EIB Performance Monitoring Plan

Prepared for

SILTRONIC CORPORATION

August 31, 2009
Project No. 8128.01.20

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EIB PERFORMANCE MONITORING PLAN

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CVOC	chlorinated volatile organic compound
DCE	dichloroethene
DEQ	Oregon Department of Environmental Quality
Dhc	*Dehalococcoides*
DO	dissolved oxygen
EIB	enhanced in situ bioremediation
FFS	Focused Feasibility Study
JSCS	Joint Source Control Strategy
MFA	Maul Foster & Alongi, Inc.
mg/L	milligrams per liter
MGP	manufactured gas plant
mV	millivolt(s)
µg/L	micrograms per liter
NWN	NW Natural
ORP	oxidation-reduction potential
PEP	Performance/Effectiveness Plan
PMP	Performance Monitoring Plan
PMW	performance monitoring well
PRB	permeable reactive barrier
RAO	remedial action objective
Revised Workplan	Revised EIB Source Control Workplan
RI	remedial investigation
SCM	source control measure
Siltronic	Siltronic Corporation
SLV	screening level value
TCE	trichloroethene
TOC/DOC	total and dissolved organic carbon
USEPA	U.S. Environmental Protection Agency
VOC	volatile organic compound
ZVI	zero-valent iron

1 INTRODUCTION

1.1 Introduction

On behalf of Siltronic Corporation (Siltronic), Maul Foster & Alongi, Inc. (MFA) has prepared the following Performance Monitoring Plan (PMP) for enhanced in situ bioremediation (EIB) of trichloroethene (TCE) and its degradation products. The PMP is a supporting document for the Revised EIB Source Control Workplan (the Revised Workplan) dated October 20, 2008, submitted to the Oregon Department of Environmental Quality (DEQ) and the U.S. Environmental Protection Agency (USEPA). These documents are provided consistent with the requirements of the Order Requiring Remedial Investigation and Source Control Measures, VC-NWR-03-16, dated February 9, 2004.

The PMP describes the EIB source control system and the optional performance enhancements added to the permeable reactive barrier (PRB) and supplemental injections installed at Siltronic. The purpose of the PMP is to identify the methods for evaluating the performance of the EIB source control measure (SCM), and includes the following sections:

Section 1—Introduction. This section includes a description of the installed system.

Section 2—Performance Monitoring Network. This section describes the performance monitoring wells (PMWs) that comprise the monitoring network, and analytical scope and schedule.

Section 3—Framework for Evaluating Data. This section clarifies the remedial action objectives (RAOs) and effectiveness criteria, consistent with the Revised Workplan. This section also describes the methods for analyzing the data from the PMWs in order to evaluate effectiveness, and identifies additional data needs.

Section 4—Criteria for Contingent Action. This section identifies short-term and long-term data trends that could require contingency actions, and suggests potential contingency actions.

The PMP incorporates information previously submitted to DEQ (including responses to comments) and is briefly summarized as follows:

The Performance/Effectiveness Plan (PEP) identified data collection objectives for the PMW network and fate and transport modeling parameters and results using the USEPA-approved REMCHLOR model (MFA, 2009c). DEQ comments regarding the PEP, and responses, are included as Appendix A.

The MFA letter dated June 2, 2009, providing initial angled PMW results (MFA, 2009b).

The MFA memorandum dated April 29, 2009, summarizing initial performance monitoring data (MFA, 2009a).

The Revised Workplan described the expanded injection scope and committed to implementation of an expanded injection program, including supplemental injection areas (MFA, 2008d).

The August 19, 2008, Addendum to the EIB Source Control Work Plan—Phase I Injection Plan, which provided the design basis for Phase I (i.e., PRB only) of the injection approach (MFA, 2008c).

The May 15, 2008, letter regarding site-specific analysis of iron, which evaluated potential secondary impacts related to metals concentrations due to in situ chemical reduction (MFA, 2008b).

The Enhanced Bioremediation Source Control Workplan submitted to DEQ on May 12, 2008, which described the initial approach for EIB implementation (MFA, 2008a).

The Focused Feasibility Study (FFS) submitted to DEQ on October 23, 2007, which identified the remedial alternatives for source control (MFA, 2007c).

The remedial investigation (RI) report submitted April 16, 2007, which described the nature and extent of TCE and its degradation products, and provided initial fate and transport parameters (MFA, 2007b).

The Pilot Study Report submitted March 9, 2007, which summarized the performance of the source area and riverbank pilot study EIB PRBs (MFA, 2007a).

Implementation of EIB in the former TCE underground storage tank area (also known as the source area) (see Figure 1-1) is consistent with Alternative 2 of the FFS recommended by Siltronic and approved by DEQ. EIB in the source area will address elevated concentrations of TCE and cis-1,2-dichloroethene (DCE), and enhanced natural attenuation processes will address concentrations of TCE, cis-1,2-DCE, and vinyl chloride in the downgradient portion of the plume.

NW Natural (NWN) will implement a groundwater extraction and treatment system to address manufactured gas plant (MGP) related impacts at the riverbank. The implementation of hydraulic control is expected to capture the entire downgradient chlorinated volatile organic compound (CVOC) plume and will thus effect riverbank source control for TCE and its degradation products while source area remediation is ongoing (see Figure 1-2). Riverbank source control is expected to be in place and operational before USEPA issues the Portland Harbor Record of Decision, which is currently estimated to be in 2012.

1.2 Description of the EIB Source Control System

The Revised Workplan and supporting documents describe the full-scale implementation of EIB using Adventus Americas, Inc.'s EHC (a combination of zero-valent iron [ZVI] and hydrophilic organic carbon) and KB-1 (dechlorinating bacteria consortium) installed as a PRB. The PRB is approximately 175 feet in length and originally consisted of three rows of injection points spaced 5 feet apart. An additional row for the PRB and three upgradient supplemental injection areas were added as initial contingency measures during development of the approach. These optional contingency measures were implemented concurrently with the full-scale implementations to enhance progress toward achieving the RAOs.

Approximately 602,000 pounds of EHC and 1,900 liters of KB-1 were injected in the PRB and supplemental areas. Based on methods developed by the EHC vendor,[1] and using data from the PMWs installed in the source area, the estimated longevity of the ZVI component of the installation ranges from 14 to 20 years. The KB-1 consortium will remain viable indefinitely, as long as reducing and anaerobic conditions persist.

Because of competing needs of the SCM for MGP-related impacts, the EIB SCM was installed only in the source area, and not at the riverbank. Significant infrastructure was removed in order to improve access and enhance complete distribution of the EIB materials. Existing buried and overhead utilities further complicated implementation, and in some places required angled injection borings. EIB materials were injected to the extent safely practicable in all areas where TCE was known or estimated to be present above the defined injection threshold (11,000 micrograms per liter [µg/L]).

[1] See technical note, Summer 2009 newsletter from www.adventusgroup.com.

2 PERFORMANCE MONITORING NETWORK

The performance monitoring network includes 34 new or existing PMWs. The wells are described in the following groups, as summarized in Table 2-1 and shown on Figure 1-1. The sampling schedule and analytical scope are summarized in Tables 2-2 and 2-3, consistent with the Revised Workplan.

2.1 Influent and PRB PMWs (Group 1)

The influent and PRB PMWs are located upgradient of and within the EIB PRB, respectively. The five influent PMWs are intended to provide data about concentrations of TCE and its degradation products in groundwater entering the EIB PRB, while the ten PRB PMWs are intended to provide data regarding degradation of TCE and its degradation products within the PRB.

Three of the five influent PMWs are located in supplemental injection areas upgradient of the PRB. The remaining influent wells include two existing well pairs (WS-13-69/105 and WS-15-85/140). These wells are located upgradient of the PRB and will provide the influent data for comparison with the PRB as intended. The WS-13-69/105 pair is also located downgradient of a supplemental injection area. The data from the Group 1 PMWs will be used to quantify progress toward RAO 1 and monitor the longevity of the EIB injection materials.

2.2 PRB Downgradient PMWs (Group 2)

Eight PMWs (WS-18-71/101; WS-39-101; WS-33-81/106; WS36-81/106, and WS-38-61) are located downgradient of the PRB. The data from these wells will be used to establish baseline attenuation rates (as described in Section 3.1.2.1) and to quantify degradation of TCE and its daughter products in groundwater downgradient of the PRB. Consistent with DEQ's recommendation, baseline samples were collected from these wells before PRB installation.

2.3 Angled and Fab 1 Downgradient PMWs (Group 3)

Eleven PMWs are located farther downgradient of the source area. Nine new PMWs and one existing well (WS-21-112) are located downgradient of the Fab 1 building. WS-24-155 was installed underneath the Fab 1 building, using angled drilling. The data from these wells will be used to monitor progress toward achieving RAO 2. The angled well will be used to predict EIB performance between Group 2 and Group 3 PMWs.

2.4 Analytical Scope and Schedule

The sampling schedule and analytical scope are summarized in Tables 2-2 and 2-3, and are similar to the monitoring for the EIB Pilot Study. The performance monitoring scope and schedule presented in this plan are more narrowly focused on providing data for demonstrating progress toward achieving the RAOs, whereas the Pilot Study monitoring included a broader scope, which was intended to also collect data to elucidate pathways and secondary impacts (e.g., related to redox-sensitive metals).

The following sections identify the analytical suites and sampling frequency for the PMW groups. Sample frequency will initially be either monthly (Group 3) or bimonthly (Groups 1 and 2[2]). As monitoring continues, sampling schedules will be optimized and/or reduced to reflect improved groundwater quality. Groundwater samples will be collected using methods and equipment consistent with the Pilot Study sampling program and the RI quarterly sampling program.

2.4.1 Target Compounds

The target compounds are TCE and its degradation products, including ethene. The monitoring frequency for these compounds should reflect the anticipated rate of change. Based on the Pilot Study data, the following sampling frequency is proposed:

Groups 1, 2—If approved, bimonthly sampling will be adequate to evaluate progress toward RAO 1 in these wells (see footnote 2). When RAO 1 has been met and maintained for one year, sampling frequency for these wells can be reduced.

Group 3—Based on estimated travel times for a front of relatively clean groundwater from the source area, the concentrations of these wells are not expected to change significantly during the first nine months following initiation of EIB injection. At DEQ's direction, monthly monitoring will be adequate to establish conditions in the Group 3 wells and estimate degradation rates.

The target compound analyses include volatile organic compounds (VOCs) by USEPA Method 8260 and Fixed Gases by ASTM D1945.[3]

2.4.2 ORP Indicators

Oxidation-reduction potential (or redox) (ORP) indicators will be important for evaluating reducing conditions throughout the plume, and include ORP-sensitive anions (sulfate/sulfide, nitrate/nitrite) and field parameters (dissolved oxygen [DO],

[2] Pending DEQ approval of a technical justification, a bimonthly schedule for Groups 1 and 2, to be submitted under separate cover.

[3] ASTM. Method D1945 Modified. American Society for Testing and Materials.

pH, and ORP). Sampling should occur at the same frequency as the target compounds.

2.4.3 EHC Distribution Indicators

Compounds or compound groups indicative of EHC distribution and reactions include total and dissolved organic carbon (TOC/DOC), volatile fatty acids, chloride, and total and dissolved iron. Since the distribution of EHC will be limited to the source area, only Group 1 and 2 PMWs will be sampled for these indicators. Sampling should occur at the same frequency as for the target compounds.

TOC/DOC, volatile fatty acids, chloride, and iron will be analyzed by USEPA Methods 415.1, HPLC, 9056, and 6010A, respectively.

2.4.4 Pathway Indicators

Under the conditions created in the PRB, CVOCs can degrade via any of several potential pathways, which include:

- Microbially mediated sequential dechlorination of TCE to DCE isomers (primarily cis-1,2-DCE), to vinyl chloride, to ethene. Dechlorination results in increased chloride as well.
- Abiotic hydrogenation of chloroalkenes to chloroalkanes—TCE is converted to 1,1,2-trichloroethane; cis-1,2-DCE is converted to 1,2-dichloroethane; and vinyl chloride is converted to chloroethane.
- Abiotic beta-elimination of TCE and cis-1,2-DCE to ethane—these compounds are converted to acetylene or chloroacetylene compounds in the presence of ZVI or ferrous iron (divalent iron). The acetylenes are unstable and break down to ethene. Beta-elimination results in increased chloride concentrations as well.

In addition to the reduction in concentrations of the target analytes, the presence of certain compounds or analytes will help identify the relative importance of the abiotic (i.e., ZVI-driven) or biologically mediated degradation pathways. These compounds include gases (ethene, ethane, acetylene, carbon dioxide, and methane) and ketones (acetone and 2-butanone, which are biological fermentation byproducts). Accordingly, these compounds will be included in the target compound analytical suite (VOCs and fixed gases).

2.4.5 *Dhc* Indicators

Sampling for *dehalococcoides* (*Dhc*) counts will be conducted at the Group 1 and Group 2 wells to document the growth and distribution of the KB-1 consortium. Baseline samples were collected prior to the KB-1 injection and confirm that *Dhc* bacteria are already present at varying levels in the EIB injection zone. Based on the anticipated growth rate of the KB-1 consortium, ongoing collection of samples should be

conducted on a quarterly basis following KB-1 injections. If the DO and the pH data suggest that conditions are not supportive of KB-1 growth (i.e., pH <5.5 and/or DO >1.0 milligrams per liter [mg/L]), sampling frequency would be increased to document restoration of the KB-1 once the pH and DO conditions have been corrected.

Baseline samples from the Group 3 PMWs will be collected, with subsequent sampling on a semiannual basis. *Dhc* counts will be analyzed by SiRem, the KB-1 vendor.

2.4.6 Analyte Groups Proposed for Discontinuation

The following analytes or analyte groups that were included in the Pilot Study sampling program are not needed to gauge progress toward achieving the RAOs, and are recommended for discontinuation following review of early performance data:

- Total and dissolved metals, including arsenic and mercury were included in the Pilot Study sampling set to determine if the reducing conditions created by EHC would result in increased metals concentrations that might impact downgradient receptors in the Willamette River. The Pilot Study data set demonstrated that increased concentrations of metals due to reducing conditions does not occur, and that the addition of EHC actually reduced concentrations of certain metals.[4] Samples will continue to be analyzed for total and dissolved iron.
- Alkalinity was included in the Pilot Study sampling program in order to evaluate potential pH changes in water chemistry that might affect metals speciation. As noted, the injection of EHC actually reduced metals concentrations, rendering the metals speciation question moot. Neither metals nor alkalinity data will be used to document progress toward the RAOs.
- Cyanide (total, free). These analytes were included in the Pilot Study sampling set at DEQ's request. The Pilot Study data set demonstrated that the addition of EHC actually reduced concentrations of cyanides in groundwater via formation of solid iron-manganese-cyanide complexes. Cyanide data will not document progress toward either RAO.
- Phosphate (as total phosphorus) was included in the Pilot Study sampling program in order to evaluate potential nutrient supply for the KB-1 consortium. The data were inconclusive and are not expected to support decision making for this work or to document progress toward either RAO.

[4] See MFA 2007a; MFA 2008b.

Siltronic will make the PMW network available for sampling for MGP-related or off-site compounds or analytes, consistent with existing access agreements.

3 FRAMEWORK FOR EVALUATING DATA

The following section describes how data from the PMWs will be used to develop the effectiveness criteria and measure progress toward the RAOs.

3.1 Objectives and Criteria

This section discusses the RAOs and effectiveness criteria for the EIB remedy. The RAOs were developed based on the results of the Pilot Study as described in the FFS, and refined during meetings and communications between Siltronic and DEQ. DEQ subsequently requested that Siltronic develop effectiveness criteria to gauge progress toward achieving the RAOs.

The EIB Pilot Study demonstrated that bioremediation is effective at reducing concentrations of TCE and its daughter products within the source area, even at high concentrations and in the presence of MGP materials. The source area was defined to include the area bounded by TCE groundwater concentrations exceeding 11,000 μg/L, i.e., 1 percent of its solubility limit. A supplemental investigation identified the area exceeding that concentration, termed the "injection threshold," which was sufficiently accessible to allow injection of EIB materials. RAO 1—reducing TCE concentrations to below the injection threshold of 11,000 μg/L in the source area—was deemed practicable based on bench testing and Pilot Study results.

Based on the riverbank EIB pilot study results in the downgradient portion of the plume, DEQ determined that RAO 2—reducing concentrations of TCE and its degradation products to below the Joint Source Control Strategy (JSCS) screening level values (SLVs) at the riverbank (i.e., downgradient of the Fab 1 building as shown on Figure 1-1)—was also appropriate. DEQ further determined that an intermediate PMW location (i.e., downgradient of the injection zone and upgradient of the riverbank) was required in order to evaluate the effectiveness of the EIB injections. This monitoring point was installed as an angled well installed under Fab 1.

To date, data from the angled PMW have not been representative of the CVOC plume. In order to document progress toward the RAOs, effectiveness criteria must be defined based on monitoring data from PMWs located upgradient and downgradient of the Fab 1 building, and used to evaluate whether contingency actions must be taken to correct and/or improve EIB performance. Specifically, TCE degradation rates in the source area must be shown to be equivalent to or to have increased relative to the Pilot Study data for RAO 1. For RAO 2, biodegradation rates for TCE and its degradation products in the downgradient portion of the plume must be shown to increase relative to current estimated

biodegradation rates. This PMP includes a description of how the rate calculations will be performed.

The effectiveness criteria in this PMP also include numerical values or trends for indicator data (ORP, EHC, and *Dhc* data described in Section 2.4) that indicate EIB effectiveness for attaining RAO 1 or 2. Monitoring data and rate comparisons for evaluating the effectiveness consistent with the criteria in this PMP will be included in subsequent periodic reports.

3.1.1 RAO 1—TCE Concentrations below Injection Threshold

The primary indicator for evaluating the effectiveness of the EIB PRB toward achieving RAO 1 will be the reduction in concentrations of TCE below 11,000 μg/L in the injection area. TCE degradation rates will be calculated using methods consistent with USEPA methods (USEPA, 2002) and compared to the Pilot Study performance data. In the event that RAO 1 has not been achieved within one year following injections, performance indicator data (ORP, EHC, and *Dhc* data) will be used to identify reasons for underperformance and to support contingency decisions.

3.1.2 RAO 2—CVOCs below JSCS SLVs at Riverbank

The effectiveness and progress of the EIB remedy toward achieving RAO 2 will be evaluated using monitoring data and predictive modeling. Trend analysis based on monitoring data from the Group 3 PMWs will be used to track progress toward and predict timeframes for attaining RAO 2. Group 3 monitoring data will also be compared to predicted concentrations developed using the USEPA REMCHLOR model as described in the PEP (and subsequent comments from DEQ). The REMCHLOR model will be updated with ongoing point decay rates from the Group 1, 2, and 3 PMWs.

3.1.2.1 Baseline Data

Data from most of the Group 3 PMWs are favorable and confirm the effectiveness of natural attenuation. As shown on Table 3-1, RAO 2 has been achieved in four of the Group 3 PMWs. Decreasing trends in other PMWs suggest that RAO 2 will be achieved in most of the wells within three years. *Dhc* bacteria have been identified in several wells and confirm that a native population of dechlorinating bacteria has been well established, as predicted and discussed in the RI report (MFA, 2007b). The baseline and early data will be provided in a separate submittal, and will be used to confirm the effectiveness of the full-scale EIB implementation for increasing the rate of natural attenuation.

There is additional inherent variability in the data because of seasonal and tidal influences on water table, establishment of reducing condition throughout the effective treatment area, microbe adaptation and reproduction, and variation in groundwater velocity with distance from the source area. Data from some of these wells and historical data from WS-21-112 and WS-11-125 confirm the high variability

of CVOC concentrations as natural attenuation reduces the overall mass of CVOCs in groundwater. The inherent variability requires rigorous statistical analysis of data trends in order to support contingency actions as described in Section 4.

3.1.2.2 Point Decay Rates and Plume Modeling

The baseline decay rates and other site data will be used as inputs and calibration targets for the contaminant fate and transport model (i.e., REMCHLOR). Data from individual Group 3 PMWs will be used to calculate individual point decay rates and estimate the time required to meet RAO 2, consistent with USEPA methods (USEPA, 2002).

It is important to note that attenuation of TCE and its degradation products in the downgradient portion of the plume is largely dominated by sequential dechlorination, where TCE is converted to DCE, DCE is converted to vinyl chloride, and vinyl chloride is converted to ethene. Consequently, a reduction in a parent compound (e.g., TCE) concentration and corresponding increase in the daughter product (i.e., DCE) concentration is expected and would be confirmation that enhanced biodegradation is effective. In order to account for the stoichiometric conversions, the monitoring data will be converted to molar concentrations. In order to accurately estimate timeframes for individual compounds to meet RAO 2, the decay rates will be adjusted to account for the daughter production rates (consistent with the methods in the RI report (MFA, 2007b).

These decay rates will also be used as input parameters for Zone 3 (i.e., the downgradient plume portion) of the REMCHLOR model. Decay rates from the Group 1 and 2 PMWs will be calculated consistent with USEPA methods as noted above and in Section 3.1.1. The decay rates will be used as input parameters for Zones 1 and 2 of the REMCHLOR model (i.e., corresponding to the PRB/Group 1 PMWs and immediately downgradient/Group 2 PMWs, respectively).

The input parameters will also reflect DEQ's comments in its August 12, 2009 letter regarding revised inputs. Once the model is calibrated using the revised inputs, it will be used to predict concentration changes over time and estimate timeframes to reach RAO 2. The current model predicts declining trends in the Group 3 PMWs (with minor, short-term increases in daughter product concentrations that are well within the historical ranges). The ongoing Group 3 monitoring data (for PMWs exceeding SLVs) will be compared to predicted changes in concentration to evaluate the effectiveness of the full-scale implementation.

If the monitoring data trends confirm that compound decay rates in the Group 3 PMWs are increased relative to the baseline decay rates, the full-scale implementation will be considered to be effective. If the monitoring data trends are decreasing consistent with the predicted trends from the REMCHLOR model, the REMCHLOR predicted timeframes for reaching RAO 2 will be used as a benchmark for further evaluating the effectiveness. Monitoring data trends will be developed

using industry standard statistical methods supported by USEPA and DEQ guidance as described in Section 4.

3.2 Angled Well Data

An angled well was installed along the presumed centerline of the TCE plume at a point approximately 300 feet downgradient of the source area and beneath Fab 1. The objective of the well is to provide data along the CVOC plume axis between the source area and the downgradient PMWs.

Based on the initial (January 2009) sampling event from the Group 3 PMWs, the CVOC plume axis was thought to fall along a line generally from the former UST area to the WS-21-112/131 location. That conclusion may have been incorrect. Figure 3-1 shows total concentrations of TCE and its degradation products in PMWs along and adjacent to the presumed plume axis. Baseline data from PMW WS-24-111 appear to be more representative of the CVOC plume axis, with lower concentrations along the initially presumed axis.

Based on the data, MFA recommends that WS-24-111 be used as a replacement for WS-24-155. In meetings, DEQ has noted a need for an "early indicator" of treated groundwater emanating from the source area. WS-24-111 is located closer to the source area than the Group 3 PMWs (and other wells, notably WS-14-125), which are located almost adjacent to the riverbank. Therefore, WS-24-111 could fulfill the "early indicator" function with the incorporation of WS-14-125 into the Group 3 PMW network.

3.3 Additional Data Needs

As discussed with DEQ and indicated above, additional data (including resolution of the revised REMCHLOR input parameters) are required before the process of estimating timeframes can proceed. The additional data needs include the predicted and actual groundwater flow rates. NWN anticipates implementing a groundwater extraction SCM at the riverbank between 2010 and 2012, which will alter the groundwater flow velocity near some or all of the Group 3 PMWs. The anticipated increase in flow velocity will alter degradation rates and predicted timeframes to reach RAO 2. Once the predicted and observed groundwater flow velocities are better understood, the predicted timeframes for reaching RAO 2 (as developed using the REMCHLOR model) will be adjusted.

As of the date of this submittal, the NWN SCM has not been installed and actual groundwater velocities have not been calculated. Once these data are available, the timeframes for reaching SLVs at the riverbank can be estimated.

4 CRITERIA FOR CONTINGENT ACTION

As noted by DEQ, certain performance indicators may indicate the need for contingency actions. Short- and long-term data trends will be evaluated in order to identify appropriate contingency actions and timing for implementation, if necessary. Due to the complexity of the multiple pathways operating in the subsurface, identifying appropriate contingency actions will require evaluation of the data set as a whole, rather than relying on individual data points.

4.1 Short-Term Data Trends and Response Actions

The results of EHC and KB-1 injections can be evaluated using both direct data (i.e., concentrations of TCE and its degradation products) and indirect data. Indirect data include ORP, DO, pH, and counts of *Dhc* bacteria. During sampling, MFA measures ORP, pH, DO, temperature, and turbidity. Of these, DO, ORP, and pH are useful parameters for evaluating effective EIB performance. These data will be collected from the Group 1 and Group 2 PMWs to evaluate the completeness of the EHC and KB-1 injections. If direct data suggest underperformance relative to the Pilot Study results, the following indirect data will be evaluated to identify potential causes and to determine if short-term response actions might be required or appropriate.

4.1.1 Dissolved Oxygen

DO data identify subsurface conditions that could impair the viability of the KB-1 anaerobic consortium. If DO data increase above approximately 1.0 mg/L, the groundwater is could impair or destroy facultative anaerobes (including *Dhc* bacteria) that are partially responsible for dechlorination of TCE and its degradation products. Consistently elevated DO data and sustained concentrations of TCE above the injection threshold throughout the Group 1 and 2 PMWs could suggest that additional EHC injections would be warranted to provide additional organic carbon and fermentation to support anaerobic conditions. In order to select the appropriate application rate, additional field and analytical data, including oxidant/reductant demand, would be required before moving forward with contingent EHC injections.

4.1.2 Redox

Field ORP data will serve two purposes: first, to confirm subsurface conditions supportive of reductive dechlorination, and second to confirm the accuracy of field DO data. The direct relationship between ORP and DO is well understood, such that increasing DO values and decreasing ORP values would suggest a calibration or performance issue with the DO instrument.[5] The ORP data will therefore be used to

[5] ORP probes and field data are generally more reliable than DO probes and field data.

check on the DO data to confirm that accurate data will be used as the basis for contingent action decisions (e.g., EHC reinjection).

ORP data provide an understanding of redox conditions in the subsurface. The organic component of EHC creates reducing conditions (e.g., about -200 to -300 millivolts [mV]) that support biologically mediated sequential dechlorination of TCE and its degradation products. The ZVI component of EHC also creates strongly reducing conditions (e.g., about -300 to -400 mV[6]) that support multiple abiotic pathways that directly degrade TCE and its degradation products.

Consistently elevated ORP values (i.e., above -25 mV) in the Group 1 and 2 PMWs may suggest the need for additional EHC injections. However, it has been noted that ORP data collected from the Group 1 and 2 PMWs may be elevated relative to reconnaissance data collected during KB-1 injection. During the Pilot Study, ORP data from monitoring wells was often found to underestimate reducing conditions relative to analytical data for redox-sensitive species (specifically, methane and sulfate). The field ORP data from the PMWs will therefore be used to confirm reducing conditions in the subsurface, but will not serve as an individual contingency trigger for reinjection.

As noted in the Pilot Study, reducing conditions were confirmed by reduction of sulfate concentrations and generation of methane. Both of the processes occur at ORP values circa -250 mV. It is important to note that successful reduction of TCE and its degradation products also occurred regardless of the sulfate and methane data trends, as documented in the Pilot Study. Therefore, sulfate and methane data from the Group 1 PMWs will be used to elucidate reasons for potential underperformance with respect to RAO 1.

4.1.3 pH Data

pH data collected during monitoring will be used to evaluate conditions that can impair the *Dhc* populations within the KB-1 consortium. Based on information from the supplier, *Dhc* activity slows below pH 5.5, and can effectively stop below pH 5. While these conditions can occur because of fermentation processes, the ZVI component of EHC reliably offsets this acidification. Measurement of these low-pH conditions may indicate whether there is a need for contingency injections of EHC with an increased fraction of ZVI in the mixture.

4.1.4 *Dhc* Counts

Periodic sampling for *Dhc* bacteria and the KB-1 culture will be a primary indicator of the distribution and viability of the biological component. As documented during the Pilot Study, data indicated successful growth in the injection zones and confirmed that downgradient distribution of the KB-1 consortium occurred.

[6] Lower redox conditions are possible but generally beyond the measurement range for field instruments.

Baseline and ongoing *Dhc* counts will be collected from the Group 1 and Group 2 wells, and from selected Group 3 wells, to further understand the distribution of *Dhc* in the groundwater. Ongoing *Dhc* counts in Group 1 and Group 2 wells that are lower than predicted by the Pilot Study performance may indicate that pH and ORP have drifted outside the optimal ranges, which might require further EHC injection. If *Dhc* growth is inhibited and pH and ORP are still within normal ranges, additional *Dhc* injections may be appropriate to enhance progress toward RAO 1, following identification of the reason for growth inhibition.

4.2 Long-Term Data Trend Evaluation

Long-term data trends will be used to evaluate the need for and type of contingency response actions. For the purposes of this document, "long-term" is intended to indicate timeframes greater than about three years from the initial injection. This timeframe is based on the following factors:

- Duration of the Pilot Study sampling period
- Conservatively long estimate of travel time from source area to riverbank
- Estimated longevity of the ZVI component of the PRB (which as noted in Section 1.2 is greater than three years)

Potential data trends that could trigger response actions include the following:

- Sustained TCE concentrations in Group 1 and 2 PMWs above the injection threshold could indicate that the EHC/KB-1 PRB is ineffective for meeting RAO 1. The Pilot Study data set does not support this scenario.
- Incomplete dechlorination (as evidenced by lack of ethene or ethane, for example) in Group 3 PMWs could indicate that the aquifer downgradient of Fab 1 is not supporting native or injected *Dhc* bacteria. These trends would be counter to the baseline data set, which indicates that complete dechlorination and generation of ethene is occurring.
- Increasing trends of daughter products (DCE isomers and vinyl chloride) in Group 3 PMWs located downgradient of Fab 1. Temporary increased concentrations of degradation products in the Group 3 PMWs could occur within the short term, but are likely to be significantly lower than historical ranges. Once the fate and transport model is calibrated,[7] the duration and magnitude of potential increases can be estimated. Concentrations of degradation products that continue to increase inconsistent with the model would suggest that complete dechlorination of TCE and its degradation products may not be occurring.

[7] Using the revised input parameters suggested by DEQ in the August 12, 2009, comment letter.

In its comments, DEQ noted that a contingency trigger for source area re-injection would consist of "two consecutive data points falling on an upward trend-line" using the Group 3 PMW data set. Due to a number of factors, there is considerable variability in concentrations of TCE and its degradation products in groundwater under baseline conditions. As a result, by chance alone, the probability of observing two successively higher concentrations of a compound in groundwater at an individual PMW is high. In order to prevent inappropriate and/or unnecessary supplemental remedial actions, an alternative and more rigorous evaluation is proposed to evaluate the need for contingency measures.

Multiple lines of evidence will be used to determine the need for contingency measures. Statistical methods will be used to evaluate temporal trends in concentrations of TCE and degradation products in Group 3 PMWs. Trend analyses will be performed using methods recommended in USEPA and DEQ guidance.[8] Factors such as sample size, data distribution, patterns in variance, and the presence of outliers will be considered when selecting a particular statistical method. If data meet the assumptions of parametric statistical methods, regression techniques will be considered. Nonparametric methods that may be considered include the Kendall test for presence of consistent trends, Sen slope test for measure of magnitude of slope, and Wilcoxon-Mann-Whitney step trend analysis. Statistical analyses will be performed after sufficient data have been collected to characterize concentrations both before and after the time in which a potential treatment effect would have reached a particular PMW.

Additional evaluations will be performed for certain chemicals found to have a statistically significant increasing trend. For example, the magnitude of the trend will be evaluated to determine if chemical concentrations at the riverbank could potentially exceed SLVs in the foreseeable future. Also, numerous other data will be reviewed to determine the likely cause of any particular trend. A thorough understanding of operating TCE degradation processes will be important when determining the need for and identifying additional response actions. Additional remedial actions will be proposed only if they have a high likelihood of achieving RAOs based on the current understanding of the system.

4.3 Potential Response Actions

In the source area, contingency actions will not be considered if data confirm that RAO 1 will continue to be met. With respect to RAO 2, options for contingency actions are limited and will require evaluation in the context of the NWN hydraulic containment measure. Assuming that the NWN hydraulic containment measure is implemented in a timely manner, initial modeling and pilot testing have predicted effectiveness for treatment of CVOCs. Alternative 5 from the Siltronic FFS was an

[8] See http://www.deq.state.or.us/lab/wqm/docs/TrendAnalysisCD.pdf; and also *Statistical Analysis of Ground-Water Monitoring Data at RCRA Facilities/Addendum to Interim Final Guidance,* USEPA, 1992.

evaluation of a pump-and-treat option for CVOCs; that option will have effectively been implemented by NWN regardless of EIB CVOC data.

The following describes the potential contingency actions, along with potential issues regarding these actions:

- Reapplication of EHC/KB-1 in the source area. This contingency would be evaluated if Group 1 and 2 PMW data clearly confirm that RAO 1 was not being met (i.e., TCE concentrations increased over the injection threshold and remain elevated). This contingency would be selected only if the direct and indirect monitoring data confirmed that the reason for rebound was insufficient application of EHC/KB-1. If the data cannot confirm that reapplication of EHC/KB-1 will address the issue, other approaches will be considered.
- Angled injection of EHC/KB-1 under Fab 1, immediately downgradient of the source area. This contingency is high-risk because of the presence of buried utilities and is not practicable, based on MFA's experience during the full-scale implementation. During angled injection in the source area, approximately 200 feet of tooling were lost because of rod breakage, which is suspected to be the result of asymmetrical loading of the box and pin joints. Furthermore, reconnaissance data describing the nature and extent of TCE above the injection threshold and below Fab 1 are not available and are not practicable to collect because of the limitations with angled direct-push drilling noted above. Absent the nature and extent information, angled injections are not likely to be accurately targeted and cannot predictably address TCE above the injection threshold.
- Injection of KB-1 downgradient of Fab 1. Based on the presence of a native strain of *Dhc* downgradient of Fab 1, it appears that conditions will support the KB-1 consortium absent the electron donor component of EHC. This contingency would be evaluated in the event that the Group 3 data clearly confirm that RAO 2 will not be achieved as a result of the source area injections.

In the event that reinjection scenarios are evaluated and found inappropriate and the Group 3 data clearly confirm that RAO 2 will not be achieved as a result of the source area injections, Alternatives presented in the FFS will be revisited.

MFA. 2007a. Letter (re: addendum to the pilot study work plan, Siltronic Corporation, 7200 NW Front Avenue, Portland, OR, ECSI #183) to D. Bayuk, Oregon Department of Environmental Quality, from J. Peale and J. Maul, Maul Foster & Alongi, Inc., Portland, Oregon. March 9.

MFA. 2007b. Remedial investigation report. Prepared for Siltronic Corporation. Maul Foster & Alongi, Inc., Portland, Oregon. April 16.

MFA. 2007c. Letter (re: focused feasibility study, Siltronic Corporation, 7200 NW Front Avenue, Portland, OR, ECSI #183) to D. Bayuk, Oregon Department of Environmental Quality, from J. Peale and T. Wall, Maul Foster & Alongi, Inc., Portland, Oregon. October 23.

MFA. 2008a. Enhanced bioremediation source control work plan, Siltronic Corporation. Maul Foster & Alongi, Inc., Portland, Oregon. May 12.

MFA. 2008b. Letter (re: DEQ comments on Siltronic FFS—site-specific analysis of iron, Siltronic Corporation, 7200 NW Front Avenue, Portland, OR, ECSI #183) to D. Bayuk, Oregon Department of Environmental Quality, from J. Peale and J. Maul, Maul Foster & Alongi, Inc., Portland, Oregon. May 15.

MFA. 2008c. Letter (re: addendum to the enhanced bioremediation source control work plan—Phase I injection plan, Siltronic Corporation, 7200 NW Front Avenue, Portland, OR, ECSI #183) to D. Bayuk, Oregon Department of Environmental Quality, from J. Peale and E. Bakkom, Maul Foster & Alongi, Inc., Portland, Oregon. August 19.

MFA. 2008d. Revised enhanced in-situ bioremediation source control work plan, Siltronic Corporation. Maul Foster & Alongi, Inc., Portland, Oregon. October 20.

MFA. 2009a. Memorandum (re: initial performance monitoring results, Siltronic Corporation). Maul Foster & Alongi, Inc., Portland, Oregon. April 29.

MFA. 2009b. Letter (re: angled well sampling results, Siltronic Corporation, 7200 NW Front Avenue, Portland, OR, ECSI #183) to D. Bayuk, Oregon Department of Environmental Quality, from J. Peale and T. Wall, Maul Foster & Alongi, Inc., Portland, Oregon. June 2.

MFA. 2009c. Letter (re: EIB performance/effectiveness plan, Siltronic Corporation) to D. Bayuk, Oregon Department of Environmental Quality, from J. Peale and T. Wall, Maul Foster & Alongi, Inc., Portland, Oregon. June 30.

USEPA. 2002. Ground water issue: calculation and use of first-order rate constants for monitored natural attenuation studies. National Risk Management Research Laboratory, Cincinnati, Ohio. November.

TABLES

Table 2-1
PMW Groups and Data Objectives
Siltronic Corporation
Portland, Oregon

Group 1—15 PMWs			
Upgradient of or in Injection Area	Objectives	Data Need	Supporting Data
WS-30-96 WS-31-106 WS-32-106	Monitor influent CVOC concentrations and PRB performance.	CVOC and mass transformation data.	Target Compounds, Chloride, Pathway Analysis
WS-32-76 WS-34-106	Predict timeframes to reach RAO 1.	Point CVOC degradation rates.	Target Compounds
WS-34-71 WS-35-106 WS-35-76 WS-37-51 WS-13-69 WS-13-105 WS-15-85 WS-15-140 WS-19-71 WS-19-101	Support REMCHLOR inputs.	CVOC concentrations, redox conditions.	Target Compounds Laboratory ORP Indicators Field ORP Indicators EHC Indicators DHC Indicators
Group 2			
Downgradient of PRB—8 PMWs			
WS-18-71 WS-18-101 WS-33-106 WS-33-81	Predict timeframes to reach RAO 1.	Point CVOC degradation rates.	Target Compounds
WS-36-106 WS-36-81	Monitor downgradient distribution of EHC/KB-1.	Redox conditions.	Laboratory/field ORP/EHC/KB-1 Indicators
WS-38-61 WS-39-101	Support rate calculations for RAO 2 and REMCHLOR inputs.	Change in CVOCs over distance.	Target Compounds
Group 3			
Downgradient or Under Fab 1—11 PMWs			
WS-21-112 WS-21-131	Monitor change in CVOCs at riverbank and under Fab 1.	Point CVOC degradation rates.	Target Compounds
WS-23-116 WS-24-111 WS-24-126	Predict timeframes to reach RAO 2 based on enhanced attenuation rate calculations.	Change in CVOCs over distance, groundwater velocity.	Target Compounds, Tracers
WS-24-155 WS-25-111 WS-25-96 WS-26-116 WS-26-86 WS-27-86	Support REMCHLOR inputs.		

Table 2-2
Past and Projected Performance Monitoring Events
EIB Source Control
Siltronic Corporation
Portland, Oregon

	Sampling Events									
Group	Q4-08	P1	P2	P3	P4	P5	P6	P7	P8	P9
Group 1 PMWs (15)										
WS-30-96		Feb-09	Mar/Apr-09	May/Jun-09	Jul-09		Sep-09		Nov-09	
WS-31-106		Feb-09	Mar/Apr-09	May/Jun-09	Jul-09		Sep-09		Nov-09	
WS-32-76/106		Feb-09	Mar/Apr-09	May/Jun-09	Jul-09		Sep-09		Nov-09	
WS-34-71/106		Feb-09	Mar/Apr-09	May/Jun-09	Jul-09		Sep-09		Nov-09	
WS-35-76/106		Feb-09	Mar/Apr-09	May/Jun-09	Jul-09		Sep-09		Nov-09	
WS-37-51		Feb-09	Mar/Apr-09	May/Jun-09	Jul-09		Sep-09		Nov-09	
WS-13-69	Nov-08		Mar/Apr-09	May-09	Jul-09		Sep-09		Nov-09	
WS-13-105	Nov-08			May-09	Jul-09		Sep-09		Nov-09	
WS-15-85/140	Nov-08			May-09	Jul-09		Sep-09		Nov-09	
WS-19-71	Nov-08			May-09	Jul-09		Sep-09		Nov-09	
WS-19-101	Nov-08		Mar/Apr-09	May-09	Jul-09		Sep-09		Nov-09	
Group 2 PMWs (8)										
WS-18-71/101	Nov-08	Feb-09	Mar/Apr-09	May-09	Jul-09		Sep-09		Nov-09	
WS-33-81/106		Jan-09	Mar-09	May-09	Jul-09		Sep-09		Nov-09	
WS-36-81/106		Jan-09	Mar-09	May-09	Jul-09		Sep-09		Nov-09	
WS-38-61		Jan-09	Mar-09	May-09	Jul-09		Sep-09		Nov-09	
WS-39-101		Jan-09	Mar-09	May-09	Jul-09		Sep-09		Nov-09	
Group 3 PMWs (11)										
WS-21-112/131		Jan-09	Apr-09	Jun-09	Jul-09	Aug-09	Sep-09	Oct-09	Nov-09	Dec-09
WS-23-116		Jan-09	Apr-09	Jun-09	Jul-09	Aug-09	Sep-09	Oct-09	Nov-09	Dec-09
WS-24-111/126		Jan-09	Apr-09	Jun-09	Jul-09	Aug-09	Sep-09	Oct-09	Nov-09	Dec-09
WS-24-155			Apr-09	Jun-09	Jul-09	Aug-09	Sep-09	Oct-09	Nov-09	Dec-09
WS-25-96/111		Jan-09	Apr-09	Jun-09	Jul-09	Aug-09	Sep-09	Oct-09	Nov-09	Dec-09
WS-26-86/116		Jan-09	Apr-09	Jun-09	Jul-09	Aug-09	Sep-09	Oct-09	Nov-09	Dec-09
WS-27-86		Jan-09	Apr-09	Jun-09	Jul-09	Aug-09	Sep-09	Oct-09	Nov-09	Dec-09

NOTES:
Thirty-four PMWs total.
Group 1 and 2 projections through end of 2009 pending DEQ approval.
Shaded areas = not sampled.

Table 2-3
Analytical Scope
Siltronic Corporation
Portland, Oregon

Analyte Group	Constituents	Analyses	Analytical Method
Target Compounds	TCE and its degradation products	Volatile Organic Compounds	USEPA 8260
	Chloride	Anions	USEPA SW9056
	Ethene, ethane	Fixed Gases	ASTM D1945
Laboratory ORP Indicators	Sulfate/sulfide; nitrate/nitrite	Anions	USEPA SW9056; USEPA 353.2
Groundwater Tracers	Ketones	Volatile Organic Compounds	USEPA 8260
EHC Indicators	Total/Dissolved Iron	Metals	USEPA 6010
	Acetic / butyric / lactic / propionic / pyruvic acid	Volatile Fatty Acids	HPLC
	Organic Carbon	Total and Dissolved Organic Carbon	USEPA 415.1
Dhc Indicators	*Dhc* bacteria	Polymerase Chain Reaction/VCR Gene Probe	Proprietary to SiRem
Pathway Analysis	Acetylenes, carbon dioxide,	Fixed Gases	ASTM D1945
	Ketones	Volatile Organic Compounds	USEPA 8260
Field ORP Indicators	Dissolved Oxygen, pH, oxidation/reduction potential		Field Instrumentation

Table 3-1
Group 3 Wells Below SLVs
Siltronic Corporation
Portland, Oregon

Well ID	DATE	TCE Total	cis-1,2-DCE Total	trans-1,2-DCE Total	1,1-DCE Total	VC Total
WS-24-126	01/28/2009	**0.51**	**1.53**	**<0.5**	**<0.5**	**0.66**
WS-24-126	04/21/2009	**0.4**	**1.1**	**<0.5**	**<0.5**	**<0.3**
WS-24-126	06/29/2009	**<0.3**	**<0.3**	**<0.5**	**<0.5**	**<0.3**
WS-24-126	07/27/2009	**<0.3**	**0.67**	**<0.5**	**<0.5**	**<0.3**
WS-26-86	01/23/2009	**<0.3**	**2.7**	**<0.5**	**<0.5**	8.85
WS-26-86	04/20/2009	**<0.3**	**2.13**	**<0.5**	**<0.5**	7.03
WS-26-86	06/30/2009	**<0.3**	**<0.3**	**<0.5**	**<0.5**	**1.21**
WS-26-86	07/24/009	**<0.3**	**0.48**	**<0.5**	**<0.5**	3.17
WS-27-86	01/22/2009	**0.32**	**0.77**	**<0.5**	**<0.5**	3.2
WS-27-86	04/20/2009	**0.45**	**0.89**	**<0.5**	**<0.5**	3.11
WS-27-86	06/30/2009	**<0.3**	**1.79**	**<0.5**	**<0.5**	**2.02**
WS-27-86	07/23/2009	**<0.3**	**1.37**	**<0.5**	**<0.5**	4.65
WS-21-131	01/29/2009	**<0.3**	156	**4.02**	**<0.5**	210
WS-21-131	04/21/2009	**1.96**	792	**8.79**	**0.64**	589
WS-21-131	06/29/2009	**2.38**	636	**3.74**	**<0.5**	424
WS-21-131	07/28/2009	**0.47**	**4.48**	**1.03**	**<0.5**	**<0.3**

NOTES:

Bold values are in compliance with RAO 2.

July data for WS-21-131 are being reviewed for representativeness.

DCE = dichloroethene.

TCE = trichloroethene.

VC = vinyl chloride.

FIGURES

Figure 1-1
Site Layout and Monitoring Wells, Groups 1, 2, and 3

Siltronic Corp.
Portland, Oregon

Legend

- Angled Well
- Monitoring Well
- Group 1
- Group 2
- Group 3
- Target Zone for Angled Well Screen
- Supplemental Injection Areas
- PRB Limits

0 50 100
Feet

Source: Aerial photograph (2007) obtained from Metro Data Resource Center

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File: X:\8128.01 Siltronic Corp\20\Projects\Fig1-1_Site Layout and Monitoring Wells, Groups 1,2, and 3.mxd
Print Date: 08-29-2009
Approved By: J. Peale
Produced By: W.Coffey
Project: 8128.01.20

Figure 1-2
Lateral Extent of Capture

Siltronic Corp.
Portland, Oregon

Legend

- Angled Well
- Monitoring Well
- Group 3 Monitoring Well

Notes:
1. Only a portion of monitoring well and geoprobe locations are posted.
2. Baseline data indicate that RAO 2 has been achieved in PMWs WS-24-126; WS-26-86/116; and WS-27-86.
3. Predicted lateral extent of capture based on documents provided by Anchor QEA.

0 20 40
Feet

Source: Aerial photograph (2007) obtained from Metro Data Resource Center

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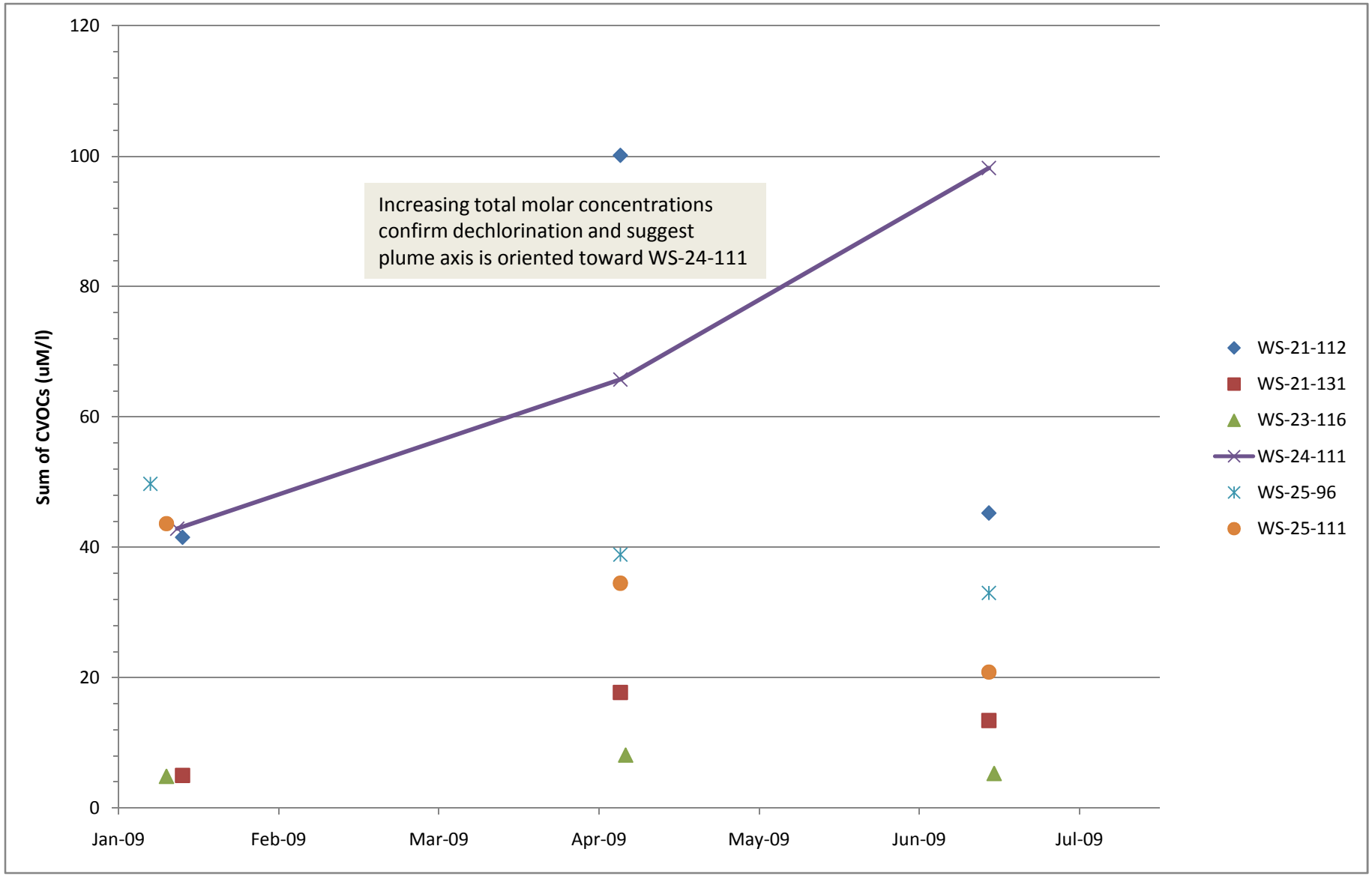
File: X:\8128.01 Siltronic Corp\20\Projects\06\Fig1-2_Lateral Extent of Capture and June CVOC Data.mxd
Print Date: 09-29-2009
Approved By: J. Peale
Produced By: R. Maronn/W. Coffey
Project: 8128.01.20/06

Figure 3-1
Sum of CVOCs in Groundwater (uM/L)
Group 3 PMWs Exceeding SLVs
Siltronic Corporation
Portland, Oregon



APPENDIX A

RESPONSE TO DEQ COMMENTS (8/12/2009)

The following DEQ comments regarding the Performance/Effectiveness Plan (in its August 12, 2009, letter) are included, with responses in italics.

Sampling and analysis of groundwater in all Group 1 and Group 2 performance monitoring wells (PMWs) consistent with the Revised EIB Work Plan approved for implementation by DEQ (i.e., monthly sampling for the full suite of analyses). Contrary to the approved sampling and analytical program, DEQ understands groundwater monitoring is currently being conducted every other month. Siltronic should resume monthly sampling effective upon receipt of this letter. Revisions to the approved performance monitoring program should be made in writing, accompanied by the technical justifications for the changes.

Siltronic has resumed monthly sampling for the Group 1 and 2 PMWs as of the date of this PMP. A revision to the Revised Work Plan requesting a bimonthly schedule and technical justification will be submitted under separate cover.

Collecting representative samples of groundwater from PMW WS-24-155, and absent the ability to collect these samples, abandoning and replacing the installation.

Monthly sampling of this PMW continues. With respect to replacing the PMW, please see Section 3.2 of the PMP.

Using projections of the time for EIB-treated groundwater to migrate beneath Fab 1, increase the sampling frequency to at least monthly at the Group 3 PMWs with the objective of monitoring the arrival and migration of treated groundwater at these installations.

Monthly sampling of the Group 3 PMWs continues.

Planning for reapplication of EIB treatment media within approximately 3 years (i.e., early summer 2012), or sooner if: 1) TCE concentrations rebound to greater than the injection threshold of 11,000 μg/L, or parts per billion, or 2) increasing concentrations of CVOCs are observed at Group 3 PMWs. For purposes of #2, two consecutive data points falling on an upward trend-line confirm increasing CVOCs concentrations and will trigger reapplication in the source zone and/or under Fab 1. These criteria are based on the following information:

> Available contingencies rely on maintaining subsurface conditions favorable to reductive dechlorination through additional EIB applications. Vender [sic] estimates for reapplication range between 3 and 5 years. The Siltronic model applies favorable EIB conditions near the source area (i.e., Zone 1) beyond five years (i.e., from 2 years to greater than 12 years from injection).

The remedial action objective for the Former UST System vicinity is to reduce TCE concentrations to less than 11,000 μg/L throughout the source area.

Siltronic's fate and transport model predicts CVOC concentrations in Group 3 PMWs should not increase.

Section 4 identifies short- and long-term data evaluation objectives and potential contingency response actions. Please note that Section 1.2 provides an updated estimate of the longevity of the ZVI component of the EIB installation (i.e., 14–21 years), consistent with methods developed by the vendor.