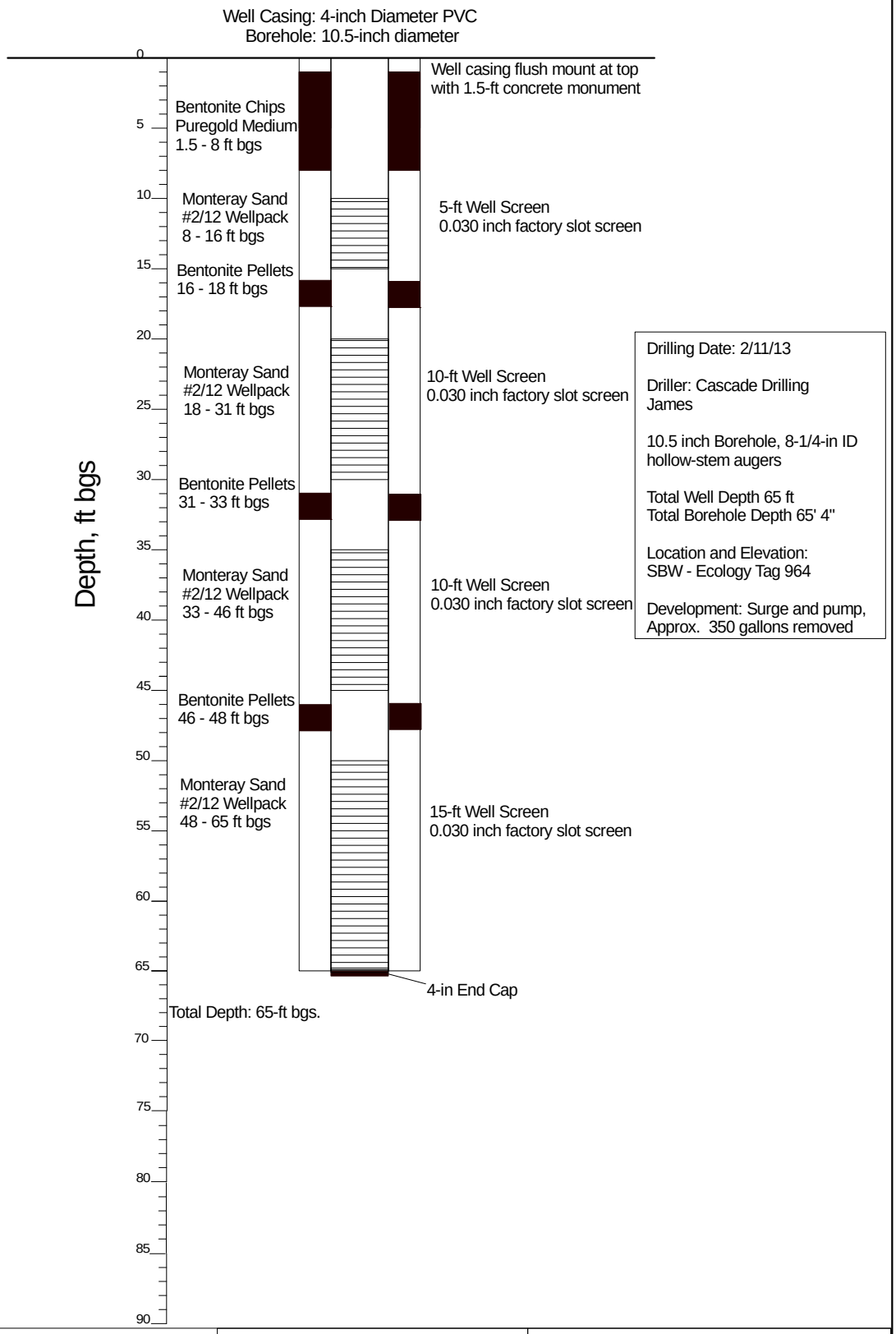
Injection Well Completion
Fox Avenue Site
Seattle, WA

Injection Well: R2-IW8



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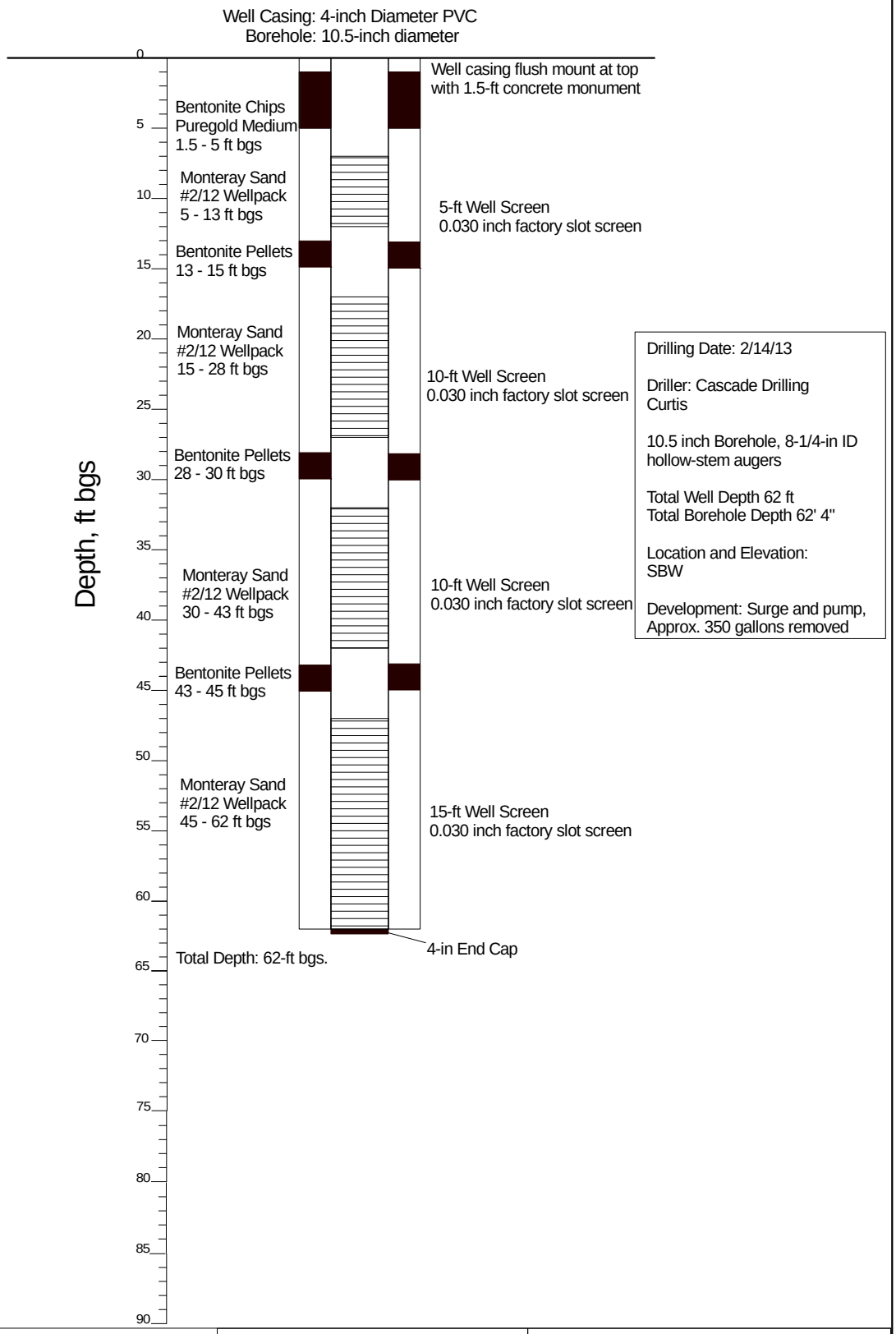
Injection Well Completion
Fox Avenue Site
Seattle, WA

Injection Well: R2-IW9



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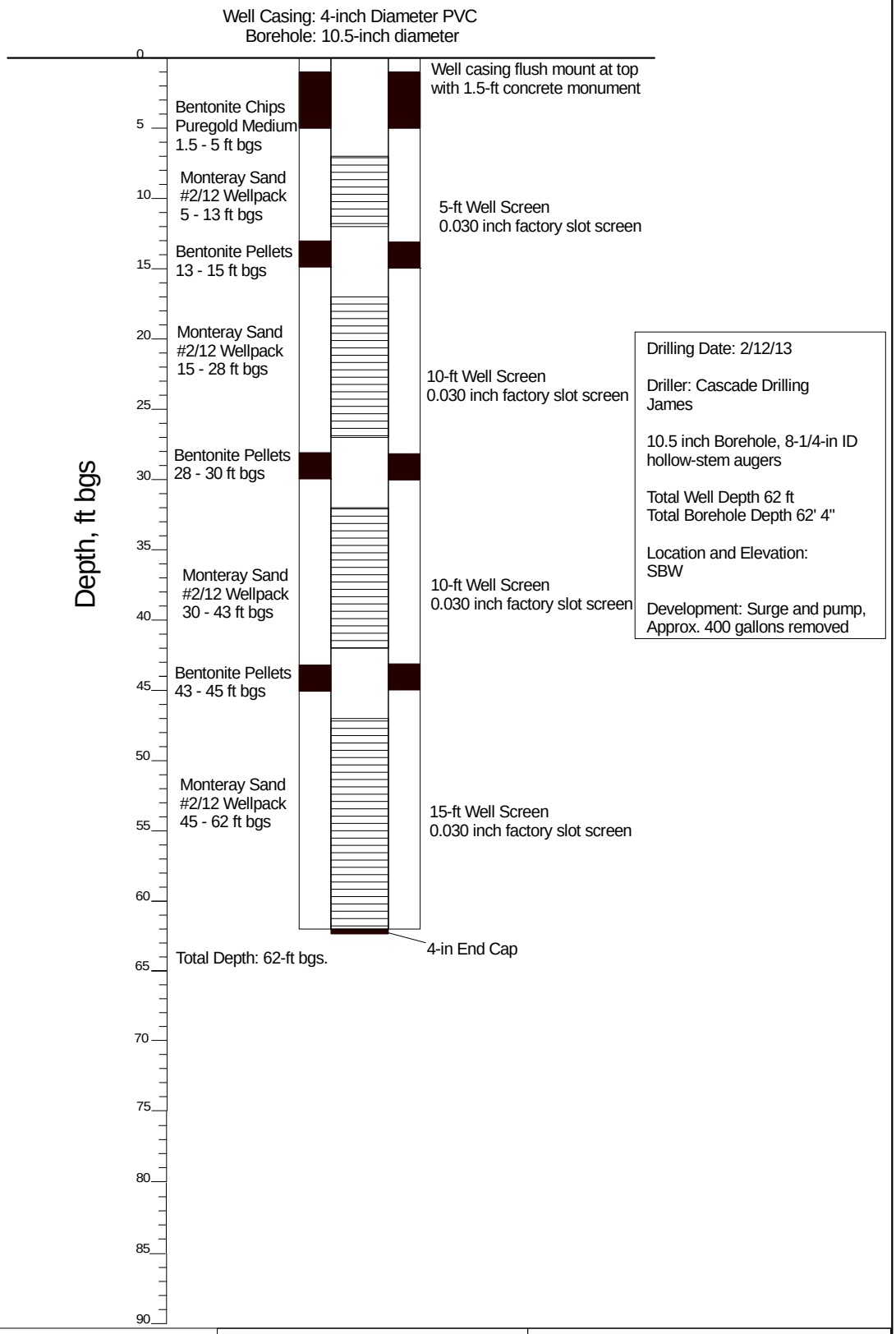
Injection Well Completion
Fox Avenue Site
Seattle, WA

Injection Well: R2-IW10



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Injection Well Completion
Fox Avenue Site
Seattle, WA

Injection Well: R2-IW11