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December 9, 2009

Mr. Jeffrey L. Field
Remedial Project Manager
Environmental Protection Agency - Region 7
SUPR
901 North 5th Street
Kansas City, Kansas 66101

Re: Feasibility Study Report
Riverfront Superfund Site, Operable Unit No. 2/6
New Haven, Missouri
Administrative Order on Consent: CERCLA-07-2004-0078

Dear Mr. Field:

In accordance with the above-referenced Administrative Order on Consent (the 2004 AOC) and on behalf of Kellwood Company, Parsons is submitting this December 2009 Feasibility Study Report.

Please feel free to call me at (716) 541-0752 if you have any questions regarding this report.

Sincerely,

Mark S. Raybuck

Mark S. Raybuck
Project Manager

cc: J. Schumacher, USGS
E. Kifer, MDNR
R. Blake, Black and Veatch
K. Grypp, Kellwood
S. Poplawski, Bryan Cave

FEASIBILITY STUDY REPORT
RIVERFRONT SUPERFUND SITE
OPERABLE UNITS NO. 2/6
NEW HAVEN, MISSOURI

Prepared on behalf of Kellwood Company for:

THE UNITED STATES ENVIRONMENTAL PROTECTION AGENCY

REGION 7

DECEMBER 2009

FEASIBILITY STUDY REPORT

RIVERFRONT SUPERFUND SITE
OPERABLE UNIT NO. 2/6
NEW HAVEN, MISSOURI

Prepared for:

United States Environmental Protection Agency
Region VII

Prepared on behalf of Kellwood Company by:

PARSONS
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DECEMBER 2009

TABLE OF CONTENTS

LIST OF FIGURES

LIST OF TABLES

LIST OF APPENDICES

LIST OF ACRONYMS

1,2-DCE	1,2-dichloroethene (total)
AOC	Administrative Order on Consent
ARARS	applicable or relevant and appropriate requirements
bgs	below ground surface
CERCLA	Comprehensive Environmental Response, Compensation, and Liability Act (also known as Superfund)
CCTV	closed circuit television
COPCs	chemicals of potential concern
DNAPL	dense non-aqueous phase liquid
EMA	Environmental Management Alternatives
ERH	electrical resistive heating
eZVI	emulsified zero valent iron
FS	Feasibility Study
FS Report	Feasibility Study Report
HRC®	hydrogen release compound
Kellwood	Kellwood Company
MCL	maximum contaminant level
MDNR	Missouri Department of Natural Resources
MNA	monitored natural attenuation
O&M	operation and maintenance
OU	Operable Unit
PCE	Tetrachloroethylene (also known as perchloroethylene and tetrachloroethene)
PRGs	Preliminary Remediation Goals
RAOs	Remedial Action Objectives
Report	Feasibility Study Report
RfDs	References Doses
RI	Remedial Investigation
RI/FS	Remedial Investigation/Feasibility Study
ROD	Record of Decision
RSDs	risk-specific doses
SARA	Superfund Amendments and Reauthorization Act
TCE	Trichloroethylene (also known as trichloroethene)
µg/kg	micrograms per kilogram
µg/L	micrograms per liter
USEPA	United States Environmental Protection Agency
USGS	United States Geological Survey
VC	vinyl chloride
VOCs	volatile organic compounds

EXECUTIVE SUMMARY

This Feasibility Study (FS), was performed to fulfill part of the requirements (along with a Remedial Investigation (RI)) of the Administrative Order on Consent, Docket No. CERCLA-07-2004-0078 (AOC) (dated March 22, 2004) entered into by the United States Environmental Protection Agency (USEPA) with Kellwood Company (Kellwood). The RI/FS process is authorized by the Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA, a.k.a. Superfund) of 1980 as amended by the Superfund Amendments and Reauthorization Act (SARA) of 1986 (i.e., Superfund program) for characterizing the nature and extent of risks posed by uncontrolled hazardous waste sites and for evaluating potential remedial options.

Site History and Background

The Kellwood Company (Kellwood) operated a tube mill at 202 Industrial Drive between 1973 and 1985. Tetrachloroethylene (PCE) was used to remove oils from fabricated parts. Kellwood sold the facility in 1985 and ceased operation of the tube mill. Investigations of volatile organic compounds (VOCs) in the area of the former Kellwood facility and the open lot immediately north of the facility began in 1989. In approximately 1990, the State of Missouri informed ARP and Kellwood Company that there were reports of disposal of cleaning solvent containing PCE or trichloroethylene (TCE) on the City-owned property just north of the former Kellwood facility.

In 1994, soil from the open lot exhibiting PCE concentrations exceeding 380,000 micrograms per kilogram (µg/kg) was excavated for off-site incineration. From 1994 to 1996, soil remaining on the open lot was tilled to maximize volatilization. Nevertheless, dense non-aqueous phase liquid (DNAPL) is present in the area of the open lot. Since March 2008, approximately 6 liters of DNAPL have been removed through periodic recovery operations.

New Haven, Missouri, is located in the northwestern part of Franklin County on the southern bank of the Missouri River. Operable Unit (OU) 2 consists of the area in the immediate vicinity of the reported hazardous substance releases. OU6 is the area to the south and southwest of OU2 where groundwater containing PCE has been observed. Surface water in the area of OU2 and OU6 flows south via unnamed tributaries to Wildcat Creek and to Boeuf Creek, which flows to the east before turning north to empty into the Missouri River.

New Haven is underlain by the geologic units of the Ozark Aquifer. The Ozark Aquifer is composed of eight lithological units, from top to bottom: the St. Peter Sandstone, Powell Dolomite, Cotter Dolomite, Jefferson City Dolomite, Roubidoux Formation, Gasconade Dolomite, Eminence Dolomite, and Potosi Dolomite. There are three geologic structures in the OU2 area: the Wildcat Creek Anticline, the Park Creek Structure, and the Berger Creek Bluff Fault, all trending northwest-southeast.

Findings of the RI

During the RI, several media were investigated including soils, sediment, surface water, sewer water, sewer sediment and groundwater at OU2 and OU6. Monitoring wells were installed in each of the laterally extensive permeable zones. The primary findings of the RI are:

- DNAPL is present in a limited area north and northwest of the former Kellwood facility.
- Soils with the highest PCE concentrations were previously removed for offsite incineration.
- The overburden and upper sandstone/upper bedrock units have higher concentrations of VOCs in groundwater than lower bedrock units. Concentrations decline substantially in the Swan Creek sandstone and lower units relative to the overburden and upper sandstone/upper bedrock. The substantial decline in levels of COPCs between the shallower overburden and upper sandstone/upper bedrock units and the Swan Creek sandstone and lower units is evidence that there are intervening strata between those units inhibiting vertical migration between them.
- Groundwater is the primary media of concern and the extent of impacts of chemicals of potential concern (COPCs) has been adequately defined both horizontally and vertically. The human health risk assessment indicated that for ingestion of groundwater by hypothetical residents, the total cancer risk was within the acceptable risk range, and the hazard index was below target levels.
- The primary risk for PCE to migrate to the lower Jefferson City/Roubidoux permeable zone is from wells with long open intervals that may short-circuit the intervening strata. However, a state promulgated well advisory is in place that more than covers the area of impacted groundwater and should preclude the future drilling of wells in a manner that could result in downward migration of COPCs. In addition, those residents who have drinking water supply wells with detections of COPCs above the maximum contaminant levels (MCLs) have whole house filtration systems which treat the groundwater to achieve the MCLs.
- The human health risk assessment concluded that the total cancer risk and total hazard index exceed target ranges for industrial workers and a hypothetical resident through inhalation of indoor air and for direct contact to soil for a hypothetical resident. These risks apply only to the area at and around the former Kellwood facility.

Remedial Action Objectives

To satisfy CERCLA requirements, remedial action objectives (RAOs) were developed. RAOs were used to develop general response actions. The RAOs developed for groundwater and soil are:

- Protect human health by eliminating exposure (i.e. inhalation, incidental ingestion, dermal contact) to soil with COPC concentrations in excess of risk-based concentrations.
- Protect human health by eliminating exposure (i.e. inhalation) to indoor air due to soil or shallow groundwater with concentrations of COPCs (as vapors) in excess of risk-based concentrations.
- Protect human health by preventing exposure (ingestion) to groundwater with concentrations greater than MCLs.
- Protect the environment by minimizing further migration of groundwater containing COPCs.
- Protect the environment by reducing COPC concentrations in soil, or eliminate the soil to groundwater pathway.
- Protect the environment by minimizing the movement of DNAPL into the groundwater system.
- Protect the environment by eliminating exposure of wildlife to surface water, sediment, and surface soils with concentrations of COPCs in excess of risk based standards. All detected concentrations in surface water and sediment were below risk based standards.

To the extent feasible, remedial actions must comply with applicable or relevant and appropriate requirements (ARARs) of federal laws and more stringent, promulgated state laws. Chemical-specific, action-specific, and location-specific ARARs for OU2/6 have been preliminarily identified and are listed in Appendix A.

Information concerning the nature and extent of impacts in the soil and groundwater and the extent of the DNAPL was used to estimate the area or volume of material or media for which remediation would be evaluated.

- The soil in the vicinity of the former Kellwood facility only exceeds the RAOs for a future hypothetical residential use scenario. Under the current industrial scenario, the only concern for soil is from indoor air resulting from vapors volatilizing from the soil. No indoor air samples were collected as part of the RI in the former Kellwood facility. Some of the alternatives address this pathway with remediation. Others focus on minimizing contact with impacted soils and continuing to provide protection for groundwater users in the area. If the soil areas are to be remediated, there are three separate areas: (1) A-1 which is the open lot north of the former Kellwood facility and a small area immediately to the west of the north end of the building; (2) A-2, located underneath Industrial

Drive; and (3) A-3, located in a small area underneath the former Kellwood facility floor in the center of the building. The A-1 area is approximately ½ acre. The volume of soil was not estimated due to variability in how it is dispersed over the bedrock. The A-2 area is approximately ½ acre in size with an estimated 4,700 cubic yards of impacted soil. The A-3 area is approximately 2,000 square feet with an estimated 650 cubic yards of impacted soil.

- The DNAPL source area is estimated to be approximately ½ acre and is closely aligned with the soil area A-1.
- Groundwater is impacted primarily in two zones: (1) the unconsolidated soils south of the former Kellwood facility, and (2) in the upper sandstone/upper bedrock unit. These impacts are above and generally isolated from the lower formation (Jefferson City / Roubidoux) that is used in the region as a groundwater source. There were no impacts above the RAOs in the Swan Creek sandstone. A few isolated impacts above the RAOs were identified in the Roubidoux formation (see **Figure 3.2**). The total area over which groundwater is impacted above the RAOs is shown on **Figure 3.2**.

General response actions were identified for both soil and groundwater impacted areas and for the DNAPL area. Remedial technologies and process options were identified for each general response action. The remedial technologies and process options identified were screened on the basis of implementability (technical and site specific) and effectiveness.

Remedial Alternatives

The remedial alternatives combine various technologies to address the soil and groundwater impacts above the RAOs and the DNAPL source. The goals in developing the preliminary remedial alternatives are to provide both a range of cleanup options and sufficient detail to adequately compare alternatives. The Alternatives evaluated in the FS are listed below.

<u>Alternative</u>

1: No action

2a: Cap over Area 1, whole-house treatment units

2b: Cap over Area 1, potable water line

3a: Thermal treatment of DNAPL, whole-house treatment units

3b: Thermal treatment of DNAPL source, potable water line

4a: Thermal treatment of DNAPL and soil, bioremediation of groundwater

4b: Thermal treatment of DNAPL and soil, in situ chemical oxidation of groundwater

4c: Thermal treatment of DNAPL and soil, in situ chemical reduction of groundwater

5: *In situ* chemical oxidation (source, road, building, and groundwater), whole-house treatment units

6: *In situ* chemical reduction (source, road, building, and groundwater), whole-house treatment units

Comparison of Alternatives

This Report contains a detailed comparative analysis of the alternatives against seven of the nine criteria required by the National Contingency Plan.

Alternative 2a is a desirable alternative as it meets the requirements for protecting human health and the environment, is the least intrusive, the lowest cost, would be easiest to obtain access to implement, and has a relatively low environmental footprint. Alternative 2a and 2b have a basic containment strategy with the installation of a cap over the historic source area. Removal of DNAPL during the RI at several wells in the area of interest has shown that removal of source material by pumping is not a viable option. During prior remedial activities, a significant quantity of impacted soil was treated by landfarming or was removed and incinerated off-site.

All of Alternatives 2 through 6 provide drinking water meeting MCLs to the residences in OU2 and OU6, provide the same level of compliance with ARARs, provide similar long-term effectiveness, and provide similar short-term effectiveness although the time for implementation varies.

Alternatives 3 through 6 include *in situ* treatment of the DNAPL source area by thermal treatment, chemical oxidation or chemical reduction. Of these three treatment processes, thermal treatment is considered to be the most effective in removing DNAPL. DNAPL is present in fractured bedrock, which presents difficulties in distributing the injection materials associated with chemical oxidation and chemical reduction options. These two processes also require a relatively large volume of materials to be injected. With thermal treatment, there is the possibility that some of the DNAPL would not be captured by the vapor extraction system. All three *in situ* treatment methods have some potential for temporarily increasing the mobility of DNAPL during the process. None of these alternatives are expected to be able to achieve regulatory groundwater concentration levels for PCE and its byproducts within the entire area of impacted groundwater in the foreseeable future. Reductions will occur, and could reach acceptable levels in certain locations

Alternatives 2b and 3b include installation of an alternative water supply system. Alternatives 2a, 3a, and 4-6 include continued operation of the whole-house treatment units at a number of residences.

Conclusion

Alternative 2a is recommended, as it provides the required protection of human health and the environment by preventing exposure to groundwater above the MCLs and the exposure of the industrial worker to impacted soil in the vicinity of the former Kellwood facility. Treatment of DNAPL or the groundwater (Alternatives 3 through 6) would provide some reduction in groundwater concentrations, but is not expected to reduce concentrations to below MCLs throughout the entire Site. The alternatives involving treatment underneath the building or within the roadway will have substantial coordination and logistical issues. Alternatives 3 through 6 are thus less preferable as they each involve significant logistical hurdles, but do not result in greater protection against exposure to COPCs. Alternatives 2b and 3b, including a potable water supply, are dependent upon approval of design plans and obtaining access for installing the system.

All the alternatives (2 through 6) require activities to be conducted on property owned by entities other than Kellwood. This will require coordination and access agreements for conducting the work. Access approval problems during the RI activities indicate that there will be difficulties and delays in obtaining access to implement some of the proposed remedies. The alternative with the fewest access issues is Alternative 2a. Alternatives 4 through 6 will have the greatest access issues. Alternatives 2b and 3b have a number of access issues due to installation of the water main and tying it into the individual properties.

SECTION 1
INTRODUCTION

1.1 PURPOSE OF FEASIBILITY STUDY

This Feasibility Study Report (FS Report or the Report) has been prepared to summarize the FS of alternatives to remediate OU2 and OU6 of the Riverfront Superfund Site, located in New Haven, Franklin County, Missouri.

The RI/FS was performed to fulfill the requirements of the AOC, Docket No. CERCLA-07-2004-0078 (dated March 22, 2004) entered into by the USEPA with Kellwood.

This FS is based on the information gathered through extensive investigations and environmental studies at OU2 and OU6 as documented in Parsons' December 2009 RI Report. The RI Report provides a detailed description of the physical settings, geology, hydrogeology, and nature and extent of impacts.

1.2 REPORT ORGANIZATION

This Report is organized into eight sections in the following manner.

1. Section 1 – Introduction: Describes the purpose and organization of the document.
2. Section 2 – Background Information: Provides a summary of the nature and extent of impacted media, and the fate and transport of COPCs.
3. Section 3 – Identification and Screening of Technologies: Discusses the RAOs, general response actions, and volumes or areas of media requiring remedial action.
4. Section 4 – Development of Alternatives: Includes a summary of the remedial alternatives considered.
5. Section 5 – Detailed Analysis of Alternatives: Includes a detailed analysis of various remedial alternatives based on eight criteria.
6. Section 6 – Comparative Analysis of Alternatives: Compares the remedial alternatives that were retained from the screening process, and presents a preferred alternative.
7. Section 7 – Summary and Conclusions: Summarizes the proposed remedial alternative(s).
8. Section 8 – References.

SECTION 2
BACKGROUND INFORMATION

2.1 SITE DESCRIPTION

OU2 and OU6 at the Riverfront Superfund Site are located in and immediately south of New Haven, Missouri. These operable units constitute two of the six OUs of the Riverfront Superfund Site (**Figure 2.1**). OU2 includes the historic operations on and in the former Kellwood facility, located at 202 Industrial Drive, New Haven, Missouri (currently a facility operated by MetalCraft Enterprises), and areas where COPCs may be present. OU6 includes the area downgradient of OU2 as identified in **Figure 2.1**. Historical investigations found that there are residual levels of PCE within OU2. Investigations performed by the Missouri Department of Natural Resources (MDNR), Geotechnology, Inc. (on behalf of Kellwood), Environmental Management Associates (EMA, on behalf of a potential buyer), the United States Geological Survey (USGS) and Black and Veatch (on behalf of the USEPA), and Parsons (on behalf of Kellwood), are summarized in the USEPA-approved January 2006 RI/FS Work Plan and in the December 2009 RI Report.

2.2 SITE HISTORY

The Kellwood Company operated a tube mill at 202 Industrial Drive between 1973 and 1985. PCE was used to remove oils from the parts fabricated using the tube mill. Spent PCE was disposed on the open lot north of the facility. Kellwood sold the facility (referred to as the former Kellwood facility) in 1985 and ceased operation of the tube mill. Investigations of VOCs in the area of the open lot and the former Kellwood facility began in 1989. A summary of previous investigations is presented in Section 2.2 of this report. In 1994, soil from the open lot exhibiting PCE concentrations exceeding 380,000 µg/kg was excavated for off-site incineration. From 1994 to 1996, soil remaining on the open lot was tilled to maximize volatilization. DNAPL is present in the area of the open lot. Since March 2008, approximately 6 liters of DNAPL has been removed from the site.

Nature and extent of impacts at OU2 and OU6 are summarized below.

2.3 NATURE AND EXTENT OF IMPACTS

2.3.1 Summary of Chemical Sources Investigated

Chemical sources investigated as a part of this RI include PCE and potential breakdown products TCE, 1,2-dichloroethene (1,2-DCE), and vinyl chloride (VC). PCE was the chemical found at the open lot north of the former Kellwood facility. Through reductive dechlorination, PCE can degrade to TCE, 1,2-DCE, and vinyl chloride. As described in Section 3 of the RI Report, DNAPL containing PCE and its breakdown compounds was detected immediately north and northwest of the former Kellwood facility. The RI sampling locations are shown on **Figures 2.2a through c** and results of the investigation are shown on **Figures 2.3 through 2.16**.

2.3.2 Distribution of Chemicals of Concern in Soil

The distribution of PCE and its breakdown products north and west of the former Kellwood facility and beneath the facility was evaluated by installation of 42 soil borings associated with Task 1 of the RI. Two samples were collected for analysis from each boring, with the exception of boring MC-1 located in the northeast corner of the former Kellwood facility and boring T-10, located on Industrial Drive north of the former Kellwood facility. **Figure 2.3** presents the detected concentrations of PCE, TCE, 1,2-DCE (total), and vinyl chloride in the samples collected from the soil borings.

Analytical results of soil samples collected as a part of the RI indicate that the extent of PCE and associated breakdown products in soil is limited to the open lot north of the former Kellwood facility, beneath the former Kellwood facility, and beneath and immediately west of Industrial Drive. Details of the distribution are provided in the RI Report.

2.3.3 Distribution of DNAPL

PCE was detected as a free-phase liquid (DNAPL) in five core holes. Three of the core holes were located on the open lot immediately north of the former Kellwood facility (**Figure 2.11**). DNAPL was detected in two core holes outside the northwest portion of the former Kellwood facility. DNAPL was detected at depths ranging from 4 feet to 22 feet below ground surface (bgs) (**Figures 2.12a and 2.12b**). There is no indication that DNAPL is present outside of this limited area. Since March 2008, approximately six liters of DNAPL have been recovered from core holes P14 (since sealed) and L12, as well as USGS monitoring well BW-20.

2.3.4 Distribution of Chemicals of Concern in Groundwater

PCE and its breakdown products TCE and 1,2-DCE have been detected in the following four laterally extensive transmissive intervals: overburden above bedrock, the upper sandstone marker bed of the Cotter Dolomite, the Swan Creek sandstone member of the Cotter Dolomite, and in the lower Jefferson City Dolomite/Roubidoux Formation. VOCs have also been detected in other, less aerially extensive, undifferentiated intervals in the Cotter Dolomite.

The distribution of PCE is widest in the upper sandstone marker bed/upper bedrock permeable zone with PCE present above the 5 micrograms per liter (µg/L) screening criterion to the west at MW-14US, and to the south at MW04A. Samples collected from the overburden at MW-14US and at MW-04A did not contain PCE. PCE is present at concentrations in the hundreds to low thousands of µg/L in the overburden throughout the southern portion of the industrial park south and southwest of the former Kellwood facility as seen in the direct push borings and in MW-1S. The distribution of PCE in the Swan Creek sandstone member is much more limited, with concentrations generally much lower and below the RAO. PCE in the lower Jefferson City/Roubidoux is limited to small isolated occurrences. Section 4.4.2 of the RI report provides details on the PCE distribution in each of these intervals. Groundwater investigation results are presented in **Figures 2.4 through 2.10**.

2.3.5 Distribution of Chemicals of Concern in Sanitary Sewers and Adjacent Soils

Five soil borings were advanced adjacent to the sewer line that serves the former Kellwood facility. The boring locations were selected to be near defects in the line to evaluate the potential for leakage of water containing COPCs from the line. Two soil samples were collected from each boring. None of the ten samples contained PCE or its breakdown products. Sanitary sewer investigation data is presented in **Figures 2.15 and 2.16**.

2.3.6 Distribution of Chemicals of Concern in Sediment and Surface Water

PCE was detected in surface water in several stream segments in OU6 south and west of the former Kellwood facility (**Figure 2.13**). PCE was detected at concentrations above the screening level at two locations along the unnamed creek west of the homes in Wildcat Creek Estates (drainage 600 on Figure 2.3 of the Work Plan). PCE was also detected at low levels (below the screening criterion) at the Boeuf Lutheran Road crossing of the stream that flows southward west of JS-14 and JS-36 (drainage 500 on Figure 2.3 of the Work Plan). This creek receives runoff from the northwestern portion of the industrial park, including the former Kellwood facility and the industrial park's detention basin as well as the area of the New Haven High School and the city park. Samples from the upper portion of the drainage basin (SW-01, SW-02, SW-03, and SW-04) did not contain detectable concentrations of PCE.

Historical samples collected by the USGS indicated that PCE was present in a spring located on the stream between samples SW-04 and SW-08. Access to sample this spring as a part of this RI was not granted. The upper sandstone marker bed of the Cotter Dolomite is reported to crop out in the stream near this spring. Access to collect a sample downstream of SW-06 was also not granted.

PCE was found to be present only at low levels at the Boeuf Lutheran Road crossing of the stream that flows southward west of JS-14 and JS-36 (drainage 500 on Figure 2.3 of the Work Plan, sample SD06). Access was not granted to sample this drainage further downstream.

PCE was detected at a concentration below the screening criterion in the sediment sample SD06-SD01-080801. No other sediment samples contained PCE.

2.4 FATE AND TRANSPORT

2.4.1 Potential Routes of Migration

Exposure may potentially occur through soil, groundwater, surface water, and sediments that contain PCE and its breakdown products TCE, 1,2-DCE, and VC. A baseline risk assessment evaluating each of these pathways is presented in Section 6 of the RI Report.

2.4.2 Chemicals of Concern Characteristics

PCE is a chlorinated solvent that is widely used as a dry-cleaning solvent and as a metal degreaser. PCE is nonflammable and has limited solubility in water. As a result, PCE may occur as a non-aqueous, free-phase liquid. PCE has a low viscosity and a density approximately twice that of water and tends to sink through groundwater to low-permeability layer, where it can then flow laterally downslope. Free-phase PCE will occupy fractures or pore spaces without mixing with the surrounding groundwater. PCE dissolved in water readily volatilizes when exposed to the atmosphere. PCE is relatively stable, but biological processes and reductive dechlorination can break the PCE down to TCE then to 1,2-DCE, and VC.

2.4.3 Chemicals of Concern Migration

Advection is the primary process controlling the transport and fate of PCE in groundwater. The primary avenues for migration are in the overburden near the bedrock interface and in the upper sandstone/upper bedrock. There is limited hydraulic connectivity between the upper sandstone/upper bedrock interval and the underlying Swan Creek sandstone, and between the Swan Creek sandstone and the underlying lower Jefferson City/Roubidoux. A discernible, but minimal hydraulic connectivity exists between the Roubidoux and the units that are utilized by the two city wells (Gasconade and lower units). Migration of PCE in groundwater to the lower Jefferson City/Roubidoux may involve a vertical short circuiting of the intervening strata. The short-circuiting may occur through natural geologic features such as a fault or fracture or through man-made features such as an open borehole. The domestic wells that have been affected by PCE appear to be related to short circuiting by an open borehole. Domestic wells with VOCs above MCLs have whole-house treatment units.

Groundwater flow from OU2 is to the south and west. Most groundwater discharges from the upper sandstone/upper bedrock and the overburden to unnamed creeks running behind the homes of the Wildcat Creek subdivision and west of JS 14 and JS 36. It is possible that groundwater containing PCE may either currently or in the future discharge directly to Wildcat Creek.

Wells MW 9US, MW 9SW, JS-25, and JS-27 are north and northeast of OU2, and groundwater collected from these four wells contained PCE. The PCE in these wells does not appear to have originated at OU2, as they are upgradient, up-dip, up the slope of the top of bedrock, and have monitoring wells and DNAPL core holes that did not contain PCE between the wells and OU2.

SECTION 3
IDENTIFICATION AND SCREENING OF TECHNOLOGIES

3.1 INTRODUCTION

The primary objective of this section of the FS Report is to develop an appropriate range of options that will be analyzed further in the detailed analysis section of the FS Report. Appropriate options that ensure the protection of human health and the environment may involve, depending on site-specific circumstances, the elimination or destruction of COPCs, the reduction of COPC concentrations to acceptable health-based levels, prevention of exposure via engineering or institutional controls, or some combination of the above. The identification and screening of technologies consists of the following steps:

- Develop RAOs for the chemical constituents and media of interest, exposure pathways, and preliminary remediation goals (PRGs) that permit a range of treatment and containment alternatives to be developed. The PRGs are developed on the basis of chemical-specific ARARs, when available, other available information (e.g., Reference Doses (RfDs)), and site-specific risk-related factors.
- Develop general response actions for each media of interest defining containment, treatment, excavation, pumping, or other actions, individually or in combination that may be taken to satisfy the RAOs for the site.
- Identify volumes or areas of extent in each media to which general response actions might be applied, taking into account the requirements for protectiveness as identified in the RAOs, and the chemical and physical characterization of the site.
- Identify and screen the technologies applicable to each general response action to eliminate those that cannot be implemented. The general response actions are further defined to specify remedial technology types (e.g., the general response action of treatment can be further defined to include chemical or biological technology types).
- Identify and evaluate technology process options to select a representative process for each technology type retained for consideration. Although specific processes are selected for alternative development and evaluation, these processes are intended to represent the broader range of process options within a general technology type.

3.2 REMEDIAL ACTION OBJECTIVES

3.2.1 Background

RAOs consist of medium-specific and/or site-specific goals for protecting human health and the environment.

RAOs aimed at protecting human health and the environment should specify:

- The chemical(s) of potential concern;
- Exposure route(s) and receptor(s);
- An acceptable COPC level or range of levels for each exposure route (i.e., a PRG).

RAOs for protecting human receptors should express both a COPC level and an exposure route, rather than COPC levels alone, because protectiveness may be achieved by reducing exposure (such as capping an area, limiting access, or providing an alternate water supply) as well as by reducing COPC levels. Because RAOs for protecting environmental receptors typically seek to preserve or restore a resource (e.g., groundwater), environmental objectives should be expressed in terms of the medium of interest and target cleanup levels, whenever possible.

Although the PRGs are established on readily available information (e.g., Rfds) and risk-specific doses (RSDs) or frequently used standards (e.g., ARARs), the final acceptable exposure levels are determined from the baseline risk assessment and the evaluation of the expected exposures and associated risks for each alternative. COPC concentrations in each media are compared with these acceptable levels and include an evaluation of the following elements:

- Whether the remediation goals for all carcinogenic COPCs, including those with goals set at the chemical-specific ARAR level, provide protection within the risk range of 10^{-4} to 10^{-7}.
- Whether the remediation goals set for all non-carcinogenic COPCs, including those with goals set at the chemical-specific ARAR level, are sufficiently protective.
- Whether environmental effects (in addition to human health effects) are adequately addressed.
- Whether the exposure analysis conducted as part of the risk assessment adequately addresses each significant pathway of human exposure identified in the baseline risk assessment. For example, if the exposure from the ingestion of soil and ingestion of drinking water are both significant pathways of exposure, goals set by considering only one of these exposure pathways may not be adequately protective.

3.2.2 Remedial Action Objectives

Based on the discussions above, RAOs at OU2 and OU6 are required for the media of soil, groundwater, and DNAPL. RAOs based on risk-based standards are summarized in Tables 3.1 and 3.2 with the associated target concentration. All of the RAOs are summarized below.

- Protect human health by eliminating exposure (i.e. inhalation, incidental ingestion, dermal contact) to soil with concentrations of COPCs in excess of risk-based standards. This RAO applies to the area around the source area in the vicinity of the former Kellwood facility.
- Protect human health by eliminating exposure (i.e. inhalation) to indoor air due to soil or shallow groundwater with concentrations of COPCs (as vapors) in excess of risk based standards. This RAO applies to the area around the source area in the vicinity of the former Kellwood facility.
- Protect human health by preventing exposure (ingestion) to groundwater with chemical concentrations greater than MCLs.
- Protect the environment by minimizing further migration of groundwater containing COPCs.
- Protect the environment by reducing the soil COPC concentrations, by eliminating or mitigating the soil to groundwater pathway.
- Protect the environment by minimizing the movement of DNAPL into the groundwater system.
- Protect the environment by eliminating exposure of wildlife to surface water, sediment, and surface soils with concentrations of COPCs in excess of ecological risk-based standards. Detected concentrations in surface water and sediment at OU2 and OU6 were below the risk-based standards listed in Table 3.2. Only one surface soil detection at P-16 was above the risk-based standards for surface soil listed in Table 3.2.

3.3 GENERAL RESPONSE ACTIONS

General response actions describe those actions that will satisfy the RAOs. Specific general response actions to satisfy the RAOs for human health and for environmental protection include no action (required), institutional actions, containment actions, and/or excavation/treatment actions. Table 3.3 summarizes the general response actions with respect to completed pathways for human health and environmental protection for soils, groundwater, and DNAPL. General response actions have not been tabulated for surface water or the sewer water / sediment. The impacts in surface water and sewer sediment media will be addressed by remedial actions in the other media. Neither the sewer water nor surface water investigations conducted as part of the RI showed COPCs above RAO levels.

3.4 VOLUMES OR AREAS OF MEDIA REQUIRING REMEDIAL ACTION

Based on the data collected during the RI, the limits of the impacts for each medium were estimated. There are three areas where general response actions may be applied.

3.4.1 Soils

The areas shown on **Figure 3.1** identify the extent of soils impacted with COPC concentrations above the RAOs. The areas where response actions may be applicable are divided into three areas.

Area A-1 is the open area to the north and west of the former Kellwood facility. The soil in this area ranges from a few inches to three feet deep. Soil is present in “pockets” of bedrock, which would make excavation difficult with standard excavation equipment.

Area A-2 is underneath Industrial Drive. This is a paved road with numerous utilities underneath the paved road. The impacts above the RAOs in this area extend to a depth varying from three to nine feet. The volume of soil within the impacted area is estimated to be 4,700 cubic yards (CY).

Area A-3 is underneath the former Kellwood facility in the center of the building near sample locations MC-04 and MC-05. MC-04 is adjacent to a floor drain. Assuming that impacts are concentrated in the backfill around the drain piping, the impacted area is approximately 650 CY based on a depth of seven to nine feet.

3.4.2 Groundwater

Groundwater impacts above the RAOs extend from north of the former Kellwood facility to the south, west of the Wildcat Creek Estates near McKenzie Drive. COPCs have been detected in the unconsolidated materials above the bedrock and in the upper sandstone/bedrock units as shown on **Figure 3.2**. Isolated impacts above the RAOs have been observed in the Jefferson City / Roubidoux unit in the immediate vicinity of wells that have been determined to have leaking liners. All of these leaking liners have been repaired. COPCs above the RAOs are generally present from 20 feet to 50 feet below grade.

A well with an improperly sealed casing in the Wildcat Creek Estates (JS-38) may have resulted in downward migration of COPCs to the lower portion of the Jefferson City Dolomite and the Roubidoux Formation. This has resulted in the detection of the COPC PCE in one adjacent well (JS-52). However, COPCs have not been detected in other nearby wells (JS-40, JS-41, JS-42) or in the deeper monitoring wells of the MW-2 cluster north of JS-52 (MW-2T2, MW-2T3, and MW-2R). COPCs were also detected in residential wells JS-37, JS-36, and JS-14 indicating these wells were also improperly sealed. A water line was extended to the JS-37 Laune residence, and the well was reconfigured with grout placed in the lower section. Liners were installed in JS-38, JS-36, and JS-14 to eliminate the vertical connection between zones.

In evaluating potential groundwater treatment alternatives, the location of the direct push boring water samples at the southern end of Industrial Drive is a logical site for placement of a groundwater treatment zone. This treatment zone area is referred to as Area A-4 and is shown on **Figure 5.3**. This proposed treatment zone would be located in the unconsolidated material (and possibly slightly into the upper bedrock) along a line approximately 730 feet long where the highest concentrations of TCE were detected during the RI.

3.4.3 DNAPL

DNAPL has been detected in the area north and west of the former Kellwood facility as shown on **Figure 3.3**. The DNAPL is located in the bedrock at a depth of 3 to 20 feet below grade. The estimated area of bedrock with DNAPL is 2,300 square yards. The DNAPL recovery efforts were initiated at selected locations (land farm grid L-12 and P-14, and BW-20) in early 2008. P-14 was subsequently abandoned per U.S. EPA's concurrence. Approximately six liters of DNAPL were recovered over a period of 17 months (March 2008 through August 2009). This area is referred to elsewhere in this report as the source area.

3.4.4 Sanitary Sewer Sediment, Sewer Water and Adjacent Soils

Sediment in the sanitary sewer had reportable concentrations of COPCs at MH-407 located in the vicinity of soil sample R-10, which had PCE levels above the RAO at a depth of 3.5 feet. DNAPL is located just to the east of this manhole. Sediment with reportable levels of COPCs was also observed at MH-331. The sediment in MH-331 is believed to be residual material that remained in a corner of the manhole during normal operation. The samples were collected prior to sewer cleaning performed to allow for closed circuit television (CCTV) inspection. The residual sediments were probably removed during the cleaning operation.

3.4.5 Sediment and Surface Water

All detections in the surface water or sediment were below the RAOs.

3.5 IDENTIFICATION AND SCREENING OF TECHNOLOGIES AND PROCESS OPTIONS

3.5.1 Initial Screening of Technologies and Process Options

Prior to beginning development and screening of alternatives, an initial screening of the remedial technologies for each of the general response actions was performed. This screening consisted of an evaluation of whether a specific remedial technology and process option was potentially applicable to the Site. Tables 3.4A, B, and C contains the remedial technologies and process options with descriptions and screening comments, indicating whether the option was retained for the second screening.

3.5.2 Further Evaluation of Process Options

The second screening of remedial technologies and process options that were retained in the first screening included an evaluation of their effectiveness and implementability. Based on this evaluation, a determination was made whether to retain the options for development of alternatives for detailed analysis. The second screening is presented in Tables 3.5A, B, and C.

3.5.3 Retained Technologies and Process Options

In situ technologies proposed for the various media include thermally enhanced vapor extraction, bioremediation, chemical oxidation, and chemical reduction. Potential thermally-enhanced vapor extraction methods include electrical resistive heating (ERH) and steam heating. Bioremediation technologies included hydrogen injection and hydrogen release compound (HRC®). Chemical oxidation technologies focused on persulfate based processes including those that are enhanced with surfactants as this chemical oxidation technology is identified as most appropriate for the site characteristics (high permeability soil and bedrock fractures) and the presence of DNAPL. Persulfate is a strong oxidant with a higher oxidation potential than hydrogen peroxide and a potentially lower soil oxidant demand than permanganate or peroxide. Chemical reduction technologies evaluated were emulsified zero valent iron (eZVI) processes.

3.5.3.1 Soils

The retained options for soil remediation are as follows:

- No action,
- Asphalt or concrete cap (required only for Area A-1, Areas A-2 and A-3 already have asphalt or concrete surfaces),
- Thermally enhanced vapor extraction (only at areas A-2 or A-3 where impacted soils are deeper),
- *In situ* chemical oxidation (only at areas A-2 or A-3 where impacted soils are deeper), and
- *In situ* chemical reduction (only at areas A-2 or A-3 where impacted soils are deeper).

3.5.3.2 Groundwater

The retained options for groundwater remediation are as follows:

- No action,
- Provide an alternate potable water supply and abandon residential wells in areas supplied with potable water,
- Institutional restrictions (already in place),
- Whole-house water treatment units,

- Groundwater monitoring (natural attenuation),
- *In situ* bioremediation (approximately at the southern end of Industrial Drive referred to herein as Area A-4),
- *In situ* chemical oxidation (Area A-4), and
- *In situ* chemical reduction (Area A-4).

3.5.3.3 DNAPL

The retained options for DNAPL remediation are as follows:

- No action,
- Institutional restrictions (for groundwater use, already in place),
- DNAPL monitoring,
- Capping,
- Thermally enhanced vapor extraction,
- *In situ* chemical oxidation, and
- *In situ* chemical reduction.

3.5.3.4 Sanitary Sewers and Adjacent Soils

The sanitary sewer manhole MH-407 will be cleaned out after the DNAPL source area is remediated to the east of the manhole.

3.5.3.5 Sediment and Surface water

The observed impacts in the surface water will be treated through natural attenuation. As the groundwater concentrations are reduced over time, the COPC concentrations in the surface water are also expected to decline.

SECTION 4
DEVELOPMENT OF ALTERNATIVES

4.1 DEVELOPMENT OF ALTERNATIVES

Prior to screening, alternatives were assembled primarily on medium-specific considerations and implementability concerns. Few details of the individual process options were identified, and the sizing requirements of technologies or remediation timeframes were only briefly evaluated.

In assembling alternatives, general response actions and the process options chosen to represent the various technologies for each medium are combined to form alternatives for the site as a whole. The assembled range of alternatives is presented in Table 4.1.

4.2 ALTERNATIVES THAT WARRANT DETAILED EVALUATION

Results of the screening process presented in Section 3 indicated that the following remedial alternatives warranted further evaluation.

1. No Action (required by guidance document). Alternative 1 would not involve any remedial actions, and the site would remain in its present condition. This alternative, required by the National Contingency Plan and CERCLA, is a baseline alternative against which the effectiveness of the other alternatives can be compared. Under the no action alternative, the site is left "as is" and no funds would be expended for monitoring, control, or cleanup. No additional maintenance or monitoring of the 4 existing whole-house treatment units would be included. However, a 5-year review of the site would be required under CERCLA.

2a. An asphalt or concrete cap would be placed over the impacted soil area north and west of the former Kellwood facility (A-1). The other areas with impacted soil are already under an asphalt road (A-2) or under a building (A-3). The A-1 area cap would also function as a cap for the DNAPL impacts in the source area. Institutional restrictions (September 2002 MDNR water well installation advisory and a subsequent amendment) currently exist to control the use of groundwater from the shallow aquifers where the groundwater is impacted. Residences with groundwater impacted with a COPC above the MCL would be provided with whole-house water treatment units. Groundwater monitoring would occur to monitor the changes in concentration over time. DNAPL recovery would continue in existing wells north of the former Kellwood facility.

2b. An asphalt or concrete cap would be placed over the impacted soil area north and west of the former Kellwood facility (A-1). The other areas with impacted soil are already under an asphalt road (A-2) or under a building (A-3). The A-1 area cap would also function as a cap for the DNAPL impacts in the source area. Institutional restrictions (September 2002 MDNR water well installation advisory and a subsequent amendment) currently exist over the entire Site to control the use of groundwater from the shallow aquifers where the groundwater is impacted. Potable water lines would be installed to provide potable water from an alternative water supply to residences. Groundwater monitoring would occur to monitor the changes in concentration over time. The source area and potable water wells would be monitored for impacts of DNAPL into the potable water wells. The existing residential water supply wells will be abandoned at residences connected to the alternative water system. DNAPL recovery would continue in existing wells north of the former Kellwood facility.

3a. The impacted soil in the area north and west of the former Kellwood facility (A-1) would be left in place and be allowed to remediate by natural attenuation. Thermally-enhanced vapor extraction would be conducted in the source area to remediate the DNAPL in area A-1. The other areas with impacted soil are already under an asphalt road (A-2) or under a building (A-3). Institutional restrictions (September 2002 MDNR water well installation advisory and a subsequent amendment) currently exist over the entire Site to control the use of groundwater from the shallow aquifers where the groundwater is impacted. Residences with groundwater impacted with a COPC above the MCL would be provided with whole-house water treatment units. Groundwater monitoring would occur to monitor the changes in concentration over time.

3b. The impacted soil in the area north and west of the former Kellwood facility (A-1) would be left in place and be allowed to remediate by natural attenuation. Thermally-enhanced vapor extraction would be conducted in the source area to remediate the DNAPL in area A-1. The other areas with impacted soil are already under an asphalt road (A-2) or under a building (A-3). Institutional restrictions (September 2002 MDNR water well installation advisory and a subsequent amendment) currently exist over the entire Site to control the use of groundwater from the shallow aquifers where the groundwater is impacted. Potable water lines would be installed to provide potable water from an alternative water supply to residences. Groundwater monitoring would occur to monitor the changes in concentration over time. The existing residential water supply wells will be abandoned at residences connected to the alternative water system.

4a. The impacted soil in the area north and west of the former Kellwood facility (A-1) would be left in place and be allowed to remediate by natural attenuation. The impacted soil from the area under the road (A-2) and under the building (A-3) would be treated by thermally-enhanced vapor extraction. Institutional restrictions (September 2002 MDNR water well installation advisory and a subsequent amendment) currently exist over the entire Site to control the use of groundwater from the shallow aquifers where the groundwater is impacted. Residences with groundwater impacted with a COPC above the MCL would be provided with whole-house water treatment units. Groundwater monitoring would occur to monitor the changes in concentration over time. Thermally-enhanced vapor extraction would be conducted in the source area to remediate the DNAPL. A line of treatment wells would be installed at the southern end of Industrial Drive (A-4). Treatment of the groundwater in the overburden and the top of the bedrock would be conducted by bioremediation.

4b. The impacted soil in the area north and west of the former Kellwood facility (A-1) would be left in place and be allowed to remediate by natural attenuation. The impacted soil from the area under the road (A-2) and under the building (A-3) would be treated by thermally-enhanced vapor extraction. Institutional restrictions (September 2002 MDNR water well installation advisory and a subsequent amendment) currently exist over the entire Site to control the use of groundwater from the shallow aquifers where the groundwater is impacted. Residences with groundwater impacted with a COPC above the MCL would be provided with whole-house water treatment units. Groundwater monitoring would occur to monitor the changes in concentration over time. Thermally-enhanced vapor extraction would be conducted in the source area to remediate the DNAPL. A line of treatment wells would be installed at the southern end of Industrial Drive (A-4). Treatment of the groundwater in the overburden and the top of the bedrock would be conducted by in situ chemical oxidation.

4c. The impacted soil in the area north and west of the former Kellwood facility (A-1) would be left in place and be allowed to remediate by natural attenuation. The impacted soil from the area under the road (A-2) and under the building (A-3) would be treated by thermally-enhanced vapor extraction. Institutional restrictions (September 2002 MDNR water well installation advisory and a subsequent amendment) currently exist over the entire Site to control the use of groundwater from the shallow aquifers where the groundwater is impacted. Residences with groundwater impacted with a COPC above the MCL would be provided with whole-house water treatment units. Groundwater monitoring would occur to monitor the changes in concentration over time. Thermally-enhanced vapor extraction would be conducted in the source area to remediate the

DNAPL. A line of treatment wells would be installed at the southern end of Industrial Drive (A-4). Treatment of the groundwater in the overburden and the top of the bedrock would be conducted by *in situ* chemical reduction.

5. The impacted soil in the area north and west of the former Kellwood facility (A-1) would be left in place and allowed to remediate by natural attenuation. The impacted soil from the area under the road (A-2) and under the building (A-3) would be treated by *in situ* chemical oxidation. Institutional restrictions (September 2002 MDNR water well installation advisory and a subsequent amendment) currently exist over the entire Site to control the use of groundwater from the shallow aquifers where the groundwater is impacted. Residences with groundwater impacted with a COPC above the MCL would be provided with whole-house water treatment units. Groundwater monitoring would occur to monitor the changes in concentration over time. The source area would be treated using chemical oxidation to reduce the concentrations in the groundwater and to reduce the DNAPL mass. The source area and potable water wells would be monitored for impacts of DNAPL into the potable water wells.

6. The impacted soil in the area north and west of the former Kellwood facility (A-1) would be left in place and allowed to remediate by natural attenuation. The impacted soil from the area under the road (A-2) and under the building (A-3) would be treated by *in situ* chemical reduction. Institutional restrictions (September 2002 MDNR water well installation advisory and a subsequent amendment) currently exist over the entire Site to control the use of groundwater from the shallow aquifers where the groundwater is impacted. Residences with groundwater impacted with a COPC above the MCL would be provided with whole-house water treatment units. Groundwater monitoring would occur to monitor the changes in concentration over time. The source area would be treated using chemical reduction to reduce the concentrations in the groundwater and to reduce the DNAPL mass.

SECTION 5
DETAILED ANALYSIS OF ALTERNATIVES

5.1 INTRODUCTION

The detailed analysis of alternatives consists of the analysis and presentation of the relevant information needed to allow decision makers to select a site remedy. During the detailed analysis, each alternative is assessed against the evaluation criteria described below. The results of this assessment are arrayed in Table 5.1 to compare the alternatives.

This approach to analyzing alternatives is designed to provide decision makers with sufficient information to adequately compare the alternatives, select an appropriate remedy, and demonstrate satisfaction of the CERCLA remedy selection requirements in the Record of Decision (ROD).

The specific statutory requirements for remedial actions that must be addressed in the ROD and supported by the FS report are listed below. Remedial actions must:

- Be protective of human health and the environment,
- Attain ARARs (or provide grounds for invoking a waiver),
- Be cost-effective,
- Utilize permanent solutions and alternative treatment technologies or resource recovery technologies to the maximum extent practicable, and
- Satisfy the preference for treatment that reduces toxicity, mobility, or volume as a principal element or provide an explanation in the ROD as to why it does not.

The EPA is in the process of developing a Superfund Green Remediation Strategy (http://www.epa.gov/superfund/greenremediation/sf-gr-strategy.pdf) to reduce negative environmental impacts that may occur during remediation. EPA has developed Principles for Greener Cleanups (http://www.epa.gov/oswer/greencleanups/principles.html) in addition to the new strategy. The principles call for EPA's cleanup programs to use greener approaches during any phase of site work, and establish the goal of evaluating cleanup actions to ensure protection of human health and the environment while reducing the environmental footprint of cleanup activities, when feasible.

Nine evaluation criteria have been developed to address the requirements and considerations required under CERCLA and to address additional technical and policy considerations that are considered to be important for selecting the remedial alternative are:

1. Overall Protection of Human Health and the Environment – The assessment against this criterion describes how the alternative, as a whole, achieves and maintains protection of human health and the environment.
2. Compliance with Applicable or Relevant and Appropriate Requirements (ARARs) – The assessment against this criterion describes how the alternative complies with ARARs, or if a waiver is required and how it is justified. The assessment also addresses other information from advisories, criteria, and guidance that the lead and support agencies have agreed are "to be considered."
3. Long-term Effectiveness and Permanence – The assessment of alternatives against this criterion evaluates the long-term effectiveness of alternatives in maintaining protection of human health and the environment after response objectives have been met.
4. Reduction of Toxicity, Mobility, and Volume – The assessment against this criterion evaluates the anticipated performance of the specific treatment technologies an alternative may employ.
5. Short-term Effectiveness – The assessment against this criterion examines the effectiveness of alternatives in protecting human health and the environment during the construction and implementation of a remedy until response objectives have been met.
6. Implementability – This assessment evaluates the technical and administrative feasibility of alternatives and the availability of required goods and services.
7. Cost – This assessment evaluates the capital and operation and maintenance (O&M) costs of each alternative.

The final two criteria, State (or support agency) Acceptance and Community Acceptance, will be evaluated after the RI and FS reports have been released to the general public in accordance with the Statement of Work and the proposed plan will be addressed as a final decision is being made and the ROD is being prepared. The criteria are as follows:

8. State Acceptance – This assessment reflects the State's apparent preferences among or concerns about alternatives.
9. Community Acceptance – This assessment reflects the community's apparent preferences among or concerns about alternatives.

An additional criterion, to evaluate the environmental footprint of the alternative, as recommended in the Superfund Green Remediation Strategy and the Principles for Greener Cleanups will be included herein.

Cost estimates for the alternatives are presented in **Appendix B**. Figures showing the proposed alternatives are shown on **Figures 5.1 through 5.3**.

Where used in this document the terms impacted soil or impacted groundwater refer to soil or groundwater with PCE concentrations above the RAOs or to the general extent of areas where the RI indicates that there is soil or groundwater with PCE concentrations above the RAOs.

All of Alternatives 2 through 6 require activities to be conducted on property owned by entities other than Kellwood. This will require coordination and access agreements for conducting the work. The process of getting approval to conduct the RI activities indicate that there may be difficulties in getting access to implement some of the proposed remedies.

5.2 INDIVIDUAL ANALYSIS OF ALTERNATIVES

5.2.1 Alternative 1: No Action

5.2.1.1 Description of Alternative

This alternative provides a baseline for comparing the other alternatives. No remedial actions would be implemented as part of the No Action Alternative. It should be noted; however, that remediation has previously taken place at the source area. Impacted soil was treated by landfarming or was excavated and destroyed off-site by incineration. The State has already instituted well construction restrictions for the area to prohibit the use of impacted groundwater and to protect the deeper aquifer from migration of impacted water through an improperly constructed supply well. Kellwood is currently providing whole-house water treatment units at four residences.

5.2.1.2 Overall Protection of Human Health and the Environment

The risks would be as determined in the baseline risk assessment, with no reduction in risk from this alternative as there would not be any remedial actions implemented. Current potentially unacceptable risk identified for the site is the industrial indoor worker for inhalation of soil or groundwater volatiles in the immediate vicinity of the former Kellwood facility. Under the anticipated future scenarios, the potential exposure pathways of concern are soil ingestion, soil dermal contact, soil inhalation, and soil and groundwater volatilization to indoor air for a future hypothetical resident in OU 2 at the source area (would require a change in zoning for area to allow residential construction) and inhalation of soil or groundwater volatiles for industrial indoor workers. The primary chemical of concern is PCE in soil and shallow groundwater.

The September 2002 MDNR water well installation advisory and a subsequent amendment set drilling and construction standards for water wells and heat pump wells in the area. These regulatory restrictions provide adequate protection against possible exposure to impacted shallow groundwater. Additionally, whole-house water treatment systems (at 4 residences; JS-14, JS-36, JS-38, and JS-52) prevent exposure to impacted deeper groundwater. To further prevent downward migration of impacted shallow groundwater into the deeper aquifer, liners were installed at JS-14, JS-36, and JS-38.

The indoor air risk is hypothetical and has not been confirmed by field measurements of indoor air impacts above the remedial action objective. No direct measurements of indoor air were collected as part of the RI.

5.2.1.3 Compliance with ARARs

As no remedial action is being performed for this Alternative, it does not comply with the applicable chemical specific ARARs for COPCs above target levels.

5.2.1.4 Long-Term Effectiveness and Permanence

This alternative provides no long-term management measures. The soil and groundwater impacts and the DNAPL will degrade and dissipate over time. There are existing whole-house water treatment units at several residences with impacted water wells; this alternative would not include continued maintenance of the water treatment units.

5.2.1.5 Reduction of Toxicity, Mobility, or Volume through Treatment

This alternative provides reduction in toxicity, mobility, or volume of the COPCs solely through natural degradation processes.

5.2.1.6 Short-Term Effectiveness

There would be no additional risks to the community, the workers, or the environment as a result of this alternative being implemented.

5.2.1.7 Implementability

There are no implementability concerns, since no action is being taken for this alternative.

5.2.1.8 Cost

There would be no cost associated with this alternative since no action would be taken.

5.2.1.9 Environmental Footprint

The environmental footprint for this alternative would appear to be small since no action would be taken. However, an alternative that does not satisfy threshold requirements for protectiveness, or does not meet other site specific cleanup objectives, is not considered a greener cleanup.

5.2.2 Alternative 2a: Asphalt or Concrete Cap, Whole-house Treatment Units, Institutional Restrictions, Groundwater Monitoring

5.2.2.1 Description of Alternative

Alternative 2a would consist of the following components:

- An asphalt or concrete cap would be placed over the impacted soil area north and west of the former Kellwood facility (A-1) which would also encompass the DNAPL source area. The other areas with impacted soil are already under an asphalt road (A-2) or under a building (A-3).
- Well construction restrictions (September 2002 MDNR water well installation advisory and a subsequent amendment) are in place for new wells constructed in OU2/OU6, to prevent impacts in the shallow aquifers from migrating to the deeper zones.
- Residences with groundwater supplies with COPC concentrations above the MCLs would be provided with whole-house water treatment units (currently provided at four residences).
- Groundwater monitoring would assess changes in concentration with time.
- The DNAPL area north of the former Kellwood facility (source area) and downgradient potable water wells left in place within the OU2 and OU6 area would be monitored.
- DNAPL recovery would continue in existing wells north of the former Kellwood facility.

5.2.2.2 Overall Protection of Human Health and the Environment

This alternative would provide the required protection to human health and the environment. Provision of a treated water supply would protect against ingestion of water with concentrations above the MCLs. Where there is impacted groundwater above the MCLs in the deep aquifer used for potable water supply, whole-house water treatment units would be supplied to provide protection to human health.

The September 2002 MDNR water well installation advisory and a subsequent amendment set drilling and construction standards for water wells and heat pump wells in the area. These regulatory restrictions provide adequate protection against possible exposure to impacted shallow groundwater. Additionally, whole-house water treatment systems (currently at four residences; JS-14, JS-36, JS-38, and JS-52) prevent exposure to impacted deeper groundwater. To further prevent downward migration of impacted shallow groundwater into the deeper aquifer, liners were installed at JS-14, JS-36, and JS-38.

The caps over the soil areas would protect against incidental ingestion, inhalation, and dermal contact with the impacted soil and with the DNAPL. It would also minimize migration of impacts to the groundwater. The indoor air risk is hypothetical and has not been confirmed by field measurements of indoor air impacts above the remedial action objective and is not addressed in this Alternative. Indoor air may be addressed through monitoring, installation of a venting system of the sub slab, or treatment of the impacts underneath the slab.

There is no exposure to the groundwater in the upper zones above the aquifer used as a drinking water source. Exposure may result from leaking well casings that may act as a conduit from the upper water zones to the deeper aquifer used as a water source. This exposure would be mitigated by periodic monitoring of the wells. Existing wells that have been found to have leaking well casings have been lined.

5.2.2.3 Compliance with ARARs

The provision of whole-house water treatment units at locations where the drinking water is impacted would comply with the requirement for providing a water supply meeting MCLs. The State ARARs would be complied with, with one exception. The requirement of the Missouri Water Quality Standards for groundwater would not be met until natural attenuation reduced the concentration of the COPCs to below the regulatory levels in the limited areas where it has migrated to the lower aquifer. The air and noise related ARARs would be applicable during the installation of the remedy. Compliance with the requirements of these ARARs would be included during preparation of the bid documents.

5.2.2.4 Long-Term Effectiveness and Permanence

Installation of an asphalt or concrete cap would be an effective and permanent solution to provide a barrier to the impacted soil and the DNAPL in the source area. It would also have the benefit of reducing the infiltration of precipitation into groundwater, and a reduction in leaching of COPCs into groundwater. The asphalt or concrete cap would need to be maintained and periodically replaced or repaired.

Provision of whole-house water treatment units would provide an effective clean potable water supply to the residences and businesses in the affected area of OU2 and OU6. The whole-house water treatment units would require periodic maintenance to replace the carbon filtration units. The liners installed in the leaking wells would prevent future potential infiltration of impacted groundwater to lower aquifers. Natural attenuation would occur in the impacted aquifer and the groundwater could, over time, meet regulatory levels.

5.2.2.5 Reduction of Toxicity, Mobility, or Volume through Treatment

Previous remedial activities reduced toxicity and volume through landfarming or the excavation and off-site incineration of impacted soils. Mobility of COPCs would be reduced with construction of the asphalt or concrete cap in the area north and west of the former Kellwood facility. The toxicity and volume would decrease over time as the COPCs are degraded through natural attenuation.

5.2.2.6 Short-Term Effectiveness

Whole-house water treatment units are in place at the residences with a water supply above MCLs, providing an immediate remedy to eliminate current and future human health risk from ingestion of the impacted groundwater. The construction of the asphalt or concrete cap would be immediately effective in eliminating the risk from the impacted soil north and west of the former Kellwood facility. The design and construction process would take approximately six months.

Construction personnel would be at minimal risk in implementing this remedy. There would be no effect on the community risk during implementation of this remedy

5.2.2.7 Implementability

Construction of an asphalt or concrete cap in the area north and west of the former Kellwood facility would require clearing of the area and installation of subgrade material. At a minimum, the cap would be constructed over the area where soil impacts exceed the RAOs and DNAPL is present in the bedrock. The property owner, City of New Haven, may request that the entire site be paved. The Site is just south of a major road in an industrial area that is accustomed to truck traffic. The traffic associated with constructing the cap should not be an issue with the community. A vehicular ramp and an access ramp used by forklifts are within the area to receive the asphalt or concrete cap. Access to the ramps would need to be maintained to allow continued operation of the current manufacturing operations in the former Kellwood facility building.

If additional residences were to require installation of whole-house water treatment units, this would be implementable, based on observed implementability of the current treatment systems.

5.2.2.8 Cost

The estimated construction costs are $570,000 with an estimated design and construction period of six months. The estimate for O&M cost for 30 years based on a 7% interest rate is a present worth of $2,730,000. The estimated total remediation cost is $3,300,000.

The cost for the pre-design investigation, design, and construction oversight are included with the construction costs. An estimated 40 wells would be sampled annually and analyzed for VOCs and monitored natural attenuation (MNA) parameters; however, it is anticipated that over time, this number of wells and frequency will be able to be reduced. DNAPL recovery would continue on a quarterly basis. Quarterly sampling and analysis would occur for the whole-house water treatment units and at City Well No. 3.

5.2.2.9 Environmental Footprint

Recycled asphalt could be utilized in the construction of an asphalt cap. Construction equipment (e.g., trucks, bulldozers, graders, backhoes) will be utilized for construction of the cap. This equipment will result in emission of greenhouse gas during the time required for the construction. The energy requirements for the whole-house water treatment units would be associated with generating and regenerating the activated carbon used in the carbon treatment units. Replacement of the carbon units is expected to be somewhere between two to five years.

5.2.3 Alternative 2b: Asphalt or Concrete Cap, Potable Water Line, Institutional Restrictions, Groundwater Monitoring

5.2.3.1 Description of Alternative

Alternative 2b would consist of the following components:

- An asphalt or concrete cap would be placed over the impacted soil area north and west of the former Kellwood facility (A-1) which would also encompass the DNAPL source area. The other areas with impacted soil are already under an asphalt road (A-2) or under a building (A-3).
- Well construction restrictions (September 2002 MDNR water well installation advisory and a subsequent amendment) are in place to prevent impacts in the shallow aquifers to be carried to the deeper aquifer for any additional wells constructed in OU2/OU6.
- The potable water lines would be installed to provide potable water from the local public water supply system to residences.
- The existing residential potable water wells would need to be abandoned upon connection of the residence to the public water supply. If potable water wells within the impacted area cannot be abandoned, then they would be monitored to evaluate the potential for leakage of impacted groundwater to the lower aquifers. Should any homeowner decline connection to the water line, the associated residential well would be monitored on an annual basis.
- Groundwater monitoring would occur to monitor the changes in concentration over time.
- The DNAPL area north of the former Kellwood facility (source area) and downgradient potable water wells left in place within the OU2 and OU6 area would be monitored as well as City Well No. 3.

5.2.3.2 Overall Protection of Human Health and the Environment

This alternative would provide protection to human health and the environment. The potable water supply would protect against ingestion of water with impacts above the MCLs. The caps over the soil areas would protect against incidental ingestion, inhalation, and dermal contact with the impacted soil and with the DNAPL. It would also minimize migration of impacts to the groundwater. The indoor air risk at the former Kellwood facility is hypothetical and has not been confirmed by field measurements of indoor air impacts above the remedial action objective and is not addressed in this Alternative. Indoor air may be addressed through monitoring, installation of a venting system of the sub slab, or treatment of the impacts underneath the slab.

The groundwater in the unconsolidated materials and the upper sand which are the primary strata containing groundwater with concentrations above the MCLs is isolated from the Jefferson City and Roubidoux zones used as a drinking water source. Exposure may result from leaking well casings that may act as a conduit from the upper water zones to the deeper aquifer used as a water source. This exposure would be mitigated by periodic monitoring of the wells. Existing wells that have been found to have leaking well casings have been lined.

5.2.3.3 Compliance with ARARs

The provision of a public potable water supply will comply with the requirement for providing a water supply meeting MCLs. The State ARARs would be complied with, with one exception. The requirement of the Missouri Water Quality Standards for groundwater would not be met until natural attenuation reduced the concentration of the COPCs to below the regulatory levels in the limited areas where it has migrated to the lower aquifer. The air and noise related ARARs would be applicable during the installation of the remedy. Compliance with the requirements of these ARARs would be included during preparation of the bid documents.

5.2.3.4 Long-Term Effectiveness and Permanence

Installation of an asphalt or concrete cap would be an effective and permanent solution to provide a barrier to the impacted soil and the DNAPL in the source area. It would also have the benefit of reducing the infiltration of precipitation into groundwater, and a reduction in leaching of COPCs into groundwater. The asphalt or concrete cap would need to be maintained and periodically replaced or repaired.

The installation of a public potable water supply would provide a permanent and effective clean potable water supply to the residences and businesses in the affected area of OU2 and OU6 whose groundwater contains COPCs above the MCL. Abandonment of the existing potable water wells in accordance with applicable requirements would prevent future potential infiltration of impacted groundwater to lower aquifers. Natural attenuation would occur in the impacted aquifer and the groundwater would, over time, meet regulatory levels.

5.2.3.5 Reduction of Toxicity, Mobility, or Volume through Treatment

Previous remedial activities reduced toxicity and volume through landfarming or the excavation and off-site incineration of impacted soils. Mobility of COPCs would be reduced with construction of the asphalt or concrete cap in the area north and west of the former Kellwood facility. The toxicity and volume would decrease over time as the COPCs are degraded through natural attenuation.

5.2.3.6 Short-Term Effectiveness

The residences with a water supply above MCLs are already provided with whole-house water treatment units. The installation of an alternate potable water supply would eliminate the current and future human health risk from ingestion of impacted groundwater. The construction of the asphalt or concrete cap would be immediately effective in eliminating the risk from the impacted soil north and west of the former Kellwood facility. The design and construction process for extending the public water supply would require approximately 18 months, assuming no delays in reaching agreement for connection to the public water supply.

Construction personnel would be at minimal risk in implementing this remedy. There would be no effect on the community risk during implementation of this remedy.

5.2.3.7 Implementability

Construction of an asphalt or concrete cap in the area north and west of the former Kellwood facility would require clearing of the area and installation of subgrade material. At a minimum, the cap would be constructed over the area where soil impacts exceed the RAOs and DNAPL is present in the bedrock. The property owner, City of New Haven, may request that the entire site be paved. The Site is just south of a major road in an industrial area that is accustomed to truck traffic. The traffic associated with constructing the cap should not be an issue with the community. A vehicular ramp and an access ramp used by forklifts are within the area to receive the asphalt or concrete cap. Access to the ramps would need to be maintained to allow continued operation of the current manufacturing operations in the former Kellwood facility building.

Extending the existing water mains, negotiating and connecting the residences to the new water supply is implementable. This would, however, require substantial effort to (1) obtain approval for installation of the water mains, (2) connect to the public water system, and (3) work with the home owners to obtain an agreement for connection of the water system. The water mains could be installed in the road right-of-ways along Highway C, Boeuf-Lutheran Road, and Wildcat Creek Lane and along property easements past the end of Wildcat Creek Lane to Boeuf-Lutheran Road, but these will need to be negotiated with the local municipality and homeowners during the design. Some homeowners may be reluctant to have their existing water wells abandoned.

5.2.3.8 Cost

The estimated construction costs are $3,304,000 with an estimated design and construction period of 18 months. The estimate for O&M cost for 30 years based on a 7% interest rate is a present worth of $2,189,000. The estimated total remediation cost is $5,493,000.

The cost for the pre-design investigation, design, and construction oversight are included with the construction costs. An estimated 40 wells would be sampled annually and analyzed for VOCs and MNA parameters. It is anticipated, however, that over time, the number of wells and frequency of sampling will be reduced. DNAPL recovery would continue on a quarterly basis. Quarterly sampling and analysis would occur for the whole-house water treatment units and at City Well No. 3 until the water main is installed and connected, and will be ongoing at City Well No. 3.

5.2.3.9 Environmental Footprint

Recycled asphalt could be utilized in the construction of an asphalt cap. The material required to provide a graded sub-base may be obtained from the excavations for installation of the extended water mains. Construction equipment (e.g., trucks, bulldozers, graders, backhoes) will be utilized for construction of the cap and the water mains. This equipment will result in emission of greenhouse gas during the time required for the construction. The energy requirements for the individual water wells would be greater than the energy requirements for providing the water from the city water system.

5.2.4 Alternative 3a: Thermally-Enhanced Vapor Extraction for DNAPL, Whole-house Treatment Units, Institutional Restrictions, Groundwater Monitoring

5.2.4.1 Description of Alternative

Alternative 3a would consist of the following components:

- The impacted soil in the area north and west of the former Kellwood facility (A-1) would be left in place and be allowed to remediate by natural attenuation. This soil was not shown to be a risk except for a hypothetical residential scenario which would require a change in zoning to be applicable. The other areas with impacted soil are already under an asphalt road (A-2) or under a building (A-3).
- Well construction restrictions (September 2002 MDNR water well installation advisory and a subsequent amendment) are in place for new wells constructed in OU2/OU6, to prevent impacts in the shallow aquifers migrating to the deeper zones.
- Groundwater monitoring would assess changes in concentration with time.

- Thermally-enhanced vapor extraction would be conducted in the source area to a depth of approximately 20 feet to remediate the DNAPL.
- Residences with groundwater supplies with COPC concentrations above the MCLs would be provided with whole-house water treatment units (currently provided at four residences).

Different techniques may be employed to apply heat *in situ* to impacted soil or bedrock. The heat can destroy or volatilize organic chemicals. As the chemicals change into gases, their mobility increases, and the gases can be extracted via vapor extraction wells for capture and cleanup in an *aboveground* treatment unit located onsite. Heat can be introduced to the subsurface by electrical resistance heating, radio frequency heating, dynamic underground stripping, thermal conduction, or injection of hot water, hot air, or steam. This evaluation of thermally-enhanced vapor extraction will be based on the processes of electrical resistive heating.

The electrical resistive heating process typically consists of co-located electrodes and recovery wells spaced approximately 15 to 20 feet apart. This technology uses the heat generated by the resistance of the soil or bedrock matrix to the flow of electrical current to raise subsurface temperatures *up to the boiling point of water.* The VOCs transition to the vapor phase and are captured by a vapor recovery system.

5.2.4.2 Overall Protection of Human Health and the Environment

This alternative would provide protection to human health and the environment. Provision of a treated water supply would protect against ingestion of water with concentrations above the MCLs. Where there is impacted groundwater above the MCLs in the deep aquifer used for potable water supply, whole-house water treatment units are supplied to provide protection to human health.

The September 2002 MDNR water well installation advisory and a subsequent amendment set drilling and construction standards for water wells and heat pump wells in the area. These regulatory restrictions provide adequate protection against possible exposure to impacted shallow groundwater. Additionally, whole-house water treatment systems (currently at 4 residences; JS-14, JS-36, JS-38, and JS-52) prevent exposure to any impacted deeper groundwater. To further prevent downward migration of impacted shallow groundwater into the deeper aquifer, liners were installed at JS-14, JS-36, and JS-38.

DNAPL treatment north of the former Kellwood facility (in area A-1) would facilitate source reduction. Additionally, DNAPL treatment would minimize migration of COPCs to groundwater. This treatment would also be expected to reduce COPC concentrations in the soil at the soil/bedrock boundary. It would also reduce COPC concentrations in the shallow groundwater, where there is a potential concern for volatilization to indoor air. The existing caps in areas A-2 and A-3 would remove the risk of contacting impacted soil. The exposed soil in the areas north and west of the former Kellwood facility soil area A-1 was not shown to be a risk except for a hypothetical residential scenario.

The groundwater in the unconsolidated materials and the upper sand which are the primary strata containing groundwater with concentrations above the MCLs is isolated from the Jefferson City and Roubidoux zones used as a drinking water source. Exposure may result from leaking well casings that may act as a conduit from the upper water zones to the deeper aquifer used as a water source. This exposure would be mitigated by periodic monitoring of the wells. Existing wells that have been found to have leaking well casings have been lined.

5.2.4.3 Compliance with ARARs

The provision of whole-house water treatment units at locations where the drinking water exceeds the MCLs would comply with the requirement for providing a water supply meeting MCLs. The State ARARs would be complied with, with one exception. The requirement of the Missouri Water Quality Standards for groundwater would not be met until natural attenuation reduced the concentration of the COPCs to below the regulatory levels in the limited areas where it has migrated to the lower aquifer. Source reduction through treatment of DNAPL may expedite this process. The air and noise related ARARs would be applicable during the installation of the remedy. Compliance with the requirements of these ARARs would be included during preparation of the bid documents.

5.2.4.4 Long-Term Effectiveness and Permanence

The thermal treatment would be a permanent solution for the reduction of DNAPL in the source area. The primary concern regarding its effectiveness would be the potential for DNAPL located in bedrock fractures to remain untreated or for DNAPL to not be captured by the vapor extraction system and to migrate downward.

Provision of whole-house water treatment units would provide an effective clean potable water supply to the residences and businesses in the affected area of OU2 and OU6 whose groundwater contains COPCs above the MCL. The whole-house water treatment units would require periodic maintenance to replace the carbon filtration units. The liners installed in the leaking wells would prevent future potential infiltration of impacted groundwater to lower aquifers. Natural attenuation would occur in the impacted aquifer and the groundwater could, over time, meet regulatory levels.

5.2.4.5 Reduction of Toxicity, Mobility, or Volume through Treatment

Previous remedial activities reduced toxicity and volume through landfarming or the excavation and off-site incineration of impacted soils. The volume of media containing COPCs would be further reduced in the DNAPL and groundwater areas at OU2 as a result of the treatment of the DNAPL source. The impacted groundwater would be reduced through natural attenuation, and would benefit from the reduced source material volume. The DNAPL removed by the thermal treatment would be treated in a granular activated carbon treatment vessel located onsite. Mobility of COPCs may decline due to the decreased mass. The vapor extraction system needs to be designed to minimize the potential for migration of DNAPL lower in the aquifer and to maximize the potential that the DNAPL is vaporized and collected. Source reduction and natural attenuation would in turn reduce toxicity over time.

5.2.4.6 Short-Term Effectiveness

Remediation of the DNAPL source area would require up to one year. Installation of the thermal treatment wells would require 80 days prior to start of the remediation system. The residences with a water supply with concentrations above MCLs are already provided with whole-house water treatment units.

Construction personnel would be at minimal risk in implementing this remedy. There would be no effect on the community risk during implementation of this remedy. Thermal treatment would require high voltage power supply. The treatment system, specifically the high voltage power source, would need to be protected from trespassers.

5.2.4.7 Implementability

Implementability concerns associated with the thermal treatment process include the following items.

- The thermal treatment process requires a high voltage power supply. As the Site is in an industrial park setting, the cost estimate is based on this power service being available.
- The installation in the area north and west of the building may be above grade except where it may interfere with vehicular traffic, which would require underground installation. This would only be in a small area near the building where an access ramp is located.

If additional residences were to require installation of whole-house water treatment units, this would be implementable, based on observed implementability of the current treatment systems.

5.2.4.8 Cost

The estimated construction costs are $2,172,000 with an estimated design and construction period of 18 months for the thermal treatment system. The estimate for O&M cost for 30 years based on a 7% interest rate is a present worth of $2,482,000. The estimated total remediation cost is $4,654,000.

The cost for the pre-design investigation, design, and construction oversight are included with the construction costs. An estimated 40 wells would be sampled annually and analyzed for VOCs and MNA parameters; however it is anticipated that over time, this number of wells and frequency will be able to be reduced.

Quarterly sampling and analysis would occur for the whole-house water treatment units and at City Well No. 3.

5.2.4.9 Environmental Footprint

This alternative would have a relatively large environmental footprint due to the power requirements for the thermal treatment system. Construction equipment (e.g., trucks, bulldozers, drill rigs) will be utilized for construction of the treatment system wells. This construction equipment will result in emission of greenhouse gas during the time required for the construction. The energy requirements for the whole-house water treatment units are associated with generating and regenerating the activated carbon used in the carbon treatment units. Replacement of the carbon units is expected to be required every two to five years.

5.2.5 Alternative 3b: Thermally-Enhanced Vapor Extraction for DNAPL, Potable Water Line, Institutional Restrictions, Groundwater Monitoring

5.2.5.1 Description of Alternative

Alternative 3b would consist of the following components:

- The impacted soil in the area north and west of the former Kellwood facility (A-1) would be left in place and be allowed to remediate by natural attenuation. This soil was not shown to be a risk except for a hypothetical residential scenario which would require a change in zoning. The other areas with impacted soil are already under an asphalt road (A-2) or under a building (A-3).
- Well construction restrictions (September 2002 MDNR water well installation advisory and a subsequent amendment) are in place for new wells constructed in OU2/OU6, to prevent impacts in the shallow aquifers migrating to the deeper zones.
- Groundwater monitoring would assess changes in concentration with time.
- Thermally-enhanced vapor extraction would be conducted in the source area to a depth of approximately 20 feet to remediate the DNAPL.
- Existing water lines would be extended to provide potable water from the local public water supply system to existing residences south of OU2 and within OU6. The potable water line would have sufficient capacity to serve new developments within the OU6 area.
- The existing residential potable water wells would need to be abandoned upon connection of the residence to the public water supply. If potable water wells within the impacted area cannot be

abandoned, then they would be monitored to evaluate the potential for leakage of impacted groundwater to the lower aquifers. Should any homeowner decline connection to the water line, the associated residential well would be monitored on an annual basis.

As with Alternative 3a, this evaluation of thermally-enhanced vapor extraction will be based on the processes of electrical resistive heating.

5.2.5.2 Overall Protection of Human Health and the Environment

This alternative would provide protection to human health and the environment. The potable water supply would protect against ingestion of water with concentrations above the MCLs.

DNAPL treatment north of the former Kellwood facility (in area A-1) would facilitate source reduction. Additionally, DNAPL treatment would minimize migration of COPCs to groundwater. This treatment would also be expected to reduce COPC concentrations in the soil at the soil/bedrock boundary. It would also reduce COPC concentrations in the shallow groundwater, where there is a potential concern for volatilization to indoor air. The existing caps in areas A-2 and A-3 would remove the risk of contacting impacted soil. The exposed soil in the areas north and west of the former Kellwood facility soil area A-1 was not shown to be a risk except for a hypothetical residential scenario.

The groundwater in the unconsolidated materials and the upper sand which are the primary strata containing groundwater with concentrations above the MCLs is isolated from the Jefferson City and Roubidoux zones used as a drinking water source. Exposure may result from leaking well casings that may act as a conduit from the upper water zones to the deeper aquifer used as a water source. This exposure would be mitigated by periodic monitoring of the wells. Existing wells that have been found to have leaking well casings have been lined.

5.2.5.3 Compliance with ARARs

The provision of a public potable water supply will comply with the requirement for providing a water supply meeting MCLs. The State ARARs would be complied with, with one exception. The requirement of the Missouri Water Quality Standards for groundwater would not be met until natural attenuation reduced the concentration of the COPCs to below the regulatory levels in the limited areas where it has migrated to the lower aquifer. However, source reduction through DNAPL treatment may expedite this process. The air and noise related ARARs would be applicable during the installation of the remedy. Compliance with the requirements of these ARARs would be included during preparation of the bid documents.

5.2.5.4 Long-Term Effectiveness and Permanence

The thermal treatment would be a permanent solution for the reduction of DNAPL in the source area. The primary concern regarding its effectiveness would be the potential for DNAPL located in bedrock fractures to remain untreated or for DNAPL to not be captured by the vapor extraction system and to migrate downward.

The installation of a public potable water supply would provide a permanent and effective clean potable water supply to the residences and businesses in the affected area of OU2 and OU6 whose groundwater contains COPCs above the MCL. Abandonment of the existing potable water wells in accordance with applicable requirements would prevent future potential infiltration of impacted groundwater to lower aquifers. Natural attenuation would occur in the impacted aquifer and the groundwater could, over time, meet regulatory levels.

5.2.5.5 Reduction of Toxicity, Mobility, or Volume through Treatment

Previous remedial activities reduced toxicity and volume through landfarming or the excavation and off-site incineration of impacted soils. The volume of media containing COPCs would be further reduced in the DNAPL and groundwater areas at OU2 as a result of the treatment of the DNAPL source. The impacted groundwater would be reduced through natural attenuation, and would benefit from the reduced source material volume. The DNAPL removed by the thermal treatment would be treated in a granular activated carbon treatment vessel located onsite. Mobility of COPCs may decline due to the decreased mass. The vapor extraction system needs to be designed to minimize the potential for migration of DNAPL lower in the aquifer and to maximize the potential that the DNAPL is vaporized and collected. Source reduction and natural attenuation would in turn reduce toxicity over time.

5.2.5.6 Short-Term Effectiveness

Remediation of the DNAPL source area would require up to one year. Installation of the treatment wells would require 80 days prior to start of the remediation system. The residences with a water supply with concentrations above MCLs are already provided with whole-house water treatment units. The installation of a public potable water supply would provide an alternate remedy to eliminate the current and future human health risk from ingestion of the impacted groundwater. The design and construction process for the public water system would take approximately 18 months based on no delays in reaching agreement for connection to the public water supply.

Construction personnel would be at minimal risk in implementing this remedy. There would be no effect on the community risk during implementation of this remedy. Thermal treatment would require high voltage power supply. The treatment system, specifically the high voltage power source, would need to be protected from trespassers.

5.2.5.7 Implementability

Implementability concerns associated with the thermal treatment process include the following.

- The thermal treatment process requires a high voltage power supply. As the Site is in an industrial park setting, the cost estimate is based on this power service being available.
- The installation in the area north and west of the building may be above grade except where it may interfere with vehicular traffic, which would require underground installation. This would only be in a small area near the building where an access ramp is located.

Extending the existing water mains, negotiating and connecting the residences to the new water supply is implementable. This would, however, require substantial effort to (1) obtain approval for installation of the water mains, (2) connecting to the public water system, and (3) work with the home owners to obtain an agreement for connection of the water system. The water mains could be installed in the road right-of-ways along Highway C, Boeuf-Lutheran Road, and Wildcat Creek Lane and along property easements past the end of Wildcat Creek Lane to Boeuf-Lutheran Road, but these will need to be negotiated with the local municipality and homeowners during the design. Some homeowners may be reluctant to have their existing water wells abandoned.

5.2.5.8 Cost

The estimated construction costs are $4,953,000 with an estimated design and construction period of 18 months for the thermal treatment system and water system installation. The estimate for O&M cost for 30 years based on a 7% interest rate is a present worth of $1,941,000. The estimated total remediation cost is $6,894,000.

The cost for the pre-design investigation, design, and construction oversight are included with the construction costs. An estimated 40 wells would be sampled annually and analyzed for VOCs and MNA parameters. It is, however, anticipated that over time, the number of wells and frequency of sampling will be reduced. Quarterly sampling and analysis would occur for the whole-house water treatment units and at City Well No. 3 until the water main is installed and connected and will be ongoing at City Well No. 3.

5.2.5.9 Environmental Footprint

This alternative would have a relatively large environmental footprint due to the power requirements for the thermal treatment system. Construction equipment (e.g., trucks, bulldozers, graders, backhoes) will be utilized for construction of the water mains. This equipment will result in emission of greenhouse gas during the time required for the construction. The energy requirements for the individual water wells would be greater than the energy requirements for providing the water from the city water system.

5.2.6 Alternative 4a: Thermally-Enhanced Vapor Extraction for Soil and DNAPL, Bioremediation for Groundwater, Institutional Restrictions, Groundwater Monitoring

5.2.6.1 Description of Alternative

Alternative 4a would consist of the following components:

- The impacted soil in the area north and west of the former Kellwood facility (A-1) would be left in place and be allowed to remediate by natural attenuation. This soil was not shown to be a risk except for a hypothetical residential scenario which would require a change of zoning to be applicable. The other areas with impacted soil are already under an asphalt road (A-2) or under a building (A-3).
- Well construction restrictions (September 2002 MDNR water well installation advisory and a subsequent amendment) are in place for new wells constructed in OU2/OU6, to prevent impacts in the shallow aquifers migrating to the deeper zones.
- Groundwater monitoring would assess changes in concentration with time.
- Thermally-enhanced vapor extraction would be conducted in the source area to a depth of approximately 20 feet to remediate the DNAPL.
- Residences with groundwater supplies with COPC concentrations above the MCLs would be provided with whole-house water treatment units (currently provided at four residences).
- A line of treatment wells would be installed approximately at the southern end of Industrial Drive (see **Figure 5.3**). Treatment of the groundwater in the overburden and the top of the bedrock would be conducted by bioremediation using these treatment wells.
- The source area and potable water wells would be monitored.

As with Alternatives 3a and 3b, this evaluation of thermally-enhanced vapor extraction will be based on the processes of electrical resistive heating.

Bioremediation will be used to provide treatment (in a line of injection wells) for the groundwater in the unconsolidated material at the southern end of Industrial Drive (A-4). Depending on site conditions, slow-release or fast-release hydrogen compounds can be used as substrates for biostimulation. Slow release substrates, such as oils (e.g., vegetable oil) and commercially produced Hydrogen Release Compound (HRC®), are relatively insoluble and produce low concentrations of hydrogen. A process for direct injection of hydrogen gas has also been developed.

Reductive dechlorination not achieved after biostimulation may indicate a lack of reductive dechlorinators, and the site may require bioaugmentation (adding dechlorinating bacteria). Bioaugmentation is not necessary at all sites.

The bioremediation processes that will be focused on in this FS will be (1) hydrogen gas injection preceded by an injection of emulsified vegetable oil or (2)) use of HRC®. For the purpose of this FS, it will be assumed that bioaugmentation will be required.

The emulsified vegetable oil injection would establish a reductive dechlorination treatment zone. The hydrogen gas injection system would then maintain the treatment zone as long as necessary with continuous delivery of additional hydrogen. Hydrogen would be supplied by a hydrogen gas generator or canisters of pressurized hydrogen gas.

Treatability testing and/or pilot testing will be required to determine the required spacing for injection wells, the injection rate of the vegetable oil and hydrogen gas, and the type of bioaugmentation required.

5.2.6.2 Overall Protection of Human Health and the Environment

Treatment of the soil in areas A-2 and A-3 would remove the risk of contacting impacted soil, and would eliminate or minimize the potential for soil vapor to enter the building. The soil in the areas north and west of the former Kellwood facility (soil area A-1) was not shown to be a risk except for a hypothetical residential scenario. DNAPL treatment north of the former Kellwood facility (in area A-1) would facilitate source reduction. Additionally, DNAPL treatment would minimize migration of COPCs to groundwater. This treatment would also be expected to reduce COPC concentrations in the soil at the soil/bedrock boundary. It would also reduce COPC concentrations in the shallow groundwater, where there is a potential concern for volatilization to indoor air. Impacted groundwater in the unconsolidated material at the southern end of Industrial Drive will be treated to limit the continued southerly migration of impacted groundwater. Where there is groundwater above the MCLs in the deep aquifer used for potable water supply, whole-house water treatment units are supplied to provide protection to human health.

The September 2002 MDNR water well installation advisory and a subsequent amendment set drilling and construction standards for water wells and heat pump wells in the area. These regulatory restrictions provide adequate protection against possible exposure to impacted shallow groundwater. Additionally, whole-house water treatment systems (currently 4 residences; JS-14, JS-36, JS-38, and JS-52) prevent exposure to any impacted deeper groundwater. To further prevent downward migration of impacted shallow groundwater into the deeper aquifer, liners were installed at JS-14, JS-36, and JS-38.

The groundwater in the unconsolidated materials and the upper sand which are the primary strata containing groundwater with concentrations above the MCLs is isolated from the Jefferson City and Roubidoux zones used as a drinking water source. Exposure may result from leaking well casings that may act as a conduit from the upper water zones to the deeper aquifer used as a water source. This exposure would be mitigated by periodic monitoring of the wells. Existing wells that have been found to have leaking well casings have been lined.

5.2.6.3 Compliance with ARARs

The provision of whole-house water treatment units at locations where the drinking water exceeds the MCLs would comply with the requirement for providing a water supply meeting MCLs. The State ARARs would be complied with, with one exception. The requirement of the Missouri Water Quality Standards for groundwater would not be met until natural attenuation reduced the concentration of the COPCs to below the regulatory levels in the limited areas where it has migrated to the lower aquifers. Source reduction through treatment of DNAPL may expedite this process. The air and noise related ARARs would be applicable during the installation and operation of the remedy, specifically if a hydrogen gas generator is used. Compliance with the requirements of these ARARs would be included during preparation of the bid documents.

5.2.6.4 Long-Term Effectiveness and Permanence

The thermal treatment would be a permanent solution for the reduction of DNAPL in the source area and for treating the impacted soil. The primary concern regarding its effectiveness would be the potential for DNAPL located in bedrock fractures to remain untreated or for DNAPL to not be captured by the vapor extraction system and to migrate downward.

The groundwater treatment zone should be effective in reducing the concentrations of impacted groundwater moving towards OU6 in the unconsolidated material. The treatment zone would be operated as long as it is effective in reducing the mass of COPCs and towards achieving the remediation goals or until the treatment is of limited effectiveness. The modifications made to wells with leaking casings, whole-house water treatment units, and the restrictions for installing new wells would protect residents from the impacted groundwater.

Provision of whole-house water treatment units would provide an effective clean potable water supply to the residences and businesses in the affected area of OU2 and OU6 whose groundwater contains COPCs above the MCLs. The whole-house water treatment units would require periodic maintenance to replace the carbon filtration units. Natural attenuation would occur in the impacted aquifer and the groundwater could, over time, meet regulatory levels.

5.2.6.5 Reduction of Toxicity, Mobility, or Volume through Treatment

Previous remedial activities have reduced toxicity and volume through landfarming or the excavation and off-site incineration of impacted soils. The mass of COPCs would be further reduced in the soil, DNAPL, and groundwater areas at OU2. The impacted groundwater would be reduced through natural attenuation where present within OU2 and OU6. The DNAPL removed by the thermal treatment would be treated in a granular activated carbon treatment vessel located onsite. The groundwater that is treated would convert the PCE to the harmless by-product, ethene, through the anaerobic process of biologically mediated reductive dechlorination. If the bioremediation process gets stalled at some point, increased concentrations of the intermediate degradation compounds TCE, 1,2-DCE, or VC could be present in the groundwater.

5.2.6.6 Short-Term Effectiveness

Remediation of the DNAPL and soil areas would take up to 1 year. Installation of the treatment wells could take 180 working days prior to start of the remediation system. Remediation within the groundwater treatment zone would continue until groundwater moving through the area achieves RAOs or there is limited effectiveness of the remediation system. This could be at least five years. The residences in OU6 that are on whole-house water treatment systems would continue to utilize these treatment systems unless the groundwater source for the residences is below MCLs.

Construction personnel would be at minimal risk in implementing this remedy. The groundwater bioremediation system may require working with pressurized gas (hydrogen). Thermal treatment may require high voltage power supply.

There would be limited effect on the community risk during implementation of this remedy. The treatment systems, specifically the high voltage power source for the thermal treatment and the hydrogen gas supply for the groundwater bioremediation system, would need to be protected from trespassers. If tampered with, the compressed hydrogen gas could become a safety hazard if there was a sudden uncontrolled release of the pressurized gas.

5.2.6.7 Implementability

Implementability concerns associated with the thermal treatment process include the following items.

- The underground utilities within the road may need to be relocated if they cannot sustain the thermal treatment temperatures. The relocation of utilities would require coordination and approval of several utility companies and the municipality. This work would interfere with traffic on Industrial Drive.
- The work within the building would need to be coordinated to minimize the impact to the MetalCraft operation.
- The thermal treatment process requires a high voltage power supply. As the Site is in an industrial park setting, the cost estimate is based on this power service being available.
- The installations would need to be all below grade for the work within Industrial Drive and within the building. The installation in the area

north and west of the building may be above grade except where it may interfere with vehicular traffic, which would require underground installation. This would only be in a small area near the building where an access ramp is located. The below grade work would take longer to install and would require temporary shutdown or limited traffic on Industrial Drive.

Implementability concerns associated with the groundwater bioremediation process include the following items.

- The area to be treated crosses Industrial Drive, just north of the intersection of Industrial Drive and Hellmann Drive. This route provides an alternate entrance to the Henniges Automotive (former GDX) facility from the entrance off of Highway C. If needed, this route could be closed during installation of the injection wells. The injection well covers within the roadway and associated piping could be placed below grade in this area.
- The location of the injection wells would need to be coordinated with the overhead power line in the vicinity.
- The hydrogen gas would be provided by compressed gas cylinders of hydrogen which would need to be maintained and replaced periodically. Alternatively, the hydrogen gas could be supplied with an on-site portable hydrogen generator which would provide a continuous supply of hydrogen gas. A hydrogen generator would require a supply of water and electricity, both of which should be readily available.

5.2.6.8 Cost

The estimated construction costs are $6,152,000 with an estimated design and construction period of 24 months for the thermal treatment system and an additional 4 years of remediation for the groundwater bioremediation system. The estimate for O&M cost for 30 years based on a 7% interest rate is a present worth of $2,810,000. The estimated total remediation cost is $8,962,000.

The cost for the pre-design investigation, design, and construction oversight are included with the construction costs. An estimated 40 wells would be sampled annually and analyzed for VOCs and MNA parameters; however it is anticipated that over time, this number of wells and frequency will be able to be reduced. DNAPL recovery would continue on a quarterly basis. Quarterly sampling and analysis would occur for the whole-house water treatment units and at City Well No. 3.

5.2.6.9 Environmental Footprint

This alternative would have a relatively large environmental footprint due to the power requirements for the thermal treatment system. The groundwater bioremediation system operation would have a relatively low environmental footprint with only minimal impact from injection of the emulsified vegetable oil and continuous injection of hydrogen gas. Installation of the injection well system would have the greatest environmental footprint within this alternative, with the materials and energy used for installation of wells on 10-foot centers across the length of the treatment zone.

5.2.7 Alternative 4b: Thermally-Enhanced Vapor Extraction for Soil and DNAPL, *In Situ* Chemical Oxidation for Groundwater, Institutional Restrictions, Groundwater Monitoring

5.2.7.1 Description of Alternative

Alternative 4b would consist of the following components:

- The impacted soil in the area north and west of the former Kellwood facility (A-1) would be left in place and be allowed to remediate by natural attenuation. This soil was not shown to be a risk except for a hypothetical residential scenario which, to be applicable, would require a change of zoning. The other areas with impacted soil are already under an asphalt road (A-2) or under a building (A-3).
- Well construction restrictions (September 2002 MDNR water well installation advisory and a subsequent amendment) are in place for new wells constructed in OU2/OU6, to prevent impacts in the shallow aquifers migrating to the deeper zones.
- Groundwater monitoring would assess changes in concentration with time.
- Thermally-enhanced vapor extraction would be conducted in the source area to a depth of approximately 20 feet to remediate the DNAPL.
- Residences with groundwater supplies with COPC concentrations above the MCLs would be provided with whole-house water treatment units (currently provided at four residences).
- A line of treatment wells would be installed approximately at the southern end of Industrial Drive. Treatment of the groundwater in the overburden and the top of the bedrock would be conducted by *in situ* chemical oxidation.
- The source area and potable water wells would be monitored.

As with previous thermal treatment alternatives, this evaluation of thermally enhanced vapor extraction will be based on the processes of electrical resistive heating.

In situ chemical oxidation will be used to provide a treatment zone for the groundwater flow through the unconsolidated material at the southern end of Industrial Drive (see **Fig. 5.3**). Chemical oxidation may be accomplished by the injection of persulfate into the groundwater. Multiple injections may be required as the impacted groundwater from the OU2 area moves past the area of injection. The cost estimate is based on re-injection occurring every three months for the term of the chemical oxidation treatment, which is estimated to be five years.

Chemical oxidation typically involves reduction/oxidation (redox) reactions that chemically convert the COPCs to nonhazardous or less toxic compounds that are more stable, less mobile, or inert. Redox reactions involve the transfer of electrons from one compound to another. Specifically, one reactant is oxidized (loses electrons) and one is reduced (gains electrons).

The most commonly used oxidants for in situ chemical oxidation are: hydrogen peroxide and catalyzed hydrogen peroxide (CHP) also referred to as modified Fenton's reagent, ozone, permanganate, persulfate, and activated persulfate. These oxidants are at times enhanced by use of a surfactant. The chemical oxidation process that will be the focus of this FS will be persulfate or activated persulfate with consideration of enhancement with a surfactant.

Treatability testing and/or pilot testing will be required to determine the required spacing for injection wells and the injection rate of the persulfate and activator.

5.2.7.2 Overall Protection of Human Health and the Environment

Treatment of the soil in areas A-2 and A-3 would remove the risk of contacting impacted soil or potential migration of soil vapors into the building. The soil in the areas north and west of the former Kellwood facility soil area A-1 was not shown to be a risk except for a hypothetical residential scenario. DNAPL treatment north of the former Kellwood facility (in area A-1) would facilitate source reduction. Additionally, DNAPL treatment would minimize migration of COPCs to groundwater. This treatment would also be expected to reduce COPC concentrations in the soil at the soil/bedrock boundary. It would also reduce COPC concentrations in the shallow groundwater, where there is a potential concern for volatilization to indoor air. Impacted groundwater in the unconsolidated material at the southern end of Industrial Drive (A-4) will be treated to limit the continued southerly migration of impacted groundwater. Where there is groundwater above the MCLs in the deep aquifer used for potable water supply, whole-house water treatment units are supplied to provide protection to human health.

The September 2002 MDNR water well installation advisory and a subsequent amendment set drilling and construction standards for water wells and heat pump wells in the area. These regulatory restrictions provide adequate protection against possible exposure to impacted shallow groundwater. Additionally, whole-house water treatment systems (currently 4 residences; JS-14, JS-36, JS-38, and JS-52) prevent exposure to any impacted deeper groundwater. To further prevent downward migration of impacted shallow groundwater into the deeper aquifer, liners were installed at JS-14, JS-36, and JS-38.

The groundwater in the unconsolidated materials and the upper sand, which are the primary strata of groundwater containing concentrations above the MCLs, is isolated from the Jefferson City and Roubidoux zones used as a drinking water source. Exposure may result from leaking well casings that may act as a conduit from the upper water zones to the deeper aquifer used as a water source. This exposure would be mitigated by periodic monitoring of the wells. Existing wells that have been found to have leaking well casings have been lined.

5.2.7.3 Compliance with ARARs

The provision of whole-house water treatment units at locations where the drinking water exceeds the MCLs would comply with the requirement for providing a water supply meeting MCLs. The State ARARs would be complied with, with one exception. The requirement of the Missouri Water Quality Standards for groundwater would not be met until natural attenuation reduced the concentration of the COPCs to below the regulatory levels in the limited areas where it has migrated to the lower aquifers. Source reduction through treatment of DNAPL may expedite this process. The air and noise related ARARs would be applicable during the installation and operation of the remedy. Compliance with the requirements of these ARARs would be included during preparation of the bid documents.

5.2.7.4 Long-Term Effectiveness and Permanence

The thermal treatment would be a permanent solution for the reduction of DNAPL in the source area and for treating the impacted soil. The primary concern regarding its effectiveness would be the potential for DNAPL located in bedrock fractures to remain untreated or for DNAPL to not be captured by the vapor extraction system and to migrate downward.

The groundwater treatment zone should be effective in reducing the concentrations of impacted groundwater moving towards OU6 in the unconsolidated material. The treatment zone would be operated as long as it is effective in reducing the mass of COPCs and towards achieving the remediation goals (estimated to be three to five years or until the treatment is of limited effectiveness. Multiple injections would be required (estimated to occur quarterly). The modifications made to wells with leaking casings, whole-house water treatment units, and the restrictions for installing new wells would protect residents from the impacted groundwater.

Provision of whole-house water treatment units would provide an effective clean potable water supply to the residences and businesses in the affected area of OU2 and OU6 whose groundwater contains COPCs above the MCL. The whole-house water treatment units would require periodic maintenance to replace the carbon filtration units. Natural attenuation would occur in the impacted aquifer and the groundwater could, over time, meet regulatory levels.

5.2.7.5 Reduction of Toxicity, Mobility, or Volume through Treatment

Previous remedial activities have reduced toxicity and volume through landfarming or the excavation and off-site incineration of impacted soils. The mass of COPCs would be further reduced in the soil, DNAPL, and groundwater areas at OU2. The impacted groundwater would be reduced through natural attenuation within OU2 and OU6. The DNAPL removed by the thermal treatment would be treated in a granular activated carbon treatment vessel located onsite.

The groundwater that is treated would convert the PCE to nontoxic compounds through decomposition reactions that would vary with persulfate concentration, pH, and oxygen concentration. If an insufficient amount of persulfate is injected or the injection does not blanket the entire treatment zone, then the technology will be less effective in reducing the concentrations of the COPCs.

5.2.7.6 Short-Term Effectiveness

Remediation of the DNAPL and soil areas would take up to 1 year. Installation of the treatment wells could take 180 working days prior to start of the remediation system. Remediation within the groundwater treatment zone would continue until groundwater moving through the area achieves RAOs or there is limited effectiveness of the remediation system. Injection of the chemical oxidation chemicals is estimated to be required approximately every three months. The residences in OU6 that are on whole-house water treatment systems would continue to utilize these treatment systems until the groundwater source for the residences is below MCLs.

Construction personnel would be at moderate risk in implementing this remedy. The groundwater *in situ* chemical oxidation system requires working with chemicals that require careful handling. Thermal treatment may require high voltage power supply.

There would be limited effect on the community risk during implementation of this remedy. The treatment systems, specifically the high voltage power source for the thermal treatment, would need to be protected from trespassers.

5.2.7.7 Implementability

Implementability concerns associated with the thermal treatment process include the following items.

- The underground utilities within the road may need to be relocated if they cannot sustain the thermal treatment temperatures. The relocation of utilities would require coordination and approval of several utility companies and the municipality. This work would interfere with traffic on Industrial Drive.
- The work within the building would need to be coordinated to minimize the impact to the MetalCraft operation.

- The thermal treatment process requires a high voltage power supply. As the Site is in an industrial park setting, the cost estimate is based on this power service being available.
- The installations would need to be all below grade for the work within Industrial Drive and within the building. The installation in the area north and west of the building may be above grade except where it may interfere with vehicular traffic, which would require underground installation. This would only be in a small area close to the building where an access ramp is located. The below grade work would take longer to install and would require temporary shutdown or limited traffic on Industrial Drive.

Implementability concerns associated with the groundwater *in situ* chemical oxidation process include the following items.

- The area to be treated crosses Industrial Drive, just north of the intersection of Industrial Drive and Hellmann Drive. This route provides an alternate entrance to the Henniges Automotive (former GDX) facility from the entrance off of Highway C. If needed, this route could be closed during construction of the injection wells. The injection wells within the roadway and associated piping could be placed below grade in this area.
- The location of the injection wells would need to be coordinated with the overhead power line in the vicinity.
- Multiple injections (cost estimate based on quarterly injections for five years) are anticipated to be required due to the size of the plume.

5.2.7.8 Cost

The estimated construction costs are $5,695,000 with an estimated design and construction period of 24 months for the thermal treatment system and an additional 4 years of remediation for the groundwater *in situ* chemical oxidation system. The estimate for O&M cost for 30 years based on a 7% interest rate is a present worth of $2,892,000. The estimated total remediation cost is $8,587,000.

The cost for the pre-design investigation, design, and construction oversight are included with the construction costs. An estimated 40 wells would be sampled annually and analyzed for VOCs and MNA parameters; however it is anticipated that over time, this number of wells and frequency of sampling will be able to be reduced. DNAPL recovery would continue on a quarterly basis. Quarterly sampling and analysis would occur for the whole-house water treatment units and at City Well No. 3.

5.2.7.9 Environmental Footprint

This alternative would have a relatively large environmental footprint due to the power requirements for the thermal treatment system. The groundwater *in situ* chemical oxidation system operation would have a low to moderate environmental footprint due to personnel needing to come to the site multiple times to inject additional persulfate. Installation of the injection well system would have the greatest environmental footprint, with the materials and energy used for installation of wells on 10 foot centers across the length of the treatment zone.

5.2.8 Alternative 4c: Thermally Enhanced Vapor Extraction for Soil and DNAPL, In Situ Chemical Reduction for Groundwater, Institutional Restrictions, Groundwater Monitoring

5.2.8.1 Description of Alternative

Alternative 4c would consist of the following components:

- The impacted soil in the area north and west of the former Kellwood facility (A-1) would be left in place and be allowed to remediate by natural attenuation. This soil was not shown to be a risk except for a hypothetical residential scenario which, to be applicable, would require a change in zoning. The other areas with impacted soil are already under an asphalt road (A-2) or under a building (A-3).
- Well construction restrictions (September 2002 MDNR water well installation advisory and a subsequent amendment) are in place for new wells constructed in OU2/OU6, to prevent impacts in the shallow aquifers migrating to the deeper zones.
- Groundwater monitoring would assess changes in concentration with time.
- Thermally-enhanced vapor extraction would be conducted in the source area to a depth of approximately 20 feet to remediate the DNAPL.
- Residences with groundwater supplies with COPC concentrations above the MCLs would be provided with whole-house water treatment units (currently provided at four residences).
- A line of treatment wells would be installed approximately at the southern end of Industrial Drive. Treatment of the groundwater in the overburden and the top of the bedrock would be conducted by *in situ* chemical reduction.
- The source area and potable water wells would be monitored.

As with previous alternatives, this evaluation of thermally enhanced vapor extraction will be based on the process of electrical resistive heating.

In situ chemical reduction will be used to provide a treatment zone for the groundwater flow through the unconsolidated material at the southern end of Industrial Drive (A-4). Chemical reduction may be accomplished by the injection of emulsified zero valent iron (eZVI) into the groundwater. The eZVI is expected to remain in the soil and interact with the groundwater for up to five years. Encapsulating ZVI in a hydrophobic membrane protects the iron from other ground-water constituents such as inorganics that might otherwise use some of the iron's reducing capacity, and thereby reduces the mass of EZVI available to treat target COPCs and reduces the overall project costs. Additionally, EZVI's vegetable oil and surfactant components enable the material to serve as a long-term electron donor and promote anaerobic biodegradation.

Treatability testing and/or pilot testing will be required to determine the required spacing for injection wells and the injection rate of the eZVI.

5.2.8.2 Overall Protection of Human Health and the Environment

Treatment of the soil in areas A-2 and A-3 would remove the risk of contacting impacted soil or potential soil vapors into the building. The soil in the areas north and west of the former Kellwood facility soil area A-1 was not shown to be a risk except for a hypothetical residential scenario.

DNAPL treatment north of the former Kellwood facility (in area A-1) would facilitate source reduction. Additionally, DNAPL treatment would minimize migration of COPCs to groundwater. This treatment would also be expected to reduce COPC concentrations in the soil at the soil/bedrock boundary. It would also reduce COPC concentrations in the shallow groundwater, where there is a potential concern for volatilization to indoor air. Impacted groundwater in the unconsolidated material at the southern end of Industrial Drive (at Area A-4) will be treated to limit the continued southerly migration of impacted groundwater. Where there is groundwater above the MCLs in the deep aquifer used for potable water supply, whole-house water treatment units are supplied to provide protection to human health.

The September 2002 MDNR water well installation advisory and a subsequent amendment set drilling and construction standards for water wells and heat pump wells in the area. These regulatory restrictions provide adequate protection against possible exposure to impacted shallow groundwater. Additionally, whole-house water treatment systems (currently 4 residences; JS-14, JS-36, JS-38, and JS-52) prevent exposure to any impacted deeper groundwater. To further prevent downward migration of impacted shallow groundwater into the deeper aquifer, liners were installed at JS-14, JS-36, and JS-38.

The groundwater in the unconsolidated materials and the upper sand which is the primary strata containing groundwater with concentrations above the MCLs is isolated from the Jefferson City and Roubidoux zones used as a drinking water source. Exposure may result from leaking well casings that may act as a conduit from the upper water zones to the deeper aquifer used as a water source. This exposure would be mitigated by periodic monitoring of the wells. Existing wells that have been found to have leaking well casings have been lined.

5.2.8.3 Compliance with ARARs

The provision of whole-house water treatment units at locations where the drinking water exceeds the MCLs would comply with the requirement for providing a water supply meeting MCLs. The State ARARs would be complied with, with one exception. The requirement of the Missouri Water Quality Standards for groundwater would not be met until natural attenuation reduced the concentration of the COPCs to below the regulatory levels where it has migrated into the lower aquifers. Source reduction through treatment of DNAPL may expedite this process. The air and noise related ARARs would be applicable during the installation and operation of the remedy. Compliance with the requirements of these ARARs would be included during preparation of the bid documents.

5.2.8.4 Long-Term Effectiveness and Permanence

The thermal treatment would be a permanent solution for the reduction of DNAPL in the source area and for treating the impacted soil. The primary concern regarding its effectiveness would be the potential for DNAPL located in bedrock fractures to remain untreated or for DNAPL to not be captured by the vapor extraction system and to migrate downward.

The groundwater treatment zone should be effective in reducing the concentrations of impacted groundwater moving towards OU6 in the unconsolidated material. The treatment zone would be operated as long as it is effective in reducing the mass of COPCs and towards achieving the remediation goals (estimated to be three to five years or until the treatment is of limited effectiveness. The modifications made to wells with leaking casings, whole-house water treatment units, and the restrictions for installing new wells would protect residents from the impacted groundwater.

Provision of whole-house water treatment units would provide an effective clean potable water supply to the residences and businesses in the affected area of OU2 and OU6 whose groundwater contains COPCs above the MCL. The whole-house water treatment units would require periodic maintenance to replace the carbon filtration units. Natural attenuation would occur in the impacted aquifer and the groundwater could, over time, meet regulatory levels.

5.2.8.5 Reduction of Toxicity, Mobility, or Volume through Treatment

Previous remedial activities have reduced toxicity and volume through landfarming or the excavation and off-site incineration of impacted soils. The mass of COPCs would be further reduced in the soil, DNAPL, and groundwater areas at OU2. The impacted groundwater would be reduced through natural attenuation within OU2 and OU6. The DNAPL removed by the thermal treatment would be treated in a granular activated carbon treatment vessel located onsite.

The groundwater that is treated would convert the PCE to nontoxic compounds through reductive dechlorination reactions. If an insufficient amount of eZVI is injected or the injection does not blanket the entire treatment zone, then the technology will be less effective in reducing the concentrations of the COPCs.

5.2.8.6 Short-Term Effectiveness

Remediation of the DNAPL and soil areas would take up to 1 year. Installation of the groundwater treatment wells could take 180 working days prior to start of the remediation system. Remediation of the groundwater treatment zone would continue until groundwater moving through this area achieves RAOs or there is limited effectiveness of the remediation system, at which time treatment would be terminated. Injection of eZVI is anticipated to only need to be conducted once based on the time frame indicated. Monitoring of the treatment effectiveness and eZVI presence will be required to determine if a second injection is required. The residences in OU6 that are on whole-house water treatment systems would continue to utilize these treatment systems until the groundwater source for the residences is below MCLs.

Construction personnel would be at minor risk in implementing this remedy. The *in situ* chemical reduction system requires working with chemicals that are messy and can stain contact surfaces, but is not toxic. Thermal treatment may require high voltage power supply.

There would be limited effect on the community risk during implementation of this remedy. The treatment systems, specifically the high voltage power source for the thermal treatment, would need to be protected from trespassers.

5.2.8.7 Implementability

Implementability concerns associated with the thermal treatment process include the following items.

- The underground utilities within the road may need to be relocated if they cannot sustain the thermal treatment temperatures. The relocation of utilities would require coordination and approval of several utility companies and the municipality. This work would interfere with traffic on Industrial Drive.
- The work within the building would need to be coordinated to minimize the impact to the MetalCraft operation.
- The thermal treatment process requires a high voltage power supply. As the Site is in an industrial park setting, the cost estimate is based on this power service being available
- The installations would need to be all below grade for the work within Industrial Drive and within the building. The installation in the area north and west of the building may be above grade except where it may interfere with vehicular traffic, which would require underground installation. This would only be in a small area close to the building where an access ramp is located. The below grade work would take

longer to install and would require temporary shutdown or limited traffic on Industrial Drive.

Implementability concerns associated with the groundwater *in situ* chemical reduction process include the following items.

- The area to be treated crosses Industrial Drive, just north of the intersection of Industrial Drive and Hellmann Drive. This route provides an alternate entrance to the Henniges Automotive (former GDX) facility from the entrance off of Highway C. If needed, this route could be closed during construction of the injection wells. The injection wells within the roadway could be placed below grade in this area.
- The location of the injection wells would need to be coordinated with the overhead power line in the vicinity.

5.2.8.8 Cost

The estimated construction costs are $6,478,000 with an estimated design and construction period of 24 months for the thermal treatment system and an additional 4 years of remediation for the groundwater *in situ* chemical reduction system. The estimate for O&M cost for 30 years based on a 7% interest rate is a present worth of $2,687,000. The estimated total remediation cost is $9,165,000.

The cost for the pre-design investigation, design, and construction oversight are included with the construction costs. An estimated 40 wells would be sampled annually and analyzed for VOCs and MNA parameters; however it is anticipated that over time, this number of wells and frequency will be able to be reduced. DNAPL recovery would continue on a quarterly basis. Quarterly sampling and analysis would occur for the whole-house water treatment units and at City Well No. 3.

5.2.8.9 Environmental Footprint

This alternative would have a relatively large environmental footprint due to the power requirements for the thermal treatment system. The groundwater treatment system operation would have a low to moderate environmental footprint due to personnel needing to come to the site only one time to inject eZVI and then to periodically monitor the process. Installation of the injection well system would have the greatest environmental footprint, with the materials and energy used for installation of wells on approximately 10 foot centers across the length of the treatment zone.

5.2.9 Alternative 5: *In Situ* Chemical Oxidation, Institutional Restrictions, Groundwater Monitoring

5.2.9.1 Description of Alternative

Alternative 5 would consist of the following components:

- The impacted soil in the area north and west of the former Kellwood facility (A-1) would be left in place and be allowed to remediate by natural attenuation. This soil was not shown to be a risk except for a hypothetical residential scenario which, to be applicable, would require a change of zoning.
- The impacted soil from the area under the road (A-2) and under the building (A-3) would be treated by *in situ* chemical oxidation.
- The source area would be treated to a depth of approximately 20 feet using chemical oxidation to reduce the DNAPL mass.
- A line of treatment wells would be installed approximately at the southern end of Industrial Drive. Treatment of the groundwater in the overburden and the top of the bedrock would be conducted by *in situ* chemical oxidation.
- Well construction restrictions would be instituted for new wells constructed in OU2/OU6, to prevent impacts in the shallow aquifers migrating to the deeper zones.
- Groundwater monitoring would assess changes in concentration with time.
- Residences with impacted groundwater would be provided with whole-house water treatment units (currently provided at four residences).
- The source area and potable water wells would be monitored.

In situ chemical oxidation may be accomplished by the injection of persulfate. The design of the treatment zone will be as noted for Alternative 4b. Treatability testing and/or pilot testing will be required to determine the required spacing for injection wells and the injection rate of the persulfate and activator.

5.2.9.2 Overall Protection of Human Health and the Environment

Treatment of the soil in areas A-2 and A-3 would remove the risk of contacting impacted soil or potential soil vapors into the building. The soil in the areas north and west of the former Kellwood facility soil area A-1 was not shown to be a risk except for a hypothetical residential scenario. DNAPL treatment north of the former Kellwood facility (in area A-1) would facilitate source reduction. Additionally, DNAPL treatment would minimize migration of COPCs to groundwater. This treatment would also be expected to reduce COPC concentrations in the soil at the soil/bedrock boundary. It would also reduce COPC concentrations in the shallow groundwater, where there is a potential concern for volatilization to indoor air. Impacted groundwater in the unconsolidated material at the southern end of Industrial Drive (Area A-4) will be treated to limit the continued southerly migration of impacted groundwater. Where there is groundwater above the MCLs in the deep aquifer used for potable water supply, whole-house water treatment units are supplied to provide protection to human health.

The September 2002 MDNR water well installation advisory and a subsequent amendment set drilling and construction standards for water wells and heat pump wells in the area. These regulatory restrictions provide adequate protection against possible exposure to impacted shallow groundwater. Additionally, whole-house water treatment systems (currently 4 residences; JS-14, JS-36, JS-38, and JS-52) prevent exposure to any impacted deeper groundwater. To further prevent downward migration of impacted shallow groundwater into the deeper aquifer, liners were installed at JS-14, JS-36, and JS-38.

The groundwater in the unconsolidated materials and the upper sand which is the primary strata containing groundwater with concentrations above the MCLs is isolated from the Jefferson City and Roubidoux zones used as a drinking water source. Exposure may result from leaking well casings that may act as a conduit from the upper water zones to the deeper aquifer used as a water source. This exposure would be mitigated by periodic monitoring of the wells. Existing wells that have been found to have leaking well casings have been lined.

5.2.9.3 Compliance with ARARs

The provision of whole-house water treatment units at locations where the drinking water exceeds the MCLs would comply with the requirement for providing a water supply meeting MCLs. The State ARARs would be complied with, with one exception. The requirement of the Missouri Water Quality Standards for groundwater would not be met until natural attenuation reduced the concentration of the COPCs to below the regulatory levels in the limited areas where it has migrated to the lower aquifers. Source reduction through treatment of DNAPL may expedite this process. The air and noise related ARARs would be applicable during the installation and operation of the remedy. Compliance with the requirements of these ARARs would be included during preparation of the bid documents.

5.2.9.4 Long-Term Effectiveness and Permanence

The *in situ* chemical oxidation treatment would be a permanent solution for the reduction of DNAPL in the source area and for treating the impacted soil. The primary concern regarding its effectiveness would be the potential for DNAPL located in bedrock fractures to remain untreated. Multiple injections may be required to achieve the treatment goals.

The groundwater treatment zone should be effective in reducing the concentrations of impacted groundwater moving towards OU6 in the unconsolidated material. The treatment zone would be operated as long as it is effective in reducing the mass of COPCs and toward achieving the remediation goals (estimated to take three to five years) or until the treatment is of limited effectiveness. Multiple injections would be required (estimated to occur quarterly). The modifications made to wells with leaking casings, whole-house water treatment units, and the restrictions for installing new wells would protect residents from the impacted groundwater.

Provision of whole-house water treatment units would provide an effective clean potable water supply to the residences and businesses in the affected area of OU2 and OU6 whose groundwater contains COPCs above the MCL. The whole-house water treatment units would require periodic maintenance to replace the carbon filtration units. Natural attenuation would occur in the impacted aquifer and the groundwater could, over time, meet regulatory levels.

5.2.9.5 Reduction of Toxicity, Mobility, or Volume through Treatment

Previous remedial activities have reduced toxicity and volume through landfarming or the excavation and off-site incineration of impacted soils. The mass of COPCs would be further reduced in the soil, DNAPL, and groundwater areas at OU2. The impacted groundwater would be reduced through natural attenuation within OU2 and OU6.

The PCE in the soil and groundwater and the DNAPL would be converted to nontoxic compounds through decomposition reactions that would vary with persulfate concentration, pH, and oxygen concentration. If an insufficient amount of persulfate is injected or the injection does not blanket the entire treatment zone (which may be the case in the fractured bedrock in the source area), then the technology will be less effective in reducing the concentrations of the COPCs.

5.2.9.6 Short-Term Effectiveness

Remediation of the DNAPL and soil areas would take up to 1 year. Remediation of the groundwater treatment zone would continue until the groundwater moving through this area achieves RAOs or there is limited effectiveness of the remediation system which could be at least five years unless it is determined sooner that the remediation system's effectiveness is limited. Injection of chemical oxidation chemicals would need to be conducted approximately every three months. The residences in OU6 that are on whole-house water treatment systems would continue to utilize these treatment systems until the groundwater source for the residences is below MCLs.

Construction personnel would be at moderate risk in implementing this remedy. The groundwater in situ chemical oxidation system requires working with chemicals that require careful handling.

There would be no change in the community risk during implementation of this remedy.

5.2.9.7 Implementability

Implementability concerns associated with the treatment process include the following items.

- The work within the building would need to be coordinated to minimize the impact to the MetalCraft operation.
- The installations would need to be all below grade for the work within Industrial Drive and within the building. The installation in the area north and west of the building may be above grade except where it may interfere with vehicular traffic, which would require underground installation. This would only be in a small area close to the building where an access ramp is located. The below grade work would take longer to install and would require temporary shutdown or limited traffic on Industrial Drive.
- The area to be treated crosses Industrial Drive, just north of the intersection of Industrial Drive and Hellmann Drive. This route provides an alternate entrance to the Henniges Automotive (former GDX) facility from the entrance off of Highway C. If needed, this route could be closed during construction of the injection wells. The injection wells within the roadway and associated piping could be placed below grade in this area.
- The location of the injection wells would need to be coordinated with the overhead power line in the vicinity.
- Multiple injections (cost estimate for groundwater based on quarterly injections for five years) are anticipated to be required due to the size of the plume.

5.2.9.8 Cost

The estimated construction costs are $2,308,000 with an estimated design and construction period of 24 months and an additional 4 years of remediation for the groundwater *in situ* chemical oxidation system. The estimate for O&M cost for 30 years based on a 7% interest rate is a present worth of $2,892,000. The estimated total remediation cost is $5,200,000.

The cost for the pre-design investigation, design, and construction oversight are included with the construction costs. An estimated 40 wells would be sampled annually and analyzed for VOCs and MNA parameters; however it is anticipated that over time, this number of wells and frequency will be able to be reduced. DNAPL recovery would continue on a quarterly basis. Quarterly sampling and analysis would occur for the whole-house water treatment units and at City Well No. 3.

5.2.9.9 Environmental Footprint

This alternative would have a low to moderate environmental footprint. The need for multiple injections increases energy use and greenhouse gas emissions. Installation of the injection well system would have the greatest environmental footprint, with the materials and energy used for installation of wells on 10 foot centers across the treatment areas.

5.2.10 Alternative 6: *In Situ* Chemical Reduction, Institutional Restrictions, Groundwater Monitoring

5.2.10.1 Description of Alternative

Alternative 6 would consist of the following components:

- The impacted soil in the area north and west of the former Kellwood facility (A-1) would be left in place and be allowed to remediate by natural attenuation. This soil was not shown to be a risk except for a hypothetical residential scenario which, to be applicable, would require a change in zoning.
- The impacted soil from the area under the road (A-2) and under the building (A-3) would be treated by in situ chemical reduction.
- The source area would be treated to a depth of approximately 20 feet using chemical reduction to reduce the DNAPL mass.
- A line of treatment wells would be installed approximately at the southern end of Industrial Drive. Treatment of the groundwater in the overburden and the top of the bedrock would be conducted by *in situ* chemical reduction (see description in Alternative 4c).
- Well construction restrictions (September 2002 MDNR water well installation advisory and a subsequent amendment) are in place for new wells constructed in OU2/OU6, to prevent impacts in the shallow aquifers migrating to the deeper zones.
- Groundwater monitoring would assess changes in concentration with time.
- Residences with groundwater supplies with COPC concentrations above the MCLs would be provided with whole-house water treatment units (currently provided at four residences).
- The source area and potable water wells would be monitored.

In situ chemical reduction may be accomplished by the injection of eZVI. The design of the treatment zone will be as noted for Alternative 4c. Treatability testing and/or pilot testing will be required to determine the required spacing for injection wells and the injection rate.

5.2.10.2 Overall Protection of Human Health and the Environment

Treatment of the soil in areas A-2 and A-3 would remove the risk of contacting impacted soil or potential soil vapors into the building. The soil in the areas north and west of the former Kellwood facility soil area A-1 was not shown to be a risk except for a hypothetical residential scenario. DNAPL treatment north of the former Kellwood facility (in area A-1) would facilitate source reduction. Additionally, DNAPL treatment would minimize migration of COPCs to groundwater. This treatment would also be expected to reduce COPC concentrations in the soil at the soil/bedrock boundary. It would also reduce COPC concentrations in the shallow groundwater, where there is a potential concern for volatilization to indoor air. Impacted groundwater in the unconsolidated material at the southern end of Industrial Drive (A-4) will be treated to limit the continued southerly migration of impacted groundwater. Where there is groundwater above the MCLs in the deep aquifer used for potable water supply, whole-house water treatment units are supplied to provide protection to human health.

The September 2002 MDNR water well installation advisory and a subsequent amendment set drilling and construction standards for water wells and heat pump wells in the area. These regulatory restrictions provide adequate protection against possible exposure to impacted shallow groundwater. Additionally, whole-house water treatment systems (currently 4 residences; JS-14, JS-36, JS-38, and JS-52) prevent exposure to any impacted deeper groundwater. To further prevent downward migration of impacted shallow groundwater into the deeper aquifer, liners were installed at JS-14, JS-36, and JS-38.

The groundwater in the unconsolidated materials and the upper sand, which are the primary strata of groundwater containing concentrations above the MCLs, is isolated from the Jefferson City and Roubidoux zones used as a drinking water source. Exposure may result from leaking well casings that may act as a conduit from the upper water zones to the deeper aquifer used as a water source. This exposure would be mitigated by periodic monitoring of the wells. Existing wells that have been found to have leaking well casings have been lined.

5.2.10.3 Compliance with ARARs

The provision of whole-house water treatment units at locations where the drinking water exceeds the MCLs would comply with the requirement for providing a water supply meeting MCLs. The State ARARs would be complied with, with one exception. The requirement of the Missouri Water Quality Standards for groundwater would not be met until natural attenuation reduced the concentration of the COPCs to below the regulatory levels where it has migrated into the lower aquifers. Source reduction through treatment of DNAPL may expedite this process. The air and noise related ARARs would be applicable during the installation and operation of the remedy. Compliance with the requirements of these ARARs would be included during preparation of the bid documents.

5.2.10.4 Long-Term Effectiveness and Permanence

The *in situ* chemical reduction treatment would be a permanent solution for the reduction of DNAPL in the source area and for treating the impacted soil. The primary concern regarding its effectiveness would be the potential for DNAPL located in bedrock fractures to remain untreated.

The groundwater treatment zone should be effective in reducing the concentrations of impacted groundwater moving towards OU6 in the unconsolidated material. The treatment zone would be operated as long as it is effective in reducing the mass of COPCs and towards achieving the remediation goals (estimated to be three to five years) or until the treatment is of limited effectiveness. Multiple injections of eZVI are not anticipated to be required. The modifications made to wells with leaking casings, whole-house water treatment units, and the restrictions for installing new wells would protect residents from the impacted groundwater.

Provision of whole-house water treatment units would provide an effective clean potable water supply to the residences and businesses in the affected area of OU2 and OU6 whose groundwater contains COPCs above the MCL. The whole-house water treatment units would require periodic maintenance to replace the carbon filtration units. Natural attenuation would occur in the impacted aquifer and the groundwater could, over time, meet regulatory levels.

5.2.10.5 Reduction of Toxicity, Mobility, or Volume through Treatment

Previous remedial activities have reduced toxicity and volume through landfarming or the excavation and off-site incineration of impacted soils. The mass of COPCs would be further reduced in the soil, DNAPL, and groundwater areas at OU2. The impacted groundwater would be reduced through natural attenuation within OU2 and OU6.

The groundwater that is treated would convert the PCE to nontoxic compounds through chemical reduction reactions. If an insufficient amount of eZVI is injected or the injection does not blanket the entire treatment zone, then the technology will be less effective in reducing the concentrations of the COPCs.

5.2.10.6 Short-Term Effectiveness

Remediation of the DNAPL and soil areas would take up to 1 year. Installation of the treatment wells could take 180 working days prior to start of the remediation system. Remediation of the groundwater treatment zone would continue until the water flowing past this area achieves the RAOs or the remediation system is of limited effectiveness, at which point its operation will be terminated. Operation of the groundwater treatment zone is estimated to be at least five years. Injection of eZVI should need to be conducted only once based on the time frame indicated. Monitoring will be required to determine if a second injection is required. The residences in OU6 that are on whole-house water treatment systems would continue to utilize these treatment systems until monitoring showed that the groundwater source is below the MCLs.

Construction personnel would be at minor risk in implementing this remedy. The groundwater *in situ* chemical reduction system requires working with chemicals that are not toxic but can stain contact surfaces.

There would be no effect on the community risk during implementation of this remedy.

5.2.10.7 Implementability

Implementability concerns associated with the treatment process include the following items.

- The work within the building would need to be coordinated to minimize the impact to the MetalCraft operation.
- The installations would need to be all below grade for the work within Industrial Drive and within the building. The installation in the area north and west of the building may be above grade except where it may interfere with vehicular traffic, which would require underground installation. This would only be in a small area close to the building where an access ramp is located. The below grade work would take longer to install and would require temporary shutdown or limited traffic on Industrial Drive.
- The area to be treated crosses Industrial Drive, just north of the intersection of Industrial Drive and Hellmann Drive. This route provides an alternate entrance to the Henniges Automotive (former GDX) facility from the entrance off of Highway C. If needed, this route could be closed during construction of the injection wells. The injection wells within the roadway and associated piping could be placed below grade in this area.
- The location of the injection wells would need to be coordinated with the overhead power line in the vicinity.

5.2.10.8 Cost

The estimated construction costs are $3,833,000 with an estimated design and construction period of 24 months and an additional 4 years of remediation for the groundwater *in situ* chemical reduction system. The estimate for O&M cost for 30 years based on a 7% interest rate is a present worth of $2,687,000. The estimated total remediation cost is $6,520,000.

The cost for the pre-design investigation, design, and construction oversight are included with the construction costs. An estimated 40 wells would be sampled annually and analyzed for VOCs and MNA parameters; however it is anticipated that over time, this number of wells and frequency of sampling will be able to be reduced. DNAPL recovery would continue on a quarterly basis. Quarterly sampling and analysis would occur for the whole-house water treatment units and at City Well No. 3.

5.2.10.9 Environmental Footprint

This alternative would have a low to moderate environmental footprint due the anticipated one time injection of eZVI followed periodically by monitoring of the process. Installation of the injection well system would have the greatest environmental footprint, with the materials and energy used for installation of wells on approximately 10 to 20 foot centers.

SECTION 6
COMPARATIVE ANALYSIS OF ALTERNATIVES

6.1 INTRODUCTION

The Alternatives evaluated in this FS were evaluated in detail in accordance with the seven evaluation criteria developed to address the requirements and considerations required under CERCLA, and the green remediation strategy under development. They were also evaluated to address additional technical and policy considerations that are considered to be important for selecting the appropriate remedial alternative. The evaluation criteria are listed below:

- Overall Protection of Human Health and the Environment;
- Compliance with Applicable or Relevant and Appropriate Requirements (ARARs);
- Long-term Effectiveness and Permanence;
- Reduction of Toxicity, Mobility, and Volume;
- Short-term Effectiveness;
- Implementability;
- Cost; and
- Environmental Footprint.

The final two CERCLA required criteria, State (or support agency) Acceptance and Community Acceptance, will be evaluated after the RI and FS reports have been released to the general public in accordance with the Statement of Work.

Six alternatives (three of which have multiple variations) for remediation of the Riverfront Superfund Site, OU2/OU6 have been evaluated.

Alternative 1 is not discussed in the following analysis as it does not provide protectiveness or comply with ARARs.

6.2 OVERALL PROTECTION OF HUMAN HEALTH AND THE ENVIRONMENT

Alternatives 2 through 6 are all protective of human health and the environment. The soil direct contact exposure applies only to hypothetical future residences for Area A-1. The exposure to indoor air from soil or groundwater is applicable only to Area A-3 (and A-1 if building were to be expanded). The groundwater in the Jefferson and Roubidoux zone which is the drinking water source for OU2 and OU6 has only isolated locations of exceedances of the RAO which have already been remedied by installation of liners in wells with leaking casings and by provision of whole-house water treatment systems. This drinking water zone is isolated from the upper non-drinking water zones which does have impacts above the RAOs over an extensive area. The cap or DNAPL treatment minimizes the dispersion of DNAPL compounds into the groundwater system. The risk based ecological standards for sediment and surface water are not being exceeded. The risk based ecological standards for surface soil is exceeded at only one isolated location.

6.3 COMPLIANCE WITH ARARS

Alternatives 2 through 6 all provide drinking water meeting the MCLs to the residences in OU2 and OU6. All of Alternatives 2 through 6 are in compliance with ARARs except that the Missouri Water Quality Standards would not be met until natural attenuation took place. Alternatives 3a, 3b, 4a, 4b, 4c, 5, and 6 would improve the groundwater quality in the upper non-drinking water zones sooner due to the treatment of the DNAPL source and for alternatives 4-6 due to the accompanying treatment of groundwater in the unconsolidated material at Area A-4 located at the southern end of Industrial Drive. None of the alternatives, however, are expected to reduce groundwater concentrations in the upper zones (which are not drinking water sources) to drinking water standards throughout the Site, because none of the treatment alternatives will be able to fully reach all of the DNAPL.

6.4 LONG-TERM EFFECTIVENESS AND PERMANENCE

Alternatives 2 through 6 would provide similar long-term effectiveness. Alternatives 2a and 2b which do not include treatment of the source area or of the downgradient upper zone groundwater require ongoing maintenance of the caps to minimize movement of groundwater through the DNAPL at the source area. Alternatives 3a and 3b provide treatment of the DNAPL source area. Alternatives 2b and 3b would provide a permanent alternative water supply but do not provide any groundwater treatment. The DNAPL source treatment method of thermal-enhanced soil vapor extraction selected for Alternatives 3 and 4 is considered to be more effective at removing DNAPL in the source area than the methods proposed in Alternatives 5 and 6. Complete removal is not possible under any of the alternatives due to the nature of DNAPL and its presence in a fractured bedrock geologic setting. All of the Alternatives except for Alternatives 2b and 3b require ongoing operation and maintenance of the whole-house water treatment units at residences with residential well water with concentrations of COPCs exceeding the MCLs. The impacted groundwater is in isolated upper water bearing zones that are not used as a potable water source. In a few locations, the impacted groundwater has migrated through leaking casings at existing wells to the water bearing zone used as a drinking water source. The leaking casings have been repaired by installation of a liner. This issue is also addressed by the September 2002 MDNR water well installation advisory and a subsequent amendment that sets restrictions on the installation of new wells.

6.5 REDUCTION OF TOXICITY, MOBILITY, OR VOLUME THROUGH TREATMENT

Alternatives 2a and 2b provide reduction in toxicity or volume through natural attenuation. The isolation cap over the source area in Alternatives 2a and 2b will also provide a reduction in mobility of the DNAPL in the source area. Alternatives 3a, 3b, 4a, 4b, 4c, 5, and 6 provide a reduction in the toxicity and volume of the DNAPL in the source area. Alternatives 4a, 4b, 4c, 5, and 6 also provide a reduction in the toxicity and volume of the impacted soil underneath the road and underneath the former Kellwood facility, and in the upper groundwater at the treatment zone located at the southern end of Industrial Drive.

Thermal treatment of the DNAPL area is considered to be the most effective alternative, with sole respect to this specific criterion. The chemical oxidation process (Alternative 5) would require a large quantity of oxidant to convert the PCE to the non toxic compound ethene. The chemical reduction process (Alternative 6) would require a large volume of eZVI. Also, these two chemical processes may be less effective in reaching the DNAPL located in the bedrock fractures.

6.6 SHORT-TERM EFFECTIVENESS

Alternatives 2 through 6 provide immediate effectiveness for the groundwater users as there are already whole-house water treatment units in place at the residences with groundwater sources with COPCs above the MCLs. Alternative 2a has the shortest pre-design investigation, design, and implementation time. The implementation time for Alternatives 2b, 3a, and 3b are longer with the addition of installation of water mains and / or DNAPL source treatment. Alternatives 4a through 6, which require installation of treatment wells on 10-foot centers, would require a comparatively longer time than other alternatives. In addition, there may be a need for treatability or pilot studies as part of the pre-design investigation for the biological, in situ chemical oxidation, and in situ chemical reduction processes. Alternatives 3a, 3b, 4a, 4b, and 4c would include the use of high voltage power.

Alternative 4a includes the use of hydrogen (as gas or part of a liquid mixture that will release hydrogen in situ). If a containerized hydrogen gas is utilized, there are safety concerns due to the presence of pressurized gas cylinders.

The oxidizing chemical, sodium persulfate, and the associated activation compound that are part of Alternatives 4b and 5 require careful attention to various aspects of handling and use.

The eZVI material (alternatives 4c and 6) requires careful handling because it can stain surfaces it comes in contact with, but is not toxic.

6.7 IMPLEMENTABILITY

Alternative 2a is the easiest and fastest to implement as it would only require installation of an asphalt or concrete cap over the empty lot north of the former

Kellwood facility. Other elements of this alternative are already in place (whole-house water treatment systems, well construction restrictions, monitoring program). This alternative would be the least intrusive and would be the easiest to obtain access agreements to conduct.

Alternative 2b would in addition to the Alternative 2a remedy components would also require the design and installation of a water distribution system. The design process for the water line and obtaining approval from regulatory agencies could be time-consuming.

Alternatives 3a and 3b require installation of thermal treatment wells in the DNAPL source area, which would be installed on 15 to 20 foot centers for the co-located electrodes and vapor recovery wells. The time for installation of these wells is estimated to be approximately 80 days. The system could be installed with the wells completed above grade except where it would interfere with vehicular traffic just west of the north end of the building. Alternative 3b would also require the design and installation of a water distribution system. Alternative 3a limits the new active remedial activities to the lot owned by the City of New Haven; however the well installation activities and the operation of the remediation system would also require coordination with activities at the MetalCraft facility to ensure minimization of disruptions. Alternative 3b would also require coordination and access agreements for installation of the water mains in addition to approval of the plans for the water system extension.

Alternatives 4a, 4b, 4c, 5, and 6 include installation of treatment wells on approximately 15 to 20 foot-centers for alternatives with the thermal treatment process and 10-foot centers for alternatives using the other treatment processes. The time for installation of these wells is estimated at 180 days. These alternatives include installation of wells in Industrial Drive and in the former Kellwood facility (MetalCraft Facility). The road operation would need to be maintained during the operation of the treatment system. The below grade work would take longer to install and would require temporary shutdown or limited traffic on Industrial Drive.

Alternatives 4a-c potentially require relocation of utilities that are in the road during the heating process, if construction materials are negatively impacted by the heat generation. The relocation of utilities would require coordination and approval of several utility companies and the municipality. This work would interfere with traffic on Industrial Drive. These alternatives also require installation of treatment wells inside of the former Kellwood facility (MetalCraft Facility). This work is estimated to take 10 days for well installation. This work would need to be coordinated to occur at times that would adversely impact the MetalCraft facility operation. The wells within the road and underneath the building would need to be completed flush to grade with required piping below ground. These alternatives would require operation of a groundwater treatment system (periodic injections into wells) in an approximately 700-foot long area near the southern end of Industrial Drive for an estimated period of five years. If required for land use, the system could be primarily installed below grade. The cost estimate is based on only the wells within and immediately adjacent to the road being installed flush with grade.

Alternatives 4a, 4b, 4c, 5, and 6 involve the most extensive and longest remedial activity. These alternatives will be the hardest to obtain approval of the land owners to implement.

6.8 COST

The Alternatives with lowest to highest total cost are as follows:

Alternative	Total Cost
2a: Cap, whole-house treatment units	$3,300,000
3a: Thermal treatment for DNAPL, whole-house treatment units	$4,654,000
5: *In situ* chemical oxidation (source, road, building, and Groundwater), whole-house treatment units	$5,200,000
2b: Cap, potable water line	$5,493,000
6: *In situ* chemical reduction (source, road, building, and groundwater), whole-house treatment units	$6,520,000
3b: Thermal treatment of DNAPL source, potable water line	$6,894,000
4b: Thermal treatment of DNAPL and soil, *in situ* chemical oxidation of groundwater	$8,587,000
4a: Thermal treatment of DNAPL and soil, bioremediation of groundwater	$8,962,000
4c: Thermal treatment of DNAPL and soil, *in situ* chemical reduction of groundwater	$9,165,000

The capital cost for the alternatives from lowest to highest are as follows:

Alternative	Capital Cost
2a: Cap, whole-house treatment units	$ 570,000
3a: Thermal treatment of DNAPL, whole-house treatment units	$2,172,000
5: *In situ* chemical oxidation (source, road, building, and Groundwater), whole-house treatment units	$2,308,000
2b: Cap, potable water line	$3,304,000
6: *In situ* chemical reduction (source, road, building, and groundwater), whole-house treatment units	$3,833,000
3b: Thermal treatment of DNAPL source, potable water line	$4,953,000
4b: Thermal treatment of DNAPL and soil, *in situ* chemical oxidation of groundwater	$5,695,000
4a: Thermal treatment of DNAPL and soil, bioremediation of	$6,152,000

groundwater	
4c: Thermal treatment of DNAPL and soil, *in situ* chemical reduction of groundwater	$6,478,000

The O&M costs have a first year annual cost ranging from approximately $200,000 to $300,000. The O&M Cost total is calculated using the net present worth for 30 years based on a 7 percent discount (from EPA guidance for developing FS cost estimates). The total O&M costs of the alternatives, from lowest to highest, are as follows:

Alternative	OMM Cost
3b: Thermal treatment of DNAPL source, potable water line	$1,191,000
2b: Cap, potable water line	$2,189,000
3a: Thermal treatment of DNAPL source, whole-house treatment units	$2,482,000
6: *In situ* chemical reduction (source, road, building, and groundwater), whole-house treatment units	$2,687,000
4c: Thermal treatment of DNAPL and soil, *in situ* chemical reduction of groundwater	$2,687,000
2a: Cap, whole-house treatment units	$2,730,000
4a: Thermal treatment of DNAPL and soil, bioremediation of groundwater	$2,810,000
5: *In situ* chemical oxidation (source, road, building, and groundwater), whole-house treatment units	$2,892,000
4b: Thermal treatment of DNAPL and soil, *in situ* chemical oxidation of groundwater	$2,892,000

6.9 ENVIRONMENTAL FOOTPRINT

The environmental footprint of the alternatives may be ranked from low to high as follows.

- Alternative 2a
- Alternative 2b
- Alternative 6
- Alternative 5
- Alternative 3a
- Alternative 3b
- Alternative 4c
- Alternative 4a

- Alternative 4b

Alternative 2a has the smallest environmental footprint. The Alternatives with thermal treatment (3a, 3b, 4a, 4b, and 4c) of the source area have high energy usage. Alternatives 4a, b, and c have the highest energy usage because they also include treatment of the soil area under the road and under the building. Alternatives 4a, 4b, 4c, 5, and 6 all involve installation of a large number of treatment wells. Alternatives 3a and 3b also include installation of treatment wells in the DNAPL source area. Alternatives 2b and 3b include addition of an alternative water supply (extended water line from existing source). The installation of this system will require substantial materials for the piping network. The operational footprint (size) of this system, however, is anticipated to be less than the individual wells and the four whole-house treatment systems.

SECTION 7
SUMMARY AND CONCLUSIONS

7.1 SUMMARY

Alternative 2a is the preferred alternative as it meets the requirements for protecting human health and the environment, provides a safe and acceptable drinking water source to affected groundwater users, is the least intrusive, has the lowest costs, would be the easiest to obtain access to implement from the landowners, and has a relatively low environmental footprint.

Alternatives 2a and 2b have a basic containment strategy with the installation of a cap over the area. Removal of DNAPL during the RI at several wells in the area of interest has shown that removal by pumping is not a viable option. During prior remedial activities, a significant quantity of impacted soil was treated by landfarming or was removed and incinerated off-site.

Alternatives 3 through 6 include *in situ* treatment of the DNAPL source area by thermal treatment, chemical oxidation or chemical reduction. Of these three treatment processes, thermal treatment is considered to be the alternative that would be most effective in removing the DNAPL. Thermal treatment does have some concerns that some of the DNAPL would not be captured by the vapor extraction system. The DNAPL is present in fractured bedrock. All three *in situ* treatment methods have some potential for temporarily increasing the mobility of DNAPL during the process. *In situ* chemical oxidation or reduction may have difficulty in reaching DNAPL in the fractures. These two processes will also require a relatively large volume of materials to be injected. None of these alternatives are expected to be able to achieve regulatory groundwater concentration levels for PCE and its byproducts within the entire area of impacted groundwater in the foreseeable future. Reductions will occur, and could reach acceptable levels in certain locations.

Alternatives 2b and 3b include installation of a public water supply system which would be installed in road right-of-ways along Highway C, Boeuf-Lutheran Road, and Wildcat Creek Lane and along obtained property easements past the end of Wildcat Creek Lane to Boeuf-Lutheran Road. Approval to install the water main in the road right of way and in the private property access areas would need to be negotiated with the local municipality and homeowners. Alternatives 2a, 3a, and 4-6 include continued operation of the whole-house treatment units at a number of residences. The costs include provision for ongoing monitoring and maintenance of these treatment systems. There are, however, no provisions for expanding this system to additional residences, as Kellwood is unaware of additional residences with groundwater containing COPCs above the MCLs.

7.2 CONCLUSION – SELECTION OF PREFERRED ALTERNATIVE(S)

Alternative 2a is recommended, as it provides the required protection of human health and the environment. This alternative provides a safe drinking water source for the residences. This alternative requires only approval of the City of New Haven to install the cap over the empty lot and could be implemented without delay. It complies with ARARs to the same extent as the other alternatives. It is effective in both the short and long-term and provides a permanent solution. No additional agreements with residents or the City are required to implement this alternative except for obtaining an agreement with the City of New Haven regarding the paving of the empty lot north of the former Kellwood facility. Minimal construction equipment is required to implement this alternative, and it has the smallest environmental footprint.

Alternatives 3 through 6 provide treatment of the DNAPL, while Alternative 2 provides isolation with a surface cap. The treatment alternatives are not likely to remove all of the DNAPL due to the nature of the DNAPL present in fractured bedrock. Alternatives 4 - 6 include groundwater treatment in a portion of the upper water (non-drinking water) zone. These alternatives will provide some reduction in groundwater concentrations, but will not result in groundwater below the RAOs throughout the treated areas. Alternatives 3(a and b) and 4 (a, b, and c) include thermal treatment which can be damaging to utilities within the treatment zone, depending on their materials of construction. The thermal treatment alternatives are also very expensive to implement. The thermal treatment alternatives have the potential for the vapor extraction system not capturing all of the vaporized DNAPL.

Alternatives 4 through 6 which provide treatment underneath the building or within the roadway will have increased coordination issues making them less preferable. Alternatives 3 through 6 have increasing intrusiveness and difficulty in obtaining access to implement the remedy.

The chemical oxidation alternatives (4b and 5) will require multiple injections of chemicals. The chemical reduction alternatives (4c and 6) are expected to only require a single injection of chemicals. The number of injections and the quantity of chemicals is difficult to evaluate with the information currently available. The DNAPL source treatment method of thermal-enhanced soil vapor extraction selected for Alternatives 3 and 4 is considered to be more effective at removing DNAPL in the source area than the methods proposed in Alternatives 5 and 6. Complete removal is not possible due to the nature of DNAPL and its presence in a fractured bedrock geologic setting.

Alternatives 2b and 3b are dependent upon being able to obtain access for installation of the potable water supply to the residences.

Alternatives 4 through 6 include treatment underneath the road and underneath part of the former Kellwood facility. Access to the building to install the remediation systems will be difficult to obtain and to implement. The thermal remediation in the road will require relocation of utilities which will involve a number of logistical issues. Also the construction will require closure or limited traffic on the road.

Alternative 4 through 6 would require treatability and / or pilot tests be conducted as part of the design. This requirement adds to the cost and time period for implementation of the alternatives.

As stated above, Alternative 2a is recommended, as it would provide the required protection, has fewer logistical issues, a lower environmental footprint, and is more readily implemented relative to other alternatives. This alternative provides a barrier to minimize leaching of surface water through the DNAPL source area and provides treated water for those residences with a water source exceeding MCLs. Many elements of this alternative are already in place including the institutional restrictions on well construction and the provision of whole-house water treatment systems.

SECTION 8
REFERENCES

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VENDORS

ARS Technologies, Inc., http://www.arstechnologies.com/

FMC Environmental Solutions, http://www.envsolutions.fmc.com/Default.aspx

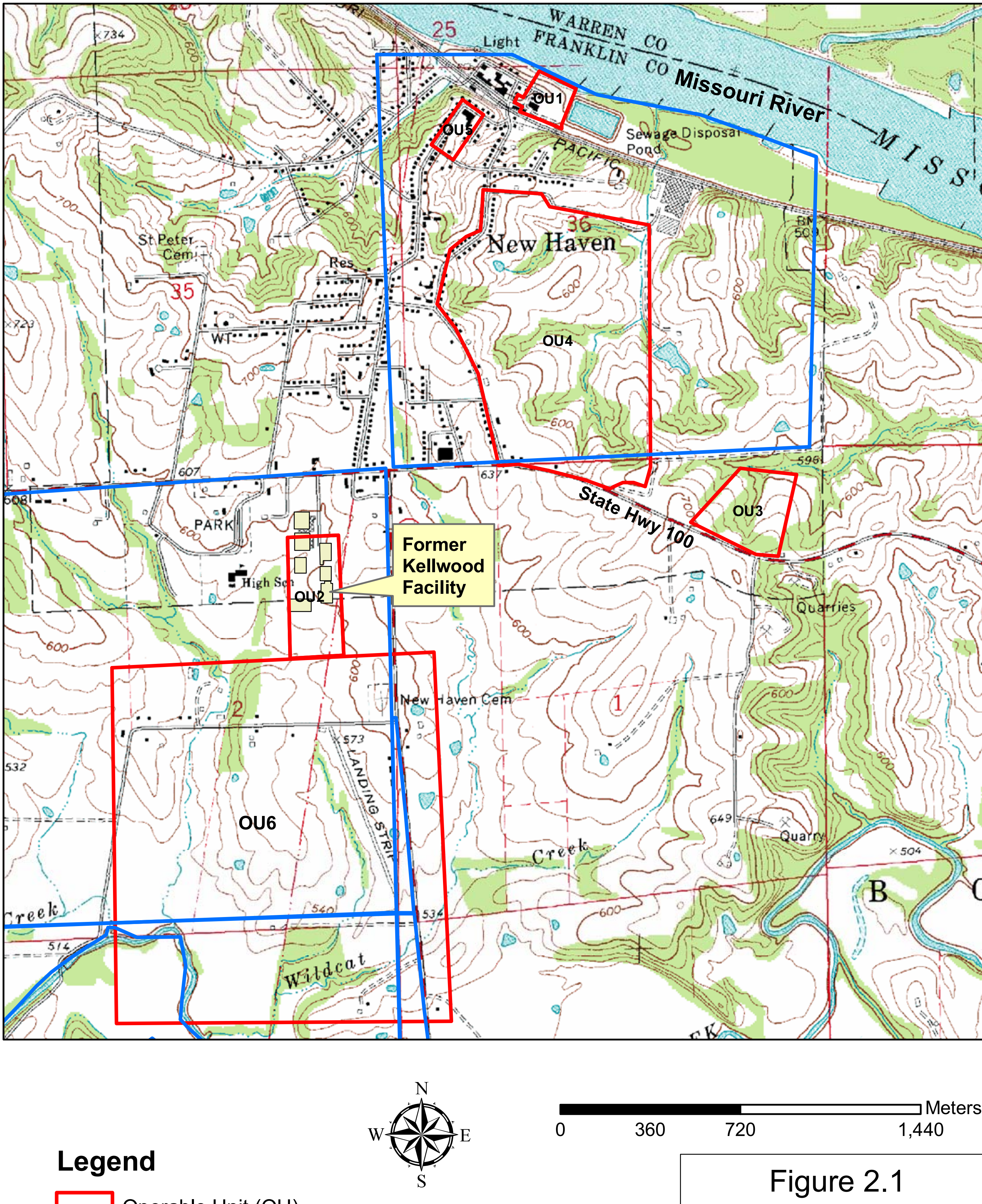
inVentures Technologies Inc., http://www.gasinfusion.com/

TerraTherm, http://terratherm.com/

TRS Group Inc., http://www.thermalrs.com/

Regenesis Advanced Technologies for Contaminated Site Remediation, http://www.regenesis.com/

VeruTEK Technologies, Inc., http://www.verutek.com/



Legend

Operable Unit (OU)

new haven city boundary

Source: OU1/OU3 RI Report (USEPA, 2003)

\\clefs01\Projects\KELLWOOD\\Reports\RI Report\Figures\FS figure 2.1.MXD
9/25/09

Figure 2.1

Site Map

Riverfront Superfund Site OU2/6
New Haven, Missouri

PARSONS

40 LA RIVIERE DRIVE, SUITE 350, BUFFALO, NY 14202

Soil Investigation

DNAPL Investigation

N
W E
S

0 45 90 180 270 360
Feet

□ DNAPL Testing Location

△ Soil Investigation

Figure 2.2a

Site Plan with Remedial Investigation Sampling Locations

Riverfront Superfund Site OU2/6
New Haven, Missouri

PARSONS

40 LA RIVIERE DRIVE, SUITE 350, BUFFALO, NY 14202

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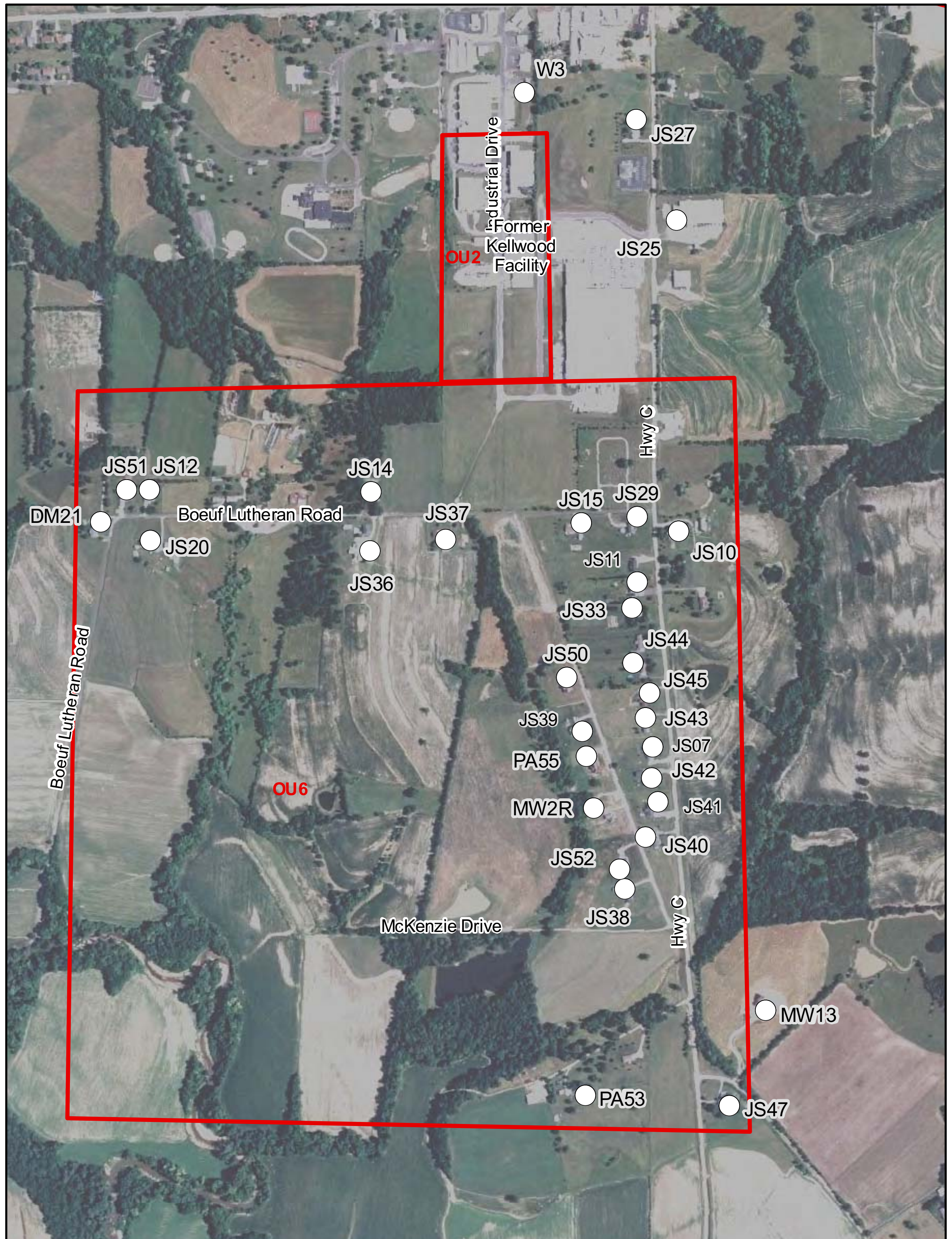
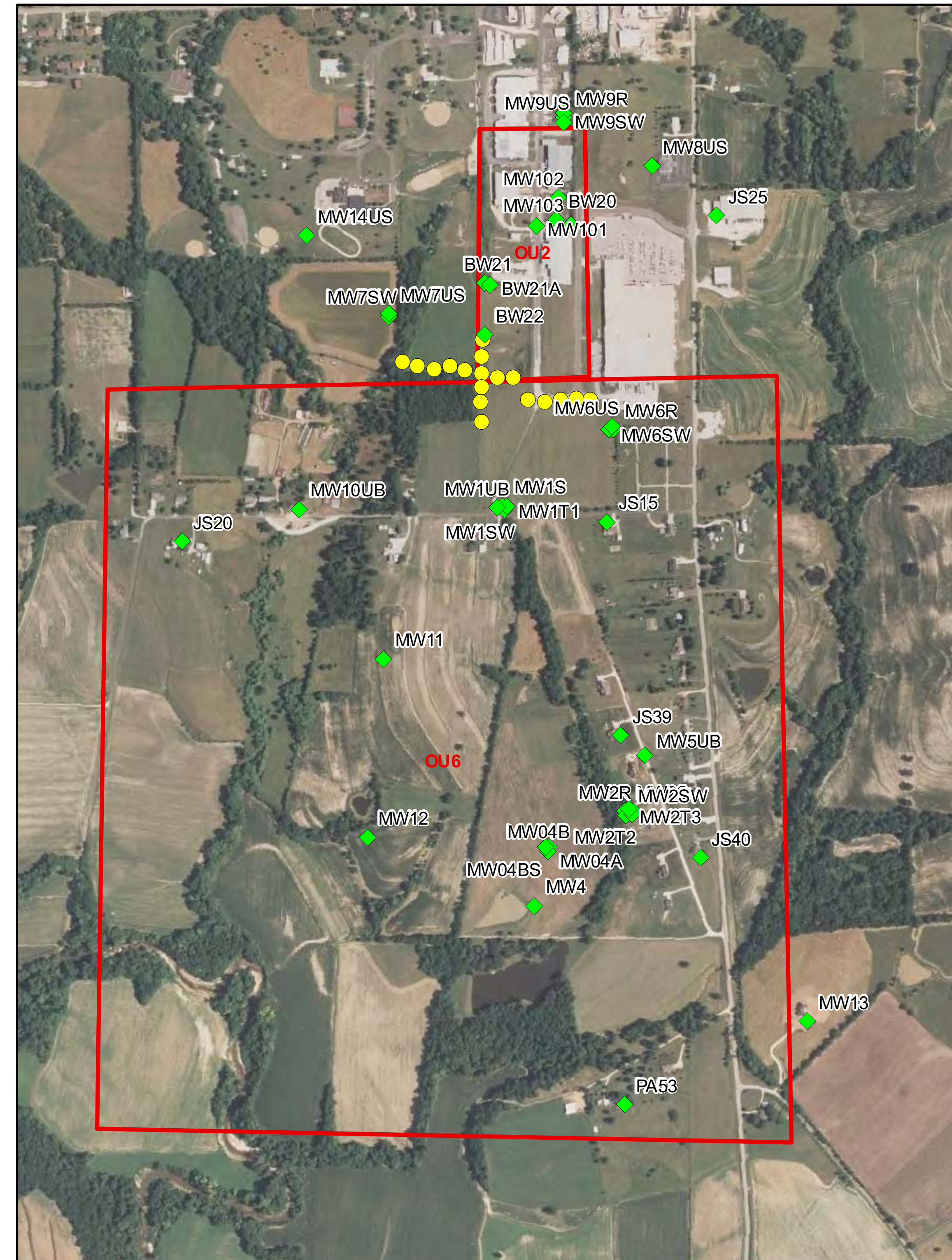


Residential Well Sampling



Groundwater Investigation (Task 2b, 2d, 2e)

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0 470 940 1,880 2,820 3,760 Feet

N
W E
S

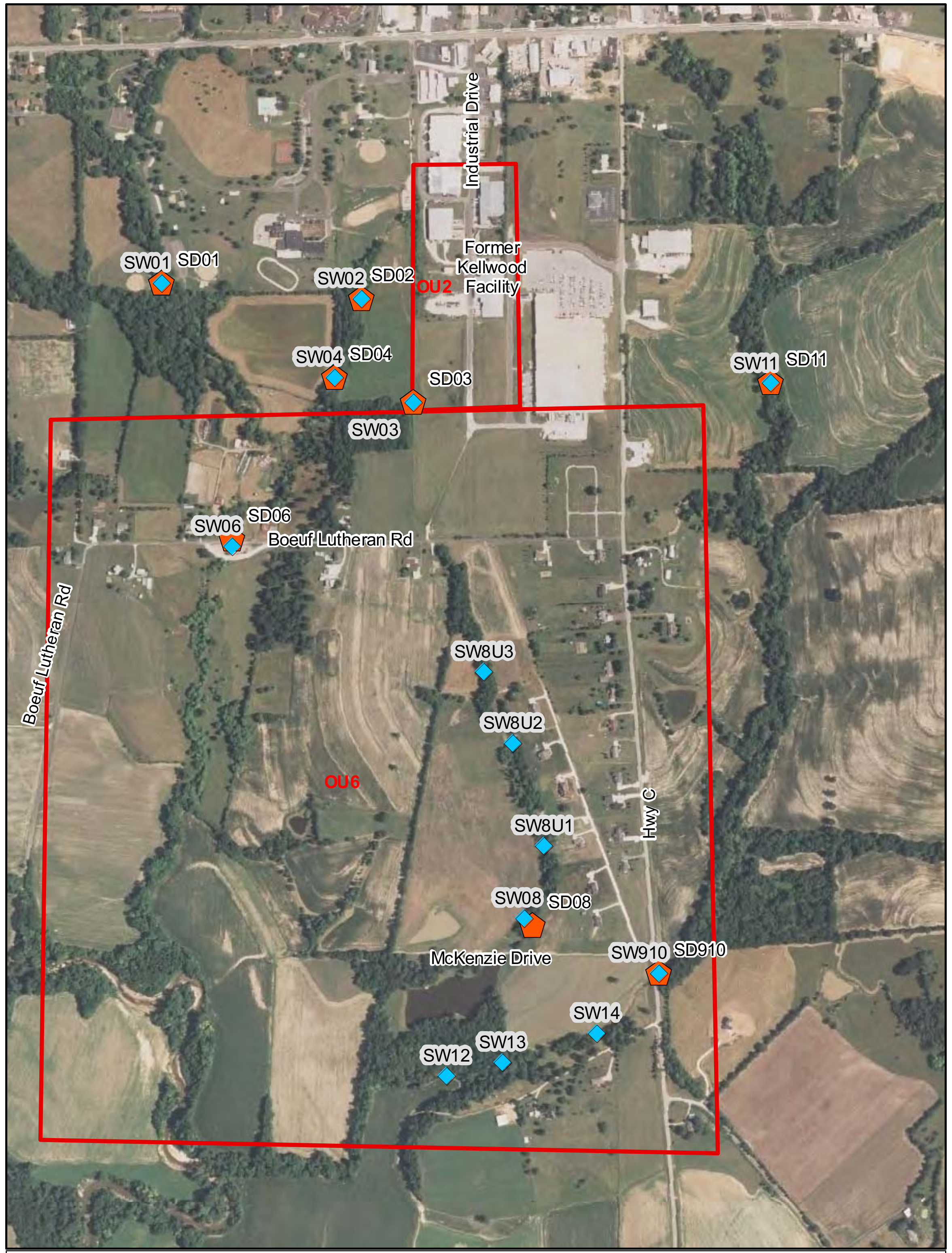
- Task 2b: Direct-push Sampling North of Boeuf Lutheran Road; See Figure 3.3 for details on sample IDs
- Task 2c: Residential Well Sampling
- Task 2d/2e: Monitoring Well Installation and Site-wide Groundwater Sampling

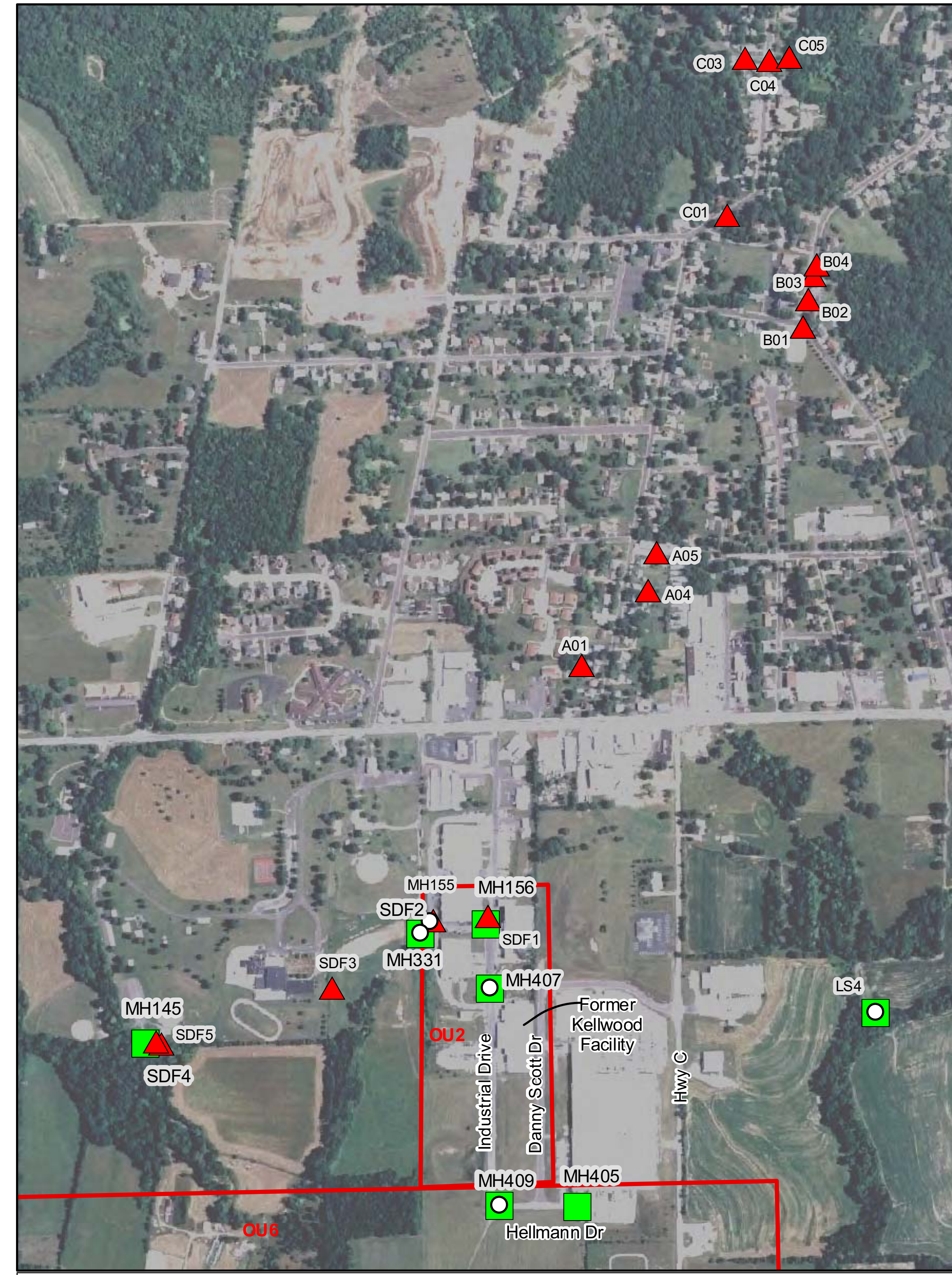
Figure 2.2b

Site Plan with Remedial Investigation Sampling Locations

Riverfront Superfund Site OU2/6
New Haven, Missouri

PARSONS
40 LA RIVIERE DRIVE, SUITE 350, BUFFALO, NY 14202





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Feet
0 370 740 1,480 2,220 2,960

Task 4: Surface Water

Task 4: Sediment

N
W E
S

Feet
0 335 670 1,340 2,010 2,680

Task 5: Sewer Sediment

Task 5: Soil Adjacent to Sewer

Task 5: Sewer Water

Figure 2.2c

Site Plan with Remedial Investigation Sampling Locations

Riverfront Superfund Site OU2/6
New Haven, Missouri

PARSONS
40 LA RIVIERE DRIVE, SUITE 350, BUFFALO, NY 14202

N
W E
S

0 25 50 100 150 200
Feet

Screening Criteria: Missouri Default Target Level for Soil

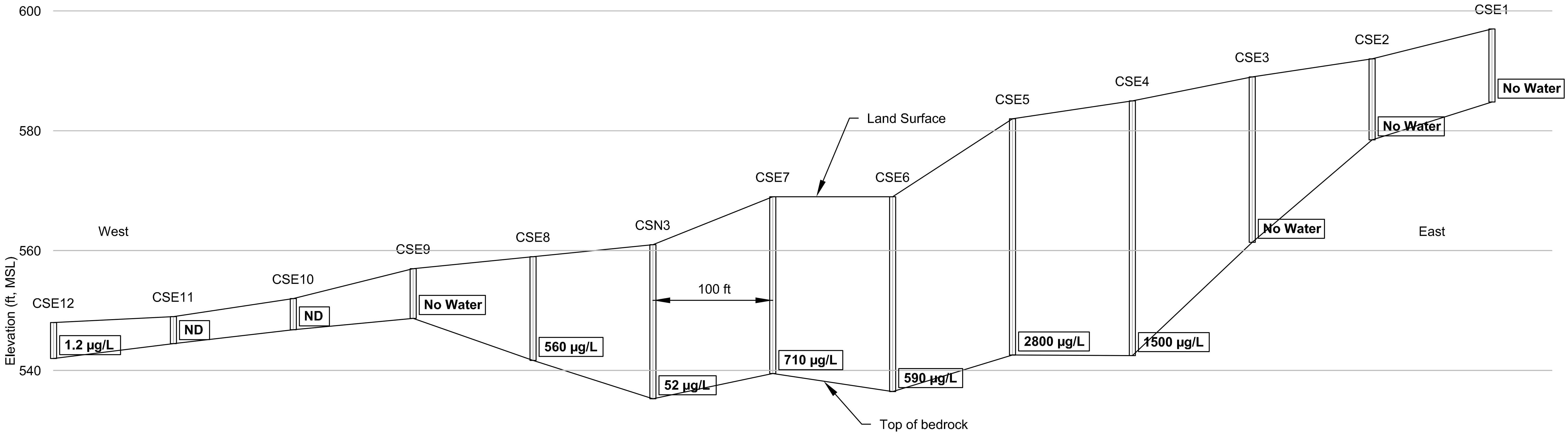
Figure 2.3

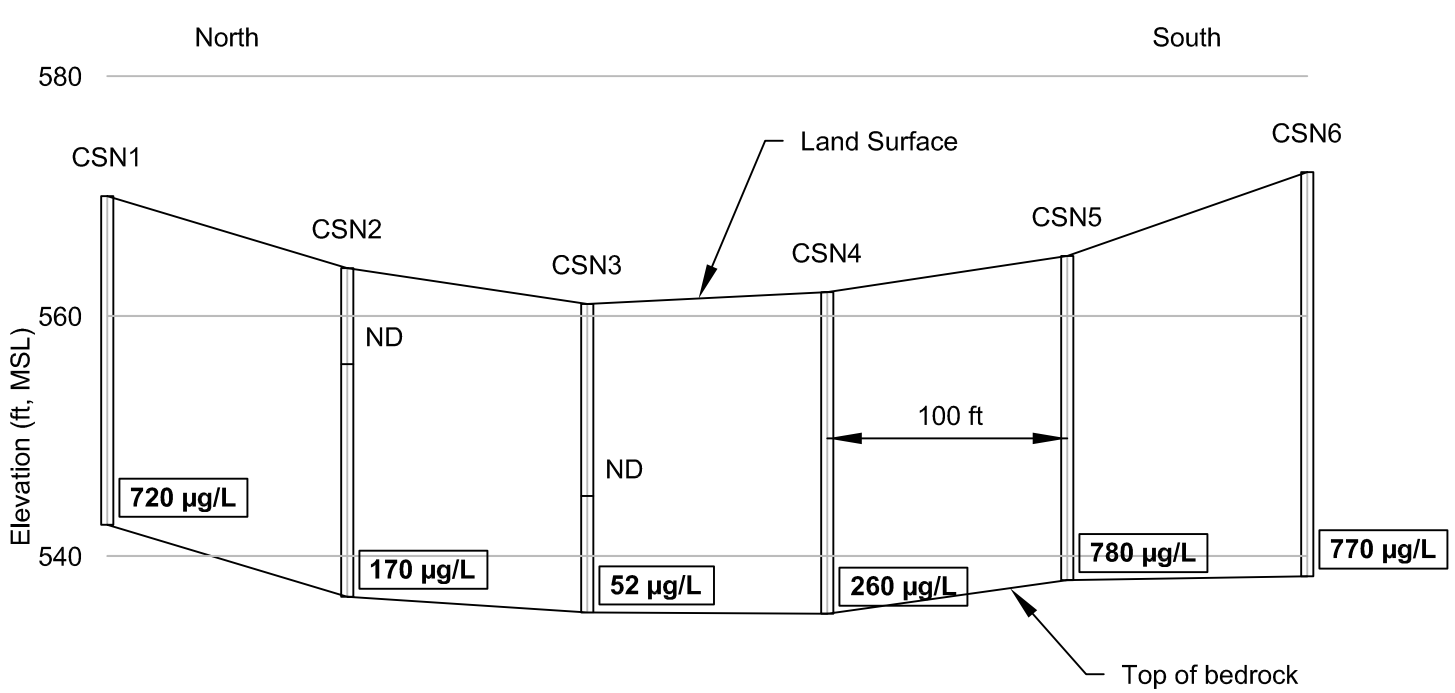
Distribution of Chemicals of Potential Concern in Soils at OU2 and OU6

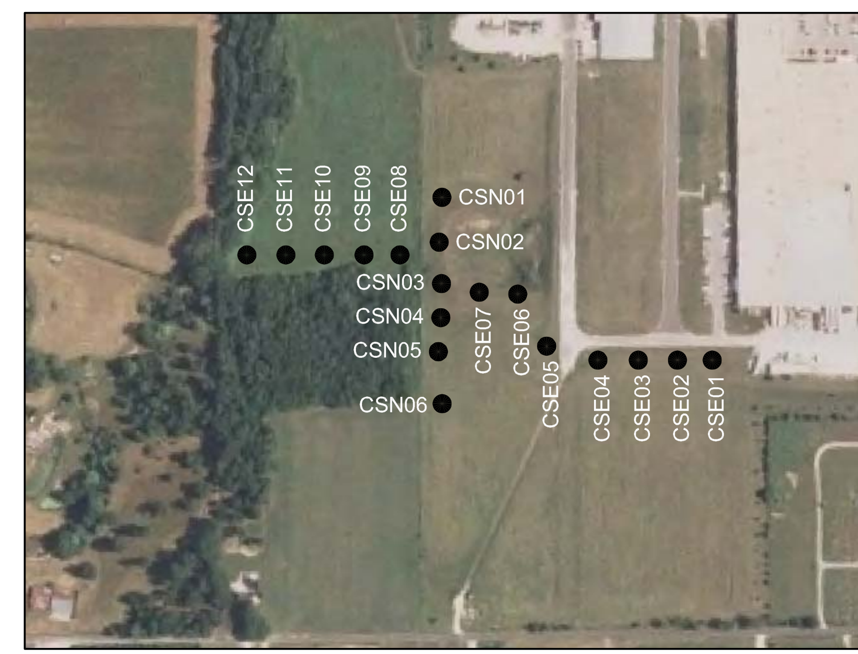
Riverfront Superfund Site OU2/6
New Haven, Missouri

PARSONS
40 LA RIVIERE DRIVE, SUITE 350, BUFFALO, NY 14202

Q:\GIS\Projects\Kellwood\MXDs\Revised 9.22.2009\Task1_soil_Revised 9.24.2009.mxd







Note: Concentrations denoted are PCE

Figure 2.4

Distribution of Chemicals of Potential Concern in Overburden Cross Section North of Boeuf Luthern Road

Riverfront Superfund Site OU2/6
New Haven, Missouri

PARSONS
40 LA RIVIERE DRIVE, SUITE 350 - BUFFALO, NY 14202

\\moche01fs01\Restoration\New Haven - Kellwood OU2\Cross Sections\FS Figure 2.4_Geologic EW Cross Sections.dwg

Screening Criteria: USEPA MCLs or Missouri Default Target Level for Water
Residential Wells Sampled from February 28 to March 28, 2008

N W E S

0 125 250 500 750 1,000
Feet

- Not Detected
- < 5 µg/L
- 5 - 100 µg/L
- > 100 µg/L
- Not Sampled

Figure 2.5a

Distribution of Chemicals of Potential Concern in Residential Wells (PCE)

Riverfront Superfund Site OU2/6
New Haven, Missouri

PARSONS
40 LA RIVIERE DRIVE, SUITE 350, BUFFALO, NY 14202

Q:\GIS\Projects\Kellwood\MXDs\Task2c_res_wells_TCE.mxd

Screening Criteria: USEPA MCLs or Missouri Default Target Level for Water
Residential Wells Sampled from February 28 to March 28, 2008

Not Detected
< 5 µg/L
5 - 100 µg/L
> 100 µg/L
Not Sampled

N W E S

0 125 250 500 750 1,000
Feet

Figure 2.5b

Distribution of Chemicals of Potential Concern in Residential Wells (TCE)

Riverfront Superfund Site OU2/6
New Haven, Missouri

PARSONS
40 LA RIVIERE DRIVE, SUITE 350, BUFFALO, NY 14202

Screening Criteria: USEPA MCLs or Missouri Default Target Level for Water
Residential Wells Sampled from February 28 to March 28, 2008
trans-1,2-DCE was not detected in any of the Residential Wells sampled

- Not Detected
- < 70 μg/L
- 70 - 100 μg/L
- > 100 μg/L
- ▲ Not Sampled

N E S

0 125 250 500 750 1,000
Feet

Figure 2.5c

Distribution of Chemicals of Potential Concern in Residential Wells (cis-1,2_DCE)

Riverfront Superfund Site OU2/6
New Haven, Missouri

PARSONS
40 LA RIVIERE DRIVE, SUITE 350, BUFFALO, NY 14202

Q:\GIS\Projects\Kellwood\MXDs\Task2c_res_wells_VC.mxd

Screening Criteria: USEPA MCLs or Missouri Default Target Level for Water
Residential Wells Sampled from February 28 to March 28, 2008

N W E S

0 125 250 500 750 1,000
Feet

Not Detected
< 2 µg/L
2 - 100 µg/L
> 100 µg/L
Not Sampled

Figure 2.5d

Distribution of Chemicals of Potential Concern in Residential Wells (Vinyl Chloride)

Riverfront Superfund Site OU2/6
New Haven, Missouri

PARSONS
40 LA RIVIERE DRIVE, SUITE 350, BUFFALO, NY 14202

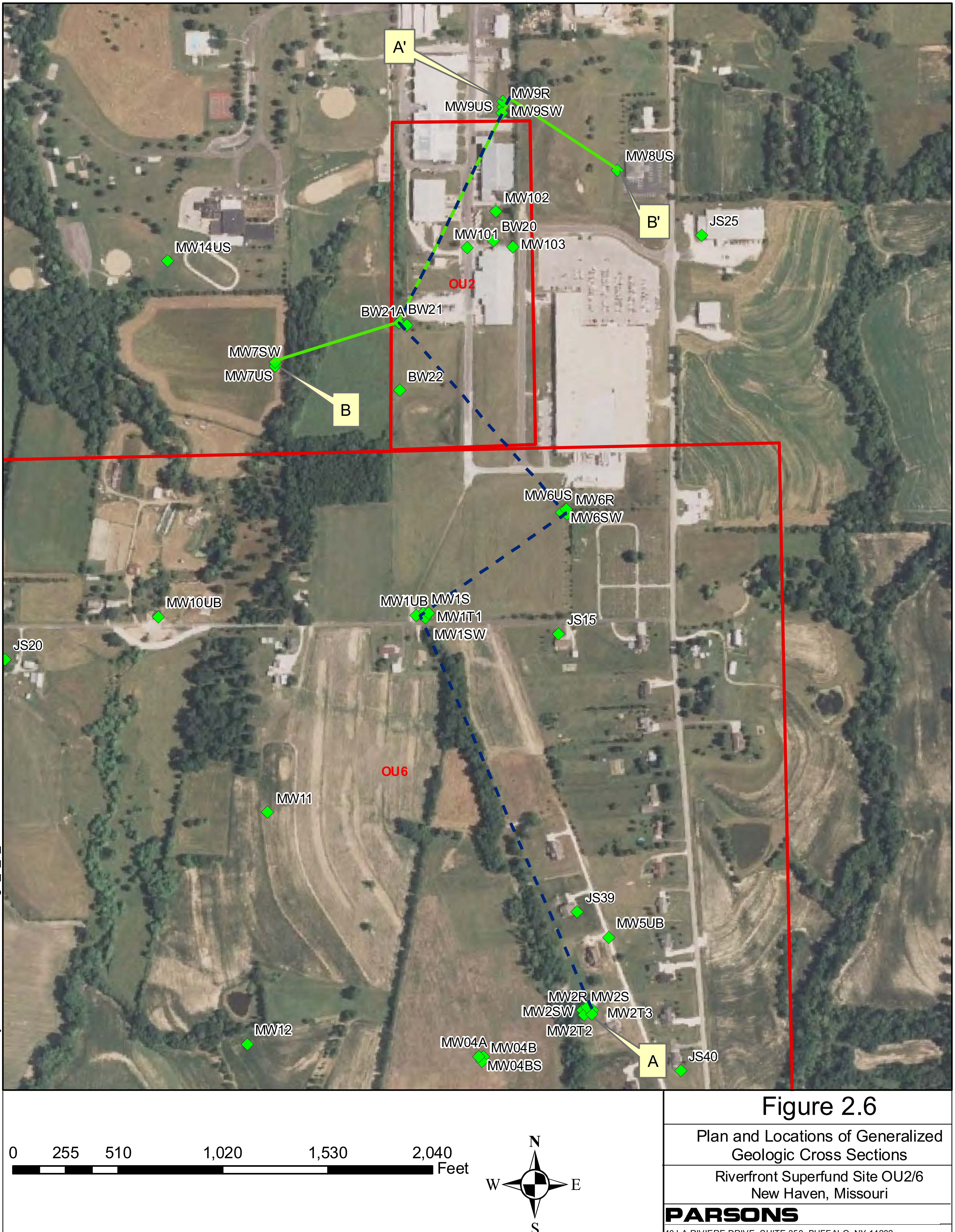


Figure 2.6

Plan and Locations of Generalized Geologic Cross Sections

Riverfront Superfund Site OU2/6
New Haven, Missouri

PARSONS

40 LA RIVIERE DRIVE, SUITE 350, BUFFALO, NY 14202

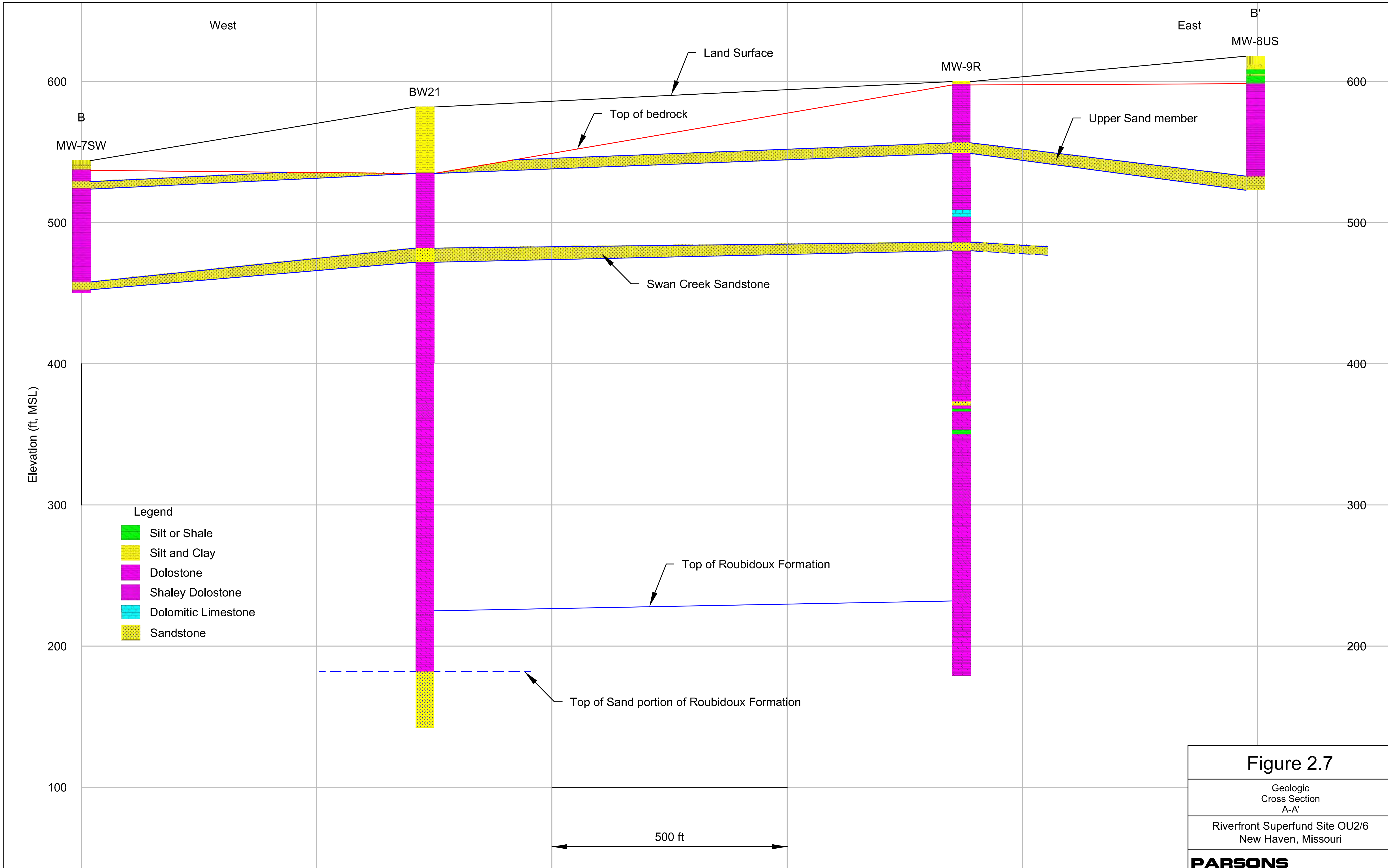


Figure 2.7

Geologic
Cross Section
A-A'

Riverfront Superfund Site OU2/6
New Haven, Missouri

PARSONS
40 LA RIVIERE DRIVE, SUITE 350 - BUFFALO, NY 14202

\\moche01fs01\Restoration\New Haven - Kellwood OU2\Cross Sections\Figure 2.7_Geologic EW Cross Sections.dwg

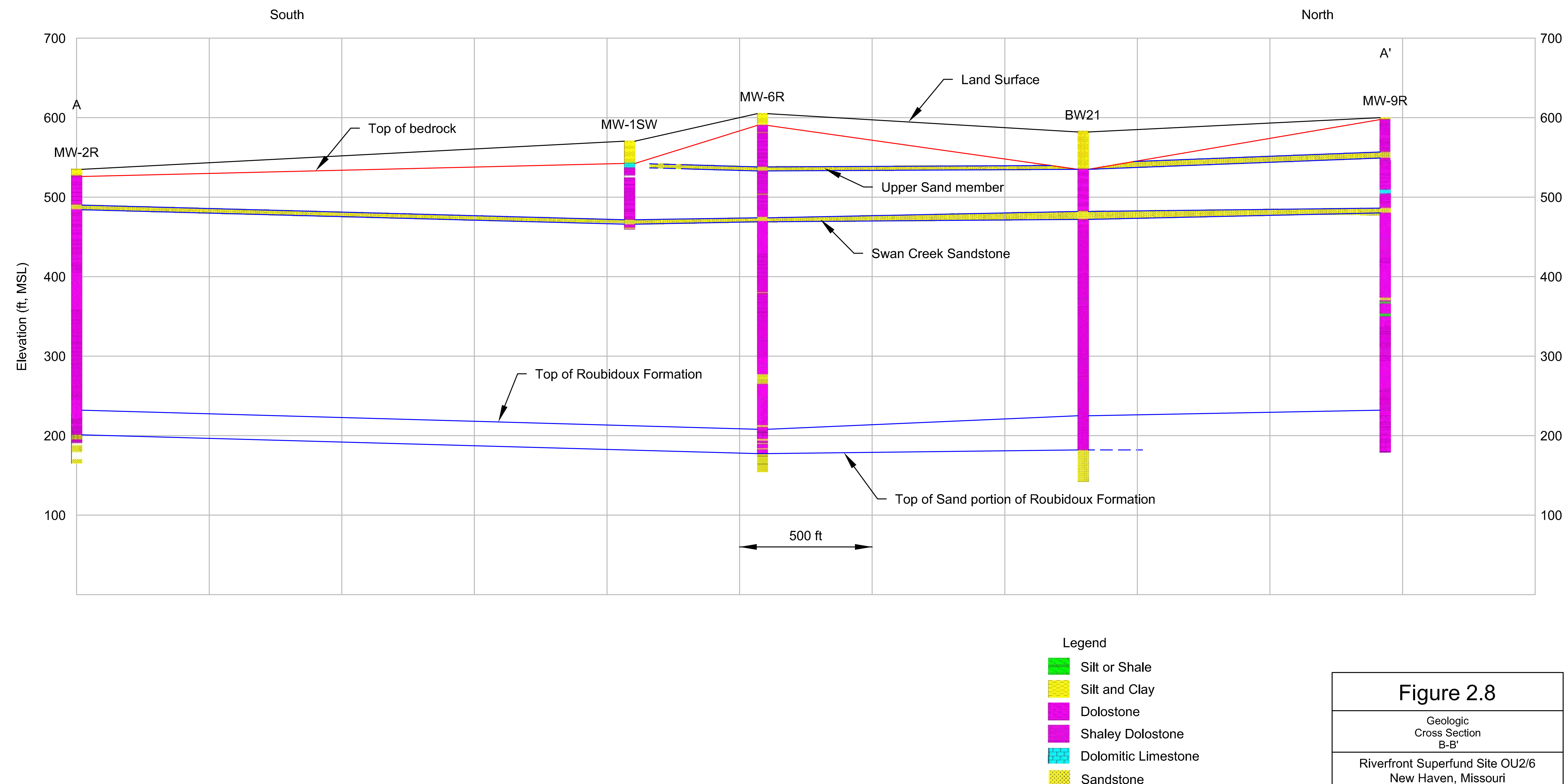


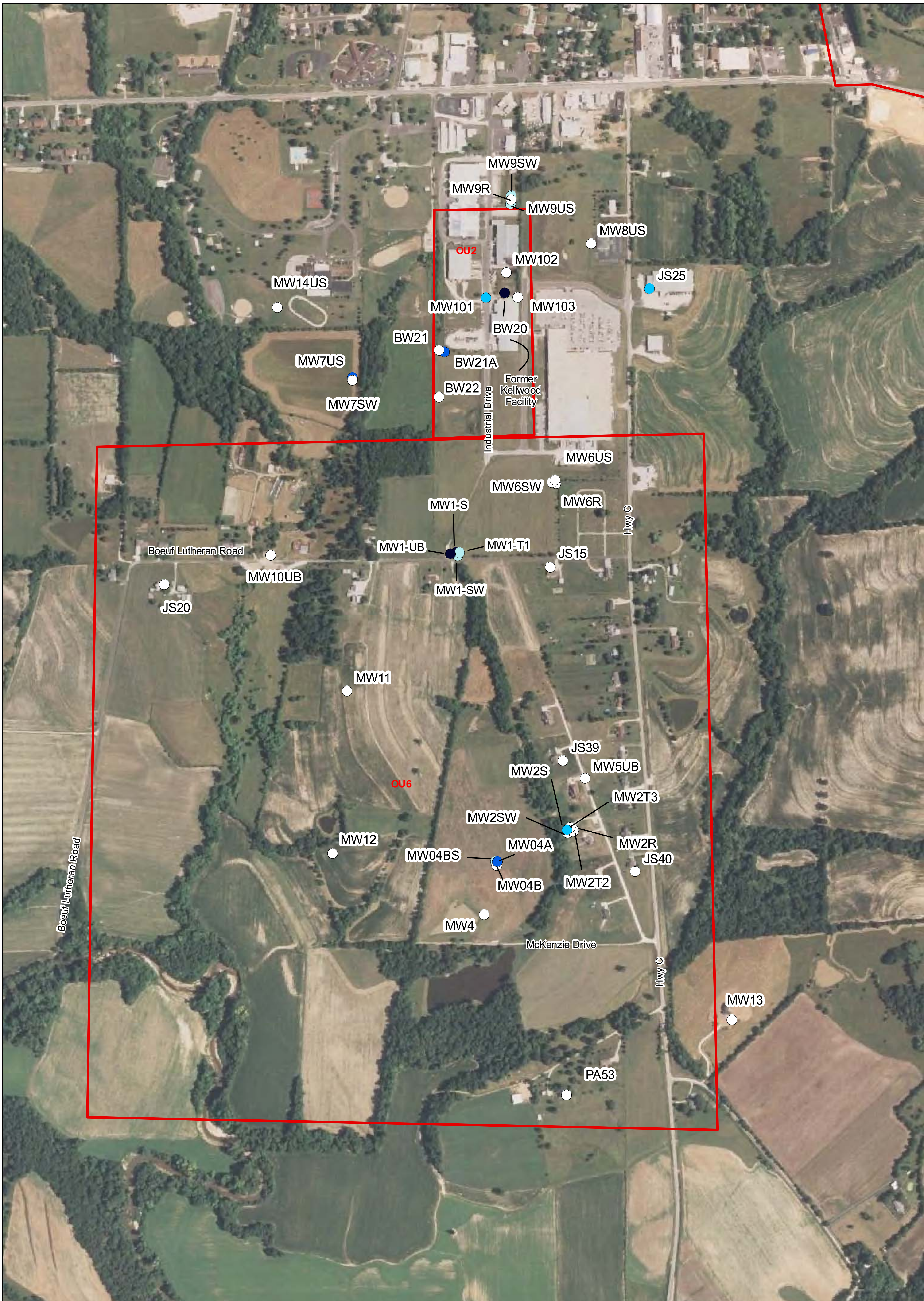
Figure 2.8

Geologic
Cross Section
B-B'

Riverfront Superfund Site OU2/6
New Haven, Missouri

PARSONS
40 LA RIVIERE DRIVE, SUITE 350 - BUFFALO, NY 14202

R:\New Haven - Kellwood OU2\Cross Sections\FS Figure 2.8_Geologic NS Cross Sections.dwg



Screening Criteria: USEPA MCLs or Missouri Default Target Level for Water
Monitoring Wells Sampled from March 2 to September 30, 2009

N
W E
S

0 125 250 500 750 1,000
Feet

- Not Detected
- < 5 µg/L (MCL)
- 5 - 100 µg/L
- > 100 - 1,000 µg/L
- > 1,000 µg/L

Figure 2.9a

Distribution of Chemicals of Potential Concern in Monitoring Wells (Site-wide GW Sampling Round-1: PCE)

Riverfront Superfund Site OU2/6
New Haven, Missouri

PARSONS
40 LA RIVIERE DRIVE, SUITE 350, BUFFALO, NY 14202

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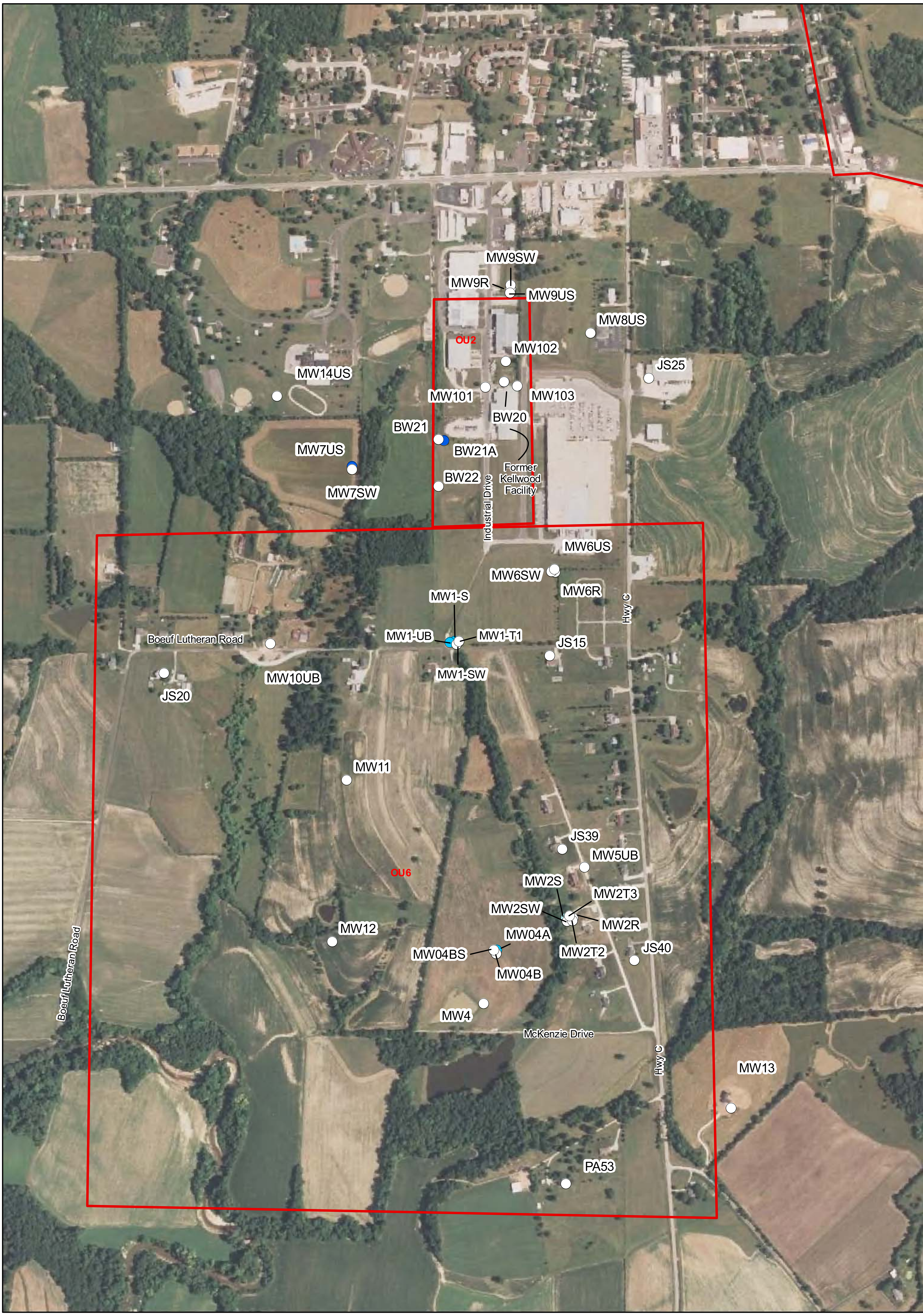

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N
W E
S

0 125 250 500 750 1,000
Feet

Screening Criteria: Federal MCLs or Missouri Default Target Levels for Water

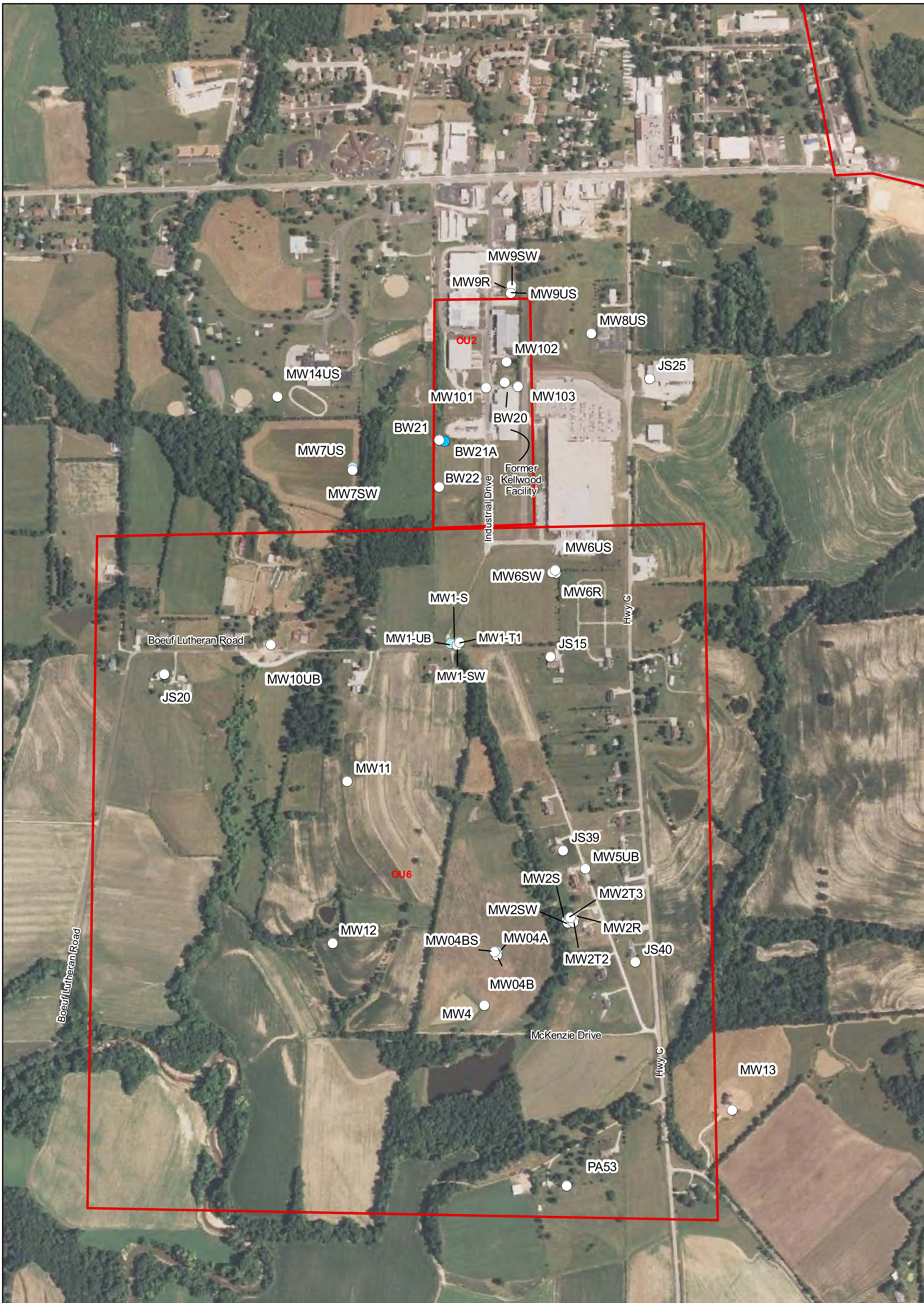
- Not Detected
- < 5 mg/L (MCL)
- 5 - 100 mg/L
- > 100 - 1,000 mg/L
- > 1,000 mg/L

Figure 2.9b

Distribution of Chemicals of Potential Concern in Monitoring Wells (Site-wide GW Sampling Round-1: TCE)

Riverfront Superfund Site OU2/6
New Haven, Missouri

PARSONS
40 LA RIVIERE DRIVE, SUITE 350, BUFFALO, NY 14202



N
W E
S

0 125 250 500 750 1,000
Feet

Screening Criteria: Federal MCLs or Missouri Default Target Levels for Water

Note:
Missouri does not have a default target level for 1,2-DCE (total). As such, the default target level for cis-1,2-DCE was used for screening at this time.

- Not Detected
- < 70 mg/L (MCL)
- 70 - 100 mg/L
- > 100 - 1,000 mg/L
- > 1,000 mg/L

Figure 2.9c

Distribution of Chemicals of Potential Concern in Monitoring Wells (Site-wide GW Sampling Round-1: 1,2-DCE)

Riverfront Superfund Site OU2/6
New Haven, Missouri

PARSONS
40 LA RIVIERE DRIVE, SUITE 350, BUFFALO, NY 14202

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Q:\GIS\Projects\Kellwood\MXDs\Revised 9.22.2009\PCE Distribution in various Trans Zones_9.29.2009.mxd

N
W E
S

0 125 250 500 750 1,000
Feet

Screening Criteria: USEPA MCLs or Missouri Default Target Levels for Water

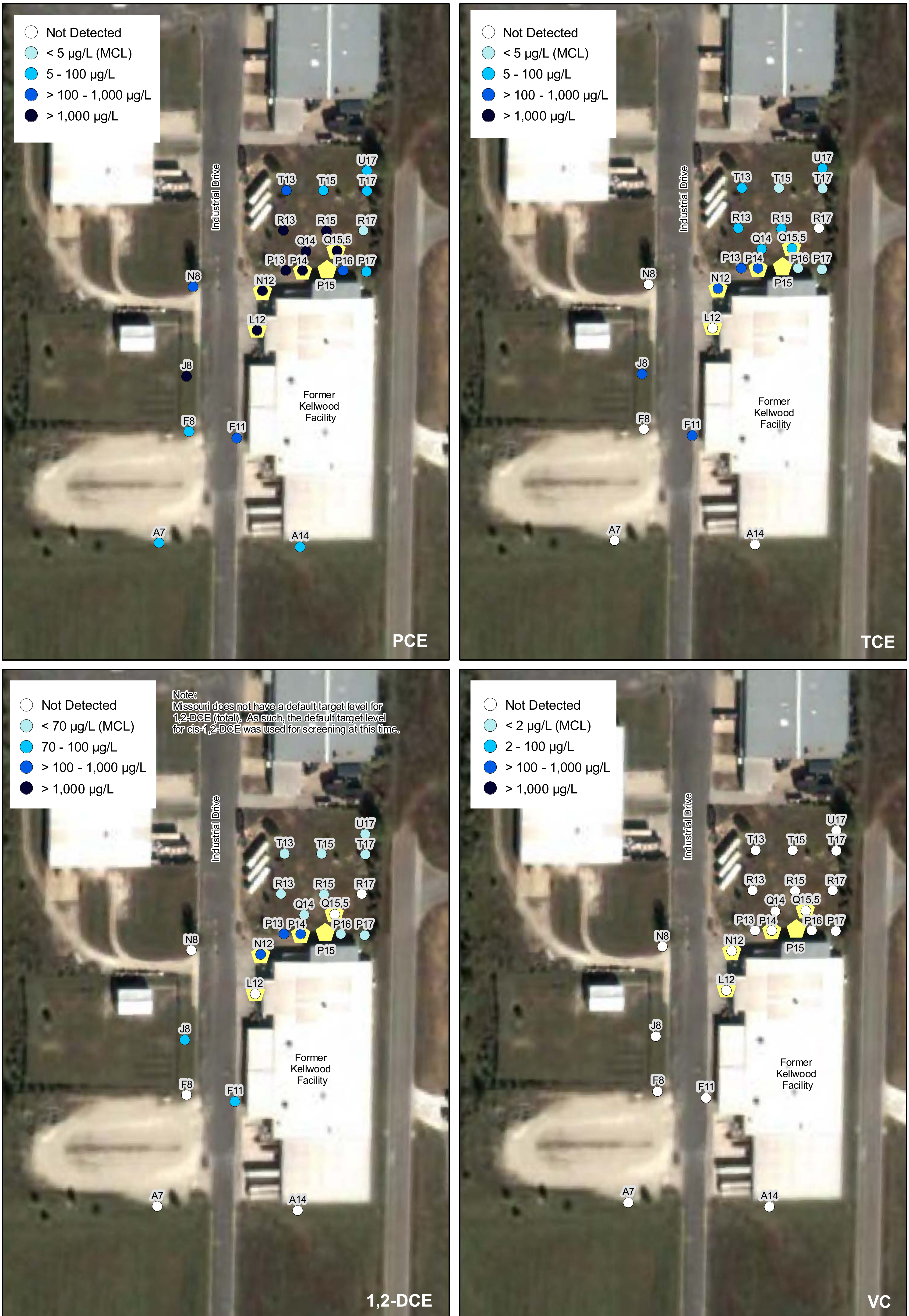
- Not Detected
- < 5 µg/L (MCL)
- 5 - 100 µg/L
- > 100 - 1,000 µg/L
- > 1,000 µg/L

Figure 2.10

Distribution of PCE
in Primary Transmissive Zones

Riverfront Superfund Site OU2/6
New Haven, Missouri

PARSONS
40 LA RIVIERE DRIVE, SUITE 350, BUFFALO, NY 14202



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N W E S

0 25 50 100 150 200
Feet

DNAPL Encountered

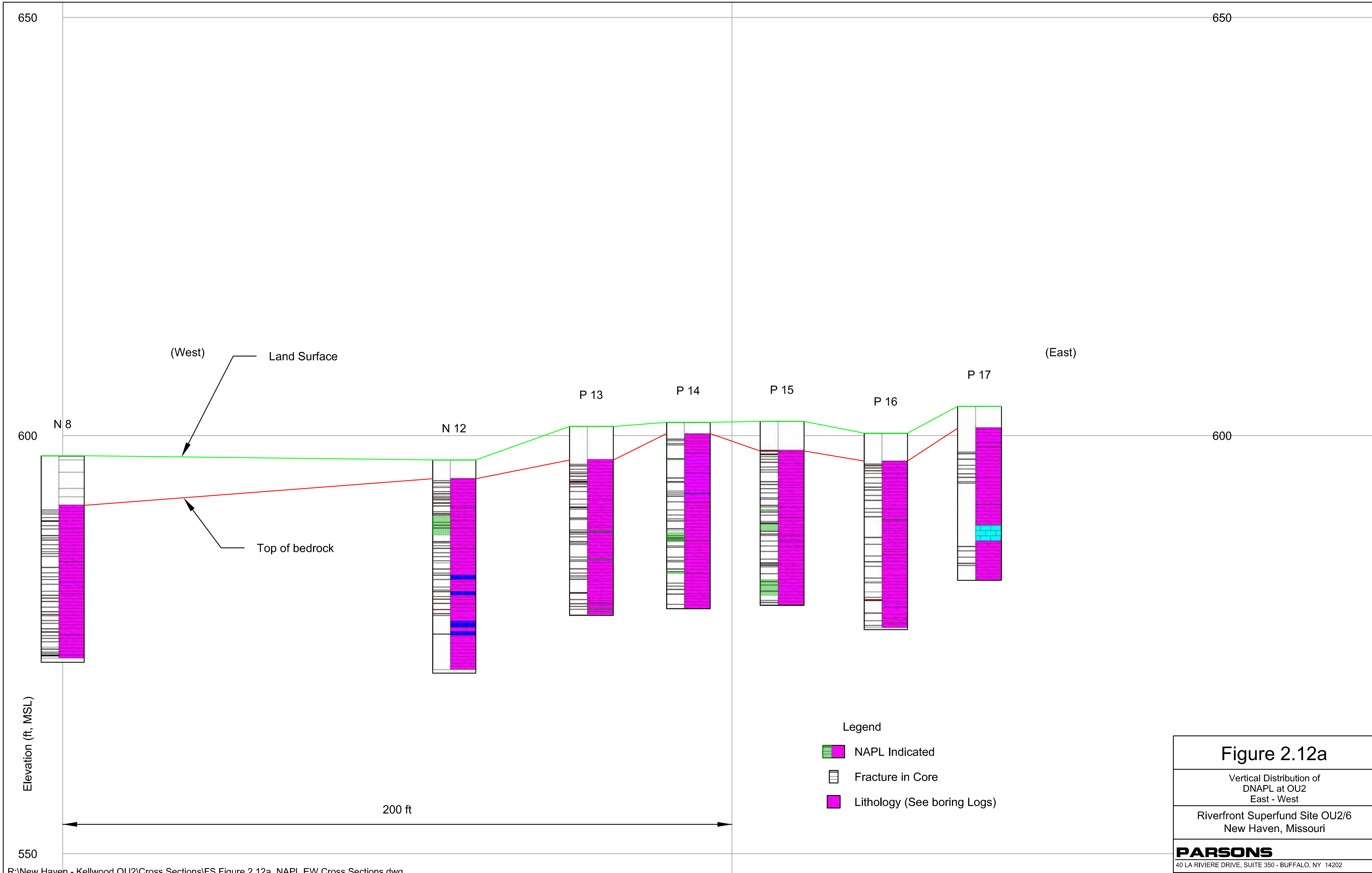
Screening Criteria: USEPA MCLs or Missouri Default Target Level for Water

Figure 2.11

Distribution of Chemicals of Potential Concern in Groundwater and DNAPL Detections at OU2

Riverfront Superfund Site OU2/6
New Haven, Missouri

PARSONS
40 LA RIVIERE DRIVE, SUITE 350, BUFFALO, NY 14202



650
650
(West)
Land Surface
(East)
P 17
P 13
P 14
P 15
P 16
N 8
N 12
600
600
Top of bedrock
Elevation (ft, MSL)
Legend
NAPL Indicated
Fracture in Core
Lithology (See boring Logs)
200 ft
550
Figure 2.12a
Vertical Distribution of
DNAPL at OU2
East - West
Riverfront Superfund Site OU2/6
New Haven, Missouri
PARSONS
40 LA RIVIERE DRIVE, SUITE 350 - BUFFALO, NY 14202
R:\New Haven - Kellwood OU2\Cross Sections\FS Figure 2.12a_NAPL EW Cross Sections.dwg

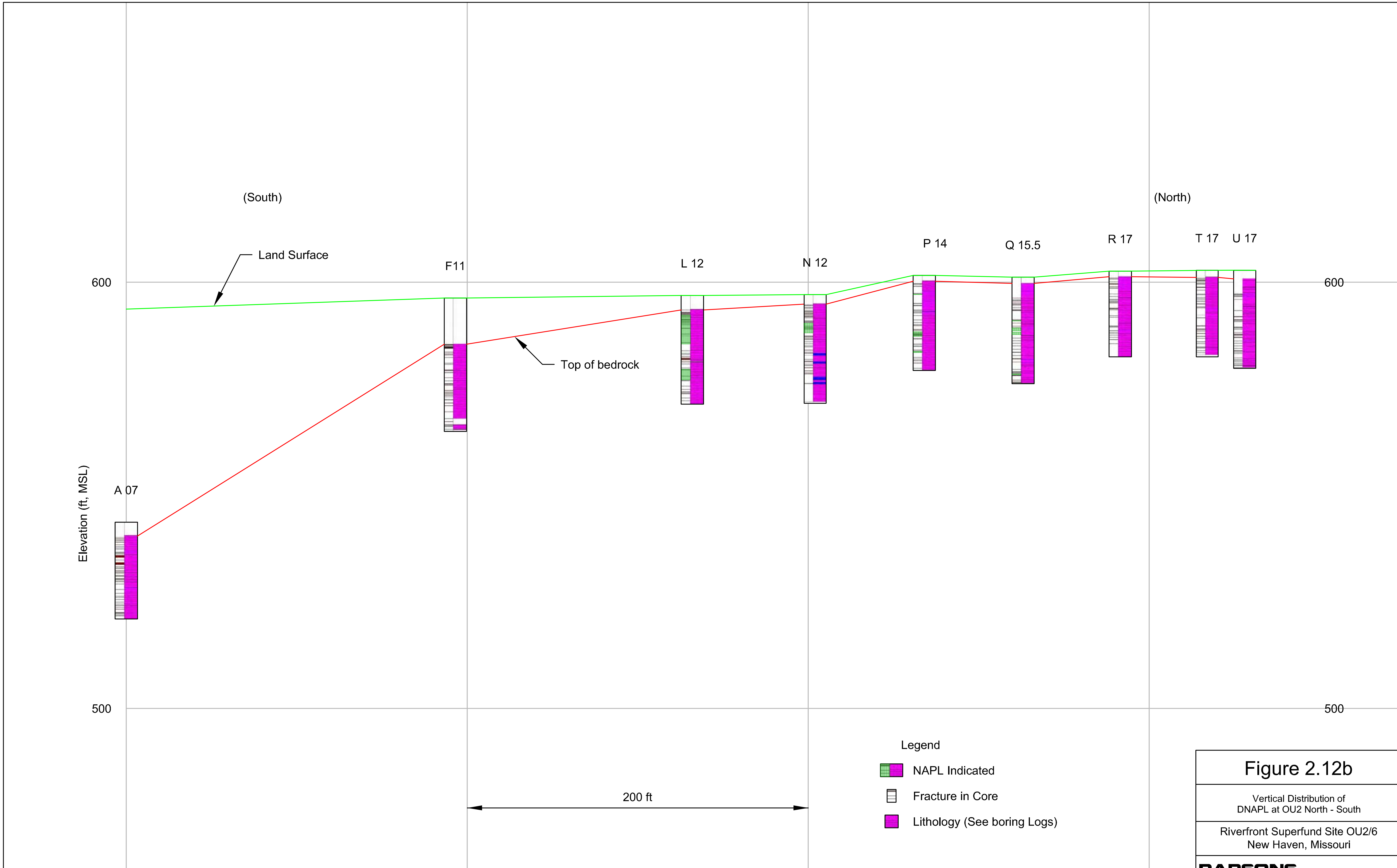


Figure 2.12b

Vertical Distribution of DNAPL at OU2 North - South

Riverfront Superfund Site OU2/6
New Haven, Missouri

PARSONS
40 LA RIVIERE DRIVE, SUITE 350 - BUFFALO, NY 14202

R:\New Haven - Kellwood OU2\Cross Sections\Figure 2.12b_NAPL NS Cross Sections.dwg

Q:\GIS\Projects\Kellwood\MXDs\Task4_sed_PCE.mxd

N W E S

0 125 250 500 750 1,000
Feet

Screening Criteria: Missouri Default Target Level for Soil
TCE, 1,2-DCE, and Vinyl Chloride were not detected at any of the sediment sampling locations

- Not Detected
- < 141 µg/kg (Missouri Default Target Level for Soil)
- Access Denied

Figure 2.13

Distribution of Chemicals of Potential Concern in Sediments at OU2 and OU6 (PCE)

Riverfront Superfund Site OU2/6
New Haven, Missouri

PARSONS
40 LA RIVIERE DRIVE, SUITE 350, BUFFALO, NY 14202

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N W E S

0 125 250 500 750 1,000
Feet

Screening Criteria: Federal MCLs or Missouri Default Target Levels for Water

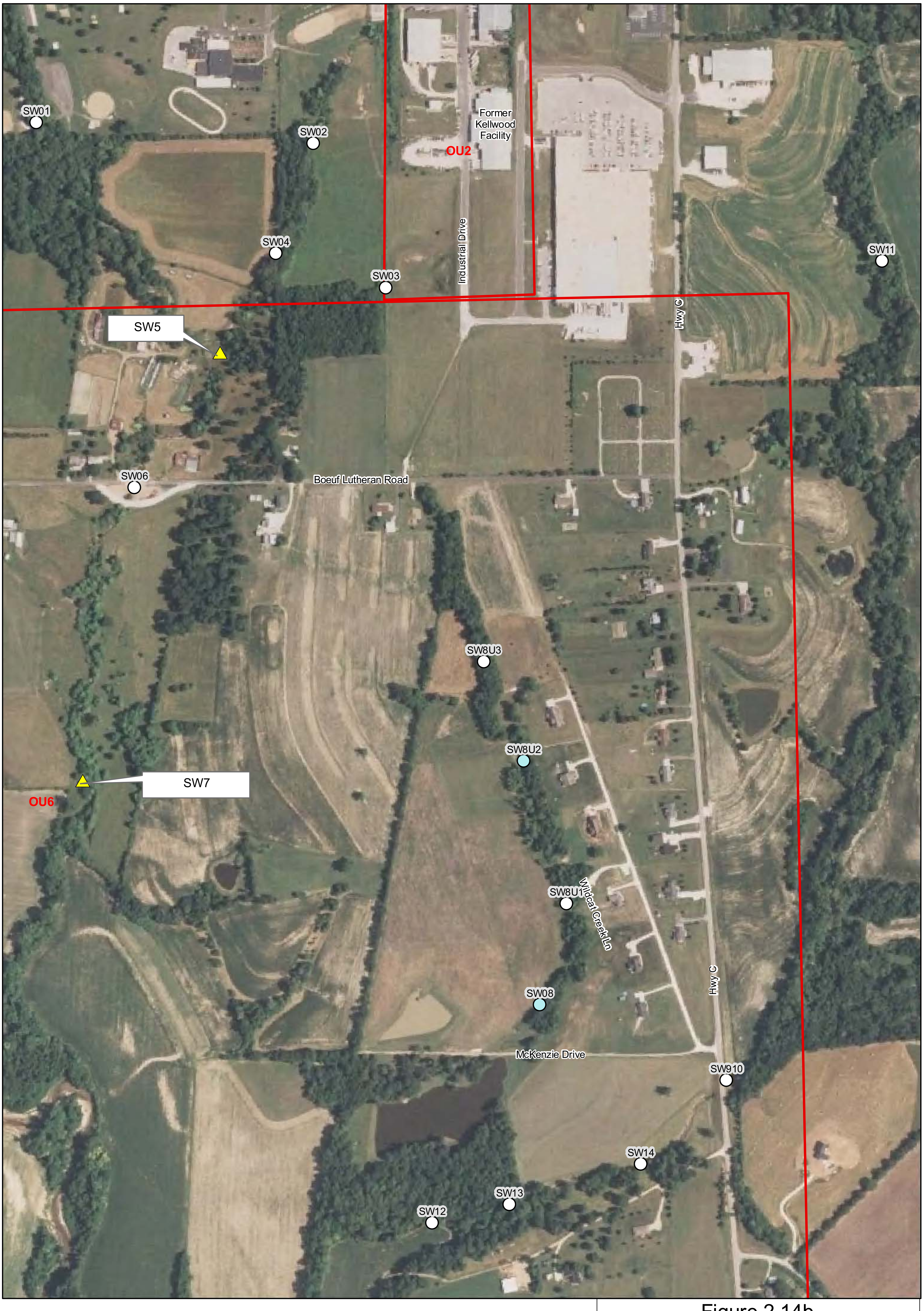
- Not Detected
- < 5 µg/L (MCL)
- 5 - 100 µg/L
- Access Denied

Figure 2.14a

Distribution of Chemicals of Potential Concern in Surface Water at OU2 and OU6 (PCE)

Riverfront Superfund Site OU2/6
New Haven, Missouri

PARSONS
40 LA RIVIERE DRIVE, SUITE 350, BUFFALO, NY 14202



Screening Criteria: Federal MCLs or Missouri Default Target Levels for Water

Figure 2.14b

Distribution of Chemicals of Potential Concern in Surface Water at OU2 and OU6 (TCE)

Riverfront Superfund Site OU2/6
New Haven, Missouri

PARSONS
40 LA RIVIERE DRIVE, SUITE 350, BUFFALO, NY 14202

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Missouri does not have a default target level for 1,2-DCE (total). As such, the default target level for cis-1,2-DCE was used for screening at this time.

- Not Detected
- < 70 µg/L (MCL)
- 70 - 100 µg/L
- Access Denied

Figure 2.14c

Distribution of Chemicals of Potential Concern in Surface Water at OU2 and OU6 (Total - 1,2-DCE)

Riverfront Superfund Site OU2/6
New Haven, Missouri

PARSONS
40 LA RIVIERE DRIVE, SUITE 350, BUFFALO, NY 14202

Q:\GIS\Projects\Kellwood\MXDs\Revised 9.22.2009\Task4_water_DCE_9.25.2009.mxd

N W E S

0 125 250 500 750 1,000
Feet

Screening Criteria: Federal MCLs or Missouri Default Target Levels for Water

Not Detected
< 2 µg/L (MCL)
2 - 100 µg/L
Access Denied

Figure 2.14d

Distribution of Chemicals of Potential Concern in Surface Water at OU2 and OU6 (Vinyl Chloride)

Riverfront Superfund Site OU2/6
New Haven, Missouri

PARSONS
40 LA RIVIERE DRIVE, SUITE 350, BUFFALO, NY 14202

Q:\GIS\Projects\Kellwood\MXDs\Revised 9.22.2009\Task4_water_VC_9.25.2009.mxd

Screening Criteria: Missouri Default Target Level for Soil
TCE, 1,2-DCE, and Vinyl Chloride were not detected at any of the sampling locations

N
W E
S

0 125 250 500 750 1,000
Feet

Sediment Sample

Soil Samples by Depth

- 0 - 3 Ft.
- > 3 - 10 Ft.
- > 10 Ft.

- Not Detected
- < 141 µg/kg (Missouri Default Target Level for Soil)
- > 141 µg/kg

Figure 2.15

Distribution of Chemicals of Potential Concern in Sanitary Sewer Sediment and in Soils Adjacent to Sewer at OU2 and OU6 (PCE)

Riverfront Superfund Site OU2/6
New Haven, Missouri

PARSONS
40 LA RIVIERE DRIVE, SUITE 350, BUFFALO, NY 14202

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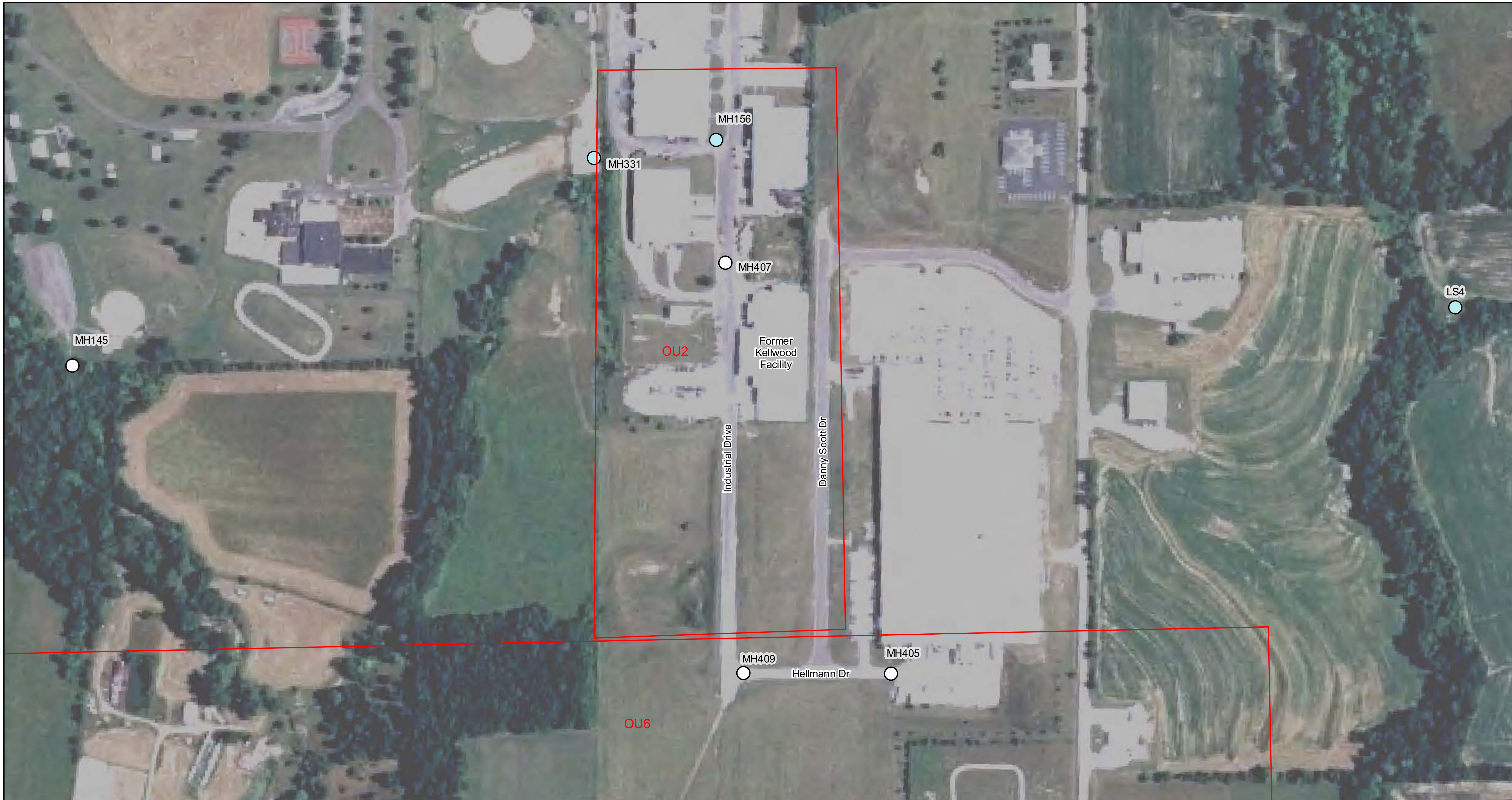


Q:\GIS\Projects\Kellwood\MXDs\Revised 9.22.2009\Task5_san_sewer_water_PCE_9.30.2009.mxd

N W E S

0 125 250 500 750 1,000
Feet

Screening Criteria: USEPA MCLs or Missouri Default Target Level for Water
TCE, 1,2-DCE, and Vinyl Chloride were not detected at any of the sampling locations

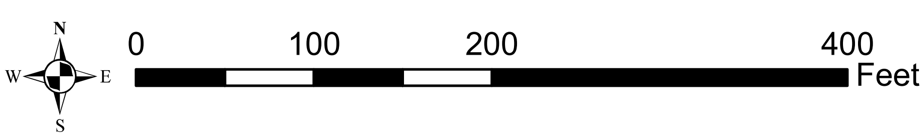
Not Detected
< 5 µg/L (MCL)
> 5 - 100 µg/L

Figure 2.16

Distribution of Chemicals of Potential Concern in Sanitary Sewer Water at OU2 and OU6 (PCE)

Riverfront Superfund Site OU2/6
New Haven, Missouri

PARSONS
40 LA RIVIERE DRIVE, SUITE 350, BUFFALO, NY 14202



Lateral Extent of Impacted Soils above RAOs

Notes:
bgs: below ground surface

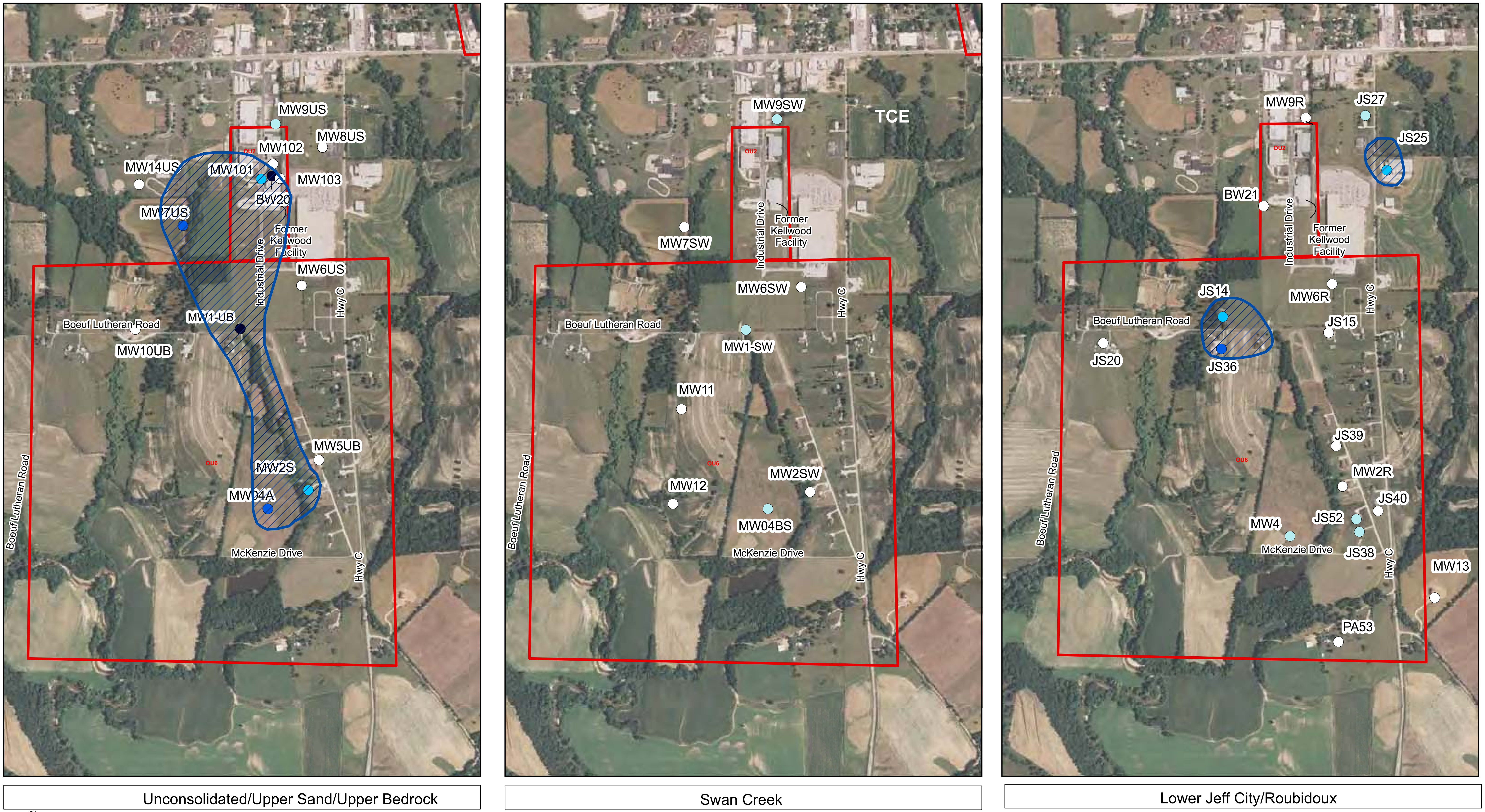
Figure 3.1

Lateral Extent of Soil Impacted Above Remedial Action Objective

Riverfront Superfund Site OU2/6
New Haven, Missouri

PARSONS
40 LA RIVIERE DRIVE, SUITE 350, BUFFALO, NY 14202

\\nysyr04fs01\PrjData\GIS\Projects\Kellwood\MXDs\Revised 12 2009\Figure_3.1.mxd



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N W E S

0 380 760 1,520 2,280 3,040 Feet

Extent of Groundwater above Remedial Action Objective

Screening Criteria: USEPA MCLs or Missouri Default Target Levels for Water

PCE Concentration

- Not Detected
- < 5 μg/L (MCL)
- 5 - 100 μg/L
- > 100 - 1,000 μg/L
- > 1,000 μg/L

Figure 3.2

Lateral Extent of Groundwater Impacted Above Remedial Action Objective

Riverfront Superfund Site OU2/6
New Haven, Missouri

PARSONS
40 LA RIVIERE DRIVE, SUITE 350, BUFFALO, NY 14202

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N W E S

0 100 200 400 Feet

Lateral Extent of DNAPL

Notes:
bgs: below ground surface

Figure 3.3

Lateral Extent of DNAPL

Riverfront Superfund Site OU2/6
New Haven, Missouri

PARSONS
40 LA RIVIERE DRIVE, SUITE 350, BUFFALO, NY 14202

Asphalt or Concrete Cap

OU Boundary

240 120 0 240

Feet

N W E S

Notes:

1. Remediation Alternative 3a includes Whole-House Treatment Units at JS14, JS36, JS38, and JS52 (see Figure 2.5a).

2. Remediation Alternative 2b includes provision of alternative water services to residences within OU6 (see Figure 2.5a).

Figure 5.1

Remediation Alternatives 2a and 2b

PARSONS

40 LA RIVIERE DRIVE, SUITE 350, BUFFALO, NY 14202

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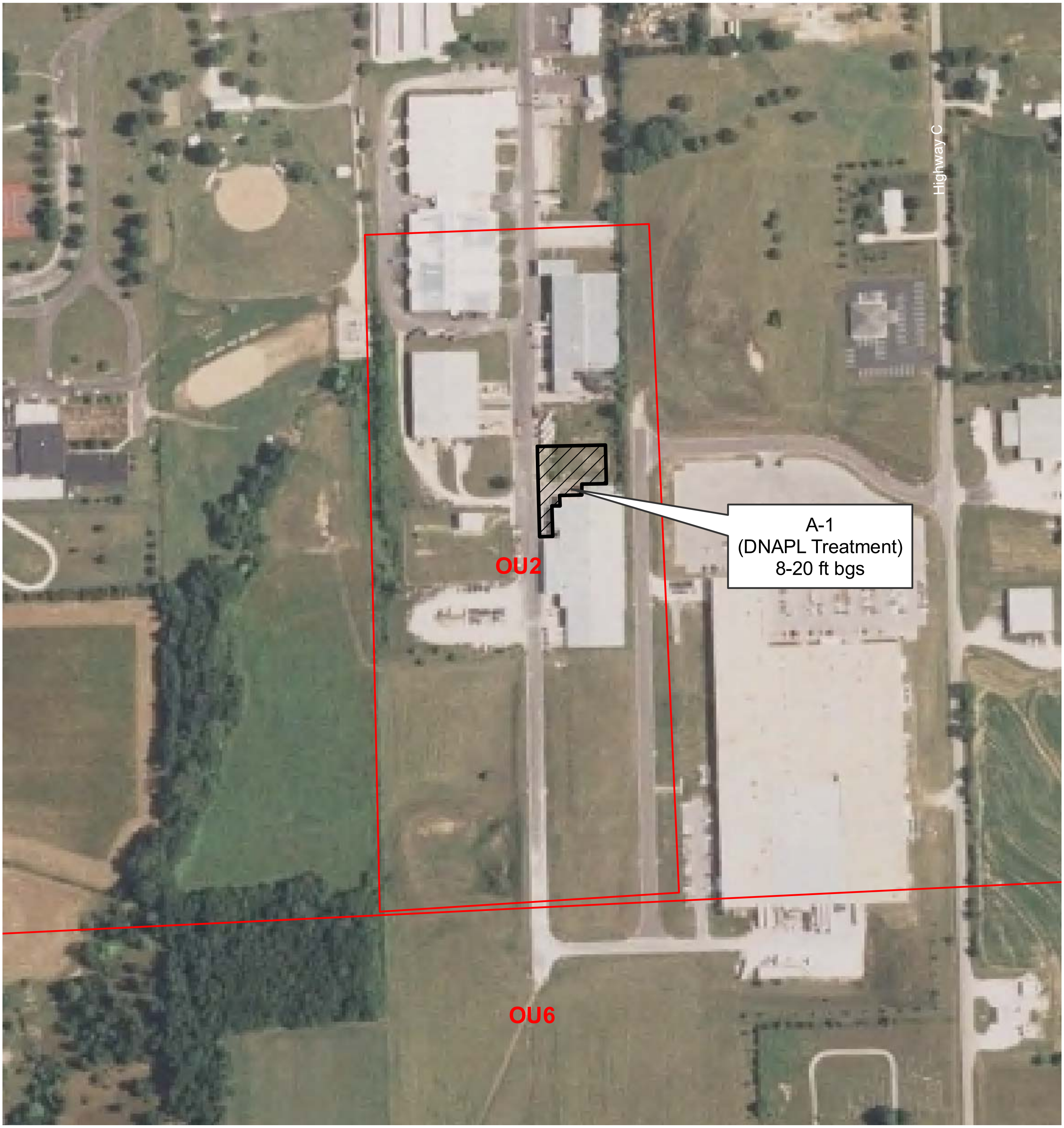

OU Boundary

Notes:
1. Remediation Alternative 3a includes Whole-House Treatment Units at JS14, JS36, JS38, and JS52 (see Figure 2.5a).

2. Remediation Alternative 3b includes provision of alternative water services to residences within OU6 (see Figure 2.5a).

Figure 5.2

Remediation Alternatives 3a and 3b

PARSONS

40 LA RIVIERE DRIVE, SUITE 350, BUFFALO, NY 14202

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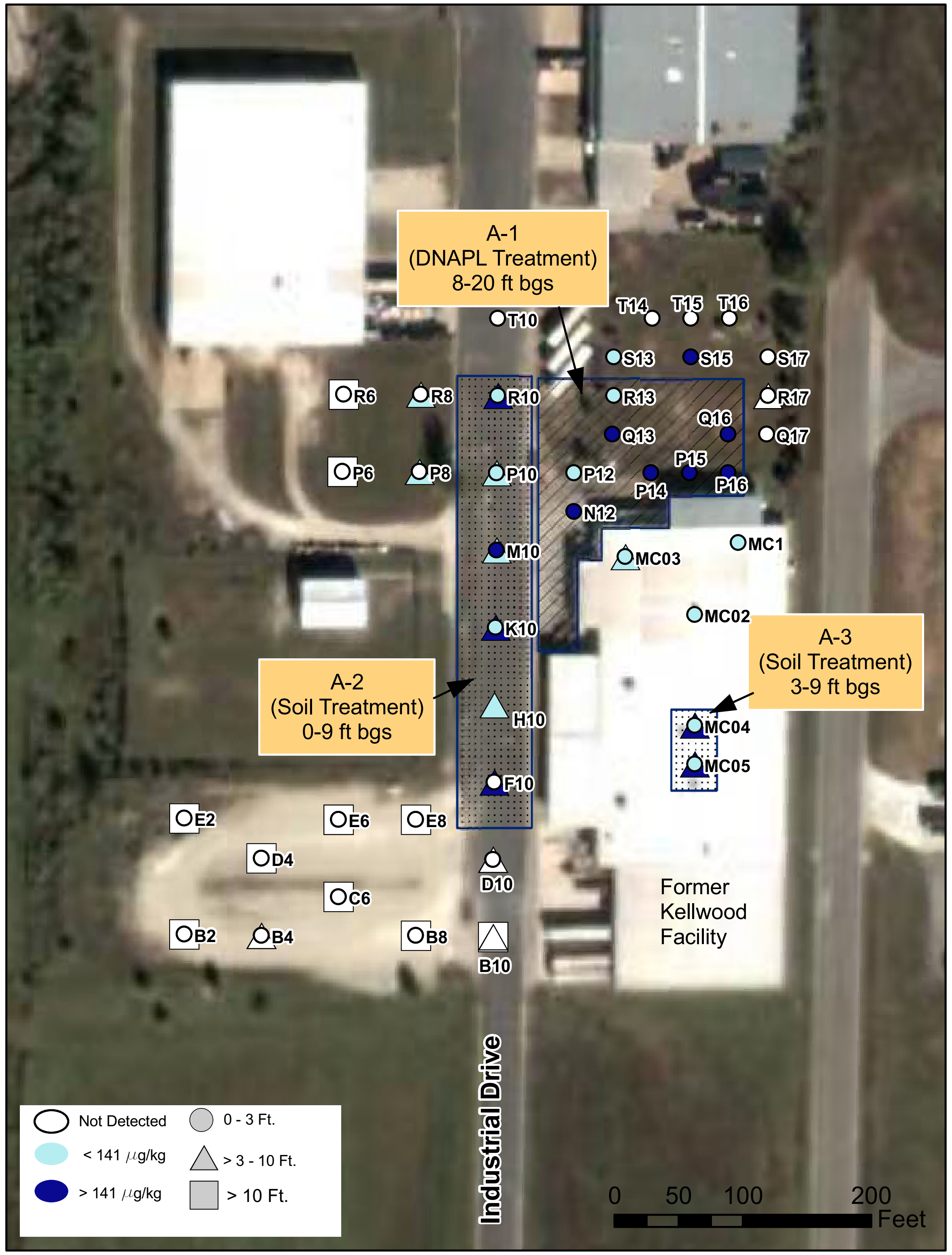

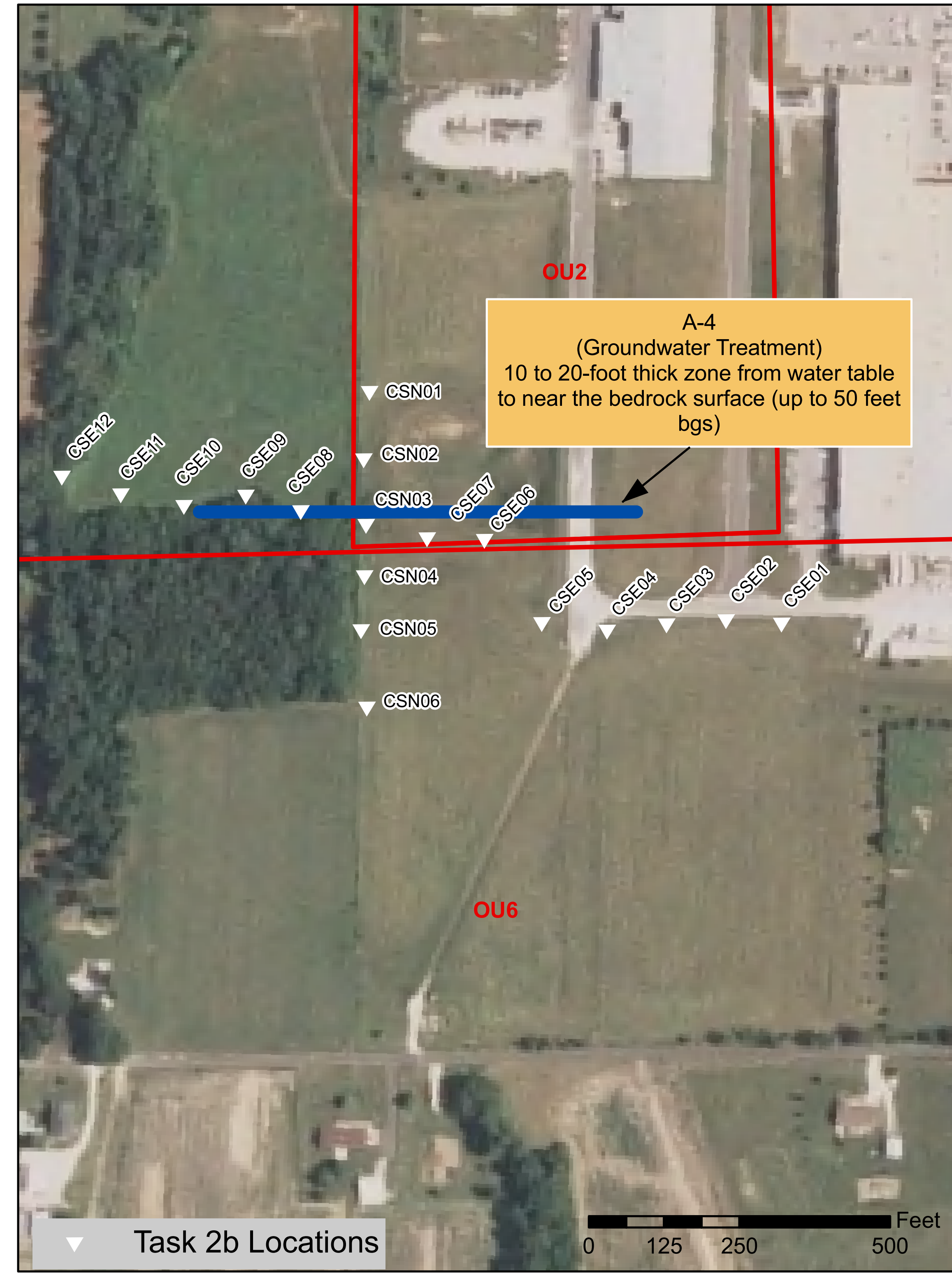

Notes:
1. bgs: below ground surface

2. Proposed treatment areas and depths are approximate and subject to change

N
W
E
S

Figure 5.3

Remediation Alternatives 4a, 4b, 4c, 5, and 6

Riverfront Superfund Site OU2/6
New Haven, Missouri

PARSONS
40 LA RIVIERE DRIVE, SUITE 350, BUFFALO, NY 14202

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Objective and Pathway	Applicable Com-pounds	Calculated Human Health Level	Calculated Site Background Level	Ground-water MCL	Target Concen-tration	Units	Basis
Protect human health by eliminating exposure (i.e. direct contact)[2] to **soil** [3] with concentrations of COPCs above risk-based values.	PCE [1]	0.675	N/A	N/A	0.675	mg/kg	Calculated using target risk of 1 x 10^{-6} (carcinogen) under a **future hypothetical residential scenario**.
Protect human health by eliminating exposure (i.e. inhalation)[2] to vapors volatilizing from **soil** [3] to indoor air with concentrations of COPCs above risk-based values	PCE [1]	0.0359	N/A	N/A	0.0359	mg/kg	Calculated using target risk of 1 x 10^{-6} (carcinogen) **future hypothetical residential scenario.**
Protect human health by eliminating exposure (i.e. inhalation)[2] to vapors volatilizing from **soil** [3] to indoor air with concentrations of COPCs above risk-based values	PCE [1]	0.272	N/A	N/A	0.272	mg/kg	Calculated using target risk of 1 x 10^{-6} (carcinogen) under a **current/future industrial scenario**.
Protect human health by eliminating exposure (i.e. inhalation) to vapors volatilizing from **groundwater** to indoor air with concentrations of COPCs	PCE [1]	0.0441	N/A	N/A	0.0441	mg/L	Calculated using target risk of 1 x 10^{-6} (carcinogen) under a **future hypothetical residential scenario**.

Objective and Pathway	Applicable Com-pounds	Calculated Human Health Level	Calculated Site Background Level	Ground-water MCL	Target Concen-tration	Units	Basis
above risk-based values.							
Protect human health by eliminating exposure (i.e. inhalation) to vapors volatilizing from **groundwater** to indoor air with concentrations of COPCs above risk-based values	PCE [1]	0.423	N/A	N/A	0.423	mg/L	Calculated using target risk of 1 x 10^{-6} (carcinogen) under a **current/future industrial scenario**.
Protect human health by eliminating exposure (i.e. ingestion) to **groundwater** with concentrations of chemicals of COPCs above risk-based values	PCE [1]	< MCL	N/A	0.005	0.005	mg/L	Calculated using target risk of 1 x 10^{-6} (carcinogen) and target hazard level of 1 (non-carcinogen) under a **future hypothetical residential scenario.**

[1] PCE is tetrachloroethylene

[2] Direct contact pathway evaluated soils in the 0 to 3 feet depth range. Inhalation pathway evaluated 0 to 10 feet.

[3] Limited to Areas A-1 and A-3 (see Figure 3.1)

N/A – Not Applicable

Applicable Compounds	Target Concentration (mg/kg)	Basis
SURFACE SOILS – Pathway: Prevent direct contact with impacted surface soils and consumption of impacted food		
PCE	9.92	Region 5 ESL

Applicable Compounds	Target Level (ug/L)	Basis
SURFACE WATER – Pathway: Prevent direct contact with impacted surface water		
PCE	45	Region 5 ESL
(Note: detected concentrations of PCE at OU2 and OU6 were below this target level.)		

Applicable Compounds	Target Level (mg/kg)	Basis
SEDIMENT – Pathway: Prevent direct contact with impacted sediment		
PCE	0.99	Region 5 ESL
(Note: detected concentrations of PCE at OU2 and OU6 were below this target level.)		

PCE = Tetrachloroethylene
ESL = Ecological Screening Level

<table>
<tr><th colspan="2">SOIL</th><th colspan="2">GROUNDWATER</th><th colspan="2">DNAPL</th></tr>
<tr><th>GENERAL RESPONSE ACTION</th><th>REMEDIAL TECHNOLOGY</th><th>GENERAL RESPONSE ACTION</th><th>REMEDIAL TECHNOLOGY</th><th>GENERAL RESPONSE ACTION</th><th>REMEDIAL TECHNOLOGY</th></tr>
<tr><td>No Action</td><td>None</td><td>No Action</td><td>None</td><td>No Action</td><td>None</td></tr>
<tr><td rowspan="4">Institutional Controls</td><td rowspan="4">Land use</td><td rowspan="3">Institutional Controls</td><td>Use Restrictions</td><td rowspan="3">Institutional Controls</td><td>Use Restrictions</td></tr>
<tr><td>Alternative Drinking Water Source</td><td>Alternative Drinking Water Source</td></tr>
<tr><td>Monitoring</td><td>Monitoring</td></tr>
<tr><td>Natural Attenuation</td><td>Monitoring</td><td>Natural Attenuation</td><td>Monitoring</td></tr>
<tr><td rowspan="2">Containment</td><td rowspan="2">Capping</td><td rowspan="2">Containment</td><td>Capping</td><td rowspan="2">Containment</td><td rowspan="2">Capping</td></tr>
<tr><td>Physical Barrier</td></tr>
<tr><td>Removal</td><td>Excavation</td><td>Removal</td><td>Groundwater Extraction</td><td>Removal</td><td>Groundwater Extraction</td></tr>
<tr><td rowspan="2">Disposal</td><td>Onsite Disposal</td><td rowspan="2"></td><td rowspan="2"></td><td rowspan="2"></td><td rowspan="2"></td></tr>
<tr><td>Offsite Disposal</td></tr>
<tr><td rowspan="5">Treatment</td><td>Physical, Ex Situ</td><td rowspan="5">Treatment</td><td rowspan="4">Ex Situ Treatment</td><td rowspan="5">Treatment</td><td rowspan="4">Ex Situ Treatment</td></tr>
<tr><td>Physical / Chemical, Ex Situ</td></tr>
<tr><td>Physical / Thermal Ex-Situ</td></tr>
<tr><td>Biological, Ex Situ</td></tr>
<tr><td>In Situ</td><td>In Situ Treatment</td><td>In Situ Treatment</td></tr>
</table>

GENERAL RESPONSE ACTION	REMEDIAL TECH-NOLOGY	PROCESS OPTIONS	DESCRIPTION	RETAIN (YES / NO)	SCREENING COMMENTS
No Action	None	None	No actions are taken to meet Remedial Action Objectives	Yes	Analysis of a No Action alternative is required.
Institutional Controls	Land use	Deed and Zoning Restrictions	Property with impacted soil has land use restrictions placed on the deeds.	Yes	May be used in conjunction with other response action technologies.
Containment	Capping	Soil	Impacted soil is covered with a compacted soil cap (native soil or clay) to minimize direct contact and ingestion of impacted soil, and to reduce infiltration of surface water.	Yes	Potentially applicable to area north and west of former Kellwood facility.
		Asphalt / Concrete	An asphalt or concrete layer is installed over impacted soil to minimize direct contact and ingestion of impacted soil, and to reduce infiltration of surface water.	Yes	Potentially applicable to area north and west of former Kellwood facility.
		RCRA cap	Impacted soil is covered by a multilayer cap meeting RCRA regulations to minimize direct contact and ingestion of impacted soil, and to reduce infiltration of surface water.	No	Not practical, area is a parking / storage area not owned by Kellwood.
Removal	Excavation	Excavation	Impacted soils are removed with excavation equipment and are disposed of or treated. If treated, soils may be placed back in excavation.	Yes	Would be potentially applicable to area north and west of former Kellwood facility. Extent of utilities in area to be excavated will be considered. Excavation of VOC-impacted soils occurred in 1994.

GENERAL RESPONSE ACTION	REMEDIAL TECH-NOLOGY	PROCESS OPTIONS	DESCRIPTION	RETAIN (YES / NO)	SCREENING COMMENTS
Disposal	On-Site Disposal	On-Site Landfill	Excavated impacted soil is transported and placed in a permitted landfill on-site.	No	Not practical, Kellwood does not own property.
		Replace in Excavation after Treatment	Excavated soil is placed back in excavation after it has been treated.	Yes	Potentially applicable to area north and west of former Kellwood facility. Soil layer is not thick. Excavation would result in removal of cobbles from soil layer and weathered bedrock.
	Offsite Disposal	RCRA Landfill	Excavated soils are transported and placed in a RCRA permitted landfill offsite.	Yes	Landfilling is an established technology for containment of impacted soil.
		Solid Waste Landfill	Excavated soils are transported and placed in a solid waste landfill offsite.	Yes	Landfilling is an established technology for containment of impacted soil.
Treatment	Physical, Ex Situ	Mechanical Separation	After excavation, impacted soil is screened to removed debris, roots, large rocks, etc.	Yes	Not a primary treatment option. May be used in conjunction with excavation and other applicable treatment option is selected.
	Physical / Chemical, Ex Situ	Solvent Extraction	Solvents are used to extract the compounds of potential concern (COPCs) from the soil. Treated soil is dewatered or allowed to dry before returning to the excavation. Spent solvent is treated and reused. Concentrated residuals require further treatment or disposal.	Yes	Established technology. Ethanol may be used to flush out PCE from soil. May be used as part of a treatment train. Because of solvent use, not considered a “green” technology.

GENERAL RESPONSE ACTION	REMEDIAL TECH-NOLOGY	PROCESS OPTIONS	DESCRIPTION	RETAIN (YES / NO)	SCREENING COMMENTS
		Solidification / Stabilization	Impacted soils are excavated and combined with cementitious (e.g., fly ash) materials, water, and reagents. The combined material is placed back in the excavation before it hardens. The COPCs are bound into the stabilized soils. Some COPCs will react chemically with the cementitious reagents.	Yes	Would require management of vapors for soils with more than low levels of organics. Fly ash currently under regulatory scrutiny.
	Physical / Thermal Ex-Situ	Incineration	Impacted soils are excavated and transported to an offsite incinerator. The organic compounds are degraded through the high temperature oxidation process.	Yes	Effective for treating organic compounds.
		Thermal Desorption	Impacted soils are excavated and treated in a low (VOCs) or high (SVOCs) temperature furnace to desorb organic compounds from the soils.	Yes	Effective for treating organic compounds.
	Biological, Ex Situ	Bioslurry Reactor	Excavated soils are placed in a reactor where they are kept in a suspension with microorganisms, nutrients, and possibly oxygen. Treated soils would be dewatered and placed back in the excavation or disposed on-site or offsite.	No	Eliminated due to complexity of process relative to other potential alternatives.

GENERAL RESPONSE ACTION	REMEDIAL TECH-NOLOGY	PROCESS OPTIONS	DESCRIPTION	RETAIN (YES / NO)	SCREENING COMMENTS
		Biopiles	Excavated soils are placed in a pile with piping to add water, air, and nutrients. The piles would be contained (bottom barrier and cover) with conditions maintained to optimize biological treatment of the COPCs.	Yes	PCE is most effectively treated with anaerobic processes. Once the soil pile is reduced anaerobically, then the reduction compounds (TCE, 1,2-DCE, and VC) may be reduced aerobically.
	In Situ	Soil-Vapor Extraction (SVE)	A system of wells is installed and a vacuum applied to extract the soil vapors. Impacted soil vapor may require treatment.	Yes	The organic compounds are sufficiently volatile for viable removal. Minimal soil thickness may prevent installation of extraction probes or hinder effectiveness of process.
		Thermally Enhanced Vapor Extraction	The soil is heated to enhance the movement of COPCs. Heating may be accomplished by air or steam or electrical resistive heating.	Yes	Heating would speed up treatment time. Only applicable where, soil thickness does not prevent installation of extraction probes.
		Bioremedia-tion (Aerobic and/or Anaerobic)	A system of injection wells is used to introduce either oxygen or an oxygen scavenger (e.g., hydrogen) along with nutrients and bacteria to facilitate aerobic or anaerobic degradation.	Yes	Anaerobic process would be effective in treating PCE and its byproducts. Vinyl chloride would be removed aerobically. Only applicable where soil thickness does not prevent installation of extraction probes.

GENERAL RESPONSE ACTION	REMEDIAL TECH-NOLOGY	PROCESS OPTIONS	DESCRIPTION	RETAIN (YES / NO)	SCREENING COMMENTS
		Chemical Oxidation / Reduction	A reducing agent or an oxidizing solution, such as hydrogen peroxide, is injected into the soil to degrade the COPCs.	Yes	Chemical oxidation would be effective in treating PCE and its byproducts. May require multiple treatments when compounds are sorbed to low permeability silts and clays. Mainly applicable where soil thickness is sufficient for injection.
		Soil Flushing	Soil is flushed in situ with water or a detergent solution to mobilize the impacts. The impacted water is intercepted, collected, and pumped to the surface for separation of the COPCs.	No	In situ solvent flushing may be effective, but it would be difficult to collect all of the flushed solvent.

GENERAL RESPONSE ACTION	REMEDIAL TECHNOLOGY	PROCESS OPTIONS	DESCRIPTION	RETAIN (YES / NO)	SCREENING COMMENTS
No Action	None	None	No actions are taken to meet Remedial Action Objectives	Yes	Analysis of a No Action Alternative is required.
Institutional Controls	Alternative Drinking Water Source	New Potable Water Supply	A public water supply would be made available to residences in impacted areas.	Yes	Potentially viable where not already implemented.
		Home treatment Units	Treatment units, such as carbon filtration units are installed on the service line to individual residences.	Yes	Already implemented at several residences.
	Use Restrictions	Deed and Zoning Restrictions	Property with impacted water has land use restrictions placed on the deeds.	Yes	May be used in conjunction with other response action technologies.
	Monitoring	Groundwater Monitoring	Short (1-5 years) and/or long term (20 + years) monitoring is implemented to record aquifer conditions and contaminant levels.	Yes	Potentially viable.
Natural Attenuation	Monitoring	Groundwater Monitoring	Monitoring, including specific parameters to evaluate natural degradation.	Yes	Potentially viable.

GENERAL RESPONSE ACTION	REMEDIAL TECHNOLOGY	PROCESS OPTIONS	DESCRIPTION	RETAIN (YES / NO)	SCREENING COMMENTS
Containment	Physical Barriers	Barrier Wall (unconsolidated zone)	A barrier is installed in the unconsolidated materials and keyed into the bedrock to prevent movement of impacted groundwater past the barrier. Wall may be soil-bentonite, cement-bentonite, or sheet piling.	No	Not implementable due to size of area, land use, and because majority of groundwater impacts are in bedrock.
		Rock Grouting	Grout is injected into bedrock to seal fractures, solution cavities, and voids.	No	Not feasible. DNAPL is present in fractures. Also, difficult to implement due to uncertainties in fracture patterns.
	Capping	Capping	An impermeable barrier is installed at the surface to minimize infiltration of surface water.	No	Effectiveness would be limited because of extent of groundwater movement and distribution. Personal property and land use prohibits this option.
Removal	Groundwater Extraction	Wells	A series of wells are installed to control the flow of groundwater, and prevent or minimize migration.	No	Not feasible due to extent of impacted groundwater, volume of water that would be required for extraction / treatment, and uncertainties in providing hydraulic control in bedrock units.

GENERAL RESPONSE ACTION	REMEDIAL TECHNOLOGY	PROCESS OPTIONS	DESCRIPTION	RETAIN (YES / NO)	SCREENING COMMENTS
		Interception Trenches	Interception trenches would be installed with perforated collection pipe within a gravel collection zone to collect impacted groundwater.	No	Impacted groundwater is in bedrock. Not technically viable due to depth of groundwater impacts.
		Fracturing	Injection of a highly pressurized fluid to extend existing fractures in bedrock or create new fractures. The fracturing would be utilized as a means to enhance extraction from the bedrock.	No	Fracturing would improve groundwater extraction through wells; however, the area is too large and impacted groundwater too deep to be practical.
Treatment	Ex-Situ Treatment	Off-site treatment facility	The extracted groundwater (wells or interception trenches) would be transported to an off-site treatment facility.	No	Extent of impacted groundwater and expected groundwater extraction volumes are too great.
		On-site treatment facility (physical, chemical, and/or biological)	The extracted groundwater would be treated in an on-site treatment facility that may include physical, chemical, and/or biological processes.	No	Extent of impacted groundwater and expected groundwater extraction volumes are too great.
	In-Situ Treatment	Air Sparging	A system of wells is installed to inject air into the groundwater to remove volatiles by air stripping. Volatiles would be transferred to the air and removed using SVE wells.	No	Impacted groundwater is primarily in bedrock. Air sparging is typically combined with SVE in a soil environ-ment making technology unsuitable. Process has limited ability to penetrate fractures in bedrock.

GENERAL RESPONSE ACTION	REMEDIAL TECHNOLOGY	PROCESS OPTIONS	DESCRIPTION	RETAIN (YES / NO)	SCREENING COMMENTS
		Thermally Enhanced Vapor Extraction	A system of co-located well pairs is installed. One with electrodes or for injection of steam and a second adjacent recovery well for vapor and or liquid extraction.	Yes	Potentially viable for source area. Steam generated from electrodes transforms COPCs to a vapor for removal by vapor extraction.
		Reactive Barrier Wall	Trenches on the downgradient side of the impacted groundwater would be installed and backfilled with permeable treatment media to remove the COPCs from the groundwater.	No	Not feasible to install due to depth of groundwater impacts in bedrock.
		Bioremediation (Aerobic and/or Anaerobic)	A system of injection wells is used to introduce either oxygen or an oxygen scavenger (e.g., hydrogen) along with nutrients and bacteria to facilitate aerobic or anaerobic degradation of the COPCs.	Yes	Potentially viable, especially in or near source areas.
		Chemical Oxidation	A system of wells is used to apply oxidizers to degrade COPCs.	Yes	Potentially viable, especially in or near source areas
		Chemical Reduction	A system of wells is used to apply a reducing agent to degrade COPCs.	Yes	Potentially viable, especially in or near source areas.
		In Well Aeration	Installation of wells with two hydraulically separated screened intervals. Air is pumped into the lower section of the well, lifting the water to re-infiltrate into the aquifer through the upper screen. Impacted vapors that are removed from the water are drawn out of the well for treatment or discharge.	No	May not work in fractured bedrock setting.

GENERAL RESPONSE ACTION	REMEDIAL TECHNOLOGY	PROCESS OPTIONS	DESCRIPTION	RETAIN (YES / NO)	SCREENING COMMENTS
No Action	None	None	No actions are taken to meet Remedial Action Objectives	Yes	Analysis of a No Action Alternative is required.
Institutional Controls	Use Restrictions	Deed and Zoning Restrictions	Property with impacted water has land use restrictions placed on the deeds.	Yes	May be used in conjunction with other response action technologies.
	Monitoring	DNAPL Monitoring	Short and/or long term monitoring is implemented to record aquifer conditions and contaminant levels.	Yes	Potentially viable.
Containment		Barrier Wall (unconsolidated zone)	A barrier is installed in the unconsolidated materials and keyed into the bedrock to prevent movement of impacted groundwater past the barrier. Wall may be soil-bentonite, cement-bentonite, or sheet piling.	No	Not implementable due to size of area, limited soil thickness in area with DNAPL, and land use.
		Rock Grouting	Grout is injected into bedrock to seal fractures, solution cavities, and voids.	No	Not feasible. DNAPL is present in fractures. Also, difficult to implement due to uncertainties in fracture patterns.
		Capping	An impermeable barrier is installed at the surface to minimize infiltration of surface water.	Yes	Applicable in areas where capping is used for soil remediation.
Removal	Extraction	Wells	Wells are installed to extract DNAPL.	Yes	DNAPL wells in plume area would reduce volume of COPCs in source area.

GENERAL RESPONSE ACTION	REMEDIAL TECHNOLOGY	PROCESS OPTIONS	DESCRIPTION	RETAIN (YES / NO)	SCREENING COMMENTS
		Interception Trenches	Interception trenches would be installed with perforated collection pipe within a gravel collection zone to collect DNAPL.	No	DNAPL is in bedrock. Not technically viable.
Treatment	In-Situ Treatment	Air Sparging	A system of wells is installed to inject air into the groundwater to remove volatiles by air stripping. Volatiles would be transferred to the air and removed using SVE wells.	Yes	Potentially viable. Typically combined with SVE.
		Thermally Enhanced Vapor Extraction	A system of co-located wells is installed. One has electrodes or injects steam and adjacent is a recovery well for vapor and or liquid extraction.	Yes	Potentially viable. Steam generated from electrodes turns DNAPL to a vapor or a mobile liquid.
		Bioremediation (Aerobic and/or Anaerobic)	A system of injection wells is used to introduce either oxygen or an oxygen scavenger along with nutrients and bacteria to facilitate aerobic or anaerobic degradation of the COPCs.	Yes	Potentially viable.
		Chemical Oxidation	A system of wells is used to apply oxidizers to degrade COPCs.	Yes	Potentially viable for degradation of PCE and its daughter products.
		Chemical Reduction	A system of wells is used to apply a reducing agent to degrade COPCs.	Yes	Potentially viable for degradation of PCE.

GENERAL RESPONSE ACTION	REMEDIAL TECH-NOLOGY	PROCESS OPTIONS	EFFECTIVE-NESS	IMPLEMENTABILITY	RELATIVE COST	RETAIN (YES / NO)	SCREENING COMMENTS
No Action	None	None	Does not meet RAOs	Easy	None	Yes	Analysis of a No Action Alternative is required.
Institutional Controls	Land use	Deed and Zoning Restrictions	Moderate	Difficult	Low	No	Land owned by others.
Containment	Capping	Soil	Moderate	Easy	Low to Moderate	No	Applicable to area north of former Kellwood facility (Area A-1). Does not prevent potential leaching to groundwater.
		Asphalt / Concrete	Moderate	Easy	Low to Moderate	Yes	Applicable to Area A-1. Soil below road (Area A-2) already contained with asphalt. Provides protection against leaching to groundwater.
Removal	Excavation	Excavation	High	Difficult in area north of former Kellwood Facility (Area A-1). Difficult to implement below road (Area A-2) or building (Area A-3).	Low	No	Would only be potentially applicable to Area A-1; however, presence of soil in pockets among bedrock makes this area difficult to excavate.
Disposal	On-Site Disposal	Replace in Excavation after Treatment	High	Moderately easy	Low	No	Not retained with screening out removal (excavation) action.

GENERAL RESPONSE ACTION	REMEDIAL TECH-NOLOGY	PROCESS OPTIONS	EFFECTIVE-NESS	IMPLEMENTABILITY	RELATIVE COST	RETAIN (YES / NO)	SCREENING COMMENTS
	Offsite Disposal	RCRA Landfill	High	Easy	High	No	Not retained with screening out removal (excavation) action.
		Solid Waste Landfill	Moderate	Easy	Moderate	No	Not retained with screening out removal (excavation) action.
Treatment	Physical, Ex Situ	Mechanical Separation	Moderate	Easy	Low	No	Not retained with screening out removal (excavation) action.
	Physical / Chemical, Ex Situ	Solvent Extraction	Moderate	Moderately difficult	Moderate	No	Not retained with screening out removal (excavation) action.
		Solidification / Stabilization	High	Difficult	Low	No	Only potentially applicable to Area A-1; however, presence of soil in pockets among bedrock makes this area difficult to stabilize.
		Incineration	High	Easy	Very high	No	Not retained with screening out removal (excavation) action.
		Thermal Desorption	High	Moderately difficult	High	No	Not retained with screening out removal (excavation) action.
	Biological, Ex Situ	Biopiles	High	Moderate	Moderate	No	Not retained with screening out removal (excavation) action.

GENERAL RESPONSE ACTION	REMEDIAL TECH-NOLOGY	PROCESS OPTIONS	EFFECTIVE-NESS	IMPLEMENTABILITY	RELATIVE COST	RETAIN (YES / NO)	SCREENING COMMENTS
	In Situ	Soil Vapor Extraction	Moderate	Difficult (Area A-1), Moderately difficult (Areas A-2 and A-3)	Moderate	No (Area A-1); Yes (Areas A-2 and A-3)	Shallow depth of soils in Area A-1 prohibits this alternative. Would be effective in Areas A-2 and A-3, but requires longer timeframe.than thermally enhanced vapor extraction.
		Thermally Enhanced Vapor Extraction	Moderate	Difficult (Area A-1), Moderately difficult (Areas A-2 and A-3)	Moderate	No (Area A-1); Yes (Areas A-2 and A-3)	Shallow depth of soils in Area A-1 prohibits this alternative. Would be effective in Areas A-2 and A-3.
		Bioremediation (Aerobic and/or Anaerobic)	Low (Anaerobic)	Difficult (Area A-1), Moderately difficult (Areas A-2 and A-3)	Moderate	No (Area A-1); No(Areas A-2 and A-3)	Shallow depth of soils in Area A-1 prohibits this alternative. Unsaturated soil would prohibit effectiveness in Areas A-2 and A-3.
		Chemical Oxidation / Reduction	Moderate	Difficult (Area A-1), Moderately difficult (Areas A-2 and A-3)	Moderate	No (Area A-1); Yes (Areas A-2 and A-3)	Shallow depth of soils in Area A-1 prohibits this alternative. Would be effective in Areas A-2 and A-3.

GENERAL RESPONSE ACTION	REMEDIAL TECH-NOLOGY	PROCESS OPTIONS	EFFECTIVE-NESS	IMPLEMENTABILITY	RELATIVE COST	RETAIN (YES / NO)	SCREENING COMMENTS
No Action	None	None	Does not meet RAOs	Easy	Low	Yes	Analysis of a No Action Alternative is required.
Institutional Controls		New Potable Water Supply	High	Moderate	Moderate	Yes	Potentially viable where not already implemented.
	Use Restrictions	Deed and Zoning Restrictions	Moderate	Difficult	Low	Yes	Property impacted is owned by others. Alternative to be used in conjunction with others (alternative potable water supply). Water well construction restrictions are in place.
	Alternative Drinking Water Source	Home treatment Units	Moderate	Moderately easy	Low	Yes	Already implemented at several residences. Units require monitoring and maintenance.
	Monitoring	Groundwater Monitoring	Moderate	Easy	Low to moderate	Yes	Residences with impacted groundwater were provided with home treatment units. Wells may need to be replaced or relined if VOCs begin to leak through casing.
Natural Attenuation	Monitoring	Groundwater Monitoring	Moderate	Easily implemented	Low to moderate	Yes	Provides additional data on PCE degradation relative to monitoring alone. Residences with impacted groundwater have been provided with home treatment units.

GENERAL RESPONSE ACTION	REMEDIAL TECH-NOLOGY	PROCESS OPTIONS	EFFECTIVE-NESS	IMPLEMENTABILITY	RELATIVE COST	RETAIN (YES / NO)	SCREENING COMMENTS
Treatment		Thermally Enhanced Vapor Extraction	Moderate	Moderately difficult to implement	High	No	Other alternatives would be much more cost effective. Only groundwater treatment would be if used for DNAPL treatment, then groundwater in same treatment zone would also be remediated.
		Bioremediation (Aerobic and/ or Anaerobic)	Moderate	Difficult to implement	Low to Moderate	Yes	Extent of impacts on offsite properties make option infeasible for entire area with impacted groundwater. May be applicable to limit movement in highest impacted zone (Area A-4 near southern end of Industrial Drive).
		Chemical Oxidation	Moderate	Difficult to implement	Low to Moderate	Yes	Extent of impacts on offsite properties make option infeasible for entire area with impacted groundwater. However, it may be applicable to a limited application area to limit movement in Area A-4.

GENERAL RESPONSE ACTION	REMEDIAL TECH-NOLOGY	PROCESS OPTIONS	EFFECTIVE-NESS	IMPLEMENTABILITY	RELATIVE COST	RETAIN (YES / NO)	SCREENING COMMENTS
		Chemical Reduction	Moderate	Difficult to implement	Low to Moderate	Yes	Extent of impacts on offsite properties make option infeasible for entire area with impacted groundwater. However, it may be applicable to a limited application area to limit movement in Area A-4.

GENERAL RESPONSE ACTION	REMEDIAL TECH-NOLOGY	PROCESS OPTIONS	EFFECTIVE-NESS	IMPLEMENT-ABILITY	RELATIVE COST	RETAIN (YES / NO)	SCREENING COMMENTS
No Action	None	None	Does not meet RAOs	Easily implemented	Low	Yes	Analysis of a No Action Alternative is required.
Institutional Controls	Use Restrictions	Deed and Zoning Restrictions	Moderate	Difficult to implement	Low	Yes	Property impacted is owned by others. Alternative to be used in conjunction with groundwater options (alternative potable water supply)
	Monitoring	DNAPL Monitoring	Moderate	Easy to implement	Low to Moderate	Yes	Alternative used in conjunction with groundwater options. DNAPL expected to continue to dissolve into groundwater.
Containment		Capping	Low to Moderate	Easy to implement	Moderate	Yes	Applicable when also used for soil remediation.
Removal	Extraction	Wells	Low to Moderate	Difficult to implement	Moderate	No	Removal quantities are small. Difficult to extract from fractures in bedrock.
Treatment	In-Situ Treatment	Air Sparging	Low to Moderate	Difficult to implement	Moderate	No	Process has limited ability to penetrate fractures in bedrock.
		Thermally Enhanced Vapor Extraction	Moderate	Moderately difficult to implement	Moderate to High	Yes	Process would vaporize or transform DNAPL in crevices to liquid phase, facilitating removal.

GENERAL RESPONSE ACTION	REMEDIAL TECH-NOLOGY	PROCESS OPTIONS	EFFECTIVE-NESS	IMPLEMENT-ABILITY	RELATIVE COST	RETAIN (YES / NO)	SCREENING COMMENTS
		Bioremediation (Aerobic and/or Anaerobic)	Low	Moderately difficult to implement	Moderate	No	Process effectiveness is impacted by ability to penetrate fractures in bedrock and presence of DNAPL above water table.
		Chemical Oxidation	Moderate	Moderately easy to implement	Moderate	Yes	Potentially viable for degradation of PCE and its break-down products.
		Chemical Reduction	Moderate	Moderately easy to implement	Moderate	Yes	Potentially viable for degradation of PCE and its break-down products.

Medium	***Technology Type***	***Area or Volume***	**Alternative 1 (No Action)**	**Alternative 2a (Cap/In-house treatment)**	**Alternative 2b (Cap/water supply)**	**Alternative 3a (Thermal Treatment of DNAPL/In-house treatment)**	**Alternative 3b (Thermal Treatment of DNAPL/water supply)**	**Alternative 4(a,b,c) (Thermal/GW treatment by 3 optional methods)**	**Alternative 5 (Chemical oxidation)**	**Alternative 6 (EZVI)**
Soil	No Action	Entire Site	•							
	Asphalt or concrete cap	A-1 (20,541 SF)		•	•					
	Thermally enhanced vapor extraction	A-2 and A-3 (144,080 CF)						•		
	In Situ Chemical Oxidation	A-2 and A-3 (144,080 CF)							•	
	In Situ Chemical Reduction *(zero valent iron)*	A-2 and A-3 (144,080 CF)								•
Groundwater	No Action	Entire Site	•							
	Institutional restrictions	Various (restrictions are to groundwater use)		•	•	•	•	•	•	•
	Home treatment units	Impacted residences		•		•		•	•	•
	Provide potable water service	TBD			•		•			
	Groundwater monitoring / Natural attenuation	Entire Site		•	•	•	•	•	•	•
	Bioremediation	730 ft line between OU2 and OU6 (A-4)						•		
	In Situ Chemical Oxidation	730 ft line between OU2 and OU6 (A-4)						•	•	
	In Situ Chemical Reduction *(zero valent iron)*	730 ft line between OU2 and OU6 (A-4)						•		•
DNAPL	No Action	Entire Site	•							
	Institutional restrictions	Various (restrictions are to groundwater use)		•	•	•	•	•	•	•
	DNAPL monitoring	Source Area and Select Potable Water Wells		•	•					
	Capping	Source Area		•	•					
	Thermally enhanced vapor extraction	Source Area (8 - 20 ft bgs)				•	•	•		
	In Situ Chemical Oxidation	Source Area (8 - 20 ft bgs)							•	
	In Situ Chemical Reduction *(zero valent iron)*	Source Area (8 – 20 ft bgs)								•

Notes:
Alternative 4 has three groundwater treatment options (bioremediation, chemical oxidation, and chemical reduction). One option or a combination of these will be selected upon further evaluation during the design phase.
Source Area: landfarm area (i.e., area north of former Kellwood facility)
Entire Site: OU2 and OU6

Criteria	Alternative 1- No Action	Alternative 2a – Asphalt or Concrete Cap (Area 1), Whole-house Treatment Units, Monitoring	Alternative 2b – Asphalt or Concrete Cap (Area 1), Potable Water Line, Monitoring	Alternative3a- Thermally Enhanced Vapor Extraction (DNAPL Source Area), Whole-house Treatment Units, Monitoring	Alternative3b- Thermally Enhanced Vapor Extraction (DNAPL Source Area), Potable Water Line, Monitoring
Overall Protectiveness					
Human Health	No reduction in risk	Cap removes contact risk for soil. Provision of treated water removes risk of groundwater consumption.	Cap removes contact risk for soil. Provision of potable water removes risk of groundwater consumption.	Provision of treated water removes risk of groundwater consumption.	Provision of potable water removes risk of groundwater consumption.
Environmental	No reduction in risk.	Cap reduces infiltration, and minimizes migration of impacts to groundwater.	Cap reduces infiltration, and minimizes migration of impacts to groundwater.	Over time, there would be a reduction in risk to the surface water as groundwater levels decrease.	Over time, there would be a reduction in risk to the surface water as groundwater levels decrease.
Compliance with ARARs					
	Does not comply with ARARs for COPCs above risk based target levels.	ARARs for groundwater concentrations of COPCs will not be met until natural attenuation has occurred to reduce concentrations below regulatory levels.	ARARs for groundwater concentrations of COPCs will not be met until natural attenuation has occurred to reduce concentrations below regulatory levels.	ARARs for groundwater concentrations of COPCs will not be met until natural attenuation has occurred to reduce concentrations below regulatory levels. Removal of DNAPL source expected to expedite the process.	ARARs for groundwater concentrations of COPCs will not be met until natural attenuation has occurred to reduce concentrations below regulatory levels. Removal of DNAPL source should expedite this process.
Long-term Effectiveness and Permanence					
Magnitude of Residual Risk	Source has not been removed. Existing risk will remain.	Provision of treated water supply eliminates ingestion risk. Source has not been removed.	Provision of a potable water supply eliminates ingestion risk. Source has not been removed.	Source will be reduced but residual DNAPL may remain in bedrock fractures . Groundwater quality downgradient should improve with reduction in DNAPL at source. Risk should be reduced. Provision of treated water supply eliminates ingestion risk.	Source will be reduced but residual DNAPL may remain in bedrock fractures. Groundwater quality downgradient should improve with reduction in DNAPL at source. Risk should be reduced. Provision of a potable water supply eliminates ingestion risk.
Adequacy and Reliability of Controls	No controls over remaining impacts. No reliability.	Existing institutional restrictions and availability of water treatment units would prohibit use of impacted groundwater for consumption.	Existing institutional restrictions and availability of alternate potable water supply would prohibit use of groundwater for consumption.	Existing institutional restrictions and availability of water treatment units would prohibit use of impacted groundwater for consumption.	Existing institutional restrictions and availability of alternate potable water supply would eliminate use of groundwater for consumption.
Need for 5 Year Review	Review required to document adequate protection of human health and the environment.	Review required to document adequate protection of human health and the environment.	Review required to document adequate protection of human health and the environment.	Review required to document adequate protection of human health and the environment.	Review required to document adequate protection of human health and the environment.
Reduction of Toxicity, Mobility, or Volume					
Treatment Process Used	None	Remedy for DNAPL is isolation, not treatment. Treated groundwater provided as required to residences.	Remedy for DNAPL is isolation, not treatment. Alternate source for groundwater provided.	Thermally enhanced vapor extraction for DNAPL, treated groundwater provided as required to residences.	Thermally enhanced vapor extraction for DNAPL. Alternate source for groundwater provided..
Statutory Preference for Treatment	Does not satisfy.	Does not satisfy.	Does not satisfy.	Satisfies for DNAPL source area.	Satisfies for DNAPL source area.
Impact on Migration to Surface Water	None	Cap reduces migration rates.	Cap reduces migration rates.	Over time, reduced groundwater concentration will decrease potential for impacts.	Over time, reduced groundwater concentration will decrease potential for impacts.
Impact on migration to sanitary sewers	None	Cap reduces migration rates.	Cap reduces migration rates.	Remediation of DNAPL in source area will mitigate impact.	Remediation of DNAPL in source area will mitigate impact.

Criteria	Alternative 1- No Action	Alternative 2a – Asphalt or Concrete Cap (Area 1), Whole-house Treatment Units, Monitoring	Alternative 2b – Asphalt or Concrete Cap (Area 1), Potable Water Line, Monitoring	Alternative3a- Thermally Enhanced Vapor Extraction (DNAPL Source Area), Whole-house Treatment Units, Monitoring	Alternative3b- Thermally Enhanced Vapor Extraction (DNAPL Source Area), Potable Water Line, Monitoring
Short-term Effectiveness					
Community Protection	Risk to community remains.	Provision of whole-house water treatment units for residences with water supply with COPCs greater than MCLs protects community from groundwater impacts.	Provision of potable water supply protects community from groundwater impacts.	Provision of whole-house water treatment units for residences with water supply with COPCs greater than MCLs protects community from groundwater impacts.	Provision of potable water supply protects community from groundwater impacts.
Worker Protection	No risk.	Minimal risk to workers constructing remedy.	Minimal risk to workers constructing remedy.	Minimal risk to workers constructing remedy. Thermal treatment may require high voltage power supply.	Minimal risk to workers constructing remedy. Thermal treatment may require high voltage power supply.
Environmental Impacts	Continued presence of impacted groundwater, DNAPL and impacted soil.	Cap construction is relatively non-intrusive. Continued presence of impacted groundwater, DNAPL and impacted soil.	Cap construction is relatively non-intrusive. Continued presence of impacted groundwater, DNAPL and impacted soil.	Treatment of DNAPL source will minimize dispersion to groundwater due to reduction in source mass and improved natural attenuation as a result of treatment upgradient.	Treatment of DNAPL source will minimize dispersion to groundwater due to reduction in source mass and improved natural attenuation as a result of treatment upgradient.
Time Until Action is Complete	Not completed.	Design and construction would take 6 months. Monitoring of natural attenuation process would be ongoing for years.	Design and construction would take 18 months. Monitoring of natural attenuation process would be ongoing for years.	Design and implementation of thermal treatment would take 18 months. Monitoring of natural attenuation process would be ongoing for years.	Design and implementation of thermal treatment and water system would take 18 months. Monitoring of natural attenuation process would be ongoing for years.
Implementability					
Ability to Construct and Operate	No construction or operation	Asphalt cap would be easy to construct. Would require clearing and grading, but this would be easy to accomplish.	Asphalt cap would be easy to construct. Would require clearing and grading, but this would be easy to accomplish. New water mains will need to be designed and installed. The water mains road right-of-ways and property easements (past the end of Wildcat Creek Lane to Boeuf-Lutheran Road) will need to be negotiated with the local municipality and homeowners during the design. Some homeowners may be reluctant to have their existing water wells abandoned.	The thermal remediation system in area A-1 would be on property owned by the City of New Haven. Activities adjacent to the building would need to be coordinated with Owner.	The thermal remediation system in area A-1 would be on property owned by the City of New Haven. Activities adjacent to the building would need to be coordinated with owner. New water mains need to be designed and installed. Road right-of-ways and property easements (past the end of Wildcat Creek Lane to Boeuf-Lutheran Road) need to be negotiated with the local municipality and homeowners. Some homeowners may be reluctant to have their wells abandoned.
Ease of Doing More Action if Needed	Other alternatives could be implemented as noted or could re-evaluate alternatives.	Other alternatives could be implemented as noted or could re-evaluate alternatives.	Other alternatives could be implemented as noted or could re-evaluate alternatives. Waterline could be extended if required to address new impacted homeowners.	The DNAPL treatment could be modified and extended or an alternate treatment method could be used.	The DNAPL treatment could be modified and extended or an alternate treatment method could be used. Waterline could be extended if required to address new impacted homeowners
Ability to Monitor Effectiveness	No monitoring included with this alternative.	Monitoring wells may be monitored to evaluate changes in groundwater concentrations. Condition of asphalt cap may be monitored visually as part of an O&M program.	Monitoring wells may be monitored to evaluate changes in groundwater concentrations. Condition of asphalt cap may be monitored visually as part of an O&M program.	Monitoring wells may be monitored to evaluate changes in groundwater concentrations.	Monitoring wells may be monitored to evaluate changes in groundwater concentrations.

Criteria	**Alternative 1- No Action**	**Alternative 2a – Asphalt or Concrete Cap (Area 1), Whole-house Treatment Units, Monitoring**	**Alternative 2b – Asphalt or Concrete Cap (Area 1), Potable Water Line, Monitoring**	**Alternative3a- Thermally Enhanced Vapor Extraction (DNAPL Source Area), Whole-house Treatment Units, Monitoring**	**Alternative3b- Thermally Enhanced Vapor Extraction (DNAPL Source Area), Potable Water Line, Monitoring**
Ability to Obtain Approvals and to Coordinate with Agencies	No approvals necessary to "do nothing."	Whole-house water treatment system already in place; would require residential approval if required in future at additional residences. Area to be capped is City of New Haven property and would require their concurrence for design of cap.	Will require approval of regulatory agencies to install a potable water system. Area to be capped is City of New Haven property and would require their concurrence for design of cap.	Whole-house water treatment system already in place; would require residential approval if required in future at additional residences. Will need access to install remediation system on City of New Haven property north of former Kellwood facility (A-1).	Will require approval of regulatory agencies to install a potable water system. Will need access to install remediation system on City of New Haven property north of former Kellwood facility (A-1).
Availability of Services and Capacities	No services required.	Construction services and capabilities for installing asphalt or concrete cap are readily available.	Construction services and capabilities are readily available.	Construction services and capabilities are readily available.	Construction services and capabilities are readily available.
Availability of Equipment, Specialists, and Materials	No equipment, materials, or specialists required.	Equipment and materials for construction of asphalt cap would be readily available.	Equipment and materials for construction of asphalt cap and for water line would be readily available.	Remediation specialists are available. Equipment and materials are readily available.	Remediation specialists are available. Equipment and materials rare readily available. Equipment and materials for construction of water line are readily available.
Availability of Technology	No technology required.	No technology required.	No technology required.	Electrical resistive heating and vapor extraction technologies are available.	Electrical resistive heating and vapor extraction technologies are available.
Environmental Footprint					
Energy Efficiency	No energy consumption	Whole-house treatment units have minimal energy consumption, and relatively low carbon consumption. Carbon in filters would need to be replaced and carbon regenerated every 3 to 5 years.	A public water system will have a smaller energy footprint than continuing to operate individual wells at each property.	Whole-house treatment units have minimal energy consumption. Carbon in filters would need to be replaced and carbon regenerated every 3 to 5 years. Thermal treatment would require a high energy consumption.	Thermal treatment results in high energy consumption. A public water system will have a smaller energy footprint than continuing to operate individual wells at each property.
Air Emissions (Green House Gases)	Minimal air emissions from vaporization from soil or surface water.	Air emissions will be generated from construction equipment and from asphalt paving process (if cap material used) during construction of remedy.	Air emissions will be generated from construction equipment during construction of remedy. Air emissions associated with operation of public water system is less than for operation of individual wells.	Air emissions will be generated from construction equipment. An estimated 166 treatment wells would be installed.	Air emissions will be generated from construction equipment during construction of remedy. An estimated 166 treatment wells would be installed.
Water Consumption	No water consumption	No change in water consumption expected with modification of water source for impacted residences.	No change in water consumption expected with change in water source.	No change in water consumption expected with modification of water source for impacted residences. Some water would be used as part of the treatment process.	No change in water consumption expected with change in water source. Some water would be used as part of the treatment process.
Land and Ecosystems	Soil and groundwater is not restored.	Risks from soil and groundwater are removed. Impacts will decrease with time due to natural attenuation.	Risks from soil and groundwater are removed. Impacts will decrease with time due to natural attenuation.	Risks from soil and groundwater are removed. Impacts will decrease with time due to natural attenuation.	Risks from soil and groundwater are removed. Impacts will decrease with time due to natural attenuation.

Criteria	Alternative 1- No Action	Alternative 2a – Asphalt or Concrete Cap (Area 1), Whole-house Treatment Units, Monitoring	Alternative 2b – Asphalt or Concrete Cap (Area 1), Potable Water Line, Monitoring	Alternative3a- Thermally Enhanced Vapor Extraction (DNAPL Source Area), Whole-house Treatment Units, Monitoring	Alternative3b- Thermally Enhanced Vapor Extraction (DNAPL Source Area), Potable Water Line, Monitoring
Material Usage and Waste Production	No materials used or wastes produced.	Recycled asphalt could be incorporated into the design of an asphalt cap. No additional whole-house treatment units are anticipated. Carbon filters would need to be replaced periodically, but carbon would be regenerated.	Initial material usage to install water lines and cap. Some excavated materials from the water main construction may be reused as part of the cap sub-base. Recycled asphalt could be incorporated into the design of an asphalt cap.	DNAPL may be recovered from treatment points in A-1 prior to injection of chemicals. Vaporized DNAPL will be collected in a granular activated carbon (GAC) vessel. The carbon will need to be regenerated. No additional whole-house treatment units are anticipated. Carbon filters are replaced periodically and the carbon regenerated.	DNAPL may be recovered from treatment points in A-1 prior to injection of chemicals. Vaporized DNAPL will be collected in a GAC vessel. The carbon will need to be regenerated.
Cost					
Capital	$0	$570,000	$3,304,000	$2,172,000	$4,953,000
First Year Annual O&M Cost	$0	$220,000	$200,000	$200,000	$180,000
Present Worth Cost of O&M	$0	$2,730,000	$2,189,000	$2,482,000	$1,941,000
Total Cost - Capital and O&M Present Worth	$0	$3,300,000	$5,493,000	$4,654,000	$6,894,000

Criteria	Alternative 4a- Thermally Enhanced Vapor Extraction (Source Area) w/ Bioremediation for GW	Alternative 4b- Thermally Enhanced Vapor Extraction (Source Area) w/ In Situ Chemical Oxidation for GW	Alternative 4c- Thermally Enhanced Vapor Extraction (Source Area) w/ In Situ Chemical Reduction for GW	Alternative 5 - Chemical Oxidation	Alternative 6 - Chemical Reduction
Overall Protectiveness					
Human Health	Provision of treated water removes risk of groundwater consumption.	Provision of treated water removes risk of groundwater consumption.	Provision of treated water removes risk of groundwater consumption.	Provision of treated water removes risk of groundwater consumption.	Provision of treated water removes risk of groundwater consumption.
Environmental	Over time, there would be a risk reduction to surface water as groundwater levels decrease.	Over time, there would be a reduction in risk to the surface water as groundwater levels decrease.	Over time, there would be a reduction in risk to the surface water as groundwater levels decrease.	Over time, there would be a reduction in risk to the surface water as groundwater levels decrease.	Over time, there would be a reduction in risk to the surface water as groundwater levels decrease.
Compliance with ARARs					
	ARARs for groundwater concentrations of COPCs may not be met until natural attenuation has occurred to reduce concentrations below regulatory levels. Groundwater treatment at southern end of Industrial Drive would improve downgradient groundwater quality.	ARARs for groundwater concentrations of COPCs may not be met until natural attenuation has occurred to reduce concentrations below regulatory levels. Groundwater treatment at southern end of Industrial Drive would improve downgradient groundwater quality.	ARARs for groundwater concentrations of COPCs may not be met until natural attenuation has occurred to reduce concentrations below regulatory levels. Groundwater treatment at southern end of Industrial Drive would improve downgradient groundwater quality.	ARARs for groundwater concentrations of COPCs may not be met until natural attenuation has occurred to reduce concentrations below regulatory levels. Groundwater treatment at southern end of Industrial Drive would improve downgradient groundwater quality.	ARARs for groundwater concentrations of COPCs may not be met until natural attenuation has occurred to reduce concentrations below regulatory levels. Groundwater treatment at southern end of Industrial Drive would improve downgradient groundwater quality.
Long-term Effectiveness and Permanence					
Magnitude of Residual Risk	Source will be reduced but residual DNAPL may remain in bedrock crevices/fractures not reached by vapor extraction wells. Groundwater quality downgradient will improve with reduction in DNAPL at source. Risk will be reduced. Provision of treated water supply eliminates ingestion risk.	Source will be reduced but residual DNAPL may remain in crevices not reached by vapor extraction wells. Groundwater quality downgradient will improve with reduction in DNAPL at source and with treatment wall at OU-2 and OU6 boundary. Risk will be considerably reduced. Provision of treated water supply eliminates ingestion risk.	Source will be reduced but residual DNAPL may remain in crevices not reached by vapor extraction wells. Groundwater quality downgradient will improve with reduction in DNAPL at source and with treatment wall at OU-2 and OU6 boundary. Risk will be considerably reduced. Provision of treated water supply eliminates ingestion risk.	Source will be reduced but residual DNAPL may remain. DNAPL may not be fully converted. Groundwater quality downgradient will improve. Risk will be considerably reduced. Provision of treated water supply eliminates ingestion risk.	Source will be reduced but residual DNAPL may remain. DNAPL may not be fully converted. Groundwater quality downgradient will improve. Risk will be considerably reduced. Provision of treated water supply eliminates ingestion risk.
Adequacy and Reliability of Controls	Existing institutional restrictions and availability of water treatment units would eliminate use of impacted groundwater for consumption.	Existing institutional restrictions and availability of water treatment units would prohibit use of impacted groundwater for consumption.	Existing institutional restrictions and availability of water treatment units would prohibit use of impacted groundwater for consumption.	Existing institutional restrictions and availability of water treatment units would prohibit use of impacted groundwater for consumption.	Existing institutional restrictions and availability of water treatment units would prohibit use of impacted groundwater for consumption.
Need for 5 Year Review	Review required to document adequate protection of human health and the environment.	Review required to document adequate protection of human health and the environment.	Review required to document adequate protection of human health and the environment.	Review required to document adequate protection of human health and the environment.	Review required to document adequate protection of human health and the environment.
Reduction of Toxicity, Mobility, or Volume					
Treatment Process Used	Thermally enhanced vapor extraction for soil and DNAPL. Bioremediation for groundwater treatment zone. Treated groundwater provided as required to residences	Thermally enhanced vapor extraction for soil and DNAPL. *In situ* chemical oxidation for groundwater treatment zone. Treated groundwater provided as required to residences.	Thermally enhanced vapor extraction for soil and DNAPL. *In situ* chemical reduction for groundwater treatment zone. Treated groundwater provided as required to residences.	Chemical oxidation (e.g., activated persulfate) of DNAPL and soil areas and for a groundwater treatment zone. Treated groundwater provided as required to residences.	Chemical reduction (e.g., eZVI) for DNAPL and soil areas and for a groundwater treatment zone. Treated groundwater provided as required to residences.

Criteria	**Alternative 4a- Thermally Enhanced Vapor Extraction (Source Area) w/ Bioremediation for GW**	**Alternative 4b- Thermally Enhanced Vapor Extraction (Source Area) w/ In Situ Chemical Oxidation for GW**	**Alternative 4c- Thermally Enhanced Vapor Extraction (Source Area) w/ In Situ Chemical Reduction for GW**	**Alternative 5 - Chemical Oxidation**	**Alternative 6 - Chemical Reduction**
Statutory Preference for Treatment	Satisfies for source area and provides treatment of upper aquifer at treatment zone located at southern end of Industrial Drive.	Satisfies for source area and provides treatment of upper groundwater aquifer at treatment zone located at southern end of Industrial Drive.	Satisfies for source area and provides treatment of upper groundwater aquifer treatment zone located at southern end of Industrial Drive.	Satisfies for source area and provides treatment of upper groundwater aquifer treatment zone located at southern end of Industrial Drive.	Satisfies for source area and provides treatment of upper groundwater aquifer at treatment zone located at southern end of Industrial Drive.
Impact on Migration to Surface Water	Over time, reduced groundwater concentration will decrease impacts.	Over time, reduced groundwater concentration will decrease impacts.	Over time, reduced groundwater concentration will decrease impacts.	Over time, groundwater concentration will decrease impacts.	Over time, groundwater concentration will decrease impacts.
Impact on migration to sanitary sewers	Remediation of DNAPL in source area will mitigate impact.	Remediation of DNAPL in source area will mitigate impact.	Remediation of DNAPL in source area will mitigate impact.	Remediation of DNAPL in source area will mitigate impact.	Remediation of DNAPL in source area will mitigate impact.
Short-term Effectiveness					
Community Protection	Provision of whole-house water treatment units for residences with water supply with COPCs greater than MCLs protects community from groundwater impacts. Source treatment will provide short-term impact at source area. .	Provision of whole-house water treatment units for residences with water supply with COPCs greater than MCLs protects community from groundwater impacts. Source treatment will provide short-term impact at source area. Multiple injections may be required of chemical oxidation compounds.	Provision of whole-house water treatment units for residences with water supply with COPCs greater than MCLs protects community from groundwater impacts.. Source treatment will provide short-term impact at source area.	Provision of whole-house water treatment units for residences with water supply with COPCs greater than MCLs protects community from groundwater impacts. Source treatment will provide short-term impact at source area. Multiple injections may be required of chemical oxidation compounds.	Provision of whole-house water treatment units for residences with water supply with COPCs greater than MCLs protects community from groundwater impacts. Source treatment will provide short-term impact at source area.
Worker Protection	Minimal risk to workers constructing remedy. Groundwater remedy may require working with pressurized gas (hydrogen). Thermal treatment may require high voltage power supply.	Moderate risk to workers constructing remedy. Groundwater remedy would require working with chemicals. Thermal treatment may require high voltage power supply.	Minor risk to workers constructing remedy. Groundwater remedy would require working with chemicals. Thermal treatment may require high voltage power supply.	Moderate risk to workers constructing remedy. Remedy would require working with chemicals.	Minor risk to workers constructing remedy. Remedy would require working with chemicals.
Environmental Impacts	Impacted groundwater may continue until groundwater concentrations reduce due to treatment and through natural attenuation.	Impacted groundwater may continue until groundwater concentrations reduce due to treatment and through natural attenuation.	Impacted groundwater may continue until groundwater concentrations reduce due to treatment and through natural attenuation.	Impacted groundwater may continue until groundwater concentrations reduce due to treatment and through natural attenuation.	Impacted groundwater may continue until groundwater concentrations reduce due to treatment and through natural attenuation.
Time Until Action is Complete	Design and implementation of treatment systems would take 2 years. Groundwater treatment would continue for up to 5 years. Monitoring of natural attenuation process would be ongoing for years.	Design and implementation of treatment systems would take 2 years. Groundwater treatment would continue for up to 5 years. Monitoring of natural attenuation process would be ongoing for years.	Design and implementation of treatment systems would take 2 years. Groundwater treatment would continue for up to 5 years. Monitoring of natural attenuation process would be ongoing for years.	Design and implementation of treatment systems would take 2 years. Groundwater treatment would continue for up to 5 years. Monitoring of natural attenuation process would be ongoing for years.	Design and implementation of treatment systems would take 2 years. Groundwater treatment would continue for up to 5 years. Monitoring of natural attenuation process would be ongoing for years.
Implementability					
Ability to Construct and Operate	The thermal remediation system in area A-1 would be on property owned by the City of New Haven. Activities adjacent to the building would need to be coordinated with Owner. A-2 remediation would require utilities in the roadway to be temporarily relocated. A-3 remediation would require access to facility building, work would probably	The thermal remediation system in area A-1 would be on property owned by the City of New Haven. Activities adjacent to the building would need to be coordinated with Owner. A-2 remediation would require utilities in the roadway to be temporarily relocated. A-3 remediation would require access to facility building, work would probably have to be conducted on weekends.	The thermal remediation system in area A-1 would be on property owned by the City of New Haven. Activities adjacent to the building would need to be coordinated with owner. A-2 remediation would require utilities in the roadway to be temporarily relocated. A-3 remediation would require access to facility building, work would probably have to be conducted on weekends.	The remediation system in area A-1 would be on property owned by the City of New Haven. Activities adjacent to the building would need to be coordinated with owner. A-2 remediation would require disruption to traffic during installation. A-3 remediation would require access to facility building, work would probably have to be conducted on weekends.	The remediation system in area A-1 would be on property owned by the City of New Haven. Activities adjacent to the building need to be coordinated with owner. A-2 remediation would require disruption to traffic during installation. A-3 remediation would require access to facility building, work would probably have to be conducted on weekends. The groundwater treatment zone would

Criteria	Alternative 4a- Thermally Enhanced Vapor Extraction (Source Area) w/ Bioremediation for GW	Alternative 4b- Thermally Enhanced Vapor Extraction (Source Area) w/ In Situ Chemical Oxidation for GW	Alternative 4c- Thermally Enhanced Vapor Extraction (Source Area) w/ In Situ Chemical Reduction for GW	Alternative 5 - Chemical Oxidation	Alternative 6 - Chemical Reduction
	have to be conducted on weekends. The groundwater treatment zone would require obtaining access to property from owners and temporary disruption to road traffic. Procedures are already in place to provide home water treatment systems.	The groundwater treatment zone would require obtaining access to property from owners and temporary disruption to road traffic. Procedures are already in place to provide home water treatment systems.	The groundwater treatment zone would require obtaining access to property from owners and temporary disruption to road traffic. Procedures are already in place to provide home water treatment systems.	The groundwater treatment zone would require obtaining access to property from owners and temporary disruption to road traffic.. Procedures are already in place to provide home water treatment systems.	require obtaining access to property from owners and temporary disruption to road traffic.. Procedures are already in place to provide home water treatment systems.
Ease of Doing More Action if Needed	The groundwater treatment could be extended or an alternate treatment method used if acceptable destruction/ degradation of PCE does not occur. The DNAPL and soil treatment could be modified and extended or an alternate treatment method used.	The treatment could be extended or an alternate treatment method used if acceptable destruction of PCE does not occur.	The treatment could be extended or an alternate treatment method used if acceptable destruction of PCE does not occur.	The treatment could be extended or an alternate treatment method used if acceptable destruction of the PCE does not occur.	The treatment could be extended or an alternate treatment method used if acceptable destruction of the PCE does not occur.
Ability to Monitor Effectiveness	Soil and groundwater samples may be collected during and after remediation is conducted to monitor effectiveness.	Soil and groundwater samples may be collected during and after remediation is conducted to monitor effectiveness.	Soil and groundwater samples may be collected during and after remediation is conducted to monitor effectiveness.	Soil and groundwater samples may be collected during and after remediation is conducted to monitor effectiveness.	Soil and groundwater samples may be collected during and after remediation is conducted to monitor effectiveness.
Ability to Obtain Approvals and to Coordinate with Agencies	Will need access to building from current owner to install remediation system below floor slab (A-3). Will need ROW access for installation of remediation system in Industrial Drive or its ROW (A-2 and A-4). Will need access to install remediation system on City of New Haven property north of former Kellwood facility (A-1).	Will need access to building from current owner to install remediation system below floor slab (A-3). Will need ROW access for installation of remediation system in Industrial Drive or its ROW (A-2 and A-4). Will need access to install remediation system on City of New Haven property north of former Kellwood facility (A-1).	Will need access to building from current owner to install remediation system below floor slab (A-3). Will need ROW access for installation of remediation system in Industrial Drive or its ROW (A-2 and A-4). Will need access to install remediation system on City of New Haven property north of former Kellwood facility (A-1).	Will need access to building from current owner to install remediation system below floor slab (A-3). Will need ROW access for installation of remediation system in Industrial Drive or its ROW (A-2 and A-4). Will need access to install remediation system on City of New Haven property north of former Kellwood facility (A-1).	Will need access to building from owner to install remediation system below floor slab (A-3). Will need ROW access for installation of remediation system in Industrial Drive or its ROW (A-2 and A-4). Will need access to install remediation system on City of New Haven property north of former Kellwood facility (A-1).
Availability of Services and Capacities	Construction services and capabilities are readily available.	Construction services and capabilities are readily available.	Construction services and capabilities are readily available.	Construction services and capabilities are readily available.	Construction services and capabilities are readily available.
Availability of Equipment, Specialists, and Materials	Remediation specialists are available. Equipment and materials required are readily available.	Remediation specialists are available. Equipment and materials required are readily available.	Remediation specialists are available. Equipment and materials required are readily available.	Remediation specialists are available. Equipment and materials required are readily available.	Remediation specialists are available. Equipment and materials required are readily available.
Availability of Technology	Electrical resistive heating and vapor extraction technologies are available. Anaerobic bioremediation technologies are available. Possibilities include gas injection (HiSOC® by Inventures Technology) and liquid injection (3DME by ReGenesis).	*In situ* chemical oxidation technologies using persulfate are available.	*In situ* chemical reduction technologies such as eZVI are available.	*In situ* chemical oxidation technologies using persulfate are available.	*In situ* chemical reduction technologies such as eZVI are available.

Criteria	Alternative 4a- Thermally Enhanced Vapor Extraction (Source Area) w/ Bioremediation for GW	Alternative 4b- Thermally Enhanced Vapor Extraction (Source Area) w/ In Situ Chemical Oxidation for GW	Alternative 4c- Thermally Enhanced Vapor Extraction (Source Area) w/ In Situ Chemical Reduction for GW	Alternative 5 - Chemical Oxidation	Alternative 6 - Chemical Reduction
Environmental Footprint					
Energy Efficiency	Thermal treatment would require a high energy consumption. Bioremediation energy consumption would be minimal.	*In situ* chemical oxidation energy consumption would be minimal and would include mixing of materials and delivery of materials into injection points	*In situ* chemical reduction energy consumption would be minimal and would include mixing of materials and delivery of materials into injection points	*In situ* chemical oxidation energy consumption would be minimal and would include mixing of materials and delivery of materials into injection points	*In situ* chemical reduction energy consumption would be minimal and would include mixing of materials and delivery of materials into injection points
Air Emissions (Green House Gases)	Air emissions will be generated from construction equipment during construction of remedy. An estimated 515 treatment wells would be installed.	Air emissions will be generated from construction equipment during construction of remedy. An estimated 515 treatment wells would be installed.	Air emissions will be generated from construction equipment. An estimated 515 treatment wells would be installed.	Air emissions will be generated from construction equipment. An estimated 515 treatment wells would be installed.	Air emissions will be generated from construction equipment during construction of remedy. An estimated 262 treatment wells would be installed.
Water Consumption	No change in water consumption expected with modification of water source for impacted residences. Water would be used as part of the treatment processes.	No change in water consumption expected with modification of water source for impacted residences. Water would be used as part of the treatment processes.	No change in water consumption expected with modification of water source for impacted residences. Water would be used as part of the treatment processes.	No change in water consumption expected with modification of water source for impacted residences. Water would be used as part of the treatment processes.	No change in water consumption expected with modification of water source for impacted residences. Water would be used as part of the treatment processes.
Land and Ecosystems	Risks from soil and groundwater are removed. Impacts will decrease with time due to natural attenuation.	Risks from soil and groundwater are removed. Impacts will decrease with time due to natural attenuation.	Risks from soil and groundwater are removed. Impacts will decrease with time due to natural attenuation.	Risks from soil and groundwater are removed. Impacts will decrease with time due to natural attenuation.	Risks from soil and groundwater are removed. Impacts will decrease with time due to natural attenuation.
Material Usage and Waste Production	DNAPL may be recovered from treatment points in A-1 prior to injection of chemicals. Vaporized DNAPL will be collected in a GAC vessel. The carbon will need to be regenerated. Over 300 injection or extraction wells and 200 thermal probes would be installed generating waste from the installation and requiring materials for installation of the wells.	DNAPL may be recovered from treatment points in A-1 prior to injection of chemicals. Vaporized DNAPL will be collected in a granular activated carbon (GAC) vessel. The carbon will need to be regenerated. Over 300 injection or extraction wells and 200 thermal probes would be installed generating waste from the installation and requiring materials for installation of the extraction and injection wells.	DNAPL may be recovered from treatment points in A-1 prior to injection. Vaporized DNAPL will be collected in a GAC vessel. The carbon will need to be regenerated. Over 300 injection or extraction wells and 200 thermal probes would require materials and generate waste during installation materials.	DNAPL may be recovered from treatment points in A-1 prior to injection of chemicals. Over 500 injection or extraction wells would be installed, generating waste from the installation and requiring materials for installation of the extraction and injection wells.	DNAPL may be recovered from treatment points in A-1 prior to injection of chemicals. Over 260 injection or extraction wells would be installed, generating waste from the installation and requiring materials for installation.
Cost					
Capital	$6,152,000	$5,695,000	$6,478,000	$2,308,000	$3,833,000
First Year Annual O&M Cost	$280,000	$300,000	$250,000	$300,000	$250,000
Present Worth Cost of O&M	$2,810,000	$2,892,000	$2,687,000	$2,892,000	$2,687,000
Total Cost - Capital and O&M Present Worth	$8,962,000	$8,587,000	$9,165,000	$5,200,000	$6,520,000

Standard Requirement, Criteria, or Limitation	Citation	Description	Comment
FEDERAL			
Safe Drinking Water Act (SDWA)			
National Primary Drinking Water Standards	40 CFR Part 141	Establish maximum contaminant levels (MCLs), which are health based standards for public water systems.	The MCLs for organic constituents are relevant and appropriate to groundwater contamination in a potential or actual drinking water aquifer.
National Secondary Drinking Water Standards	40 CFR Part 143	Establish secondary maximum contaminant levels (SMCLs), which are non-enforceable guidelines for public water systems to protect the aesthetic quality of the water.	SMCLs may be relevant and appropriate if treated groundwater is used as a source of drinking water.
Maximum Contaminant Level Goals (MCLGs)	40 CFR Part 141	Establishes non-enforceable drinking water quality goals. The goals are set to levels that produce no known or anticipated adverse health effects. The MCLGs include an adequate margin of safety.	MCLGs for organic constituents may be relevant and appropriate if a more stringent standard is required to protect human health and the environment.
Underground Injection Control (UIC) Regulations	40 CFR 144 – 147	Provides for protection of underground sources of drinking water.	If an alternative involves underground injection, this part would be applicable or relevant and appropriate.

Standard Requirement, Criteria, or Limitation	Citation	Description	Comment
Clean Water Act			
Water Quality Standards	40 CFR Part 131	Establishes non-enforceable standards to protect aquatic life.	May be relevant and appropriate to surface water discharges, or may be a TBC. Also, may be relevant and appropriate to groundwater remediation in Missouri based on the Water Quality Standards, 10 CSR 20-7.031.
Clean Air Act			
National Primary and Secondary Ambient Air Quality Standards	40 CFR Part 50	Establishes standards for ambient air quality to protect public health and welfare. Establishes treatment technology standards for fugitive emissions to air.	If an alternative involves emissions governed by these standards, then the requirements would be applicable.
Noise Control Act	42 USC 4901	Activities must not result in noise that will jeopardize the health or welfare of the public.	Regulation is handled on a state and local level
STATE			
Waste Characterization	10 CSR 25-3.260(1)(H)2	Requires that wastes at the site be characterized to determine if the wastes meets the definition of hazardous waste in the citation.	These standards would be applicable or relevant and appropriate
Identification and Listing of Hazardous Waste	10 CSR 25-4.261	Defines those solid wastes which are subject to regulations as hazardous wastes under 10CFR25.	These standards would be applicable or relevant and appropriate
Missouri Risk Based	Technical	Outlines a risk based process for	These standards would be

Standard Requirement, Criteria, or Limitation	Citation	Description	Comment
Corrective Action (MRBCA)	Guidance issued April 2006 and updated June 2006 and June 2008	determining cleanup goals at sites with known or suspected hazardous substance contamination.	applicable or relevant and appropriate
Missouri Water Quality Standards	10 CSR 20-7.031	Outlines the criteria for protection of waters of the state, surface water bodies and groundwater	These standards would be applicable or relevant and appropriate
Missouri Air Pollution Control Program	10 CSR 10-6	Ambient concentrations of VOCs should be less than their respective acceptable ambient air levels at the Site boundary.	If an alternative involves discharge of contaminants to the air, these requirements would be relevant and appropriate.
Well Construction Code	10 CSR 23	Regulates the construction and abandonment of domestic water wells (23-3) and monitoring wells (23-4).	If an alternative includes installing new or abandoning wells, these requirements may be applicable or relevant and appropriate.

Construction Cost Estimate for Alternative 2a:
Asphalt or Concrete Cap, Whole House Water Treatment, Instiitutional Restrictions, Groundwater Monitoring

Job No.: 442906
Riverfront Superfund Site OU2 / OU6
Location: New Haven, Missouri

PARSONS
ESTIMATE WORK SHEET

Item	Description	Ref.	Quant.	Unit	Unit Cost	Total
	Mobilization and Demobilization of Equipment and Personnel		1	LS	$20,000	$20,000
	Temporary Facilities and Equipment					
	Temporary Construction Trailers		1	LS	$2,000	$2,000
	Temporary Decontamination Equipment		1	LS	$2,000	$2,000
	Emergency Spill Equipment		1	LS	$1,000	$1,000
	Sediment and Erosion Controls		1	LS	$2,000	$2,000
	Temporary Work Zone Fencing and Signs		1	LS	$2,000	$2,000
	Health and Safety Air Monitoring and Preparation of H&S Records		1	LS	$2,000	$2,000
	Construction Surveys and Final Record Drawings		1	LS	$2,000	$2,000
	Preparation of Plans and Schedules					
	Preparation of H&S Plan / Spill and Emission Control Plan		1	LS	$3,000	$3,000
	Preparation of a Sediment and Erosion Control Plan		1	LS	$3,000	$3,000
	Preparation of a General Earthwork Plan		1	LS	$3,000	$3,000
	Preparation of the Construction Schedule		1	LS	$2,000	$2,000
	Asphalt or Concrete Cap					
	Clearing and Grubbing of Area 1		2	Acre	$1,500	$3,000
	Regrading of the Existing Surface		10,000	SY	$2	$20,000
	Provide Base for Asphalt or Concrete cap		1,600	CY	$25	$40,000
	Install Asphalt or Concrete Cap		90,000	SF	$3	$270,000
	Design and Oversight					
	Cap Design (Assuming Preliminary and Final Design only)		1	LS	$25,000	$25,000
	Long Term Monitoring Program Development		1	LS	$10,000	$10,000
	Construction Oversight (Cap)		4	WK	$6,000	$24,000
	Preparation of Closure Report		1	LS	$20,000	$20,000
	Subtotal Construction Costs					$456,000
	Subtotal Construction Costs w/ Contingency (25%)					**$570,000**
	O&M Costs (30 years)					
	Annual GW Monitoring (40 wells - VOCs and Nat. Atten. Parameters)		1	YR	$120,000	$120,000
	Annual Site Inspections and Reporting		1	YR	$40,000	$40,000
	Annual Cap Maintenance		1	YR	$10,000.00	$10,000
	Home Water Treatment Unit O&M and Providing Bottled Water		1	YR	$50,000	$50,000
	Subtotal O&M Costs (annual)					$220,000
	Subtotal O&M Costs (30 years @ 7%)					**$2,730,000**
	TOTAL REMEDIATION CONSTRUCTION & O & M COSTS				**Total**	**$3,300,000**

NOTES

Whole-house water Treatment System (WHWT) is currently operating at JS-14, JS-36, JS-38, and JS-52.
Bottled water is currently being provided to JS-14, JS-36, JS-38, JS-52, JS-27, and PA-55
O&M Costs for WHWT include periodic replacement of carbon units and quarterly monitoring of the systems
Annual Site Inspections include quarterly DNAPL recovery at BW-20 and L-12 (area north of Former Kellwood Facility)
Construction Period: 1 month

Construction Cost Estimate for Alternative 2b

Asphalt or Concrete Cap, Potable Water Line, Institutional Restrictions, Groundwater Monitoring

Job No.: 442906 — **PARSONS**

Riverfront Superfund Site OU2 / OU6 — **ESTIMATE WORK SHEET**

Location: New Haven, Missouri

Item	Description	Ref.	Quant.	Unit	Unit Cost	Total
	Mobilization and Demobilization of Equipment and Personnel		1	LS	$75,000	$75,000
	Temporary Facilities and Equipment					
	Temporary Construction Trailers		1	LS	$6,000	$6,000
	Temporary Decontamination Equipment		1	LS	$2,000	$2,000
	Emergency Spill Equipment		1	LS	$1,000	$1,000
	Sediment and Erosion Controls		1	LS	$10,000	$10,000
	Temporary Work Zone Fencing and Signs		1	LS	$2,000	$2,000
	Health and Safety Air Monitoring and Preparation of H&S Records		1	LS	$10,000	$10,000
	Construction Surveys and Final Record Drawings		1	LS	$10,000	$10,000
	Preparation of Plans and Schedules					
	Preparation of H&S Plan / Spill and Emission Control Plan		1	LS	$5,000	$5,000
	Preparation of a Sediment and Erosion Control Plan		1	LS	$5,000	$5,000
	Preparation of a General Earthwork Plan		1	LS	$5,000	$5,000
	Preparation of the Construction Schedule		1	LS	$2,000	$2,000
	Asphalt or Concrete Cap					
	Clearing and Grubbing of Area 1		2	Acre	$1,500	$3,000
	Regrading of the Existing Surface		10,000	SY	$2	$20,000
	Provide Base for Asphalt or Concrete cap		1,600	CY	$25	$40,000
	Install Asphalt or Concrete Cap		90,000	SF	$3	$270,000
	Water Mains					
	Water Main Installation and Connection		1	LS	$1,500,000	$1,500,000
	Tie In to Water Main		30	Ea	$6,000	$180,000
	Existing private water well abandonment		30	Ea	$5,000	$150,000
	Design and Oversight					
	Predesign Investigation		1	LS	$60,000	$60,000
	Water Piping Design		1	LS	$100,000	$100,000
	Cap Design (Assuming Preliminary and Final Design only)		1	LS	$25,000	$25,000
	Long Term Monitoring Program Development		1	LS	$10,000	$10,000
	Construction Oversight (Cap)		4	WK	$6,000	$24,000
	Construction Oversight (Water line)		18	WK	$6,000	$108,000
	Preparation of Closure Report		1	LS	$20,000	$20,000
	Subtotal Construction Costs					$2,643,000
	Subtotal Construction Costs w/ Contingency (25%)					**$3,304,000**
	O&M Costs (30 years)					
	Annual GW Monitoring (40 wells - VOCs and Nat. Atten. Parameters)		1	YR	$120,000	$120,000
	Annual Site Inspections and Reporting		1	YR	$40,000	$40,000
	Home Water Treatment Unit O&M and Providing Bottled Water (3yr)		1	YR	$30,000	$30,000
	Annual Cap Maintenance		1	YR	$10,000	$10,000
	Subtotal O&M Costs (annual)					$200,000
	Subtotal O&M Costs (30 years @ 7%)					**$2,189,000**
	TOTAL REMEDIATION CONSTRUCTION & O & M COSTS				**Total**	**$5,493,000**

NOTES

Ref 1 Costs for water treatment not included in estimate.
Whole-house water Treatment System (WHWT) is currently operating at JS-14, JS-36, JS-38, and JS-52.
Bottled water is currently being provided to JS-14, JS-36, JS-38, JS-52, JS-27, and PA-55
O&M Costs for WHWT include periodic replacement of carbon units and quarterly monitoring of the systems
Annual Site Inspections include quarterly DNAPL recovery at BW-20 and L-12 (area north of Former Kellwood Facility)
Construction Period: 6 months

Construction Cost Estimate for Alternative 3a:
Thermal Treatment for DNAPL, Whole House Water Treatment, Institutional Restrictions, Groundwater Monitoring

Job No.: 442906 | **PARSONS**
Riverfront Superfund Site OU2 / OU6 | **ESTIMATE WORK SHEET**

Location: New Haven, Missouri

Item	Description	Ref.	Quant.	Unit	Unit Cost	Total
	Mobilization and Demobilization of Equipment and Personnel		1	LS	$75,000	$75,000
	Temporary Facilities and Equipment					
	Temporary Construction Trailers		1	LS	$6,000	$6,000
	Temporary Decontamination Equipment		1	LS	$2,000	$2,000
	Emergency Spill Equipment		1	LS	$1,000	$1,000
	Sediment and Erosion Controls		1	LS	$10,000	$10,000
	Temporary Work Zone Fencing and Signs		1	LS	$2,000	$2,000
	Health and Safety Air Monitoring and Preparation of H&S Records		1	LS	$10,000	$10,000
	Construction Surveys and Final Record Drawings		1	LS	$10,000	$10,000
	Preparation of Plans and Schedules					
	Preparation of H&S Plan / Spill and Emission Control Plan		1	LS	$5,000	$5,000
	Preparation of a Sediment and Erosion Control Plan		1	LS	$5,000	$5,000
	Preparation of a General Earthwork Plan		1	LS	$5,000	$5,000
	Preparation of the Construction Schedule		1	LS	$2,000	$2,000
	Thermally Enhanced Vapor Extraction of DNAPL Source Area		1	LS	$1,400,000	$1,400,000
	Design and Oversight					
	Predesign Investigation.		1	LS	$25,000	$25,000
	Water Well and Piping Design		1	LS	$75,000	$75,000
	Thermal Treatment Design(Assuming Preliminary and Final Design only)		1	LS	$50,000	$50,000
	Long Term Monitoring Program Development		1	LS	$10,000	$10,000
	Construction Oversight (Thermal Treatment System)		4	WK	$6,000	$24,000
	Preparation of Closure Report		1	LS	$20,000	$20,000
	Subtotal Construction Costs					$1,737,000
	Subtotal Construction Costs w/ Contingency (25%)					**$2,172,000**
	O&M Costs (30 years)					
	Annual GW Monitoring (40 wells - VOCs and Nat. Atten. Parameters)		1	YR	$120,000	$120,000
	Annual Site Inspections and Reporting		1	YR	$30,000	$30,000
	Home Water Treatment Unit O&M and Providing Bottled Water		1	YR	$50,000	$50,000
	Subtotal O&M Costs (annual)					$200,000
	Subtotal O&M Costs (30 years @ 7%)					**$2,482,000**
	TOTAL REMEDIATION CONSTRUCTION & O & M COSTS				**Total**	**$4,654,000**

NOTES

Whole-house water Treatment System (WHWT) is currently operating at JS-14, JS-36, JS-38, and JS-52.
Bottled water is currently being provided to JS-14, JS-36, JS-38, JS-52, JS-27, and PA-55
O&M Costs for WHWT include period replacement of carbon units
Construction Period: 12 months
Remediation Technology Costs are provided by a vendor

Construction Cost Estimate for Alternative 3b

Thermal Treatment for DNAPL, Potable Water Line, Institutional Restrictions, Groundwater Monitoring

Job No.: 442906 — **PARSONS**

Riverfront Superfund Site OU2 / OU6 — **ESTIMATE WORK SHEET**

Location: New Haven, Missouri

Item	Description	Ref.	Quant.	Unit	Unit Cost	Total
	Mobilization and Demobilization of Equipment and Personnel		1	LS	$75,000	$75,000
	Temporary Facilities and Equipment					
	Temporary Construction Trailers		1	LS	$6,000	$6,000
	Temporary Decontamination Equipment		1	LS	$2,000	$2,000
	Emergency Spill Equipment		1	LS	$1,000	$1,000
	Sediment and Erosion Controls		1	LS	$10,000	$10,000
	Temporary Work Zone Fencing and Signs		1	LS	$2,000	$2,000
	Health and Safety Air Monitoring and Preparation of H&S Records		1	LS	$10,000	$10,000
	Construction Surveys and Final Record Drawings		1	LS	$10,000	$10,000
	Preparation of Plans and Schedules					
	Preparation of H&S Plan / Spill and Emission Control Plan		1	LS	$5,000	$5,000
	Preparation of a Sediment and Erosion Control Plan		1	LS	$5,000	$5,000
	Preparation of a General Earthwork Plan		1	LS	$5,000	$5,000
	Preparation of the Construction Schedule		1	LS	$2,000	$2,000
	Thermally Enhanced Vapor Extraction of DNAPL Source Area		1	LS	$1,400,000	$1,400,000
	Treatment System Wells					
	Well Installation		1	LS	$210,000	$210,000
	Well Abandonment at Completion		1	LS	$17,000	$17,000
	Water Mains					
	Water Main Installation and Connection		1	LS	$1,500,000	$1,500,000
	Tie In to Water Main		30	Ea	$6,000	$180,000
	Existing private water well abandonment		30	Ea	$5,000	$150,000
	Design and Oversight					
	Predesign Investigation.		1	LS	$60,000	$60,000
	Water Well and Piping Design		1	LS	$100,000	$100,000
	Thermal Treatment Design(Assuming Preliminary and Final Design only)		1	LS	$50,000	$50,000
	Long Term Monitoring Program Development		1	LS	$10,000	$10,000
	Construction Oversight (Thermal Treatment System)		4	WK	$6,000	$24,000
	Construction Oversight (Water Line)		18	WK	$6,000	$108,000
	Preparation of Closure Report		1	LS	$20,000	$20,000
	Subtotal Construction Costs					$3,962,000
	Subtotal Construction Costs w/ Contingency (25%)					**$4,953,000**
	O&M Costs (30 years)					
	Annual GW Monitoring (40 wells - VOCs and Nat. Atten. Parameters)		1	YR	$120,000	$120,000
	Annual Site Inspections and Reporting		1	YR	$30,000	$30,000
	Home Water Treatment Unit O&M and Providing Bottled Water		1	YR	$30,000	$30,000
	(3 years)					
	Subtotal O&M Costs (annual)					$180,000
	Subtotal O&M Costs (30 years @ 7%)					**$1,941,000**
	TOTAL REMEDIATION CONSTRUCTION & O & M COSTS				**Total**	**$6,894,000**

NOTES

Whole-house water Treatment System (WHWT) is currently operating at JS-14, JS-36, JS-38, and JS-52.

Bottled water is currently being provided to JS-14, JS-36, JS-38, JS-52, JS-27, and PA-55

O&M Costs for WHWT include period replacement of carbon units

Construction Period: 15 months

Remediation Technology Costs are provided by a vendor

Construction Cost Estimate for Alternative 4a
Thermally Enhanced Vapor Extraction for Soil and DNAPL, Bioremediation for Groundwater, Institutional Restrictions, Groundwater Monitoring

Job No.: 442906
Riverfront Superfund Site OU2 / OU6

Location: New Haven, Missouri

PARSONS
ESTIMATE WORK SHEET

Item	Description	Ref.	Quant.	Unit	Unit Cost	Total
	Mobilization and Demobilization of Equipment and Personnel		1	LS	$75,000	$75,000
	Temporary Facilities and Equipment					
	Temporary Construction Trailers		1	LS	$5,000	$5,000
	Temporary Decontamination Equipment		1	LS	$5,000	$5,000
	Emergency Spill Equipment		1	LS	$2,000	$2,000
	Sediment and Erosion Controls		1	LS	$2,000	$2,000
	Temporary Work Zone Fencing and Signs		1	LS	$2,000	$2,000
	Health and Safety Air Monitoring and Preparation of H&S Records		1	LS	$10,000	$10,000
	Construction Surveys and Final Record Drawings		1	LS	$10,000	$10,000
	Preparation of Plans and Schedules					
	Preparation of H&S Plan / Spill and Emission Control Plan		1	LS	$5,000	$5,000
	Preparation of a Sediment and Erosion Control Plan		1	LS	$5,000	$5,000
	Preparation of a General Earthwork Plan		1	LS	$5,000	$5,000
	Preparation of the Construction Schedule		1	LS	$2,000	$2,000
	Thermally Enhanced Vapor Extraction		1	LS	$2,973,000	$2,973,000
	Groundwater Bioremediation					
	Emulsified Vegetable Oil Injection		1	LS	$100,000	$100,000
	Hydrogen Gas Generation System		1	LS	$50,000	$50,000
	Hydrogen Gas Injection System		1	LS	$400,000	$400,000
	Treatment System Wells					
	Well Installation		1	LS	$1,045,000	$1,045,000
	Well Abandonment at Completion		1	LS	$84,000	$84,000
	Design and Oversight					
	Predesign Investigation.		1	LS	$25,000	$25,000
	Thermal Enhanced Vapor Extraction System Design		1	LS	$25,000	$25,000
	Groundwater Bioremediation System Design		1	LS	$25,000	$25,000
	Long Term Monitoring Program Development		1	LS	$10,000	$10,000
	Construction Oversight (Thermal)		4	WK	$6,000	$24,000
	Construction Oversight (Bioremediation)		2	WK	$6,000	$12,000
	Preparation of Closure Report		1	LS	$20,000	$20,000
	Subtotal Construction Costs					$4,921,000
	Subtotal Construction Costs w/ Contingency (25%)					**$6,152,000**
	O&M Costs (30 years)					
	Annual GW Monitoring (40 wells - VOCs and Nat. Atten. Parameters)		1	YR	$120,000	$120,000
	Annual Site Inspections and Reporting		1	YR	$30,000	$30,000
	Bioremediation System Operation (5 yrs)		1	YR	$80,000	$80,000
	Home Water Treatment Unit O&M and Providing Bottled Water		1	YR	$50,000	$50,000
	Subtotal O&M Costs (annual)					$280,000
	Subtotal O&M Costs (30 years @ 7%)					**$2,810,000**
	TOTAL REMEDIATION CONSTRUCTION & O & M COSTS				**Total**	**$8,962,000**

NOTES

Whole-house water Treatment System (WHWT) is currently operating at JS-14, JS-36, JS-38, and JS-52.
Bottled water is currently being provided to JS-14, JS-36, JS-38, JS-52, JS-27, and PA-55
O&M Costs for WHWT include period replacement of carbon units
Construction Period: 18 months for the thermal treatment system and an additional 4 years for the groundwater bioremediation system
Remediation Technology Costs are provided by a vendor

Construction Cost Estimate for Alternative 4b:
Thermally Enhanced Vapor Extraction for Soil and DNAPL, In Situ Chemical Oxidation for Groundwater, Institutional Restrictions, Groundwater Monitoring

Job No.: 442906 | **PARSONS**
Riverfront Superfund Site OU2 / OU6 | **ESTIMATE WORK SHEET**

Location: New Haven, Missouri

Item	Description	Ref.	Quant.	Unit	Unit Cost	Total
	Mobilization and Demobilization of Equipment and Personnel		1	LS	$75,000	$75,000
	Temporary Facilities and Equipment					
	Temporary Construction Trailers		1	LS	$5,000	$5,000
	Temporary Decontamination Equipment		1	LS	$5,000	$5,000
	Emergency Spill Equipment		1	LS	$2,000	$2,000
	Sediment and Erosion Controls		1	LS	$2,000	$2,000
	Temporary Work Zone Fencing and Signs		1	LS	$2,000	$2,000
	Health and Safety Air Monitoring and Preparation of H&S Records		1	LS	$10,000	$10,000
	Construction Surveys and Final Record Drawings		1	LS	$10,000	$10,000
	Preparation of Plans and Schedules					
	Preparation of H&S Plan / Spill and Emission Control Plan		1	LS	$5,000	$5,000
	Preparation of a Sediment and Erosion Control Plan		1	LS	$5,000	$5,000
	Preparation of a General Earthwork Plan		1	LS	$5,000	$5,000
	Preparation of the Construction Schedule		1	LS	$2,000	$2,000
	Thermally Enhanced Vapor Extraction		1	LS	$2,973,000	$2,973,000
	Groundwater In Situ Chemical Oxidation					
	ISCO Injection		1	LS	$180,000	$180,000
	Treatment System Wells					
	Well Installation		1	LS	$1,045,000	$1,045,000
	Well Abandonment at Completion		1	LS	$84,000	$84,000
	Design and Oversight					
	Predesign Investigation.		1	LS	$30,000	$30,000
	Thermal Enhanced Vapor Extraction System Design		1	LS	$25,000	$25,000
	Groundwater ISCO System Design		1	LS	$25,000	$25,000
	Long Term Monitoring Program Development		1	LS	$10,000	$10,000
	Construction Oversight (Thermal)		4	WK	$6,000	$24,000
	Construction Oversight (ISCO)		2	WK	$6,000	$12,000
	Preparation of Closure Report		1	LS	$20,000	$20,000
	Subtotal Construction Costs					$4,556,000
	Subtotal Construction Costs w/ Contingency (25%)					**$5,695,000**
	O&M Costs (30 years)					
	Annual GW Monitoring (40 wells - VOCs and Nat. Atten. Parameters)		1	YR	$120,000	$120,000
	Annual Site Inspections and Reporting		1	YR	$30,000	$30,000
	ISCO Monitoring (5 Years)		1	YR	$100,000	$100,000
	Home Water Treatment Unit O&M and Providing Bottled Water		1	YR	$50,000	$50,000
	Subtotal O&M Costs (annual)					$300,000
	Subtotal O&M Costs (30 years @ 7%)					**$2,892,000**
	TOTAL REMEDIATION CONSTRUCTION & O & M COSTS				**Total**	**$8,587,000**

NOTES

Whole-house water Treatment System (WHWT) is currently operating at JS-14, JS-36, JS-38, and JS-52.
Bottled water is currently being provided to JS-14, JS-36, JS-38, JS-52, JS-27, and PA-55
O&M Costs for WHWT include period replacement of carbon units
Construction Period: 18 months for thermal treatment and an additional 4 years for the groundwater system
Remediation Technology Costs are provided by a vendor

Construction Cost Estimate for Alternative 4c:
Thermally Enhanced Vapor Extraction for Soil and DNAPL, In Situ Chemical Reduction for Groundwater, Institutional Restrictions, Groundwater Monitoring

Job No.: 442906 — **PARSONS**

Riverfront Superfund Site OU2 / OU6 — **ESTIMATE WORK SHEET**

Location: New Haven, Missouri

Item	Description	Ref.	Quant.	Unit	Unit Cost	Total
	Mobilization and Demobilization of Equipment and Personnel		1	LS	$75,000	$75,000
	Temporary Facilities and Equipment					
	Temporary Construction Trailers		1	LS	$5,000	$5,000
	Temporary Decontamination Equipment		1	LS	$5,000	$5,000
	Emergency Spill Equipment		1	LS	$2,000	$2,000
	Sediment and Erosion Controls		1	LS	$2,000	$2,000
	Temporary Work Zone Fencing and Signs		1	LS	$2,000	$2,000
	Health and Safety Air Monitoring and Preparation of H&S Records		1	LS	$10,000	$10,000
	Construction Surveys and Final Record Drawings		1	LS	$10,000	$10,000
	Preparation of Plans and Schedules					
	Preparation of H&S Plan / Spill and Emission Control Plan		1	LS	$5,000	$5,000
	Preparation of a Sediment and Erosion Control Plan		1	LS	$5,000	$5,000
	Preparation of a General Earthwork Plan		1	LS	$5,000	$5,000
	Preparation of the Construction Schedule		1	LS	$2,000	$2,000
	Thermally Enhanced Vapor Extraction		1	LS	$2,973,000	$2,973,000
	Groundwater In Situ Chemical Reduction					
	eZVI Injection		1	LS	$800,000	$800,000
	Treatment System Wells					
	Well Installation		1	LS	$1,045,000	$1,045,000
	Well Abandonment at Completion		1	LS	$84,000	$84,000
	Design and Oversight					
	Predesign Investigation.		1	LS	$30,000	$30,000
	Thermal Enhanced Vapor Extraction System Design		1	LS	$25,000	$25,000
	Groundwater eZVI System Design		1	LS	$25,000	$25,000
	Long Term Monitoring Program Development		1	LS	$10,000	$10,000
	Construction Oversight (Thermal)		4	WK	$6,000	$24,000
	Construction Oversight (eZVI)		3	WK	$6,000	$18,000
	Preparation of Closure Report		1	LS	$20,000	$20,000
	Subtotal Construction Costs					$5,182,000
	Subtotal Construction Costs w/ Contingency (25%)					**$6,478,000**
	O&M Costs (30 years)					
	Annual GW Monitoring (40 wells - VOCs and Nat. Atten. Parameters)		1	YR	$120,000	$120,000
	Annual Site Inspections and Reporting		1	YR	$30,000	$30,000
	GW Treatment Monitoring (5 years)		1	YR	$50,000	$50,000
	Home Water Treatment Unit O&M and Providing Bottled Water		1	YR	$50,000	$50,000
	Subtotal O&M Costs (annual)					$250,000
	Subtotal O&M Costs (30 years @ 7%)					**$2,687,000**
	TOTAL REMEDIATION CONSTRUCTION & O & M COSTS				**Total**	**$9,165,000**

NOTES

Whole-house water Treatment System (WHWT) is currently operating at JS-14, JS-36, JS-38, and JS-52.
Bottled water is currently being provided to JS-14, JS-36, JS-38, JS-52, JS-27, and PA-55
O&M Costs for WHWT include period replacement of carbon units
Construction Period: 18 months for thermal treatment and an additional 4 years for the groundwater system
Remediation Technology Costs are provided by a vendor

Construction Cost Estimate for Alternative 5:
In Situ Chemical Oxidation, Institutional Restrictions, Groundwater Monitoring

Job No.: 442906 — **PARSONS**
Riverfront Superfund Site OU2 / OU6 — **ESTIMATE WORK SHEET**

Location: New Haven, Missouri

Item	Description	Ref.	Quant.	Unit	Unit Cost	Total
	Mobilization and Demobilization of Equipment and Personnel		1	LS	$75,000	$75,000
	Temporary Facilities and Equipment					
	Temporary Construction Trailers		1	LS	$5,000	$5,000
	Temporary Decontamination Equipment		1	LS	$5,000	$5,000
	Emergency Spill Equipment		1	LS	$2,000	$2,000
	Sediment and Erosion Controls		1	LS	$2,000	$2,000
	Temporary Work Zone Fencing and Signs		1	LS	$2,000	$2,000
	Health and Safety Air Monitoring and Preparation of H&S Records		1	LS	$10,000	$10,000
	Construction Surveys and Final Record Drawings		1	LS	$10,000	$10,000
	Preparation of Plans and Schedules					
	Preparation of H&S Plan / Spill and Emission Control Plan		1	LS	$5,000	$5,000
	Preparation of a Sediment and Erosion Control Plan		1	LS	$5,000	$5,000
	Preparation of a General Earthwork Plan		1	LS	$5,000	$5,000
	Preparation of the Construction Schedule		1	LS	$2,000	$2,000
	In Situ Chemical Oxidation					
	ISCO Injection		1	LS	$480,000	$480,000
	Treatment System Wells					
	Well Installation		1	LS	$1,045,000	$1,045,000
	Well Abandonment at Completion		1	LS	$84,000	$84,000
	Design and Oversight					
	Predesign Investigation.		1	LS	$30,000	$30,000
	Treatment System Design		1	LS	$25,000	$25,000
	Long Term Monitoring Program Development		1	LS	$10,000	$10,000
	Construction Oversight		4	WK	$6,000	$24,000
	Preparation of Closure Report		1	LS	$20,000	$20,000
	Subtotal Construction Costs					$1,846,000
	Subtotal Construction Costs w/ Contingency (25%)					**$2,308,000**
	O&M Costs (30 years)					
	Annual GW Monitoring (40 wells - VOCs and Nat. Atten. Parameters)		1	YR	$120,000	$120,000
	Annual Site Inspections and Reporting		1	YR	$30,000	$30,000
	ISCO Monitoring & Reinjection at wall (5 Years)		1	YR	$100,000	$100,000
	Home Water Treatment Unit O&M and Providing Bottled Water		1	YR	$50,000	$50,000
	Subtotal O&M Costs (annual)					$300,000
	Subtotal O&M Costs (30 years @ 7%)					**$2,892,000**
	TOTAL REMEDIATION CONSTRUCTION & O & M COSTS				**Total**	**$5,200,000**

NOTES

Whole-house water Treatment System (WHWT) is currently operating at JS-14, JS-36, JS-38, and JS-52.
Bottled water is currently being provided to JS-14, JS-36, JS-38, JS-52, JS-27, and PA-55
O&M Costs for WHWT include period replacement of carbon units
Construction Period: 18 months for DNAPL and soil treatment and an additional 4 years for the groundwater bioremediation system
Remediation Technology Costs are provided by a vendor

Construction Cost Estimate for Alternative 6:
In Situ Chemical Reduction, Institutional Restrictions, Groundwater Monitoring

Job No.: 442906 — **PARSONS**

Riverfront Superfund Site OU2 / OU6 — **ESTIMATE WORK SHEET**

Location: New Haven, Missouri

Item	Description	Ref.	Quant.	Unit	Unit Cost	Total
	Mobilization and Demobilization of Equipment and Personnel		1	LS	$75,000	$75,000
	Temporary Facilities and Equipment					
	Temporary Construction Trailers		1	LS	$5,000	$5,000
	Temporary Decontamination Equipment		1	LS	$5,000	$5,000
	Emergency Spill Equipment		1	LS	$2,000	$2,000
	Sediment and Erosion Controls		1	LS	$2,000	$2,000
	Temporary Work Zone Fencing and Signs		1	LS	$2,000	$2,000
	Health and Safety Air Monitoring and Preparation of H&S Records		1	LS	$10,000	$10,000
	Construction Surveys and Final Record Drawings		1	LS	$10,000	$10,000
	Preparation of Plans and Schedules					
	Preparation of H&S Plan / Spill and Emission Control Plan		1	LS	$5,000	$5,000
	Preparation of a Sediment and Erosion Control Plan		1	LS	$5,000	$5,000
	Preparation of a General Earthwork Plan		1	LS	$5,000	$5,000
	Preparation of the Construction Schedule		1	LS	$2,000	$2,000
	In Situ Chemcial Reduction (eZVI)					
	Area 1 - DNAPL		1	LS	$330,000	$330,000
	Area 2 - Soil at Building		1	LS	$40,000	$40,000
	Area 3 - Soil at Industrial Drive		1	LS	$530,000	$530,000
	GW Treatment Wall		1	LS	$800,000	$800,000
	Treatment System Wells					
	Well Installation		1	LS	$1,045,000	$1,045,000
	Well Abandonment at Completion		1	LS	$84,000	$84,000
	Design and Oversight					
	Predesign Investigation.		1	LS	$30,000	$30,000
	Treatment System Design		1	LS	$25,000	$25,000
	Long Term Monitoring Program Development		1	LS	$10,000	$10,000
	Construction Oversight		4	WK	$6,000	$24,000
	Preparation of Closure Report		1	LS	$20,000	$20,000
	Subtotal Construction Costs					$3,066,000
	Subtotal Construction Costs w/ Contingency (25%)					**$3,833,000**
	O&M Costs (30 years)					
	Annual GW Monitoring (40 wells - VOCs and Nat. Atten. Parameters)		1	YR	$120,000	$120,000
	Annual Site Inspections and Reporting		1	YR	$30,000	$30,000
	GW Treatment Monitoring (5 years)		1	YR	$50,000	$50,000
	Home Water Treatment Unit O&M and Providing Bottled Water		1	YR	$50,000	$50,000
	Subtotal O&M Costs (annual)					$250,000
	Subtotal O&M Costs (30 years @ 7%)					**$2,687,000**
	TOTAL REMEDIATION CONSTRUCTION & O & M COSTS				**Total**	**$6,520,000**

NOTES

Whole-house water Treatment System (WHWT) is currently operating at JS-14, JS-36, JS-38, and JS-52.

Bottled water is currently being provided to JS-14, JS-36, JS-38, JS-52, JS-27, and PA-55

O&M Costs for WHWT include period replacement of carbon units

Construction Period: 18 months for DNAPL and soil treatment and an additional 4 years for the groundwater bioremediation system

Remediation Technology Costs are provided by a vendor