

Response Action Contract for
Remedial, Enforcement Oversight, and Non-Time Critical
Removal Activities at Sites of Release or Threatened Release of
Hazardous Substances in
EPA Region VIII

U. S. EPA Contract No. 68-W5-0022

Final
Remedial Investigation Addendum Report
for
Bountiful/Woods Cross
5th South PCE Plume (OU2)
Davis County, Utah

July 2005

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Prepared for:
U. S. Environmental Protection Agency
Region VIII
999 18th Street, Suite 500
Denver, Colorado 80202

Prepared by:
CDM Federal Programs Corporation
1331 17th Street, Suite 1100
Denver, Colorado 80202

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Prepared by: _____ Date: _____
Frank R. Morris, P.G.
Project Manager

Reviewed by: _____ Date: _____
Clint Werden, P.G.
Technical Reviewer

Reviewed by: _____ Date: _____
Kim Zilis
RAC VIII QA Coordinator

Approved by: _____ Date: _____
Mario Robles
EPA Region VIII Remedial Project Manager

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Acronyms

AF	attenuation factor
amsl	above mean sea level
AS	sub-slab vapor boring
BHHERA	baseline human health and ecological risk assessment
BFC	Bountiful Family Cleaners
bgs	below ground surface
BTEX	benzene, toluene, ethylbenzene, and xylene
CAHs	chlorinated aliphatic hydrocarbons
CDI	chronic daily intake
CDM	CDM Federal Programs Corporation
CERCLA	Comprehensive Environmental Response, Compensation, and Liability Act
CF	conversion factor
CLP	Contract Laboratory Program
cm/sec	centimeters per second
cm ³ /cm ³	cubic centimeter per cubic centimeter
cm ³ /gm	cubic centimeter per gram
COC	contaminant of concern
COPC	contaminants of potential concern
CRQL	contract required quantitation limit
CTE	central tendency exposure
°C	degrees Celcius
DEP	David Early Property
DI	deionized
DNAPL	dense non-aqueous phase liquid
DO	dissolved oxygen
DPT	direct push technology
DQOs	data quality objectives
EC	electrical conductivity
ECD	electron capture detector
EPA	U. S. Environmental Protection Agency
FID	flame ionization detector
FS	feasibility study
ft	feet or foot
ft/day	feet per day
ft ² /day	feet squared per day
GC	gas chromatograph
gm/cm ³	gram per cubic centimeter
gm/gm	gram per gram
gpm	gallons per minute
HHERA	human health and ecological risk assessment
HIF	human intake factor
HQ	hazard quotient
ID	identification

I-15	interstate highway 15
IA	indoor air
IWOR	Intermountain Waste Oil Refinery
k	hydraulic conductivity
Kd	soil water partitioning coefficient
[koc]	organic carbon partitioning coefficient
L	lower aquifer zone
M	middle aquifer zone
MCL	maximum contaminant level
MIP	membrane interface probe
MNA	monitored natural attenuation
MP	membrane interface probe boring
MS/MSD	matrix spike/matrix spike duplicate
MTBE	methyl tert-butyl ether
mV	millivolt
MW	monitoring well
ng	nanograms
ORP	oxidation reduction potential
OU	operable unit
OU1	HatchCo/Kelly Site
OU2	Unknown Source Plume
PCE	tetrachloroethene
PCR	polymerase chain reaction
PID	photoionization detector
ppb	parts per billion
PRP	potentially responsible party
QA	quality assurance
QC	quality control
RAC	Response Action Contract
RBC	risk based concentration
RfD	reference dose
RI	remedial investigation
RME	reasonable maximum exposure
RPD	relative percent difference
SA	study area
SAP	sampling and analysis plan
SDG	sample delivery group
SF	inhalation slope factor
Site	Bountiful/Woods Cross OU 2 Superfund Site
SOP	standard operating procedure
SPME	solid phase microextraction
SRC	Syracuse Research Center
STL	Severn Trent Laboratories
TCE	trichloroethene
TOC	total organic carbon
TCR	target cancer risk
U	upper aquifer zone
UDEQ	Utah Department of Environmental Quality

$\mu\text{g} / \text{kg}$	micrograms per kilogram
$\mu\text{g} / \text{L}$	micrograms per liter
$\mu\text{g} / \text{m}^3$	micrograms per cubic meter
VC	vinyl chloride
VOC	volatile organic compound
2-D	two dimensional
3-D	three dimensional

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Section 1

Introduction

This addendum to the final remedial investigation (RI) report serves to document the Phase 3 source area investigation effort at the Bountiful/Woods Cross Operable Unit (OU) 2 Superfund Site (Site) and incorporates salient information from a fifth round of groundwater sampling over the entire Site.

All RI activities for this addendum were conducted by CDM Federal Programs Corporation (CDM) under the Response Action Contract (RAC) No. 68-W5-0022, which provides support to the U.S. Environmental Protection Agency (EPA) Region 8 under work assignment No. 114-RICO-088G. This report documents the results of the Phase 3 field effort, and incorporates the results of the source area sampling into the remedial investigation of the Site. The results of a fifth comprehensive round of groundwater sampling are also presented. Based on the most up to date information for OU2, an analytical groundwater model was also run and predictions for contaminant fate and transport are presented for various scenarios. The Phase 3 field effort is outlined in the sampling and analysis plan (SAP) addendum for Phase 3 – Source Area Investigation and Sampling (CDM 2005), which was the guiding document for this investigation.

1.1 Purpose and Objectives

The purpose of this RI addendum is to (1) document the source of the tetrachloroethene (PCE) contamination and define the vertical and horizontal extent of any residual contamination in the vadose zone and (2) further describe the fate and transport of the PCE and trichloroethene (TCE) groundwater contamination previously documented within the "Unknown Source Plume" (OU2). The compiled data from this RI will be used in combination with other information from potentially responsible party (PRP) reports as a basis for the feasibility study (FS) to follow.

The primary objectives of the Phase 3 investigation were to address data gaps identified by the EPA in the Bountiful Family Cleaners (BFC) RI report (Bowen Collins & Associates 2004) and conclusively identify the source of the OU2 PCE/TCE contamination. The BFC RI mentions an abandoned septic system for the original BFC dry cleaning establishment that was documented by the South Davis Sewer District in 1966 during a lateral hookup with the main sewer line. However, the location of the septic system was not indicated. Locating and characterizing this potential source was one of the main target objectives of the Phase 3 investigation.

A secondary objective was to conduct a fifth round of groundwater sampling to obtain another temporal data set and support an analytical groundwater modeling effort to determine whether the groundwater plume has stabilized or still expanding. Specific objectives of the Phase 3 investigation are described below:

- Conduct an indoor air and sub-slab soil vapor survey in the BFC basement to identify areas (or pockets) where residual or free product may be located under the building within the vadose zone. If elevated levels of PCE (i.e., exceeding 10 times the EPA Region 8 screening level of 2.1 micrograms per cubic meter ($\mu\text{g}/\text{m}^3$), are detected, expand the sub-slab soil vapor investigation to adjacent buildings. The resulting data will also be used by Syracuse Research Center (SRC) to support the baseline risk assessment addendum report addressing vapor intrusion.
- Profile the vadose zone to locate areas with elevated chlorinated aliphatic hydrocarbon (CAH) detections using a membrane interface probe (MIP) to identify and map (in three dimensions) the potential contaminant pathways and extent of migration. Analyze off-gases from the MIP on site for immediate speciation of volatile organic compounds (VOCs) to qualitatively identify the contaminant(s) of concern (COC). Collect electrical conductivity data points in soil vadose zone with the MIP to infer the lithology of the area for use in future fate and transport modeling efforts.
- Install up to three groundwater monitoring wells in the vicinity of the source area to monitor the vertical extent of groundwater contamination and develop more accurate hydraulic gradient information. At least one of the wells would be constructed with the potential to be converted to extraction/injection wells for support of proposed remedial action alternatives. However, discussions with EPA during the Phase 3 sampling event led to postponement of installation of any new wells until the remedial design phase.
- Collect soil samples for laboratory analysis to quantitatively confirm PCE concentrations at locations identified as containing the highest levels based on the MIP data.
- Synoptically measure groundwater levels in all monitoring wells to refine the groundwater flow model. Re-survey the HatchCo/Kelly Site (OU1) monitoring wells to confirm continuous datum across the entire Site.
- Conduct a final round of groundwater sampling for all monitoring wells in OU1 and OU2, as well as selected domestic wells downgradient. Perform groundwater sample analyses for VOCs and natural attenuation parameters to provide data for remedial alternatives.

1.2 Organization of the Report

This RI addendum report provides documentation of field activities and data evaluation associated with the Phase 3 investigation. All reporting related to Phase 1 and 2 results are supported in preceding sections of the final RI report.

- Section 1 contains a brief introduction, purpose, and organization of the report detailing the Phase 3 investigation.

- Section 2 presents the technical approach for the Phase 3 field activities.
- Section 3 provides additional details concerning the environmental setting and recent hydrogeological findings.
- Section 4 includes the analytical results, quality assurance (QA) and quality control (QC) issues, data validation/evaluation, and the data quality assessment.
- Section 5 describes the updated nature and extent of contamination based on the fifth round of groundwater sampling results and analysis of the groundwater modeling effort.
- Section 6 discusses the fate and transport details and documentation of the parameters used in the groundwater modeling.
- Section 7 summarizes recent updates to the baseline risk assessment performed by SRC based on the indoor air and sub-slab vapor data collected during Phase 3.
- Section 8 provides the summary and conclusions.
- Section 9 provides the references cited in this report.

The organization outlined above follows the format established in the earlier sections of this RI, and generally conforms to EPA's 1988 guidance for conducting RI/FS under the Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA).

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Section 2

Phase 3 Field Investigation

2.1 Technical Approach

The Phase 3 field investigation was designed to locate the areas of highest concentrations of contaminants in the vadose zone of the suspected source area. Soil vapor samples were first collected from study area (SA)-4, including the BFC, David Early property (DEP), and retail stores to the west. Based on the locations targeted by the soil vapor results, the vadose zone was profiled by means of Membrane Interface Probe (MIP) sampling, to depths of up to 74 feet below ground surface (bgs). Site wide groundwater sampling was also conducted and static water levels were measured to gain necessary information to model the fate and transport of the COCs throughout the entire OU2 plume (Figure 2-1).

Figure 2-2 shows a close up of the source area (BFC/DEP) within SA-4 where indoor air (IA) and soil vapor (AS) samples were collected to determine the source of PCE contamination. In a similar manner, Figure 2-3 shows where specific MIP boring (MP) locations inside and outside of buildings were located. The actual sample locations are discussed in the following sub-sections under their respective tasks.

Each SA boundary, with corresponding well locations for the entire Site, is illustrated in Figure 2-1. The sample location identification (ID) ties all associated data to one specific location. The location "SA01-MW01U" imbedded in the sample ID number relates data from that sample to a specific location shown on the map (i.e., the upper aquifer zone in monitoring well MW01 located in study area 1).

2.2 Field Investigation Tasks

2.2.1 Task 1 - Indoor Air and Sub-Slab Vapor Sampling and Analysis

The first objective of the Phase 3 field investigation was to identify areas with the highest concentrations of COCs in the air in an effort to locate potential residual or free product contamination under the buildings. This involved collecting indoor air samples followed by sub-slab vapor sampling inside buildings directly in contact with vadose zone soils in the source area (BFC/DEP). The source area was identified during the Phase 1 field investigation based on the highest concentrations of PCE observed in the shallow groundwater.

A maximum of 15 air/vapor samples were slated for collection, including one indoor air sample from within each building in which sub-slab air samples were collected. However, the DEP buildings were under renovation at the time of sampling and much of the space inside was exposed to outside air; therefore, they were not sampled for ambient air concentrations. Instead, two indoor air samples were collected in different areas of BFC and one indoor air sample was collected from the retail store hallway. All Phase 3 indoor air sample locations are shown in Figure 2-2. Sub-slab

stainless steel vapor probes were then installed at each sample location after indoor air sampling had been completed.

One sub-slab vapor sample was first collected at each of the two structures on the DEP. The samples were collected as close to the center of the building as practical. Five samples were collected inside the BFC as shown in Figure 2-2. A map of the BFC basement floor plan was obtained from the independent report cited in Section 2.2 of the Final SAP Addendum for Phase 3 – Source Area Investigation and Sampling (CDM 2005) and was the basis for locating samples inside the BFC. These locations considered the former locations of the chemical storage tanks, sumps, and the highest PCE levels from soil samples noted in the BFC RI report (Bowen Collins & Associates 2004).

Four sub-slab air samples (plus a duplicate) and one indoor air sample were collected along a hallway from within the retail store immediately to the west of BFC (Figure 2-2). There were several grade-level (elevation) changes from one building to the other with the DEP buildings the highest and the retail building the lowest. The basement grade level in the retail store is approximately two feet lower than the dry cleaner basement, and the DEP slab is about eight feet higher than the dry cleaner basement.

These results are described in Section 4.1 and were the basis for continued investigations in the source area. Due to the fact that these data were used in the risk assessment addendum (SRC 2005), all sample results were validated/evaluated and are included in Appendix D.

2.2.2 Task 2 - Membrane Interface Probe Sampling

The second objective of the Phase 3 field investigation was to profile the vadose zone in SA-4. The MIP was deployed by a direct-push technology (DPT) rig at prime target areas (i.e., within the highest PCE concentration zones with respect to Phase 1 groundwater results, soil gas anomalies, and the sub-slab air results from Task 1). The initial MIP location (MP01) was situated as close as possible to the highest passive soil gas anomaly (CDM 2005). Figure 2-3 shows all MP locations which were offset either on 25- to 50-foot centers to detect and bracket shallow occurrences of CAH contamination in the vadose zone. The boring locations were chosen to close in on the highest concentrations and ultimately achieve a good three-dimensional (3-D) representation of the vadose zone stratigraphy and contaminant levels. Twenty-five profile locations were sampled within the BFC/DEP source area at depths up to 74 feet bgs. The groundwater table was measured at an average depth of 78 feet bgs during this period of field investigation.

The MIP system and its associated mobile laboratory provided continuous measurements of VOCs in the vadose zone. The probe contained a permeable

membrane, which was maintained within a steel block at approximately 120 degrees Celcius (°C). As the probe was driven into the subsurface, VOCs in the soil were volatilized by the heat, diffused through the membrane under a concentration gradient, entered the nitrogen carrier gas stream, and were delivered to the surface. The VOC content of the carrier gas stream was then measured using a gas chromatograph (GC) equipped with a photoionization detector (PID) and an electron capture detector (ECD) in series. The ECD in particular is very sensitive to chlorinated compounds (i.e., PCE).

For detections greater than 1,000 millivolt (mV) on the ECD, compound speciation of the contaminated gas stream was performed by using a GC (Hewlett Packard (HP) 5890). In this step, the effluent from the detectors was trapped in a glass sample tube, subsequently concentrated onto a soil phase microextraction (SPME) fiber, and injected into the GC utilizing a flame ionization detector (FID).

In addition to the detection of subsurface VOCs, the MIP tool was equipped with an electrical conductivity (EC) dipole array at the leading edge of the tool for measuring the electrical conductivity of the surrounding soil and the soil pore water. The EC was used to infer the lithology of the soil in contact with the probe. As a general rule, the EC of soil is inversely proportional to grain size, so sands and clays are easily distinguishable.

These results were evaluated and displayed in 3-D to determine the vertical and horizontal extent of the CAH contamination as described in Section 4.2. All data and chromatograms for the off-gas speciation are included in Appendix B.

2.2.3 Task 3 – Drilling and Monitoring Well Installations

Up to three additional monitoring wells were originally scoped to be drilled and completed in the source area. Two conventional monitoring wells were planned to be completed into the shallow aquifer capable of being used for remediation purposes, if deemed appropriate. One of the monitoring wells was designed to be completed as a multi-port BarCAD® system well (minimum 6-inch diameter) to a maximum depth of 200 feet (similar to the downgradient monitoring wells MW01 through MW05) for delineating the vertical extent of groundwater contamination.

Locations for these three source area monitoring wells were not identified in the SAP Addendum (CDM 2005) because they were to be located based on the results from Task 2. However, it was determined by EPA that these data points were not critical for RI decisions, and these additional wells were postponed.

2.2.4 Task 4 – Comprehensive Groundwater Sampling

Prior to groundwater sampling, synoptic water levels (static conditions) were measured in all monitoring wells in OU1 and OU2 within a 48-hour period. These data were used to define current water level conditions and refine the groundwater flow model developed for contaminant fate and transport predictions.

All onsite monitoring wells (including selected domestic wells) were sampled. The monitoring wells sampled during the Phase 3 investigation are shown in Figure 2-1. The conventional monitoring wells were sampled using low-flow techniques (CDM 2005) with either a compressed nitrogen-driven bladder pump system and disposable Teflon® bladders or a peristaltic pump for water table conditions shallower than 25 ft bgs. Teflon® tubing was used for sampling all monitoring wells. The BarCad® wells were sampled by releasing compressed nitrogen into the wellhead manifold and returning groundwater to the surface through a Teflon® line.

During this comprehensive fifth round of sampling, groundwater samples were collected from 40 monitoring wells in OU1 and OU2 (15 and 25, respectively). Each sample was split for analysis. One split was analyzed for natural attenuation parameters (i.e., alkalinity, conductivity, total iron and manganese, nitrate/nitrite, pH, oxidation/reduction potential [ORP], sulfate, chloride, and dissolved oxygen [DO]) by a subcontracted laboratory or in the field (Section 6.2). The other split was analyzed for VOCs by EPA's Contract Laboratory Program (CLP).

The Utah Department of Environmental Quality (UDEQ) was tasked by EPA to conduct the domestic well sampling. The domestic well samples were tracked and labeled with the CDM-collected samples and submitted to the CLP laboratory for VOC analysis only. A total of 20 domestic wells were selected for sampling during this round (Section 4.3).

2.3 Chemical Analysis and Analytical Methods

The air samples for Task 1 were sent to a subcontracted laboratory (Severn Trent Laboratories [STL]-Los Angeles) for VOC analysis by Method TO-15. All Phase 3 soil and groundwater samples were sent to CLP laboratories (Ceimic and A4 Scientific, respectively) for VOC analysis. The soil samples and associated QA/QC samples were analyzed using CLP method OLM04.3 (low to medium concentration organics) while all groundwater samples and their associated QA/QC samples were analyzed using CLP method OLC03.2 (low concentration organics). Groundwater samples were also split and sent to an independent STL-Denver for analyses of natural attenuation parameters not determined in the field (Table 2-1).

Field tests included pH, DO, ORP, conductivity, turbidity, temperature, and ferrous iron. Ferrous iron was analyzed immediately after collection using a HACH pocket colorimeter. Dissolved iron and manganese, alkalinity nitrate/nitrite, total organic carbon (TOC), sulfate, and chloride analyses are not included in the CLP program. Since the aquifer in general does not appear to be conducive to methanogenesis, the dissolved gases (methane, ethane, and ethane) analyses were limited only to samples from the OU1 source area. This is where full scale reductive dechlorination is most evident, at least historically.

Section 3

Site Characteristics

3.1 Environmental Setting

3.1.1 Geology

The Phase 3 investigation provided more detail on the vadose zone within the BFC/DEP area. The significant lateral discontinuity and heterogeneity of the subsurface stratigraphy observed across the entire Site can be seen on a smaller scale in the source area. The stratigraphy as inferred by the electrical conductivity of the MIP shows the lenticular and discontinuous character of individual clay rich zones (Appendix B). No other geological information was gained from this portion of the study.

3.1.2 Hydrogeology

Static groundwater elevations measured just prior to the April 2005 round of groundwater sampling vary about 23 ft over the 400-acre Site and range from approximately 4,267 feet above mean sea level (amsl) to 4,244 feet amsl. Figure 3-1 presents the groundwater potentiometric map for each zone (U, M, and L) during the April 2005 (Phase 3) sampling event. Contours in red represent the static water level for the upper (U) aquifer completions, blue represents the middle (M) aquifer completions, and green represents the lower (L) aquifer completions. All zones are completed in the "shallow" East Shore aquifer.

A groundwater divide is still apparent in the vicinity of MW04U and MW03U. The groundwater levels have been slowly recovering in the shallow aquifer since a rapid drop occurred in the summer of 2003 (documented in the Phase 2 portion of this RI). Presumably this drop was caused by periods of heavy municipal pumping and increasing drought conditions. The fluctuations have resulted in local reversals of flow direction from the presumed regional flow direction (west-northwest) in the uppermost portion of the shallow East Shore aquifer. Table 3-1 summarizes the water level data for the fifth (April 2005) round of sampling.

The observed horizontal hydraulic gradient in the uppermost aquifer zone during the Phase 3 period averaged about 0.0053 feet per foot (ft/ft). The greatest range in hydraulic gradient was observed in the upper portion of the aquifer and in the vicinity of the apparent mounding around MW03U (near the HatchCo/Kelly Site), extending north to MW04U and then west towards the Warm Springs fault (Figure 3-1). The apparent groundwater "high" in the OU1 area shows a shift in the high to the southwest (Figure 3-2) compared to the mapped potentiometric surface in the HatchCo RI report (HDR 2003a and b). The well with the highest water level was MW06S, resulting in the potential for a more northerly flow component in the HatchCo plume. Note that the OU1 monitoring wells were re-surveyed during the Phase 3 field investigation. There was an approximately 3-ft shift downward in elevation for all of the OU1 monitoring wells (Appendix G). Where the middle and

lower zones of the aquifer were tested, the horizontal gradient remained consistent with previous measurements on the order of 0.001 to 0.002 ft/ft.

Vertical hydraulic gradients from each of the multi-port BarCad® MWs were also calculated and reported for each sampling event (Table 3-2). A significant amount of variation was evident across the Site, from upgradient unconfined to confined artesian conditions, and over the seasonal sampling periods. The head difference between the upper and middle zones still showed the greatest separations, ranging from an upward -6.95 feet (artesian) to a downward 11.73 feet (recharge). Corresponding vertical gradients measured during the Phase 3 investigation ranged from an upward -0.09 ft/ft to a downward 0.10 ft/ft. The middle to lower zone yielded vertical gradients from -0.01 to 0.02 ft/ft.

3.2 Conceptual Model

The aquifer of interest at the Site is identified as the East Shore aquifer, which consists of a complex assemblage of interbedded sand, silt, and clay lithologies. The shallow portion of the aquifer has been subdivided in the downgradient plume area into U, M, and L units that are at least partially isolated by clayey intervals. A PCE plume extends approximately 1.5 miles downgradient (west) from the source at BFC/DEP. The highest concentrations in groundwater occur beneath the BFC where concentrations as high as 264 micrograms per liter ($\mu\text{g}/\text{L}$) have been observed in groundwater from geoprobe grab samples of the uppermost aquifer. A single permanent well (BC01U) is located at the source and has a maximum PCE concentration of 110 $\mu\text{g}/\text{L}$ and a *cis*-1,2,-DCE concentration of 68 $\mu\text{g}/\text{L}$. Overall, the groundwater monitoring has indicated that degradation of PCE is not significant under the current biogeochemical conditions, since degradation products TCE and *cis*-1,2-DCE occur at concentration of less than about 2 $\mu\text{g}/\text{L}$ downgradient, where they are present. Adsorption of PCE onto the aquifer matrix will cause this contaminant to move at a lower velocity than that of groundwater. In addition, the Warm Springs fault intersects the PCE plume trend; however, this structural feature does not appear to limit overall westerly migration of the PCE in the deeper units. The extent of PCE in the upper unit coincides with the location of the fault, suggesting that transport in the upper zone is impacted by the fault (i.e., seeps).

Groundwater in the aquifer flows principally toward the west. However, this flow direction is affected locally by groundwater pumping from several municipal and industrial wells in the area (Figure 3-1). The flow direction is similar for each of the zones within the East Shore aquifer. The horizontal hydraulic gradient shows variation across the fault zone, with gradients being flatter on the eastern side of the fault and steeper on the western side. Multi-point BarCAD® systems have been monitored at the Site and provide information of vertical gradients. In areas upgradient of the Warm Springs fault, vertical gradients indicate a downward flow potential. Well MW-02, which is near the fault, also indicates a downward flow

potential for most monitoring periods. Well MW-01, which is located west of the fault, indicates a potential for upward flow between the zones.

Quantitative assessment of the future movement of the PCE plume requires estimates of both hydraulic parameters and geochemical characteristics that impact mobility of PCE. The estimated values for parameters that were used in groundwater modeling are addressed in Sections 5.0 and 6.0.

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Section 4

Analytical Results and QA/QC Requirements

This section provides an overview of the samples collected and analytical results. It also includes an explanation of the QA/QC field samples, various laboratory programs, a summary of the data validation/evaluation, and achievement of the DQOs. All custody and documentation for field and CLP laboratory work was conducted in accordance with the final SAP Addendum (CDM 2002) using EPA's Forms II Lite software and tracking forms.

Appendix A includes the data validation report and laboratory report forms for the indoor air and sub-slab vapor analyses. Appendix B includes MIP response logs and speciation chromatograms. Appendix C includes analytical data summary tables for Phase 3 CLP groundwater and soil sampling, subcontracted air analyses, and microbial polymerase chain reaction (PCR) analysis. Note that all natural attenuation data are presented in Section 6.2. Appendix D includes the data validation reports and evaluation forms for all CLP VOC analyses. Laboratory reporting forms for the CLP data (with qualifiers as appropriate) are also included in Appendix D. Appendix E contains the chain-of-custody forms.

4.1 Indoor Air and Sub-Slab Vapor Sampling and Analysis

Three indoor air and twelve sub-slab samples (including one duplicate) were collected from BFC, DEP, and the adjacent retail stores. The indoor air samples were collected prior to sub-slab drilling. Three 6-liter Summa® canisters (two placed in separate areas of BFC and one in the retail store hallway) drew air for a 24-hour sample period by means of a calibrated flow regulator.

After the indoor air canisters were removed, sub-slab sampling was performed in accordance with "Draft Standard Operating Procedure (SOP) for Installation of Sub-Slab Vapor Probes and Sampling Using EPA Method TO-15 to Support Vapor Intrusion Investigations," included in attachment B in the SAP addendum (CDM 2005). Holes were drilled through the concrete slab and capped stainless steel vapor probes were set into the slab using a cement/bentonite slurry. The probes were allowed to cure overnight before the sample vacuum canisters were attached. The sub-slab air was collected in six liter Summa® canisters over a 30-minute sampling period. The sample start/stop times and initial/final canister vacuum readings were recorded on the chain of custody with other pertinent information and shipped to the laboratory.

PCE was the predominant target compound, detected at the highest concentrations throughout all of the air samples. Some benzene, toluene, ethylbenzene, and xylene (BTEX) compounds and trimethylbenzenes were also detected (Table 4-1). The highest

indoor air PCE concentration was found in the interior portion of the dry cleaner building next to the sauna (IA02A; 19,000 micrograms per cubic meter [$\mu\text{g}/\text{m}^3$]). The highest sub-slab PCE concentration was found below the BFC rental space (AS03V; 120,000 $\mu\text{g}/\text{m}^3$). Figure 4-1 shows the distribution of sub-slab vapor concentrations for PCE under the buildings and is color coded for areas where the indoor air would demonstrate risk-based concentration (RBC) levels over a target cancer risk (TCR) of 1E-04 (red for workers [7150 $\mu\text{g}/\text{m}^3$] and yellow for residents [2810 $\mu\text{g}/\text{m}^3$]), using a 1/100 attenuation factor for vapor intrusion. The RBCs for PCE in indoor air were calculated as follows:

$$C_{(subslabair)} = C_{(indoorair)} \times AF$$

Where:

C = concentration
AF = attenuation factor

$$C_{(indoorair)} = \frac{TCR(CF)}{(HIF)(SF)}$$

CF = conversion factor = 1000 $\mu\text{g}/\text{mg}$
HIF = human intake factor
SF = slope factor

The HIF at 6.99E-02 for a worker and 1.78 E-01 for a resident, and the inhalation SF of 2.0 E-02 for PCE are from Tables 3-3 and 3-5 of the baseline human health and ecological risk assessment (BHHERA) addendum (SRC 2005).

Validated data are included in Appendix A and these were provided to SRC for completion of the BHHERA addendum report. Section 7.0 summarizes the risk assessment findings.

4.2 Membrane Interface Probe and Soil Sampling

The MIP procedure developed by Geoprobe Systems, Inc. provides real-time detection of VOCs, including dense non-aqueous phase liquids (DNAPLs) in both the vadose and saturated zones. A single point standard was used for probe calibration, and the results are considered qualitative screening data, providing relative concentrations of VOCs at various locations and depths. The detectors do not provide a quantitative concentration of VOCs in the soil; however, the response level from the detector corresponds to the amount of VOCs present in the carrier gas, which is proportional to the amount of VOCs in the medium at that particular location (see Section 2.2.2).

The MIP survey consisted of 25 DPT borings, with depths averaging 65 ft bgs. The initial location (MP01) was selected based on a previous high passive soil gas sample location as well as placed within the highest Phase 1 groundwater isoconcentration contour (200 µg/L). Subsequent boring locations were determined by evaluating the results observed at each previous offset boring. The MIP profiles recorded depth in feet, rate of penetration, EC, ECD response, and PID response. All profiles are included in Appendix B.

The EC and the ECD are sensitive indicators of soil type and chlorinated hydrocarbon levels, respectively. The PID levels can help determine if other hydrocarbon compounds (e.g., benzene, toluene, ethylbenzene and xylenes (BTEX)) are also present. If an initial MIP response was over 1,000 mV (1 volt) at any particular depth, an off-gas sample was collected as described in Section 2.2 for speciation analysis. A total of 61 off-gas samples were analyzed. Chromatograms for all off-gas samples are included in Appendix B, and a summary of results is recorded on Table 4-2.

Figure 4-2 indicates zones where the ECD response exceeded the 1 volt level (yellow color), which in turn can be related to off-gas containing CAH compounds (e.g., PCE). The maximum possible reading on the ECD is 15 volts, and these zones are shown in the darkest shade of red. Associated off-gas speciation indicates qualitatively that the compound relative concentrations are primarily PCE and vinyl chloride (VC). In a similar manner, PID results over 1-volt are shown in Figure 4-3. Note that the highest PID response is limited to the southwest corner of the grid on the DEP side, which is likely because of the higher concentration of other hydrocarbons (i.e., BTEX) released from the automotive repair facility. Although PID responses were detected on the north side of BFC, very little BTEX compounds were detected and total response was less than 1-volt.

In order to get a better understanding of the distribution of COCs in the vadose zone, the MIP results are also presented in a 3-D perspective view from different angles and directions (Figures 4-4 through 4-6). The ECD results are shown for detections over 1 volt (yellow to red) because they are the most indicative of the PCE levels. In addition, these contaminant zones can also be seen in relation to EC values that are indicative of clay rich zones (dark gray), which can perch contamination and are potential barriers to vertical movement.

A follow up to the MIP investigation was a limited soil-sampling event, which attempted to target the higher ECD and speciation anomalies. A total of 14 soil samples were collected from these zones by DPT methods described in the SAP Addendum (CDM 2005). The soil sample locations could not be placed exactly where the MIP borings were because they were abandoned with bentonite. As a result, offsets of approximately 2 feet were marked off from the original MIP borings (see Figure 4-2).

The soil samples were sent to a separate CLP laboratory (Ceimic) for analysis by EPA CLP Method OLM04.3 (Multi-Media, Multi-Concentration Statement of Work for Organic Analyses). This method has a base reporting limit of 10 micrograms per kilogram ($\mu\text{g}/\text{kg}$) ($10 \mu\text{g}/\text{L}$ for aqueous trip blank) for the COCs. Table 4-3 lists the sample results for selected COCs. The location and depths of each sample can be determined from the CDM sample ID. The sample number 05B-SA04-SB01V-SB-061 was located in soil boring SB01 and the depth indicated by the last two digits (i.e., 61 feet bgs). Although results show that PCE was detected in most of the samples, the concentrations are very low. This is probably due to the residual product being widely dispersed and only locally concentrated in the media (i.e., hard to target) and/or due to the loss of volatiles inherent in both the sampling and analytical process. The highest PCE concentration was $190 \mu\text{g}/\text{kg}$ (diluted) from a zone 6 feet bgs near boring MP22. All CLP VOC soil results are shown in Appendix C.

4.3 Comprehensive Groundwater Sampling

A total of 60 groundwater samples were collected from existing monitoring and domestic wells. Reporting limits were required below the maximum contamination level (MCL) of $5 \mu\text{g}/\text{L}$ for PCE and therefore the groundwater samples were sent to the laboratory for analysis by CLP method OLC03.2, Low Concentration Organic Statement of Work, with a base reporting limit of $0.50 \mu\text{g}/\text{L}$ for the COCs. Splits of all groundwater samples were also sent to a non-CLP laboratory for the analysis of the natural attenuation parameters. As listed in the SAP addendum (CDM 2005), the laboratory natural attenuation parameters consisted of dissolved iron and manganese, nitrate-nitrite, chloride, sulfate, total organic carbon, and alkalinity. Field measurements consisted of pH, ferrous iron, conductivity, ORP, DO, turbidity, and temperature. Dissolved gases (i.e., methane, ethene, and ethane) were requested for five of the samples collected from the OU1 HatchCo site. All groundwater samples were shipped to the assigned CLP laboratory (A4 Scientific) for VOC analysis and the subcontract laboratory (STL) for natural attenuation analyses. VOC results for April 2005 (Round 5) are reported for OU1 and OU2 on Tables 4-4 and 4-5, respectively.

Phase 3 (Round 5) results indicate that the portion of the Site centered on BFC/DEP still had the highest PCE concentrations ($110 \mu\text{g}/\text{L}$) for CLP analysis of shallow groundwater. This sample was collected from the only existing permanent monitoring well currently in the source area. The well location is BC01U, the sample identification from this well is 05B-SA04-MW01U-GW-005. The well was installed by the PRP in December 2003 in boring BCI-SS-13 (Bowen Collins & Associates 2004), and PCE was detected at $88 \mu\text{g}/\text{L}$. Phase 3 (Round 5) was the first time CDM has sampled the monitoring well.

All other previously sampled OU2 monitoring wells were re-sampled during this round and included the full suite of VOC and natural attenuation parameters. The domestic wells downgradient were again sampled by UDEQ personnel and included most of the previously sampled locations. Figures 4-7 through 4-14 show the variation

in PCE concentrations in each of the existing monitoring wells from March 2003 (Round 1) through April 2005 (Round 5) along with changes in water levels. Note that during Round 5, five of the domestic wells detected levels of PCE over MCLs (4 were located on residential properties).

Figure 4-15 shows the Site-wide distribution of PCE and degradation compounds detected in all monitoring wells (including U, M, and L aquifer zones) and domestic wells sampled during April 2005 (Round 5). Results for all compounds are included in Appendix C.

OU1 wells were also sampled during the April 2005 comprehensive sampling event to determine what changes (if any) have occurred since the last sampling round by the PRP (HatchCo). In addition to the HatchCo monitoring wells, three of the Holly refinery monitoring wells, MW-02S, 02D, and 03S, were also included in this round. Note that though there are Holly refinery wells numbered 02 and 03, they are distinguishable from the RI monitoring wells in that the suffix to the well number is "S" and "D", for shallow and deep, whereas the RI well suffixes are "U", "M" and "L" for upper, middle, and lower aquifers. The compounds detected in these wells correspond very closely with those of the HatchCo plume and are immediately downgradient in the same portion of the aquifer. Figure 4-16 shows the current distribution of total CAH compounds. Total CAHs were originally used in the HatchCo RI/FS to depict the plume.

In addition to the VOCs, natural attenuation parameters were also analyzed in separate split samples from all wells. These results are presented and discussed in Section 6.2.

4.4 QA/QC Samples

Three types of QA/QC samples were outlined in the SAP Addendum (CDM 2005): duplicate samples, equipment rinsate blanks (if necessary), and trip blanks. Duplicate samples were to be collected at a frequency of one per 10 (10 percent). Trip blanks were planned at rate of one blank per cooler containing samples for VOC analysis. Equipment rinsates were only required when the same sampling apparatus is shared from one sample location to the next and the possibility exists for cross contamination. All sampling tubing and most of the equipment were dedicated or disposable.

4.4.1 Duplicate Samples

Field precision objectives were assessed through the collection and analysis of field duplicate samples for both the air and groundwater media. A total of 60 groundwater samples and 14 air samples (not including QA/QC samples) were collected by CDM during the Phase 3 field investigation. Eight field duplicate samples were collected, one air and seven groundwater duplicates, resulting in a field duplicate frequency of 7.1 percent for air samples, 11.7 percent for the waters. To obtain an air duplicate, a

tee was put in the line from the single sample probe to two separate air canisters. The rates that each canister approached ambient pressure may not be identical accounting for some deviation in the duplicate results. Based on the total number of air samples collected, one duplicate sample was considered adequate. Duplicate samples were not collected for soils as two subsequent core samples are still two discrete samples at different depths. A soil duplicate collected through the DPT method would require homogenization which would impact the integrity of the sample.

The relative percent difference (RPD) between a target compound in the native sample and the duplicate was calculated whenever either sample result was greater than five times the Contract Required Quantitation Limit (CRQL). The five times criteria was used to avoid greater than 100 percent differences when a target compound was reported in one sample just above the reporting limit and the other sample was not reported. The RPD was calculated using the following equation:

$$RPD = \frac{|S - D|}{(S + D) \div 2} * 100$$

Where S = first sample value (original value)
D = second sample value (duplicate value)

The National Functional Guidelines do not specify control limits for duplicate sample analyses. However, out of 26 target compound duplicate pairs evaluated, 13 had RPDs greater than 35 percent. Most of these compounds with RPDs greater than 35 percent were accompanied by other target compounds with comparisons below 35 percent, and the target compounds detected in each sample were similar. However, one sample pair, 05B-OU01-MW01S-GW-005 and 05B-OU01-MW01S-GW-305, analyzed in sample delivery group (SDG) H1EK7 did not compare well by any criteria. Out of six target compounds that met the criteria for comparison, all six had RPDs of 100 percent or greater, such that any compound that was detected in one sample at greater than 5 times the reporting limit was not detected or detected at less than 1.0 µg/L in the duplicate. Qualifiers are not applied to samples on the basis of field duplicate data but the data for this sample and its duplicate must be evaluated before use. There is a gap in the sequential use of tag numbers between these two samples and a gap in the sequential assignment of EPA IDs, both evidence of some error in the field or during processing. The data from these two samples should at least be questioned, if not rejected. These samples are not part of this RI and do not affect the interpretations of the Phase 3 data for OU2. They were collected during the sampling effort and the data presented here at the request of the EPA.

4.4.2 Blank Samples

Trip blanks and rinsate blanks were used to monitor the possibilities of cross contamination of the samples. Trip blanks are used to monitor the possibility of the

transfer of target compounds from one sample to another within the common cooler shared in shipment. This blank is only included with samples requiring analysis of VOCs. Rinsates are required when sampling equipment is shared and is used to monitor the effectiveness of the cleaning procedure used for decontamination of the sampling equipment in the field. One trip blank was included in each cooler containing samples to be analyzed for VOCs. One rinsate blank was collected during this investigation. The sample was collected from Type I deionized (DI) water run through the decontaminated casing of the bladder pump used for sampling MW06U (05B-SA02-MW06U-GW-505). All other equipment and tubing were dedicated to individual sampling ports. If an analyte is detected in a method, trip or rinsate blank, any associated positive result less than five times (10 times for common laboratory contaminants) may be considered a false positive. In accordance with the National Functional Guidelines data that met this criteria would be qualified as undetected. Data evaluation summaries documenting laboratory and field blank results are included in Appendix C.

4.5 Data Assessment

The data used in this RI and associated risk assessments were assessed through a data evaluation program that includes data validation and data evaluation in accordance with EPA guidelines. Prior to use of the data, this evaluation measure ensures the quality is defined and that a known confidence in the usability of the data is ensured.

4.5.1 Data Validation and Evaluation

Qualified CDM validators evaluated and validated the data. In accordance with the procedures outlined in the approved SAP Addendum (CDM 2005) for this sampling event, at least 10 percent of all VOC data were validated. The remaining samples in the data packages were evaluated. The natural attenuation data were not validated or evaluated for usability, but the data packages were reviewed for completeness. The data validation and evaluation reports are provided in Appendix D. Included with these reports are copies of the original report forms with validation/evaluation qualifiers.

Data validation was performed in accordance with the *USEPA Contract Laboratory Program National Functional Guidelines for Low Concentration Organic Data Review* dated June 2001, or *USEPA Contract Laboratory Program National Functional Guidelines for Organic Data Review* dated October 1999, whichever was applicable.

Data evaluation was a partial validation that reviewed the following:

- Holding times
- Preservation
- Surrogates (i.e., system and deuterated monitoring compounds)

- Blanks
- Matrix spike/ matrix spike duplicates
- Field duplicates

The initial calibration standards and continuing calibration standards assessment and qualifications, as well as a mathematical reproduction of the final results based on the laboratory raw data, were not included in the evaluation process.

Laboratory data were qualified during the data validation/evaluation process using a standardized set of qualifiers:

Data Qualifier	Description
U	The material was analyzed for but not detected above the level of the associated value. The associated value is either the sample quantification limit or the sample detection limit.
UJ	The material was analyzed for but not detected. The associated value is an estimate and may be inaccurate or imprecise.
J	The associated value was an estimated quantity.
R	The data were rejected.

Analytical data quality was assessed through the data validation/evaluation process. All data that were not rejected were determined usable for their intended purpose. The only results that were rejected were 4-methyl-2-pentanone and 2-hexanone in two samples. These results are unusable. These results were rejected based on one deuterated monitoring compound recovery less than 20 percent. Because these two compounds are not primary analytes of interest at the Site and there were minimal rejections based on the overall number of results, the data set is determined to be complete.

Several results were also qualified as not detected "U" during validation/evaluation based on the detection of the same compound in an applicable QC blank. Numerous sample results for both aqueous and soil samples were qualified as estimated (J/UJ) due to initial and continuing calibration criteria, deuterated monitoring compounds, and/or internal standard response. Validation reports and evaluation tables are included in Appendix D.

The data set for this investigation is usable for the intended purpose except for 4-methyl-2-pentanone and 2-hexanone data in two samples, which were rejected as described above. This data set has met the completeness goal for this project and provides the information necessary to achieve the data quality objectives.

4.6 Modifications to the SAP Addendum

The following modifications to the SAP Addendum (CDM 2005) resulted in the changes listed below:

- Six-liter Summa® canisters were used for all air samples as opposed to the one-liter Summa canisters stated in the SAP. The laboratory selected for air analysis (STL-LA) uses six-liter Summa canisters exclusively as they provide adequate sample if dilutions or other re-analyses are required. This modification did not impact the sampling program objectives.
- The SAP Addendum stated the decision for additional air sampling at DEP or the retail stores would be made on the basis of the results from BFC samples obtained from 24-hour rush turnaround analysis. Based on time constraints in the field, rapid turnaround costs, and the uncertainty of the timeliness of receiving results, samples from each of the buildings were collected and shipped together. As expected from initial screening (i.e., PID readings), the PCE levels in the BFC were well above the defined action levels and all of the samples would have been collected either way. This modification did not impact the sampling program objectives.
- The DO meter or probe was not functioning properly during the Phase 3 groundwater sampling event (i.e., negative values recorded), so results could not be used. However, the ORP was operational and provided usable results for evaluating similar properties. This modification did not impact the sampling program objectives.
- The additional monitoring wells that were planned in SA-4 were not drilled based on previous discussions with EPA that new wells were not be necessary at this time with the data presently available for completing the RI/FS.
- The northern extent of the mainline sewer was not evaluated by the MIP due to the concentrated effort (all 25 borings) required to bracket the shallow source on the BFC property.
- These modifications are still considered remaining data gaps.

4.7 Achievement of Data Quality Objectives

Table 4-6 presents a summary of the DQO from the SAP Addendum (CDM 2005) and includes text describing how and if DQOs were achieved.

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Section 5

Nature and Extent of Contamination

5.1 Groundwater Modeling Results

In order to assess potential future concentrations of PCE in groundwater at the Site and assess continued migration of the plume, a simple two-dimensional (2-D) analytical model describing flow and transport was used. Calculations were conducted using a commercial analytical modeling package (AquiferWin32). The simple analytical approach is adequate for meeting the objectives of the analysis and consistent with the quantity of data available at the Site. The Site hydrogeology is complex, which makes use of a simple homogeneous representation of the aquifer subject to uncertainty, especially since vertical flow components induced by deep pumping wells are known to exist. The analytical approach does not allow consideration of these vertical flow components.

A rudimentary calibration of the model was conducted to assess the consistency between observed groundwater flow pathways (interpreted from the contaminant plume) and estimates of hydraulic characteristics. Water level data from April 2005 were used as calibration targets since this period has the greatest number of measurements. Water levels across each of the zones were averaged at each well, with the exception of wells MW01, MW03, and MW04. These wells were not used due to the higher vertical gradients. Calculated water levels from the simple model were compared to the observed average water levels as a measure of the agreement between the model and field data. A qualitative comparison of groundwater flow direction in the model and the observed plume configuration was also done.

The analytical approach assumes that the aquifer is uniform, homogeneous with hydraulic properties constant through the domain. A uniform, planar hydraulic gradient was used to simulate regional flow. The effects of pumping wells in the vicinity were simulated by superimposing drawdown due to pumping of each well on this regional flow field. All pumping impacts were calculated as steady state. The modeled water levels were compared with the April 2005 water levels from Site measurements, and the groundwater flow pathways were compared to the plume configuration. The nearby Bountiful municipal well (Figure 5-1) was assumed to be pumping at one-half its total capacity, since the calibration period is one of low water usage. Other municipal wells in the vicinity were not used during the low demand period. The Holly refinery wells were also simulated but at a rate of 10 percent of their actual rate since they are screened much deeper than the portion of the aquifer affected by the PCE plume. The 10 percent was determined by eliminating higher percentages that resulted in plume capture under simulated conditions. The hydraulic conductivity (k) assumed in the modeling was 119 feet per day (ft/day), since this was determined from the recovery data from a long-term test conducted adjacent to the area (Section 6.1.1). The hydraulic conductivity in the model was varied as a check of the reasonableness of this estimate. Testing of lower hydraulic conductivities

indicates too great a change in flow direction due to pumping of the municipal wells, and higher overall differences between the observed and modeled water levels; thus, the value of 119 ft/day was selected. Since the model does not account for vertical flow components, the zone of capture for the shallow portion of the aquifer impacted by the PCE plume tends to be over estimated. The municipal and industrial wells pump from deeper zones in the aquifer; thus, their impacts in the shallow portion of the aquifer would actually be diminished by intervening lower permeability interbeds.

The model parameters selected for use in the assessment of future transport were as follow:

- Regional planar hydraulic gradient 0.0011 ft/ft
- Regional groundwater flow direction N 65 W
- Pumping rate at Bountiful well 1100 gallons per minute (gpm)
- Pumping rate at Holly refinery wells 70 gpm
- Hydraulic conductivity 119 ft/day

When pumping at the Bountiful well and the two Holly Refinery wells is superimposed on the simplified regional flow, the potentiometric surface and resulting flow pathways from the BFC are shown on Figure 5-1. This simplified representation of groundwater flow at the Site is in reasonable agreement with the flow direction inferred from the plume configuration. The simplified model is not able to represent the variable gradients observed at the Site but is rather an average of all three zones (U, M, and L).

An evaluation of the development of the PCE plume was conducted using the simplified model. This evaluation included the effects of dispersion and adsorption. A longitudinal dispersivity of 100 feet and a transverse dispersivity of 10 feet were estimated based on literature sources cited above. The sorption was simulated using a retardation factor of 1.6. The effective porosity of the aquifer has not been determined but is estimated to range from 0.1 to 0.25.

The history of releases at the Site is unknown; however, Site data suggest that initial releases probably occurred while a septic tank/leach field was in operation decades ago on the property currently owned by BFC. These facilities were decommissioned in 1966 when the dry cleaner was connected to the public sewer. However, there is no documentation that the septic system was ever removed. Releases from the source area were hypothesized to occur 50 years ago for evaluation of consistency of the observed plume with a modeled plume.

Two simulations, representing the upper and lower limit estimates of effective porosity, were conducted. These simulations used a line source to release mass to the aquifer sufficient to result in a PCE concentration approximating 260 µg/L at the source area. This source concentration was assumed to be constant during the entire simulation period. In reality, it is likely that source concentrations were higher in the past when releases of PCE likely occurred. The plume configuration after 50 years of transport from this continuous source was then calculated for the range in effective porosity. The plume extent was modeled for the 0.1 and 0.25 effective porosity values after 50 years of transport. The extent of the modeled plume more closely corresponds to the observed extent after 50 years with the upper limit on effective porosity, so this value was used in remaining simulations (Figure 5-2). The modeled downgradient concentrations are somewhat higher than those currently observed at the Site; however, this is a limitation of considering this as a 2-D system, since the model does not consider vertical mixing, which will result in dilution. In the 3-D system (as in the field), vertical mixing due to vertical hydraulic gradients and dispersion will lead to dilution of the leading edge of the plume. Extension of the simulation time, assuming that the source remains active, indicates that the plume will continue to expand in the downgradient direction. In fact, this is documented in the latest round of sampling (April 2005) where one of the furthest downgradient middle zone domestic wells (DW05) exceeded the MCL for PCE for the first time since sampling started in 2003.

In order to assess the relative effectiveness of source remediation on future groundwater concentrations, additional simulations were conducted that used the simulated plume extent at 50 years and then removed the source so that no additional mass was added to the plume. These simulations were carried forward to assess the relative impact on downgradient concentrations after source area remediation. Figures 5-3 and 5-4 show a comparative analysis of the simulated plume 30 and 60 years, respectively, with and without removal of the source. This modeling effort indicates that the plume will persist and continue to expand in the downgradient direction for a substantial period of time. PCE concentrations are presented in mg/L. Transport considers dispersion and sorption but no degradation is included. The 2-D assumptions also exaggerate the persistence of the plume again because no vertical mixing is considered.

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Section 6

Contaminant Fate and Transport

This section describes the subsurface fate and the mobility of PCE based on the recent groundwater modeling results. TCE and *cis*-1,2-DCE are only discussed in this section as biodegradation byproducts of PCE. An understanding of the fate and transport of PCE is necessary to evaluate future potential exposure risks and to evaluate remedial technologies at the FS stage.

Also the latest and most comprehensive results for natural attenuation parameters are briefly discussed in Section 6.2

6.1 Analytical Groundwater Modeling

The objective of the modeling analysis was to assess the future extent and concentrations at the current downgradient extent of the PCE plume originating at the BFC property. Simplifying assumptions and analytical models were used in this analysis. Section 3.2 summarized the Site conditions and the conceptual model. The basis for the estimates of flow parameters and transport/fate characteristics used in the modeling analysis are discussed in the following subsections.

6.1.1 Contaminant Transport

Transport processes include physical mechanisms that control movement of contaminants in the groundwater. The primary process leading to migration of dissolved constituents in groundwater is groundwater flow, or advection. Other important transport processes include dispersion or mixing and, to a much lesser extent, liquid phase diffusion. Advection is the dominant transport process active at the Site.

Parameters that affect groundwater velocities include hydraulic conductivity, hydraulic gradient, and effective porosity. A single slug test, reported in the RI, was conducted at well BK01, which is located south of the BFC where the estimated hydraulic conductivity was determined to be 56 ft/day. Since the aquifer is about 194 feet thick in this area, the transmissivity is calculated at 10,864 feet squared per day (ft²/day). Aquifer tests have been reported at two of the municipal wells that are near the Site, including the Bountiful well and the West Bountiful 5th Well, which are shown on Figure 3-1. The Bountiful well has a capacity of about 2,250 gpm and has a reported transmissivity of 1,500 ft²/day, with a saturated thickness of 166 feet. Water level records from this test were available in the drinking water source protection plan (Bountiful City 1996), and the recovery was re-analyzed. A corrected transmissivity of about 19,700 ft²/day was estimated. This new information results in an estimate for hydraulic conductivity of 119 ft/day averaged across the productive saturated thickness. The West Bountiful 5th well is located near the downgradient extent of the PCE plume, has a reported capacity of 1,800 gpm, with a transmissivity

of 11,500 ft²/day. The reported productive aquifer thickness is 230 feet, which results in an average hydraulic conductivity of 50 ft/day.

Potentiometric surface maps were utilized for the quarterly data from 2003. The upper aquifer near the Site is impacted by pumping from municipal wells located to the south and southeast of the Site. No deeper zone monitoring wells are available near the BFC; however, a similar flow pattern is expected for the deeper zone. This municipal pumping modifies the groundwater flow direction from a westerly trend to one where a groundwater divide develops west of the source area, with flow moving both to the west and to the southeast. The fact that a continuous PCE plume exists in the downgradient direction suggests that the overall average flow direction has been to the west, or else contamination originating from the BFC property would have been largely captured by the municipal wells. Two industrial wells for the Holly refinery are also completed in deep portions of the East Shore aquifer, below the elevation of the lower zone monitored at the Site, and pump at an average rate of 700 gpm.

The hydraulic gradient ranges from about 0.001 to 0.0053 ft/ft, based on Site measurements. No direct determinations of effective porosity have been made at the Site, so a typical range in values for an unconsolidated aquifer of 0.1 to 0.25 was selected for this analysis. The velocity of groundwater can be estimated using Darcy's Law to estimate groundwater flow and correcting for the effective porosity of the aquifer to account for the actual open area through which the groundwater is flowing. This equation for groundwater velocity is as follows:

$$velocity = \frac{k * i}{effective _ porosity}$$

Where:

- velocity - average velocity of a particle of groundwater
- k - hydraulic conductivity
- i - hydraulic gradient
- effective porosity - interconnected pore space through which groundwater flows (note that this is lower than the total porosity)

The range in groundwater velocity can be estimated using upper and lower limits on each of the parameters. Hydraulic conductivity was not varied over the entire range since the value of 56 ft/day is reasonable, considering the productive nature of the aquifer. The lower limit on average velocity would occur using the low value of hydraulic gradient (0.0015) and the high value for effective porosity (0.25), resulting in a velocity of 0.34 ft/day. The upper limit on average velocity when the hydraulic gradient is 0.0053 and the effective porosity is .1 would be 2.97 ft/day.

Other factors impacting transport at the Site are physical processes that lead to mixing and dispersion of contaminants in groundwater. Groundwater does not travel

through the pore space in an aquifer at a uniform rate. The variability in the size of pores, degree of interconnection, and the irregular path that an individual particle of water actually follows results in variation in groundwater velocity. This variability in groundwater velocity causes mixing or dispersion of dissolved contaminants that move with the groundwater. The result of these processes is a spreading of a contaminant front in three dimensions. This mixing is most pronounced along the direction of flow, with a lesser degree of mixing laterally. Vertical mixing due to dispersion is much lower in magnitude due to the typical stratification in aquifer materials. Diffusion will also lead to some mixing, as chemical concentration gradients drive transport from areas of higher concentration to areas with lower concentrations. This process is very minor and can be ignored in aquifers with moving water since advection and dispersion will dominate transport. Dispersion coefficients are estimated as a function of the transport distance, based on relationships that are reported in the literature.

6.1.2 Fate Characteristics

Fate processes impact the persistence or mobility of contaminants. The fate processes of interest at the Site include sorption, which limits the mobility of contaminants in groundwater, and degradation reactions that transform or destroy the contaminant. Sorption is the primary process active at the Site impacting mobility and persistence of the primary contaminant. Other fate processes that are active at the Site, such as volatilization, may impact persistence of these constituents in groundwater. The mass loss to the vadose zone due to volatilization is expected to be minor, since this mass exchange occurs only at the water table and it has limited impact below this depth. The principal contaminant at the Site is PCE, with low levels of some degradation products of PCE, such as TCE and *cis*-1,2-DCE, present in the groundwater. The lack of degradation products indicates that biogeochemical conditions are not currently favorable for anaerobic biodegradation to occur; thus, degradation is not considered in the analysis.

Sorption is a generic term addressing a variety of processes where chemicals of concern are adsorbed or absorbed on the aquifer matrix, limiting their mobility in groundwater. This sorption may occur on sites, such as natural organic carbon particles on aquifer materials, but may also occur to a lesser degree on inorganic surfaces such as clay or iron minerals. Sufficient organic carbon is present to impact the transport of PCE. The chemical characteristic that defines the degree to which a chemical is adsorbed is the organic carbon partitioning coefficient ($[k_{oc}]$), which is reported in numerous sources for the chemicals of interest. This coefficient defines the degree to which a chemical will partition onto the solid phase sorption sites. At concentrations observed at the Site, this process is assumed to be linear, instantaneous, and reversible. A bulk measure of the adsorption capacity of the aquifer material may be estimated using the $[k_{oc}]$ and the organic carbon concentration in the soil. This term is described as the soil water partitioning coefficient (K_d). K_d may be estimated by multiplying the fraction of organic carbon

present in the soil by the [koc] value for the chemical of interest. Kd describes this equilibrium partitioning of a chemical between soil and water in contact with this soil in the following equation:

$$Kd = \frac{Cs}{Cw}$$

Where:

- Kd - soil water partitioning coefficient (cubic centimeter per gram [cm³/gm])
- Cs - Equilibrium concentration in soil phase (gram per gram [gm/gm])
- Cw - Equilibrium concentration in water phase (gram per cubic centimeter [gm/cm³])

Once Kd has been estimated for the chemicals of interest and the aquifer material at the property, the effective velocity of the contaminants may be estimated and used in modeling. These equilibrium sorption processes have the effect of slowing movement of contaminants relative to the groundwater velocity. The ratio of the velocity of the groundwater to that of the contaminant front is referred to as the retardation factor (R). A value of 1 for R indicates that the contaminant moves at the same velocity as groundwater. The R value can be estimated from the following equation:

$$R = 1 + \frac{Kd * density}{total_porosity}$$

Where:

- R - Ratio of average groundwater velocity to average contaminant velocity
- Kd - soil water partitioning coefficient (cm³/gm)
- Density - dry bulk density of aquifer soil (gm/cm³)
- Total_porosity - total porosity of aquifer material (cubic centimeter per cubic centimeter [cm³/cm³])

The organic carbon concentration for soils has not been determined at the Site; however, it is available from another nearby Superfund site (IWOR) with similar lithologies in the same aquifer. A total of 49 analyses of TOC were available. A probability plot of the concentration distribution for the TOC data approximated a log-normal distribution (Figure 6-1). The geometric mean TOC value, which is used for the calculations, is 0.0005gm/gm. Recent [koc] values reported by EPA for PCE indicates a value of 265 cm³/gm. Retardation factors may be calculated using the above equations, and estimates for total porosity (0.37), TOC (0.0005 gm/gm) bulk density (1.67 gm/cm³) and the [koc] values are noted above. This results in an estimated Kd for PCE of 1.6.

6.2 Monitored Natural Attenuation

As part of this investigation, all groundwater samples from existing monitoring wells were analyzed for natural attenuation parameters to provide some baseline information to determine the potential for biodegradation at the Site. Although this RI is focused on OU2, a full round of sampling was also conducted at all the HatchCo (OU1) monitoring wells and three of the refinery wells downgradient at EPA's request. The groundwater samples from this round (April 2005) were analyzed for chloride, nitrate/nitrite, sulfate, alkalinity, TOC, temperature, pH, DO, ORP, ferrous iron, dissolved manganese, and dissolved iron in addition to the CLP VOCs (see Table 6-1). Although these analyses provide information to initially assess monitored natural attenuation (MNA) as a remedial alternative, more information may be needed to completely evaluate MNA at the Site.

The analytical results for parameters significant to natural attenuation are presented in Table 6-1. The OU2 groundwater data do not suggest reductive dechlorination would occur naturally. Some indicators are that the ORP is relatively high, ferrous iron is rarely detected, and few breakdown products of PCE, such as *cis*-1,2-dichloroethene and vinyl chloride, were noted. In general, current conditions at the Site are not conducive to reductive dechlorination. Reductive dechlorination might be an option for remediation if changes are made to the aquifer environment.

Results for OU1 are included in Table 6-1; however, they are not relevant to the RI and are presented here upon request and for use by EPA. A quantitative PCR analysis was also performed on three of the OU1 samples from HatchCo wells MW02S, MW03S, and MW04S. The analytical results are included in Appendix C.

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Section 7

OU2 Risk Assessment

Analytical results from the Phase 3 indoor air and sub-slab vapor samples were supplied to Syracuse Research Corporation (SRC) to conduct a supplementary risk analysis and update to their baseline human health and ecological risk assessment (HHERA), as appropriate.

7.1 Risk Assessment Summary

SRC prepared a Baseline HHERA for the Bountiful/Woods Cross Site, Bountiful Utah Operable Unit 2 Addendum, Evaluation of Risks from Inhalation of Vapors at the Source Area, (SRC 2005) to supplement this RI. This addendum assessed the air sample data. It was noted in the risk assessment that the human health risks were assessed in accordance with current EPA guidelines for Superfund Sites. This section summarizes the risk assessment addendum.

7.1.1 Quantification of Human Exposure

There are three main sources of VOCs in indoor air:

- Sources within the building
- Intrusion of vapors released from contaminated soil and groundwater beneath the building
- Contamination in ambient air

The contribution from the sub-slab air to total indoor air was estimated using an attenuation factor of 1/10 and a less conservative attenuation factor of 1/100 (SRC 2005). The exposure point concentrations based on this pathway were estimated and were provided for both attenuation factors.

For this risk assessment, contaminants of potential concern (COPC) were defined as any contaminant that meets all of the following criteria: (1) has one or more toxicity values, (2) was detected in at least one air sample, (3) is not associated with laboratory blanks, and (4) has a maximum concentration that exceeds a conservative risk-based concentration.

The exposure points evaluated during this risk assessment were on a building-by-building basis except for BFC where different uses were occurring within one building, in which case current risks were evaluated on a room-by-room basis. A risk assessment was also performed for hypothetical future residents. Because the number of samples at the Site was relatively low (i.e., statistically valid estimates of the 95 percent upper control limit could not be calculated), the maximum detected value was used to determine risk at the Site. If the chemical was never detected, half the average detection limit was used.

Other variables affect human exposure such as body weight, intake rate, and exposure duration. Because these specifics cannot be determined for a general risk assessment, default values for central tendency exposure (CTE) and reasonable maximum exposure (RME) recommended by EPA were used.

7.1.2 Toxicity Assessment

For human health, the chemical- and route-specific toxicity values developed by EPA (i.e., Integrated Risk Information System or Superfund Technical Support Center) were applied. The cancer slope factors for TCE are currently controversial. The most conservative approach is based on the assumption that the oral slope factor proposed in 2001 is also applicable to inhalation exposure without adjustment. Risks were evaluated in this HHERA based on this most conservative approach.

7.1.3 Risk Characterization

7.1.3.1 Human Receptors

The hazard quotient (HQ) was calculated by dividing the chronic daily intake (CDI) by the reference dose (RfD). If the result was less than or equal to one, it is considered that there is no noncancer health risk to a human (and visa versa if the HQ is greater than one). Cancer risk to humans is estimated in terms of probability that an individual will develop cancer by age 70 through exposure to a chemical. Cancer risk for each chemical was determined using lifetime average chronic daily intake of the chemical for the Site and the slope factor for the chemical. All excess cancer risks are then summed across all chemicals and exposure pathways. In general, EPA considers cancer risks of one in one million to be negligible. Cancer risks above one in ten thousand may be considered to exceed EPA's target risk levels and it may be subject to a remedial action. Values between these end points are evaluated on a case-by-case basis.

The following human health conclusions for the Site were presented in the risk assessment:

- Both cancer and noncancer risks to both workers and to hypothetical future residents exceed EPA's target risk levels at all exposure units at the BFC. Cancer risks are predominantly from PCE. Noncancer risks are primarily driven by PCE and/or trimethylbenzene.
- DEP risks were based solely on the probable indoor air concentration from vapor intrusion. Based on the more conservative attenuation factor of 1/10, both noncancer and cancer risks from VOCs are within EPA's target risk range. The cancer risk exceeds the level of concern only for the reasonable maximum exposure for a hypothetical future resident. Noncancer risks are attributed to 1,2,4- and 1,3,5-trimethylbenzene.

- Predicted risks to workers within the retail area west of the BFC are below EPA's target risk level for cancer and noncancer based on indoor air and sub-slab air. Cancer risks for hypothetical future workers, based on predicted concentrations of VOCs intruding from sub-slab air, exceeded the EPA's target risk levels when a 1/10 attenuation factor was used to predict future concentrations. These levels are not exceeded if the attenuation factor is calculated at 1/100.

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Section 8

Summary and Conclusions

The goal of this RI addendum is to report the results of the Phase 3 field investigation and to estimate groundwater contaminant migrations by way of a simplified analytical model, both of which are used to characterize the nature and extent of PCE/TCE contamination at Bountiful/Woods Cross 5th South PCE Plume OU2. Essentially, the data gained from this phase of the investigation strongly supported the previous conclusions reported in the RI, and there were no contradictory findings.

8.1 Phase 3 – Source Area Investigation Summary

The Phase 3 sampling provided supplemental information toward isolating the specific high PCE concentration areas and the air sampling used in the BHHERA identified a significant risk from exposure to indoor air.

The MIP sampling and the groundwater sampling all correspond, reinforcing the likely source of the PCE contamination the BFC property. The highest MIP-ECD response, the highest PCE concentration from the MIP-SPME speciation, the highest soil sample analyzed in the laboratory, the highest shallow groundwater result, and the highest sub-slab vapor analysis result all coincide with the northwest corner of the BFC building. Concentrations were an order of magnitude higher in this area for all four media.

These maximum MIP responses and highest soil concentration obtained from a depth of 8 feet strongly suggests a shallow source in this vicinity. Historical aerial photography from 1966 and documentation from the South Davis Sewer District (within a month of each other) suggest that this "hot spot" may have been the approximate location of the original dry cleaner septic system drain field, prior to BFC hooking up to the city mainline sewer. There is no documentation that the septic system was ever removed. A "solvent saver unit," presumably for recycling perchloroethene was one of the fixtures that the dry cleaner listed on the permit for a service lateral.

8.2 Groundwater Modeling Summary

A site conceptual model was formulated based on investigation results that indicate an extensive PCE plume is present in the upper portion of the East Shore aquifer, extending from the source at the BFC property to the west approximately 1.5 miles. This aquifer is highly productive and is extensively developed for municipal and industrial water supplies. Several wells are located in the vicinity of the plume that affect groundwater flow directions and cause them to vary on a seasonal basis. The municipal and industrial wells produce most of their water from intervals that are much deeper than the vertical extent of the PCE plume. Groundwater flow in the upper portion of East Shore aquifer is to the west toward discharge points near the Great Salt Lake. A simplified analytical approach to modeling of groundwater flow

and transport of PCE was implemented to assess the potential for continued migration of the PCE plume under both no-action and source remediation alternatives. The modeling analysis indicates that expansion of the plume will likely occur even if the source is removed. Concentrations will diminish in the plume over time under the source removal alternative.

8.3 Conclusions

All findings in the addendum report are consistent with earlier findings reported in the main body of the RI. The information gained as a result of the Phase 3 investigation is as follows:

- An abandoned septic drain field on BFC property (taken out of service in 1966 by the previous property owner) is the primary source of PCE contamination below the property. This has been verified with the levels of contamination observed and/or measured by sub-slab vapors, MIP response and speciation, and soil concentrations. Residual DNAPL is inferred, however, free-product has not been observed.
- PCE and other volatile constituents are considered above EPA risk-based concentrations for indoor air at the BFC. These levels can be at least partially related to the soil gas and soil concentrations observed below the building and which likely contribute to the indoor air by vapor intrusion.
- PCE groundwater concentrations remain the highest at the BFC and move offsite at levels above MCLs for a distance of 1.5 miles. Contamination is observed at various depths and reaching deeper aquifer zones as evidenced by multi-port monitoring wells and downgradient domestic wells. Samples from domestic wells on residential properties that have PCE levels above MCLs include DW05 (Simmonds), DW16 and 17 (East) and DW25 (Ungerma).
- The PCE is the predominant contaminant throughout the extent of the plume (with very low concentrations of a few degradation compounds). The natural attenuation parameters measured do not demonstrate conditions currently conducive to reductive dechlorination.
- A simple 2-D analytical groundwater model predicts continued plume expansion in a westerly direction under both source removal and no action alternatives. However, high yield municipal and other water supply wells potentially have a profound influence on the plume.

Another potential source associated with the BFC/DEP that was not addressed in this investigation due to various limitations is the main sewer line leading north from the lateral off the property. The lack of information along this northern sewer line is considered a data gap.

At least one more monitoring well (preferably a multi-port system) is needed in SA-4 near the source area to characterize the vertical extent of contamination in the aquifer. These are items that should be considered in the future as part of a pilot study or pre-remedial design investigation.

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Section 9

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Appendix A Sub-Slab Vapor Probe and Indoor Air Analyses

Appendix B

Membrane Interface Probe Profiles and Speciation Results

Appendix C

Summary of Phase 3 Analytical Results

Appendix D Data Validation Reports and Form-1 Summary Sheets for CLP Analyses

Appendix E

Chain-of-Custody Forms

Appendix F

Field Data Sheets

Appendix G

Phase 3 - Surveyed Elevations