RECORD OF DECISION

RIVERFRONT SITE
OPERABLE UNIT 4
MAIDEN LANE AREA

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Prepared by
U.S. Environmental Protection Agency
Region 7
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30017107
Superfund

RECORD OF DECISION
RIVEFRONT SITE
OPERABLE UNIT 4: MAIDEN LANE

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PART I THE DECLARATION

1.1 Site Name and Location

Riverfront Site (MOD981720246)
Operable Unit 4 (OU4) Maiden Lane Area
New Haven, Missouri 63068

1.2 Statement of Basis and Purpose

This decision document presents the selected remedy for the Riverfront Superfund site (Site), OU4, the Maiden Lane area, located in New Haven, Missouri. The selected remedy was chosen in accordance with the Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA), 42 U.S.C. §§ 9601-9675, as amended, and the National Oil and Hazardous Substances Pollution Contingency Plan (NCP), 40 CFR Part 300. This decision is based on the Administrative Record file for OU4.

The state of Missouri, acting through the Missouri Department of Natural Resources (MDNR), concurs with the selected remedy.

1.3 Assessment of Site

The response action selected in this Record of Decision (ROD) is necessary to protect the public health or welfare or the environment from the actual or threatened release of hazardous substances into the environment.

1.4 Description of Selected Remedy

The remedial action selected for OU4[1] addresses contaminated soil and groundwater in the fractured bedrock and is summarized below.

<u>Soils</u> – The hazardous substances in the soils at OU4 are tetrachloroethene (PCE), trichloroethene (TCE), and vinyl chloride. The remedial action selected to address these contaminants of concern (COCs) consists of the injection of a chemical oxidant to enhance chemical oxidation of the COCs, monitoring, and institutional controls (ICs).

The contaminated soils at OU4 are considered to be "principal threat" wastes because the COCs are considered to be mobile source materials. Although contaminated groundwater also poses a risk, it is not considered a principal threat as defined by the Environmental Protection Agency (EPA) guidance[2]. The most highly contaminated soils in the source area were treated during an EPA-lead removal action conducted in 2007. The residual contamination that remains following that removal action will be addressed as part of the

[1] The remedial action selected for OU4 appeared as "Alternative 3" in the Proposed Plan.
[2] *A Guide to Principal Threat and Low Level Threat Waste*, OSWER 9380.3-06FS (November 1991).

selected remedy through *in situ* chemical oxidation. The injection of chemical oxidants will create an *in situ* reactive zone where the COCs will be reduced to their harmless constituents. This will result in the remediation of the soil source area.

EPA anticipates that ICs will be effective in reducing the potential for exposure to the contaminated soils during the remedial action and until the remedial action objectives (RAOs) for the soils have been achieved. The primary IC for soils will be informational/educational. EPA, through the five-year review process, will continue to periodically inform and educate the owners of the properties where soil contamination is present of the potential health hazards posed by the COCs.

Fractured Bedrock Groundwater – The hazardous substances in the fractured bedrock groundwater plume are PCE; TCE; cis-1,2-dichloroethene; and trans-1,2-dichloroethene. Remediation of the contaminated soil source area will eliminate the continued migration of contaminants into the groundwater. It is expected that the groundwater plume will discharge over time into the nearby Missouri River. (Due to the large volume of water in the river and the relatively small quantity of COCs being discharged into the river from the plume, the plume contaminants are not detectable in the river and pose no threat.) With the remediation of the contaminant source area, the contaminant levels in the groundwater are expected to decrease over time to a level that is protective of human health.

ICs and long-term groundwater monitoring are also components of the selected remedy for the groundwater. Currently, there are no unacceptable groundwater or surface water exposures at OU4. All of the residences and businesses within OU4 are served by municipal water, and there are no known wells providing potable water at OU4. OU4 is within an area designated "Special Area 3" in the MDNR, Division of Geology and Land Survey, Well Construction Code [10 C.S.R. 23-3.100(7)]. As a result of this designation, well drilling restrictions are in place that preclude the installation of any well within or near the plume that may result in an unacceptable exposure of humans to groundwater contamination. In addition to these restrictions, EPA, through the five-year review process, will continue to periodically inform and educate the owners of the properties where groundwater contamination is present of the potential health hazards posed by the COCs and the need to comply with state well installation requirements.

Long-term groundwater monitoring will be conducted by EPA to track COC movement and attenuation. The monitoring will serve two functions: (1) it will alert EPA to any changes in plume migration that may result in unacceptable exposures, enabling EPA to take action to prevent such exposures; and (2) it will generate data on the expected attenuation of the COCs in the groundwater plume, thus providing information to EPA regarding the potential need for additional soil source area response actions and informing EPA and the state's consideration of the need for continuing ICs for OU4.

Groundwater monitoring will be accomplished by obtaining groundwater samples from existing bedrock monitoring wells and performing laboratory analysis on the samples for

COCs. Provisions will be made for the abandonment of any monitoring wells, pursuant to MDNR requirements, at such time as the RAOs are met or a determination is made by EPA that monitoring is no longer necessary.

1.4.1 Fractured Bedrock Technical Impracticability Evaluation Report

This selected remedial action provides for the overall protection of human health and the environment, a "threshold" criterion for remedy selection as set forth in the NCP; however, it does not meet the second NCP threshold criterion of compliance with ARARs. Due to the highly fractured and variable bedrock conditions found at OU4, compliance with all ARARs through containment, collection, treatment, or other technologies is technically impracticable from the engineering perspective as well as disproportionately expensive for any potential benefit realized. As a result, a waiver for certain chemical-specific ARARs is invoked in this ROD. The rationale for invoking the Technical Impracticability (TI) waiver is detailed in the *Fractured Bedrock Technical Impracticability Evaluation Report* (TI Report) which is included in the Administrative Record file for this remedial action. The findings of the TI Report are summarized below.

The TI Report is part of the phased OU4 environmental investigation which includes the Feasibility Study (FS) and informs EPA's decision on the practicability of achieving certain identified ARARs, within a reasonable time frame, for groundwater in bedrock impacted from the OU4 soil source area.

A remedy selected to address contamination at a site must achieve ARARs or provide the basis for an ARAR waiver. ARARs may be waived for any of six reasons set forth in section 121(d)(4) of CERCLA, 42 U.S.C. § 9621(d)(4), including where compliance with the requirement is technically impracticable from an engineering perspective. The term "engineering perspective" refers to factors such as feasibility, reliability, scale or magnitude of a project, and safety. While cost is a consideration in determining whether TI applies, it is "generally not a major factor unless compliance would be inordinately costly." *Guidance for Evaluating the Technical Impracticability of Ground-Water Restoration*, EPA OSWER Directive 9234.2-25, September 1993 (the "TI Guidance") (quoting the Preamble to the NCP).

The TI Guidance specifies that a TI waiver evaluation generally should include the following components based on site-specific information and analyses:

1. Specific ARARs or media cleanup standards for which TI determinations are sought
2. Spatial area over which the TI decision will apply
3. Conceptual model that describes the site geology, hydrology, groundwater contamination sources, transport, and fate
4. An evaluation of the restoration potential of the site

5. Estimates of the costs of existing or proposed remedy options
6. Any additional information or analyses EPA deems necessary for the TI evaluation

In developing the TI Report, the range of groundwater remedial alternatives evaluated in the FS was considered. The FS evaluated bedrock groundwater remedial alternatives against the set of nine criteria prescribed in Section 300.430(e)(9)(iii) of the NCP. The evaluation demonstrated that of the groundwater remedial alternatives developed and retained for detailed evaluation, none were able to fully satisfy the NCP criteria of "compliance with ARARs." The FS determined that the evaluated remedial alternatives for bedrock groundwater would not be able to reduce COC concentrations below chemical-specific ARARs/target cleanup levels (TCLs) within a reasonable time frame.

1.4.2 Technical Impracticability Report Conclusions

Based on the information collected during the OU4 groundwater investigations, active restoration of the contaminated groundwater at OU4 is determined by EPA to be technically impracticable from an engineering perspective for the following reasons:

1. The depth of the contaminated groundwater. The OU4 contaminated groundwater may extend to depths of more than 400 feet below ground surface (bgs) in the center of the contaminant plume while at the downgradient edge (base of the Missouri River flood plain), the plume is approximately 360 feet bgs.

2. Detailed fracture diameter, spacing, orientation, vertical extent, and connectivity within and between formations are unknown and cannot be accurately determined. As noted in Section 4.3.3.1 of the TI Report, because of the plume's size and depth, the surface topography above the plume, and the heavy residential development above the plume, it is impracticable and perhaps impossible to fully ascertain contaminant migration in the groundwater; it is technically impracticable from an engineering perspective to effectively remediate such contamination in a cost-effective manner.

3. Dissolved PCE contamination will have diffused into interstitial spaces, dead-end fractures, and solution voids along contaminated fracture flow paths. While it may be possible to remediate the main groundwater flow channels (if their locations could be determined, see item 2 above), remediation of the dead-end fractures, solution voids, and interstitial spaces will be driven by reverse diffusion of the dissolved PCE out of the cut-off spaces, a very slow process, further increasing the time needed to meet federal and state groundwater cleanup levels.

4. The area above the plume is very steep and rugged and is a heavily developed residential area. Finding sufficient suitable locations on the steep and developed terrain to install the large number of treatment or extraction wells

necessary for active remediation would be very difficult. If attempted, it may be necessary to use angle drilling to attempt to reach the portions of the plume. Therefore, it may not be possible to treat the entire plume. In addition, diffusion of untreated water into the remediated volumes of the plume may cause the treated volumes to not meet the remediation standards (rebound contamination).

5. While it is believed that the plume, overall, is stable or declining, monitoring the remediation of the plume will be complicated by the physical size and the varying contaminant levels created by earlier events such as droughts and wet years and subsurface conditions. Placing sufficient monitoring wells would be difficult for the reasons listed in item 4 above. In addition, because the monitoring data may not actually reflect results of the remediation activities, decisions on how to manage the remediation system may be overly aggressive if a historical increasing trend overwhelms the decreases from remediation activities. Conversely, a historical decreasing trend may lead to a premature step-down or cessation of remediation activities by artificially amplifying the effectiveness of the remediation.

6. If there is dense nonaqueous phase liquid (DNAPL) present in the bedrock below the source area soils, all of the difficulties discussed above will be exacerbated in the portion of the plume below the source area soils. PCE in the form of mobile DNAPL may have migrated into fractures that pinch out. DNAPL may also have migrated along bedding planes. Residual nonaqueous phase liquid (NAPL) may also remain in fractures along which the DNAPL migrated. DNAPL in fractures will be much more difficult to remove or treat than dissolved PCE even if the fracture is directly intersected by a treatment or extraction well. DNAPL in pinched-out fractures will take even longer to treat than any residual DNAPL in accessible fractures. All of these residual DNAPLs will act as sources of recontamination for groundwater. For the downgradient portion of the plume where DNAPL contamination is not present, items 1 through 5 above already suggest that active remediation of the plume is impracticable. The possible presence of DNAPL below the source area would be an additional complicating factor in actively remediating the plume.

Statutory Determination

The selected remedy is consistent with CERCLA and to the extent practicable, the NCP. The selected remedy is protective of human health and the environment, complies with federal and state requirements that are applicable or relevant and appropriate to the remedial action (except as waived), and are cost effective. The fractured bedrock remedy does not meet the regulatory preference for treatment since it is technically impracticable from an engineering perspective to treat groundwater in the bedrock. The soil remedy does meet the regulatory preference for treatment.

Because the selected remedy will result in hazardous substances, pollutants, or contaminants remaining on-site above levels that allow for unlimited use and unrestricted exposure, EPA will review the remedy no less often than every five years after initiation of the selected remedy to ensure that the remedy is or will be protective of human health and the environment.

1.6 ROD Data Certification Checklist

The following information is included in the Decision Summary section of this ROD. Additional information can be found in the Administrative Record file for the Site, OU4.

- COCs and their respective concentrations – Section 7.1.1
- Baseline risk presented by the COCs – Section 7.1.9
- How source materials constituting principal threats are addressed – Section 11.0
- Current and reasonably anticipated future land use assumptions and current and potential future beneficial uses of groundwater in the baseline risk assessment and ROD – Section 5.1
- Potential land and groundwater use that will be available at the Site as a result of the selected remedy – Section 13.4
- Estimated capital, annual operation and maintenance, total present worth costs, discount rate, and the number of years over which the remedy cost estimates are projected – Section 12.3
- Key factor(s) that led to the selected remedy – Section 12.1

1.7 Authorizing Signature

Cecilia Tapia, Director
Superfund Division

3/26/09
Date

PART II THE DECISION SUMMARY

1.0 Site Name, Location, and Description

The Riverfront Superfund site (Site), Operable Unit 4 (OU4), including the source area soils referred to as the "Maiden Lane area" are located south of downtown New Haven, Missouri, between Maupin Avenue and Miller Street. The Maiden Lane area is a residential area that lies about 2,600 feet upgradient of city well W2. New Haven (population 1,867) is located along the southern bank of the Missouri River in Franklin County, Missouri, about 50 miles west of St. Louis, Missouri (Figure 1-1). The Comprehensive Environmental Response, Compensation, and Liability Information System Identification Number for the Site, which includes OU1 through OU6, is MOD981720246. The lead agency for the Site is the U.S. Environmental Protection Agency (EPA). The Missouri Department of Natural Resources (MDNR) is the support agency. The expected source of cleanup monies for this OU is the Superfund.

OU4 is a 192-acre area located in the north-central part of New Haven and is generally bordered on the west by Maupin Avenue, on the south by Circle Drive, and extends east of Miller Street into undeveloped land within the city limits. OU4 straddles the topographic divide between the Missouri River to the north and Boeuf Creek to the south. The OU4 boundary encompasses a plume of tetrachloroethene- (PCE) contaminated groundwater that extends from a 0.2-acre source area south of Maiden Lane, north to the Missouri River. OU4 includes the soil source area and extends under OU5 (Old Hat Factory) and OU1 (Front Street) (Figure 1-2).

2.0 Site History and Enforcement Activities

2.1 Site History

In 1986, MDNR began analyzing samples collected from public supply wells for volatile organic compounds (VOCs). During this initial sampling effort, PCE and trichloroethene (TCE) were detected in New Haven's public supply wells W1 and W2. These wells are located in the northern part of the city. Concentrations of PCE in water samples from W2 increased steadily from 28 micrograms per liter (µg/L) in 1986 to 140 µg/L in 1993 when the well was removed from service. Concentrations of PCE in water samples from W1 generally were less than 5 µg/L; however, because W1, which is located in the Missouri River flood plain, had a history of bacterial contamination attributed to poor surface-casing seal, it was disconnected from the city's distribution system in 1989. In late 1988 and early 1994, two additional wells (W3 and W4, respectively) were installed in the southern part of the city. No VOCs have been detected in wells W3 and W4.

Following the discovery of the contamination, several investigations of the potential sources were made by MDNR and EPA beginning in the late 1980s and into the early 1990s. The initial investigations of PCE contamination of the public supply wells began with a Preliminary Assessment conducted by MDNR and concluded with an Expanded Site Investigation (ESI) conducted by EPA. The ESI concluded that PCE was released at

a former manufacturing facility in downtown New Haven but was inconclusive about other PCE sources because of the limited amount of data on groundwater flow in the area. In 1998, EPA tasked the U.S. Geological Survey (USGS) for technical assistance in understanding the hydrogeology of the New Haven area and to provide information on the possible directions of groundwater flow and PCE migration from potential sources identified in the ESI. USGS conducted an ESI/Remedial Investigation (RI) that was completed in early 2000. In July 2000, as a result of the additional data collected during the ESI/RI, EPA placed the Site on the National Priorities List (NPL) and asked USGS for assistance in conducting an RI. The Site was officially placed on the NPL in December 2000, and EPA initiated an RI of what is referred to as the Riverfront Site.

The Site encompasses six OUs in and around the city of New Haven (Figure 1-2). The OUs have been designated based on the results of prior investigations and information received through interviews with local citizens regarding waste generation and disposal. These areas have facilities which are possible sources of the PCE contamination and include a former manufacturing facility in downtown New Haven (OU1), a metal fabrication plant in south New Haven (OU2), the Old City Dump (OU3), an undeveloped area south of contaminated city well 2 (OU4), a former hat factory (OU5), and an area with contaminated domestic wells south of the city (OU6).

The RI at OU4 was complicated because there was no known source of PCE, and the original OU4 area was designated based upon the area being upgradient and upslope from city well W2 (based on the ESI/RI water level map) and alleged dumping of industrial wastes east of Miller Street. Information gathered from previous investigations (OU1 and OU3) that occurred throughout the more than 600-acre area of the city, south of the Missouri River and north of State Highway 100, is included as part of the OU4 investigation.

As the overall Site RI progressed and the OU4 investigation began in earnest during 2003, the area of interest shifted from east of Miller Street to the Maiden Lane area. By 2005, the original OU4 area was abandoned and redefined as a similar size (192 acres) area encompassing a plume of PCE in the bedrock aquifer primarily west of Miller Street. Through an iterative and thoughtful process of tracking PCE through the bedrock aquifer, monitoring wells were installed progressively upgradient from city well W2. Groundwater information collected from these monitoring wells combined with sampling data from tree cores, streams, and soil samples, along with information obtained from interviews with area residents resulted in the identification of the OU4 PCE source area.

This relatively small (0.2 acre) source area, south of Maiden Lane, is the likely source of the PCE contamination that eventually lead to the closure of city wells W1 and W2.

2.2 Remedial Investigation Activities at OU4

The primary contaminant of concern (COC) at OU4 is PCE and its degradation products TCE, cis-dichloroethene (cis-DCE), and vinyl chloride (VC). Although the OU4

investigation did not begin in earnest until after the completion of OU1 and OU3 investigations and subsequent remedial actions in 2003, some investigative activities at OU4 began with the start of the overall EPA Site RI in 2001. As described previously, the OU4 investigation was initially driven by the conclusions in the 2001 ESI/RI that:

1. A groundwater divide in the bedrock aquifer existed in the vicinity of State Highway 100 with shallow groundwater flow moving northward from that divide toward city well W2.

2. There was an unidentified source of the detection of PCE in monitoring well BW-02 that is located upgradient (south) of city well W2.

Complicating the OU4 investigation was the absence of any known PCE use or disposal in the mostly residential area between well BW-02 and the shallow groundwater divide and the presence of PCE contamination more that 500 feet deep in the bedrock aquifer at city well W2.

Early (2001-2003) activities at OU4 generally focused on reconnaissance sampling of all creeks and the review of historical aerial photography looking for areas of land disturbance consistent with the possible dumping of wastes. A detailed reconnaissance (walk-over survey) of the entire area, including tree core sampling, was conducted along with a metal detector survey, Ground Penetrating Radar (GPR) survey, and soil borings collected at selected areas. At the time of theses activities, a methodical "walk upgradient" of monitoring well installation was done to track the plume of PCE contamination in the groundwater south of city well W2. A chronological summary of major EPA activities at OU4 is provided in Table 2-1.

The following sections discuss the environmental media investigated and the general approach to sampling these media. The sections are presented in the order in which they were conducted in the field (e.g., tree core sampling, surface water and spring sampling) followed by groundwater and soil investigations.

2.2.1 Tree Core Sampling

Tree core samples have been collected from 148 trees within OU4 and in an area south of city well W2. Tree coring initially focused on the area east of Miller Street—an area where it was suspected that PCE was disposed (Area A). The first tree core samples were collected in April 2000 within Area A along the 210 tributary. Tree core samples were also collected along a fence line behind a number of residences on the east side of Miller Street in response to interviews with area residents that indicated that waste PCE may have been used along the fence line as a weed killer.

Tree core samples were collected from a total of 93 trees in the Maiden Lane area of OU4. The sampling was done in three separate rounds. The first round of sampling was conducted in September 2001 and consisted of 37 trees (JS100 - JS141) from across the Maiden Lane area and including several trees along sanitary sewer mains south and north

of the sampling area. The second round of sampling occurred during July 2003 and focused on 15 trees at the former Kellwood Company (Kellwood) research facility (sample prefix "JKR"). The third and final round of sampling occurred in October 2003 in which 41 trees (sample JS300 and above) in the area east of Maupin Avenue and south of Maiden Lane were sampled (Figure 2-1).

2.2.2 Stream and Spring Sampling

A total of 132 samples have been collected from 80 stream or spring sites at and in the vicinity of OU4 (Figure 2-2). One hundred and twelve of the samples were analyzed by a portable gas chromatograph (GC) and thirty samples were tested at an analytical laboratory. A reconnaissance of each tributary in the OU4 area and vicinity was conducted during off-leaf, wet weather conditions during 2000-2001. Although sampling was done in wet weather conditions to identify seeps, it was timed to avoid actual runoff conditions that might dilute groundwater discharges into the streams. During the reconnaissance, each tributary was walked and locations of seeps, pools, debris, possible dump sites, fence lines, old building, bedrock exposures, etc., were noted.

Because OU4, and more specifically the Maiden Lane area, is situated across a topographic high, runoff or shallow groundwater could potentially discharge into one of four drainages: the 760 tributary to the south, the 210 tributary to the east, the 300 tributary to the north, and the part of the 400 tributary to the northwest. The primary drainage for most of the area is the 760 tributary which flows generally south from Maiden Lane toward State Highway 100. Except during runoff, this drainage is dry and flow does not begin until nearly 0.75 miles to the south of the Maiden Lane area. Consequently, no VOC samples were collected from the upper reaches of the 760 tributary. However, samples were collected from the lower reaches of the 760 tributary south of State Highway 100 as part of the OU6 reconnaissance. The 300 tributary and the 210 tributary are likely discharge points for groundwater within the shallow bedrock in the northeastern and northern portions of OU4. A small flow (less than 0.2 liters per minute [L/min]) of perennial flow in the 300 tributary was traced to a small spring referred to as "Bates" Spring in the OU1 RI. During the OU4 RI, a small seep was discovered in the 210 tributary where the upper sandstone bed was exposed in the creek channel. A small pool at the base of the one-foot high exposed sandstone bed collected seepage from several thin bedding seams in the sandstone. The pool was designated as sampling site 210TB-C6. Seepage into the pool was small and on the order of 0.1 to 0.2 L/min. As part of the survey for PCE, a number of samples were collected from the 210 tributary upstream and downstream from this pool and from the 220 tributary to the south.

2.2.3 Groundwater Investigation

The groundwater investigation can be divided into two components: (1) those activities that were conducted as part of the ESI/RI and the overall Site RI/FS from 1999 through 2002, and (2) those OU4 activities beginning in 2003 that specifically focused on the

Maiden Lane area. A total of 38 monitoring wells, in 20 clusters, were installed in the bedrock aquifer as part of the investigations at the Site—24 bedrock monitoring wells are associated with the OU4 investigation (Figure 2-3).

As part of the OU4 RI, more than 200 groundwater samples were submitted for laboratory analysis from public supply wells, industrial wells, and completed monitoring wells. In addition, more than 600 groundwater or drill-cutting samples from monitoring well boreholes or completed monitoring wells were analyzed using a portable GC. The results of borehole geophysics, discrete samples, and packer testing in city well W2 were used to design target intervals for bedrock monitoring wells installed during the ESI/RI and subsequent investigations. A potentiometric map developed from completed bedrock monitoring wells was used to build a conceptual model of probable PCE transport to closed city wells W1 and W2. Based on the potentiometric contours, analysis of groundwater samples from well clusters, and geophysical and packer testing in city well W2, the source of PCE contamination in city wells W1 and W2 was determined to be an unidentified source upgradient (south) and likely between the contaminated city wells and the shallow groundwater divide located in the vicinity of State Highway 100—the Maiden Lane area.

2.2.4 Soil Investigation

As part of the OU4 RI, a total of 76 soil borings were conducted. The borings were done as part of six separate mobilization efforts between December 2001 and January 2007. A total of 286 soil samples were analyzed from these borings with a portable GC, and 23 samples were sent to an analytical laboratory. Samples analyzed by the portable GC generally were collected at two- to four-foot intervals in each boring. The initial 17 borings were done in December 2001 to assess soil contamination east of Miller Street (in Area A or along fence rows east of Miller Street) and to ensure PCE-contaminated soils were not present at the future locations of monitoring well cluster BW-08. Six borings were done in a vacant field in conjunction with the city of New Haven in response to interviews of area residents alleging wastes of unknown origin may have been dumped in this area. The remaining four mobilization efforts involved the installation of 54 soil borings done in the Maiden Lane area of OU4 as the RI focused on this area after the tree core and groundwater sampling indicated this area was the probable PCE source area.

<u>Maiden Lane Area Soil Borings</u>

Phase I – 2003 (Assumption Catholic Church)

Phase I soil borings were shallow (less than four feet deep) and collected during a reconnaissance of the Church's parking lot. These borings were done to investigate the possible use and disposal of waste PCE on the gravel parking area prior to it being covered with asphalt. A GPR survey was also done over a section of the parking lot to locate a buried, domestic water well. A total of 10 borings was done at this location.

Phase II – 2004 (Maiden Lane Sewer Line)

Phase II was conducted to determine if PCE contamination was present in soils along the sanitary sewer line beneath Maiden Lane and to determine if PCE was present in soils near trees cored in 2001 and 2003 that had detections of PCE. A total of 19 borings was done—10 along the south side and behind the curb on Maiden Lane and near the intersection of Maiden Lane and Miller Street and 9 in the back yards of residences south of Maiden Lane. Borings along Maiden Lane were intended to determine if significant quantities of PCE were released from the clay-tile gravity line or the force main beneath the street (Figure 2-4).

Phase III – 2005 (Former Kellwood research facility and 104 Maiden Lane)

The Phase III soil sampling effort was done in November 2005 to determine if PCE was present in soils at the former Kellwood research facility at 704 Maupin Avenue and to characterize the extent of the PCE contamination in the soil at the south end of the 104 Maiden Lane residence. Eleven borings were done on the east and southeast part of the former Kellwood research facility. Borings were advanced to eight feet deep with soil samples collected every two feet for analysis for PCE and other VOCs using the portable GC.

Eleven borings were done at the south end of the property at 104 Maiden Lane and adjoining parcels (Figure 2-5). These borings were done in response to PCE previously detected in trees in this area, PCE found in several Phase II borings in the vicinity, and responses to interviews with former and current residents in the area and their relatives. Particular attention focused on a pipe that was determined to be a gray water line that surfaced at the south end of the property near the old garage located at 104 Maiden Lane.

Phase IV – 2007 (Maiden Lane and Overburden Wells)

The Phase IV borings were done near the old garage during January 2006 to collect soil samples for determining the permanganate soil oxygen demand. These samples were used to assist in the design of a time-critical-removal action conducted by EPA to treat PCE-contaminated soils in the vicinity of the old garage and gray water line. As part of the Phase IV soil investigation effort, three shallow (less than 12 feet deep), temporary monitoring wells were installed in the vicinity of the old garage at 104 Maiden Lane to determine concentrations of PCE and other VOCs in perched water within the overburden. These wells were installed to obtain baseline VOC levels in perched water before and after the chemical oxidant injection used in the removal action (Figure 2-6).

2.2.5 Sanitary Sewer Investigation

Reconnaissance sampling of the city sanitary sewer system was conducted in 2001 with additional samples collected during 2002 and 2003. A focused sampling of selected sewer lines was also done during 2004 as part of the OU5 RI/FS.

The 2001 sanitary sewer reconnaissance was done in response to interviews with former employees of the former Kellwood facility at OU2 indicating that waste PCE was allegedly disposed of in floor drains that were connected to the city's sanitary sewer system. The reconnaissance focused on sewer lines downstream from the OU2 facility. Maps of the city sewer system provided by the City Engineer were used to trace the route of effluent from the OU2 facility through the system to the wastewater lagoon. Samples from the sewer system were collected from inflows into manholes. Ten samples were collected from six manholes in the Maiden Lane area and vicinity.

2.2.6 Indoor Air Quality Sampling

As a result of the detection of PCE in samples from tree cores, soils, and shallow perched groundwater in the Maiden Lane area, indoor air samples were collected from five residences and from the New Haven Elementary School. The indoor air samples from the school were collected in September 2002 as part of a reconnaissance sampling at OU1, OU2, and OU4.

2.2.7 Maiden Lane Removal Action

A time-critical-removal action was conducted to mitigate the high levels of PCE detected in soils near the old garage south of 104 Maiden Lane. The removal action consisted of the injection of approximately 3,400 gallons of sodium permanganate directly into 90 injection points in the contaminated soil and perched groundwater to destroy the PCE and other VOCs by chemical oxidation. The permanganate injections were done in two phases—the first was done in May 2007 in an area primarily southwest and adjacent to the old garage, and the second was conducted in October 2007 focusing on an area north of the old garage.

3.0 Community Participation

Community relation activities for the Site were initiated by EPA prior to the issuance of the RODs for OU1 and OU3, with a notice of the availability of these documents in the *New Haven Leader* on July 30, 2003. The public meeting for these RODs was held on July 29, 2003. Since then, EPA has conducted periodic meetings with New Haven officials and the general public to update them regarding Site work. Fact sheets, publication of notices, development of a Riverfront Web site for public use, and attendance by EPA representatives at city council meetings have been utilized to address comments from concerned citizens.

The RI Report, FS, and the Proposed Plan for OU4 were made available to the public in December 2008 through January 2009. These can be found in the Administrative Record file maintained at the EPA Region 7 Records Center, 901 North 5th Street, Kansas City, Kansas, and at the New Haven Scenic Regional Library, 109 Maupin, New Haven, Missouri. The notice of availability of these documents was published in the *New Haven*

Leader on December 31, 2008. A public meeting for the Proposed Plan was held on January 6, 2009. The public comment period for the Proposed Plan began on December 31, 2008, and ended on January 29, 2009. No public comments were received on the Proposed Plan.

4.0 Scope and Role of the Operable Unit and Response Action

The Site, as with many Superfund sites with multiple OUs, is complex and challenging. A number of removal actions have been conducted at several OUs to address soil source areas and groundwater contamination. The removal action at OU1 consisted of the excavation and disposal of approximately 500 cubic yards (yd^3) of PCE-contaminated soil and the rerouting and replacement of a polyethylene waterline that was part of the city's public water supply. The OU6 removal action conducted by Kellwood consisted of one resident being connected to the public water supply and the installation of whole-house filtration units to the residences outside the city limits that had their private drinking water wells contaminated with PCE above the MCL. In accordance with the Administrative Order on Consent for OU6 (EPA Docket No. 07-2002-0091), Kellwood continues to monitor the filtration units and the PCE levels in the groundwater. The removal action conducted by EPA at OU4 in 2007 consisted of the injection of sodium permanganate into the Maiden Lane contaminant source area. While this action resulted in the breakdown of some of the PCE into its nonhazardous constituents, the sampling data indicate that contaminants remain in the soils and that such contaminants continue to mobilize into the shallow aquifer and migrate. There is no use of groundwater within OU4. Because of the proximity of OU4 to the Missouri River valley, which serves as a drain for regional and shallow groundwater flow, the PCE detected in the shallow bedrock at OU4 is not a threat to the public supply wells W3 and W4 located south of and upgradient from OU4 or domestic wells outside of the city limits.

5.0 Conceptual Site Model

The conceptual site model serves as the foundation for evaluating the restoration potential of the Site. The conceptual site model incorporates information on site geology, hydrogeology, contaminant fate, and transport and current and potential receptors.

Much of the site-specific information on OU4 was developed during the groundwater investigation of OU4. The groundwater investigation at OU4 can be divided into two components: (1) those activities that were conducted as part of the ESI/RI and the overall Site RI/FS from 1999 through 2000, and (2) those activities beginning in 2003 that specifically focused on the Maiden Lane area of OU4.

5.1 Site Characteristics

The general conceptual site model on which OU4 response actions are based consists of a VOC soil source area containing 256 yd^3 of contaminated soils that provide the source for groundwater contamination. These soils contain a total estimated at 470 kilograms (kg) (about 77 gallons of pure product) of PCE. The total mass of PCE was calculated by

multiplying the smaller of the average or the 75th percentile PCE concentration within each depth interval by the interval thickness and the area estimated to contain PCE above the residential preliminary remedial goal (PRG). It is estimated that more than 90 percent of the estimated total mass of PCE are contained within soils below 15 feet in depth.

The groundwater contaminant plume at OU4 is more than 3,800 feet long and nearly 3,000 feet wide at its downgradient edge where it discharges into the Missouri River. A geographic information system was used to generate a smoothed-grid surface of estimated PCE concentrations in the bedrock aquifer and estimate the volume of contaminated groundwater and the total mass of PCE in groundwater (Figure 5-1).

A grid of contaminated aquifer thickness was created with three zones—A, B, and C. Zone A was 100 feet thick and represented a vertical "cone" of contaminated aquifer extending from the surface at the Maiden Lane source area (lateral extent of 5,200 ft^2) to just below the base of the upper sandstone bed.

Zone B was estimated to be 10 feet thick and represents the highly contaminated bedrock in the Maiden Lane area wells (BW-10, BW-11, and BW-13) within and adjacent to the upper sandstone bed.

Zone C was assumed to be 25 feet thick representing an assumed thickness of beds carrying PCE contamination in wells further downgradient from the Maiden Lane source area, such as well BW-02.

Based on the above assumptions regarding thickness of contaminated zones and a porosity of 10 percent, the total mass of PCE in the OU4 plume was estimated at approximately 26 kg. This mass represents about 2.6 kg in Zone A, 1.8 kg in Zone B, and 21 kg in the downgradient distal part of the plume outside the Maiden Lane area.

5.1.1 Physical Characteristics

References/sources for the following physical characteristics data can be found in the RI and FS reports.

5.1.2 Demography, Land Use, and Wildlife

New Haven, Missouri, is about 50 miles west of St. Louis, Missouri (Figure 1-1). The city is similar in character to other small Missouri towns and cities along the Missouri River with historic late 1800-era homes along the steep river valley slopes overlooking a downtown business district adjacent to the river. The region is generally rural and consists of gently rolling hills with farmland and scattered deciduous forests. Near the Missouri River, the topography becomes more rugged. New Haven straddles an east-west trending topographic divide that separates the Missouri River valley to the north from the Boeuf Creek valley to the south (Figure 1-2). The divide is about one mile

south of the Missouri River and is asymmetrical with steep slopes to the north and shallow slopes to the south. State Highway 100 runs east-west through the city just south of the topographic divide.

New Haven has a population of 1,867 with an incorporated area of approximately 2.7 square miles (mi^2). New Haven contains a mixture of medium- to high-density single family and multifamily residential areas. Land use in the area between the Missouri River and State Highway 100 is predominantly single-family homes and several churches. The New Haven downtown business district is located on a narrow (less than 600 feet wide) strip of the Missouri River flood plain and consists of several small shops and restaurants; a few homes; and several small, old manufacturing facilities. The eastern part of the city is mostly deciduous forest, and areas outside the city are mostly mixed agricultural use of row crops (corn and soybeans) and pasture with scattered deciduous forests.

New Haven is located along the northern boundary of the Salem Plateau physiographic subprovince of the Ozark Plateaus Province. The Salem Plateau is characterized by a moderate to rugged terrain with thin soils and narrow steep-walled valleys. Topographic relief is the result of gradual uplift of the Ozark Dome in southern Missouri and erosion of the uplifted rocks by precipitation runoff and streamflow. The topographic relief in the New Haven area is accentuated because of its proximity to the Missouri River which controls the base level for most streams in western and central Missouri.

South of State Highway 100 land use is mostly commercial and industrial with smaller amounts of rural and new residential areas and park land. Several manufacturing facilities are within the city limits. These facilities produce automotive door seals, custom aluminum tubing, and synthetic fabrics. These facilities employ several hundred residents, some living outside the city limits.

New Haven is located in the Central Irregular Plains ecological region. The Missouri River has six designated beneficial uses including protection of warm water aquatic life and human health fish consumption, irrigation, livestock and wildlife watering, boating and canoeing, drinking water supply, and industrial water supply. The river is a riparian wetland and supports a wide variety of wildlife including five rare or endangered species: the sickelfin chub (*Macrhybopsis meeki)*, sturgeon chub (*Macrhybopsis gelida*), plains killfish (*Fundulus zebrinus*), lake sturgeon (*Acipenser fulvescens*), and the pallid sturgeon (*Scaphirhynchus albus*). The river is also a sanctuary for a wide variety of waterfowl and birds. An inventory from the *Clarence Cannon National Wildlife Refuge* (about 60 miles northeast of New Haven) indicates endangered birds such as the commonly observed bald eagle (*Haliaeetus leucocephalus*), or the rarely observed peregrine falcon (*Falco peregrinus anatum*), and the piping plover (*Charadrius melodus*) may be found in the area.

5.1.3 Hydrogeology of the New Haven Area

Two major aquifers are important in the New Haven area: (1) the Ozark aquifer, and (2) the Missouri River alluvial aquifer. These aquifers are used extensively in Missouri for domestic, industrial, and public water supply. In the New Haven area, the Ozark aquifer provides all domestic, industrial, and public water. For distinction, monitoring wells completed in the Ozark aquifer will be referred to as bedrock monitoring wells; those monitoring wells completed in the Missouri River alluvial aquifer will be referred to as alluvial monitoring wells.

Ozark Aquifer

New Haven is underlain by units of the Ozark aquifer. The Ozark aquifer is a thick sequence of water-bearing dolostone, limestone, and sandstone formations ranging in age from Late Cambrian to Middle Devonian. Although these units collectively are a regional aquifer, the water-yielding capacity of the individual units varies. Geologic units of the Ozark aquifer present in the New Haven area range in age from Late Cambrian through Ordovician, and increasing in age are the St. Peter Sandstone, Powell Dolomite, Cotter Dolomite, Jefferson City Dolomite, Roubidoux Formation, Gasconade Dolomite (including the basal Gunter Sandstone Member), Eminence Dolomite, and Potosi Dolomite (Figure 5-2). The geologic names used here conform to terminology used by MDNR Division of Geology and Land Survey. In the New Haven area, the Ozark aquifer is more than 1,000 feet thick.

The uppermost bedrock unit exposed in the vicinity of OU4 is the Cotter Dolomite. The thickness of the Cotter Dolomite unit is variable because of erosion and ranges from about 85 feet beneath the Missouri River alluvium to a maximum of about 330 feet beneath the Maiden Lane area of OU4. The Cotter Dolomite is a tan, finely crystalline, silty-to-sandy, cherty dolostone with thin greenish-gray mudstone/shale. The Cotter Dolomite also contains scattered fine-grained, well cemented sandstone beds that usually are less than two feet thick. Two thicker sandstone beds in the Cotter Dolomite—the "upper sandstone" and the Swan Creek sandstone—were used as marker beds in the subsurface and at surface exposures. The upper sandstone is four to six feet thick, fine-grained, massively bedded sandstone. The unit is exposed in many creeks and tributaries in the New Haven area at an altitude of about 550 feet. Where the upper sandstone is exposed in creek beds, small seeps are common indicating that the unit may be more permeable than the surrounding dolostone. In the Maiden Lane area of OU4, the upper sandstone unit is about 100 to 150 feet deep. Drill logs from monitoring wells indicate that the dolostone adjacent to the upper sandstone is typically more weathered than the surrounding dolostone. Groundwater yields from the upper sandstone and adjacent weathered dolostone to monitoring wells typically are less than three gallons per min (gal/min) but are variable and range from less than 0.5 to more than 20 gal/min in monitoring wells installed at the various OUs within the Site. In the Maiden Lane area of OU4, monitoring wells BW-10, BW-11, BW-13, and BW 14 are open to the upper sandstone unit and adjacent dolostone (Figure 5-2). Yields to these wells during sampling typically range from 0.3 gal/min (BW-10) to about 1.0 gal/min (BW-11).

The Jefferson City Dolomite underlies the Cotter Dolomite and in New Haven is about 150 to 165 feet thick. The unit is not exposed at the surface in the New Haven area. The Jefferson City Dolomite has similar lithology to the overlying Cotter Dolomite, and the two units often are undifferentiated and termed the Cotter and Jefferson City Dolomites. The Jefferson City Dolomite generally is a tan to light gray, fine-to-medium crystalline, dolostone or argillaceous dolostone.

Overall, the Cotter Dolomite and the Jefferson City Dolomite are poor water-producing formations and typically have low vertical and horizontal hydraulic conductivities. Where these units are exposed at the surface, they can impede vertical infiltration of precipitation more than older units such as the Roubidoux Formation. Water level data from monitoring well cluster BW-04 indicate a relatively steep vertical hydraulic gradient through the Cotter and Jefferson City Dolomites of about 0.2 feet per foot. In the Maiden Lane area, the vertical gradients range from 0.35 to 0.71 feet per foot.

The Roubidoux Formation underlies the Cotter and Jefferson City Dolomites. The Roubidoux Formation is the first unit encountered in the New Haven area that yields reliable quantities of water. Slug-test data from several monitoring wells completed in the Roubidoux Formation indicate that the average hydraulic conductivity is 1.8 feet per day, about 10 times higher than that of the overlying Cotter and Jefferson City Dolomites. In the New Haven area, the Roubidoux Formation is about 110 to 120 feet thick. Yields from monitoring wells range from 5 to 80 gal/min.

The Gasconade Dolomite underlies the Roubidoux Formation with an average thickness in the New Haven area of about 300 feet. The Gasconade Dolomite is divided into two informal units: (1) the upper and lower Gasconade Dolomite, and (2) the basal Gunter Sandstone Member. The upper Gasconade Dolomite tends to be less permeable than the overlying Roubidoux Formation or the underlying lower Gasconade Dolomite. Yields from wells to both the upper and lower Gasconade Dolomite generally range from 50 to 75 gal/min. The Gunter Sandstone Member is the basal unit of the Gasconade Dolomite and is a target zone for many high-capacity wells in southern Missouri. Yields from the Gunter Sandstone Member typically range from 40 to 50 gal/min; however, yields from production wells open to this unit just east of New Haven can be as high as several hundred gal/min.

The Eminence Dolomite, which underlies the Gasconade Dolomite, is a medium to coarsely crystalline dolostone with little or no chert. Well logs indicate that the Eminence Dolomite averages about 160 feet thick in the New Haven area. The Potosi Dolomite is the lowermost unit in the Ozark aquifer and consists primarily of massive to thickly bedded "vuggy" dolostone with abundant drusy quartz. The lower Gasconade Dolomite and the underlying Eminence and Potosi Dolomites are important sources of water for high-capacity wells in New Haven and throughout most of southern Missouri. Yields from these wells typically range in the hundreds of gal/min or more. Closed city wells W1 and W2 were completed in the Potosi Dolomite.

Unconsolidated Surficial Deposits

Unconsolidated surficial deposits in OU4 were mapped as part of a geologic mapping effort of the entire New Haven area. These deposits consist of Quaternary-age loess (Ql), residual deposits of the Buffalo Series (Buffalo "a" Subunit and Buffalo "o" Subunit), Quaternary-age alluvium, and Quaternary-age terrace deposits. The youngest surficial deposit mapped at OU4 is loess (Ql) deposited during the Pleistocene Epoch. The loess is a tan to light brown, wind-blown deposit generally consisting of uniform silt-size particles. Locally, the loess is weathered and may contain variable quantities of clay. The loess occurs at the surface throughout the upland areas of OU4.

5.1.4 Geologic Structure

Bedrock units in the region have a regional dip to the northeast. A structural contour map (Figure 5-3) from the top of the upper sandstone unit in the Cotter Dolomite indicates a dip of about 60 feet to the northeast over about 2.5 miles (0.5 percent) in the New Haven area. Fractures or joints in the bedrock are common and typically trend southeast-northwest and southwest-northeast. Several major structural features have been mapped in the New Haven area including the Berger Creek fault that is projected to cross near the southwestern part of OU4. Geologic logs from monitoring well installation indicated no notable rubble zones or zones of broken and highly weathered bedrock indicative of faulting in OU4. About 160 feet of highly weathered bedrock with large amounts of cobbles and orange clay were penetrated during the installation of monitoring well BW-22 located at OU2 in the southern part of the city. These may be attributed to a fault possibly associated with the Park Creek structure. Additional structure may exist in the northern part of OU4 because of the anomalously low altitudes of the top of the Jefferson City Dolomite and the Roubidoux Formation encountered in city well W3.

5.1.5 Fractures, Jointing, and Weathering

Fracturing, jointing, and weathering significantly influence groundwater flow in fractured bedrock aquifers. Joints are common in Cotter-Jefferson City outcrops in the vicinity of New Haven. The joints are generally vertical and have an orthogonal (lying at right angles) pattern. The joints set strike southeast-northwest and southwest-northeast.

5.1.6 Groundwater Flow

Groundwater in the Ozark aquifer is unconfined throughout most of southern Missouri. In the New Haven area there are two general flow systems within the Ozark aquifer: (1) a deep "regional" flow system controlled by regional topography within southern Missouri, and (2) a "local" or shallow (less than 300 to 400 feet deep) flow system controlled by the topography within the New Haven area (Figure 5-2).

Regional groundwater movement generally is from upland areas between major rivers and streams toward valleys where it discharges as base flow into the streams. From New Haven, the regional flow system extends for tens of miles and generally is from upland

areas more than 90 miles south of New Haven northward toward the Missouri River. The Missouri River and associated alluvial aquifer are regional groundwater discharge areas for the Ozark aquifer. The regional flow system generally occurs in the deeper parts of the aquifer (Roubidoux Formation and deeper units) except near regional recharge or discharge areas where flow enters or leaves the aquifer.

Superimposed on the regional flow system is a shallower flow system controlled by the topography in the New Haven area. During the 2001 ESI/RI, direction of groundwater flow in the New Haven area was determined by mapping the shallow potentiometric surface within the upper Ozark aquifer using measured water levels in area domestic and public supply wells. The shallow flow system in New Haven exists primarily within the Cotter and Jefferson City Dolomites. In New Haven, a shallow groundwater divide is centered along State Highway 100 immediately south of the topographic divide and just south of OU4.

Shallow groundwater south of this divide flows south, opposite the regional flow and toward Boeuf Creek. Shallow groundwater north of the divide flows north, in the direction of regional flow toward the Missouri River. Along the shallow groundwater divide near State Highway 100, a downward gradient exists between the shallow and deeper flow systems. The measure of the downward gradient decreases with increasing distance (north or south) away from the shallow groundwater divide. Further to the north, the vertical gradient reverses and moves upward near the Missouri River where regional flow dominates. This is substantiated by upward flow under ambient conditions in public supply well W2 and upward gradients in bedrock well clusters BW-00 and BW-01 located in OU1. To the south, the direction of the gradient between the shallow and deep flow systems is unknown. At the Missouri River, flow paths from the regional flow system and the shallow flow system converge and move upward into the alluvial valley.

5.2 Nature and Extent of Contamination

The following sections focus on the nature and extent of PCE contamination and its degradation products—TCE, cis-DCE, and VC in vegetation, surface water and springs, groundwater, and soils at OU4. A summary describing the results of the reconnaissance sampling of the sanitary sewer system and indoor air sampling is also presented.

5.2.1 Occurrence of PCE in Tree Core Samples

Tree coring initially focused on the area east of Miller Street near the suspected dump Area A. Low levels (less than 1.5 micrograms per kilogram [μg/kg]) of PCE were detected in core samples from 8 of the 54 trees cored in this area. Except for a detection of 1.4 μg/kg of PCE in a tree located at the headwaters of the 216 tributary, all the PCE detections were less than 0.5 μg/kg in trees along the 210 tributary and within the suspected dump Area A. The PCE detections in these trees are probably caused by the uptake of PCE-contaminated water from the 210 tributary that originates at the groundwater seep at location 210-TB-C6 (Figure 2-3).

The general absence of PCE detections in trees not in proximity to the 210 tributary is consistent with the lack of disturbed areas on historical aerial photographs, negative response of a metal detector sweep of the area, and lack of debris noted during a visual inspection of the area. PCE was not detected in tree cores collected along fence lines behind several residences on the east side of Miller Street.

PCE was detected in 24 of 94 tree core samples collected from the Maiden Lane area of OU4 and vicinity. The highest concentrations detected (estimated at more than 50 μg/kg) were in core samples from trees JS-106, JS-107, JS-112, JS 324, and JS 340 (Figure 5-4). These trees were within 200 feet of each other and near an old garage or along the remnants of an old barbed wire fence running south from the old garage.

Lower PCE concentrations (less than 15 μg/kg) were detected in two trees growing along the eastern part of Maiden Lane. Trace concentrations (estimated at 0.2 to 3.9 μg/kg) also were detected in 4 of the 15 cores at the former Kellwood research facility and several trees south of Maiden Lane.

The assumption at the beginning of the Maiden Lane area tree coring effort was that PCE may have or was continuing to leak from the sanitary sewer system. The source of PCE was assumed to be OU2. The low concentrations of PCE detected in trees JS-100 and JS-114, along the eastern part of Maiden Lane, were consistent with this initial assumption since these trees are in proximity to where the force main from the southern part of the city discharges effluent into an old brick manhole and gravity tile line beneath the intersection of Maiden Lane and Miller Street. However, core samples from trees on the east side of this intersection did not contain PCE. Trace detections of PCE in trees JS-105, JS-111, JS-135, JS-138, and JS-338 that were along or near the force main and gravity lines may be attributable to and consistent with responses from interviews that PCE was sprinkled along sidewalks on the eastern part of Maiden Lane to control weeds. The high PCE levels detected in trees JS-106, JS-107, JS-112, JS-324, and JS-340 were consistent with the information compiled from interviews of former area residents and relatives that established waste PCE was dumped into a basement floor drain at 104 Maiden Lane. The floor drain was connected to a gray water line that discharged along the back of the property just east of the old garage. Using correlations between PCE concentrations in trees, soils, and shallow groundwater at OU1 and at other areas, the PCE levels in trees near the old garage suggest the presence of a relatively shallow source of PCE in the soils and groundwater in the tens of thousands μg/kg or more.

5.2.2 Distribution of PCE in Surface Water and Springs

PCE was detected in surface water and spring samples from two of the four tributaries draining OU4—the 210 tributary to the northeast and the 300 tributary to the north (Figure 2-2). The highest concentration of PCE (maximum 30.3 μg/L) was detected in the 210 tributary at the location of 210TB-C6. The upper reaches of the 210 tributary are dry, but a small (less than 0.2 L/min) flow begins in the upper sandstone bed crops out in the creek bed at an altitude of about 550 feet. Site 210TB-C6 is a small pool located at

the base of the sandstone exposure where the flow begins. PCE levels in 11 water samples from this Site, analyzed by the laboratory, ranged from 3.0 to 30.3 μg/L (average of 18.2 μg/L). TCE and cis-DCE were also detected in all 14 samples submitted to the laboratory with maximum concentrations of 1.6 μg/L and 1.4 μg/L, respectively.

PCE was also detected in the 300 tributary north of OU4. Similar to other streams, a low (less than 0.2 L/min) flow begins where the upper sandstone bed is exposed in the creek bed at an altitude of approximately 550 feet. The point where flow begins is about 1,000 feet downstream from the former Kellwood research facility and is referred to as "Bates Spring." Two water samples were collected from Bates Spring in November 2000 and April 2001. The November 2000 sample, analyzed with the portable GC, contained PCE at 5.4 μg/L. The April 2001 sample, analyzed by the portable GC and analytical laboratory, contained PCE at 3.82 μg/L and 3.8 μg/L, respectively. The PCE levels in the 300 tributary decreased quickly downstream and were estimated at 0.54 μg/L at sample location of 3000TB-00. TCE, cis-DCE, and VC were not detected in water samples from Bates Spring or from the 300 tributary. Water samples were also collected from nine sites along the 400 tributary system (400, 410, and 420 tributaries) and analyzed for VOCs using the portable GC. Four sites were sampled along the 410 tributary that directly receives runoff from the northwestern part of OU4 and the Maiden Lane area. Neither PCE nor other VOCs were detected in any samples collected from the 400, 410, and 420 tributaries.

5.2.3 Distribution of PCE in Groundwater at OU4

More than 200 groundwater samples have been collected from 23 monitoring wells completed in the bedrock aquifer that are associated with OU4. Water samples were also collected from two domestic/industrial wells located at the Orchard Street fabric plant (JS-30); a fertilizer plant (JS-34) in downtown New Haven; and also from city wells W2, W3, and W4.

Analyses of groundwater samples indicate that a plume of PCE contamination in the bedrock aquifer extends from just south of the Maiden Lane source area, near the old garage, northeast to the Missouri River. The plume is approximately 3,800 feet long and nearly 3,000 feet wide at the downgradient edge near the Missouri River (Figure 5-5). Within the plume, PCE concentrations range from less than 1 μg/L in well BW-08A to more than 9,000 μg/L in well BW-13 (Figure 5-5). The concentrations of PCE decrease from thousands μg/L in wells less than 700 feet downgradient from the old garage (BW-10 and BW-13) to several hundred μg/L about 2,100 feet downgradient at wells BW-02 and BW-05. PCE concentrations decrease further to less than 30 μg/L about 3,000 feet downgradient near the Missouri River in wells BW-01 and JS-34. Based on the PCE concentrations in bedrock monitoring well clusters and potentiometric surfaces generated from the water level measurements in the deeper monitoring wells at OU4, the PCE plume is migrating from the Maiden Lane source area northward.

The vertical distribution of PCE in the bedrock aquifer at OU4 was examined by portable GC analysis of drill cuttings at the time of drilling and from comparison of PCE

concentrations in samples from completed monitoring well clusters. Drill cutting analysis indicated that the PCE contamination originating from the Maiden Lane source area plunges deeper as groundwater flows generally northward toward the Missouri River (Figure 5-6).

The plunging contamination is driven by the steep downward vertical gradient and uncontaminated recharge infiltrating into the subsurface north of the source area. Rather than a homogenous plume, the vertical profile of PCE contamination in the bedrock more likely resembles "fingers" of contamination oriented laterally along zones of higher permeability such as bedding planes or within units like the upper sandstone and the Swan Creek member of the Cotter Dolomite. Near the source area, the contamination appears restricted to the Cotter Dolomite; but further downgradient, it migrates into the Jefferson City Dolomite and the Roubidoux Formation (Figure 5-7).

The maximum depth of contamination is probably limited by the extent of vertical migration of dense nonaqueous phase liquid (DNAPL) in the bedrock and the convergence of flow lines as groundwater deeper in the aquifer attempts to discharge into the Missouri River. At city well W2 borehole geophysical measurements made during the ESI/RI indicated upward flow in the borehole from units beneath the Roubidoux Formation, and that flow was exiting the borehole within the Roubidoux Formation.

The vertical distribution of PCE in bedrock monitoring well clusters closely resembles the distribution in the drill cutting samples. The highest PCE concentrations were detected in samples from the Maiden Lane area monitoring wells BW-13 (3,300 to 9,100 μg/L) and BW-10 (320 to 2,300 μg/L) that are 240 and 600 feet below ground surface (bgs), respectively, downgradient from the source area. Except for well cluster BW-11 adjacent to the source area, PCE concentrations in the Maiden Lane well clusters were substantially higher in the deeper wells (BW-10, BW-13, and BW-14) that are open to the upper sandstone unit compared to wells BW-10A, BW-13A, and BW-14A that monitor the shallow bedrock at these clusters.

PCE concentrations decreased with increasing depth in well cluster BW-11 probably due to the well cluster being immediately upgradient but downslope from the source area. Perched water containing PCE appears to be migrating down slope from the source area to this nearby well cluster along the overburden bedrock contact or within the upper part of the bedrock as evidenced by the higher PCE concentrations in well BW-11A-S and BW-11A-D that monitor these two zones. Outside the Maiden Lane area, the highest PCE concentrations were in wells BW-02 (148 to 350 μg/L) and BW-05 (65 to 200 μg/L). In general, in the downgradient area of OU4, PCE was either not detected or detected below the maximum contaminant level[3] (MCL) in the shallow wells and higher than the MCL in the deeper clustered wells. Overall, PCE was the most frequently detected VOC in groundwater samples and detected in the greatest concentrations. PCE

[3] The maximum contaminant level (MCL) is the maximum permissible level of contaminant in water which is delivered to the free-flowing outlet of the ultimate user of a public water system. MCLs are promulgated by EPA pursuant to the Safe Drinking Water Act, 42 U.S.C. §§ 300f-300j-26 and are codified at 40 CFR Part 141.

was detected in 76 percent (194 of 255) of the groundwater samples from the bedrock aquifer at OU4. The maximum PCE level of 9,100 µg/L was detected in the initial sample (09/29/2005) from the completed monitoring well BW-13. Drill cuttings from the BW-13 borehole, at 140 feet deep, contained more than 15,000 µg/L PCE. TCE was detected in 29 percent of the samples with most detections being in samples from the Maiden Lane area monitoring wells.

5.2.4 Distribution of PCE and Other VOCs in Soils

East Miller Street, Suspect Dump Area A, and Fence Lines

PCE was detected above the reporting limit (1 µg/kg) for the portable GC in only 1 of the 16 soil borings collected east of Miller Street (Figure 5-8). PCE was detected in both the 1.0-foot deep sample (estimated at 0.8 µg/kg) and the 3.0-foot deep sample (estimated at 2.2 µg/kg) from boring JSH-14. Boring JSH-14 was collected within a narrow strip (about 230 feet wide) of alluvial sediments between the old barn and the 210 tributary. The presence of low to trace PCE concentrations in soil samples from this boring could be attributed to PCE-contaminated water discharging from the seep at the location 210TB-C6, about 50 feet upstream from the boring. PCE was not detected in nearby boring JSH-15.

Former Kellwood Research Facility and Assumption Church Parking Area

No PCE was detected in any of the 21 soil borings collected at the former Kellwood research facility or church parking area (Figure 5-8). A total of 39 soil samples was analyzed by the portable GC from these sites—three of which had laboratory split samples analyzed. The absence of PCE in composite soil borings beneath the church parking lot dispels the rumor that waste oil containing PCE or waste PCE may have been sprayed on the gravel area before it was covered with asphalt. The absence of PCE in soil borings from the former Kellwood research facility is consistent with interviews with former facility employees that indicated that PCE was not among the chemicals used at the former facility.

Maiden Lane Sanitary Sewer Line

PCE was detected in samples from five soil borings (ML-04, ML-6A, ML-07, ML-08, and ML-09) located near the sanitary sewer line that runs along the south side of Maiden Lane (Figure 5-8). The concentrations detected were less than or equal to 214 µg/kg. The highest concentrations were detected at depths greater than 10 feet. All borings containing detectable PCE were in close proximity to the residence along Maiden Lane where a former employee brought waste PCE home to use as a drain cleaner and possibly a weed killer. The sanitary sewer that runs beneath the south part of Maiden Lane is less than 10 feet deep. The deepest boring in the area was ML-6A which was advanced to refusal at 23 feet beneath the driveway of the residence to the west, about 20 feet from boring ML-07. The highest PCE levels (39.3 and 70 µg/kg) in ML-6A were collected in samples from 21 and 23 feet deep.

The detection of low PCE levels in deeper soils along Maiden Lane is consistent with PCE detected in shallow (less than 40 feet deep) drill cuttings and drill water samples collected during installation of BW-13 located across the street from borehole ML-6A. The shallow PCE encountered during drilling of well BW-13 and the PCE in deeper samples from Maiden Lane soil borings probably have a common source. A possible source is PCE released from the service line from the residence as well as the gravity line beneath Maiden Lane receiving effluent from the residence.

In addition, the release of PCE from the force main that received PCE from the OU2 facility that discharges into nearby manhole MH-085 cannot be ruled out with the available data. This will be determined in the potentially responsible party-lead RI/FS currently being conducted at OU2 and OU6.

Maiden Lane Source Area (Old Garage)

Substantial PCE concentrations (greater than 1,000,000 µg/kg) were detected in soil borings in the vicinity of the old garage on the southern end of the property of 104 Maiden Lane (Figure 5-9). PCE was detected in 100 of the 125 soil samples collected from the soil borings in the vicinity of the old garage. Concentrations of PCE above the EPA Region 9 PRG of 438 µg/kg were detected in one or more soil samples from 14 of the 21 borings. PCE exceeded the PRG in nearly 50 percent of all soil samples from this area.

The maximum PCE concentrations detected were 8,000,000 µg/kg, estimated by the portable GC, in a sample collected from a depth of 16.0 feet from boring ML-406 and 6,100,000 µg/kg in a laboratory-analyzed sample collected from a depth between 17.2 and 18.6 feet in boring ML-408. Black stains of DNAPL PCE were identified in a soil core from boring ML-204 (thin seam of oily liquid at 10.7 feet), ML-406 (15 to 16 feet deep) and ML408 (17.2 to 18.6 feet deep). The entire soil core below 4.0 feet deep in boring ML-408 had a strong PCE odor and appeared dry.

Borings containing the highest PCE concentrations and visual DNAPL stains were located down slope of the gray water line outlet. PCE disposed of into the floor drain inside the residence probably exited the end of the gray water line and ran a short distance along the shallow drainage ditch before infiltrating into the soils. Because it was likely disposed of as a DNAPL, the dense PCE migrated downward through the entire soil profile. DNAPL spread laterally when it encountered more permeable zones such as the thin, sandy bed within the residuum at 10.7 feet deep in boring ML-204 or the top of the weathered bedrock. The detection of high PCE concentrations up slope of the gray water line outlet at boring ML-206, ML-402, and ML-405 indicates that PCE also probably leaked through joints in the clay-tile line.

Concentrations of PCE generally increased with increasing depth in soil borings near the old garage. In most cases, the highest PCE levels and visual detection of DNAPL were found within coarser-grain zones with sandy, cherty, clay residuum overlying the

weathered bedrock. It is probable that substantial PCE contamination and DNAPL have also migrated into and along bedding planes and fractures in the underlying bedrock as evidenced by the large PCE levels in monitoring wells BW-13, about 250 feet north of the old garage.

Results from laboratory and portable GC analyses of soils indicate that approximately 256 yd^3 of PCE-contaminated soils are present at the Maiden Lane source area near the old garage. These soils contain an estimated total of approximately 77 gallons of PCE. The total mass of PCE was calculated by multiplying the smaller of the average or the 75th percentile of PCE concentrations within each depth interval.

5.2.5 Distribution of PCE and Other VOCs in Sanitary Sewers and Adjacent Soils

PCE was detected in sanitary sewer samples at concentrations ranging from 0.1 μg/L to more than 20 μg/L. PCE was not detected in background samples from sewer lines upstream from OU2 (MH-409, MH-055E, and MH-055N) or lines draining other areas of the city. Trace (less than 1.0 μg/L) concentrations of PCE were detected in samples downgradient from the Maiden Lane source area (Figure 5-9). The sanitary sewer sampling occurred at various locations over a three-year period from 2001 through 2004. Overall, the highest concentrations of PCE were detected in areas within or downstream from OU2. Consistent with historical (pre-1980s) PCE use and disposal in the sanitary sewer at OU2, concentrations of PCE generally decreased with increasing distance downstream from OU2.

Although it is believed that several gallons of PCE were disposed of daily in the sanitary sewer during the 1970s and 1980s, the presence of PCE cannot be exclusively attributed to activities at OU2 as PCE is a common ingredient in a variety of consumer products, automotive parts degreasers, and brake cleaners.

The detection of trace concentrations of PCE in sample MH-113E (0.3 to 0.44 μg/L) by portable GC and laboratory analyses indicates that PCE had been or was being discharged into the gravity line that runs beneath Maiden Lane. Given the known use of waste PCE as a drain cleaner at the residence on 104 Maiden Lane, the detection of PCE in sample MH-113E suggests that PCE may also have been dumped in drains connected to the gravity sanitary sewer line beneath Maiden Lane resulting in the residual PCE observed MH-113E.

5.2.6 Distribution of PCE in Indoor Air Samples in the Maiden Lane Area

A total of 21 indoor air samples, 2 outside air samples, and 1 duplicate sample was collected from four residences and the New Haven Elementary School at OU4. Overall, concentrations of PCE and its degradation products in indoor air samples were low and generally within the expected range of "background noise" for indoor air. PCE was detected in all 21 samples at concentrations ranging from 0.08 to 6.2 micrograms per cubic meter ($\mu g/m^3$). The highest concentrations of PCE and its degradation products tended to be in samples from sites located near the PCE source area. Because of the

sensitivity of the analytical method and the widespread use of PCE and other VOCs in a variety of consumer products and industrial materials, the detection of low concentrations (less than 1.0 $\mu g/m^3$) of PCE was expected. The outdoor air samples from OU4 contained PCE at 0.13 and 0.47 $\mu g/m^3$.

For the Site, a screening level of 3.0 $\mu g/m^3$ was established as an indoor air level of concern. Only one sample contained PCE higher (6.2 $\mu g/m^3$) than the level of concern. The two remaining samples from location C (dining room) contained PCE at levels less than 1.0 $\mu g/m^3$.

6.0 Current and Potential Future Site and Resource Use

OU4 is located in New Haven, Franklin County, Missouri, approximately 20 miles east of Herman and 15 miles west of Washington. The city is similar in character to other small towns and cities along the Missouri River with historic late 1800-era homes along steep river valley slopes overlooking a downtown business district adjacent to the river.

Land use north of State Highway 100 including the downtown area is mostly residential. Land use south of State Highway 100 and outside of the city is mostly agricultural (pasture with row crops). Future land use within OU4 is anticipated to be similar to its current use.

The Maiden Lane area is a subpart of OU4. The Maiden Lane area encompasses about 20 acres centered along Maiden Lane between Maupin Avenue and Miller Street. Land use in the Maiden Lane area is single-family residential and includes the 3.8-acre Assumption Catholic Church at the northwest corner of the intersection of Maiden Lane and Miller Street.

7.0 Summary of Site Risks

This section summarizes the results of the risk assessment conducted for OU4. This report is based primarily on the available information collected as part of the RI conducted for OU4. Information concerning background data, site description, site history, previous investigations, and scope of the investigation is provided in detail in the RI.

The purpose of the Human Heath Risk Assessment (HHRA) is two-fold. First, the HHRA provides an evaluation of the potential threat to human health associated with the release or potential release of COCs from the identified OU4 area. The primary objective of this evaluation is to identify the final list of the contaminants of potential concern (COPC) and their exposure pathways, conduct a toxicity assessment for each COPC, conduct an exposure assessment, and assess current and future adverse effects on humans under the no action alternative.

The second purpose of the HHRA is to evaluate the need for remedial action. This evaluation focuses on a determination of whether or not the site presents risks greater than the acceptable range. This analysis will identify those COCs and the affected media that drive the need for remedial action.

7.1 Summary of Human Health Risk Assessment

This section summarizes the results of the baseline HHRA for OU4 including a summary of the COCs, the exposure assessment, the toxicity assessment, and the characterization of human health risks.

7.1.1 Identification of Contaminants of Concern

The results of the RI conducted at OU4 are presented in the RI Report. The degree and extent of the site-related chemical contamination has been characterized by multimedia sampling including vegetation, soil, surface water, sediment, groundwater, sanitary sewer water, and indoor air. The contaminants analyzed and detected in the various media are limited to VOCs. In the following sections, an assessment of the contaminants detected in the various media will be made, contaminants will be characterized for OU4, contaminants will be screened, and COPCs will be identified (Table 7-1). COPCs are those constituents that are most likely to present a risk to potential human health receptors at OU4.

7.1.2 Contamination Assessment

The complete discussion of sampling methods and analytical results are presented in the RI Report. In this section, sampling results are presented for each environmental matrix sampled at OU4. The constituents detected are summarized by frequency of detection (i.e., the number of samples in which the constituent was positively detected in relation to the number of samples analyzed for that constituent) and the minimum and maximum values of the constituents that were detected. Only those constituents positively detected in at least one sample were included in this summary.

The complete, raw analytical data are presented in Appendix A of the HHRA. Data were grouped according to the type of analysis conducted and the medium sampled. Data were also separated by the location sampled.

In the following sections, a summary of the nature of the constituents present in the various environmental media at OU4 is presented.

<u>Surface Water</u>

A total of 132 surface water samples was collected from the 210, 300, and portions of the 400 and the 760 tributaries at OU4. These include samples that were screened on-site with a field GC as well as those samples that were analyzed at an off-site laboratory. Only samples analyzed at the off-site laboratory were selected for this risk assessment. A

total of 15 surface water samples was collected from the 210 tributary. The collected samples were only analyzed for VOCs. COPCs detected in the selected surface water samples are presented in Table 7-2. All detected constituents include acetone; chloromethane; cis-1,2-dichloroethene; total 1,2-dichloroethene; methylene chloride; naphthalene; PCE, toluene; TCE; VC; and total xylenes and are presented in Appendix B, Tables 2-1 through 2-7 of the HHRA.

Surface Soil

Approximately 70 surface soil samples (0-2 feet bgs) were collected from 76 locations at OU4. This includes samples that were screened on-site with a field GC, as well as those samples that were analyzed at an off-site laboratory. Only samples analyzed at the off-site laboratory were selected for this risk assessment (a total of 11 surface soil samples). The collected samples were only analyzed for VOCs. COPCs detected in selected surface soils are presented in Table 7-3. All detected constituents include chloromethane; cis-1,2-dichloroethene; methylene chloride; PCE; TCE; and VC and are presented in Appendix B, Tables 2-1 through 2-7 of the HHRA.

Groundwater

More than 200 groundwater samples were collected from OU4 during the period from 1999 through 2007. The collected groundwater samples were analyzed only for VOCs. In accordance with risk assessment guidelines, because of the large number of historical sample results, only the most recent sample results (data from 2006 and 2007) were selected for the purposes of the risk assessment. During 2006 and 2007, a total of 81 samples was collected from the monitoring wells at OU4. COPCs detected in the groundwater samples are presented in Table 7-4.

Surface and Subsurface Soil (Combined)

Surface and subsurface soil samples (0-23 feet bgs) were collected from 76 locations at OU4. A total of 286 soil samples was collected from these locations (this includes samples that were screened on-site with a field GC as well as those samples that were analyzed at an off-site laboratory). Only samples analyzed by the off-site laboratory were selected for this risk assessment (a total of 11 surface soil samples). The samples collected were only analyzed for VOCs. COPCs detected in the samples are presented in Table-7-5. All detected constituents include acetone; carbon disulfide; chlorobenzene; chloromethane; cis-1,2-dichloroethene; trans-1,2-dichloroethene; total 1,2-dichloroethene; ethylbenzene; methyl ethyl ketone; methylene chloride; PCE; toluene; TCE; VC; and total xylenes and are presented in Appendix B, Tables 2-1 through 2-7 of the HHRA.

Sanitary Sewer Water

Samples from the sanitary sewer system were collected from the inflows into manholes. A total of 33 samples was collected within the OU4 area, and one additional sample was

collected just north of OU4 (this includes samples that were screened on-site with a field GC as well as those samples that were analyzed at an off-site laboratory). Only those samples analyzed at the off-site laboratory (a total of seven samples) were selected for this risk assessment. The samples collected from the sanitary sewer were analyzed only for VOCs. COPCs detected in the sewer water samples are presented in Table 7-6. All detected constituents include acetone, bromomethane, methylene chloride, PCE, and toluene and are presented in Appendix B, Tables 2-1 through 2-7 of the HHRA.

Indoor Air

A total of 21 samples of indoor air was collected from several residences in the OU4 area in 2002, 2003, and 2004. The samples were only analyzed for VOCs. COPCs detected in the indoor air samples are presented in Table 7-7. All detected constituents include PCE, TCE, and more than 25 other VOCs and are presented in Appendix B, Tables 2-1 through 2-7 of the HHRA.

7.1.3 Exposure Assessment

The exposure assessment uses the site description and constituent characterization to identify potentially exposed human receptor populations, identify potential exposure pathways, and calculate estimated daily intakes of COPCs. Behavioral and physiological factors influencing exposure frequency and levels are presented in a series of exposure scenarios as a basis for quantifying constituent intake levels by receptor populations for each identified pathway.

To predict the constituent levels to which receptors would be exposed, site-specific information such as climate, geology, soils, groundwater, surface water, population demographics, land use, water use, and agricultural practices are examined. Once these exposure levels are determined, they will be compared with the appropriate health effects criteria to characterize human health risks.

The approach taken in the actual calculation of the exposure is to provide a detailed discussion of each of the exposure routes (Figure 7-1) that has been determined to be potentially significant at OU4. The complete exposure assessment discussion can be found in Section 3.0 of the HHRA.

7.1.4 Exposure Point Concentrations

An exposure point concentration (EPC) is the concentration of a COPC in an environmental medium that may reach a potential receptor. The EPC is typically defined as the average concentration contacted by the receptor at the exposure point. Pursuant to EPA guidance, a conservative estimate of this average concentration is the 95th percent upper confidence limit (95 percent UCL) of the arithmetic mean. The 95 percent UCL

was used as Reasonable Maximum Exposure (RME) for OU4. In the event that the calculated 95 percent UCL concentration exceeded the maximum detected concentration at the exposure area, then the maximum detected concentration was used as the RME concentration

The central tendency exposure (CTE) concentration is the arithmetic mean exposure (the average estimate) or the medium exposure (the medium estimate). For purposes of the HHRA, the arithmetic mean concentration was selected as the CTE exposure point concentration. The 95 percent UCL and arithmetic mean concentrations for each COPC were derived for each exposure area using EPA's ProUCL Software Version 4.0.

Exposures at OU4 were evaluated for soil, groundwater, air, surface water, and sanitary sewer water. EPCs for soil, groundwater, indoor air, surface water, and sanitary sewer water were based on measured concentrations. EPCs for outdoor air were based on the results of predictive modeling. A summary of EPCs for each COPC in each exposure medium is provided in Tables 7-2 through 7-9.

7.1.5 Exposure Assessment Summary

The exposure assessment includes a characterization of the exposure setting and population demographics as well as an identification of exposure pathways and quantification of exposure intakes for each receptor group at OU4.

A fate and transport analysis of COPCs was conducted and in conjunction with the source area characteristics, potential constituent migration and exposure pathways at OU4 were identified. An exposure pathway analysis was then conducted to identify those pathways to be included in the detailed quantitative analysis. Through this exposure assessment process, the complete exposure pathways (i.e., those pathways in which COPCs are expected to reach receptors) at OU4 have been identified. The complete pathways quantitatively evaluated in the HHRA are:

- Current Ingestion of COPCs in Surface Soil by Residents
- Future Ingestion of COPCs in Combined Surface and Subsurface Soil by Residents
- Current/Future Ingestion of COPCs in Combined Surface and Subsurface Soil by Workers (Industrial and Construction)
- Current/Future Inhalation of COPCs in Indoor Air (vapor intrusion pathway) by Residents and Industrial Workers
- Current/Future Inhalation of COPCs in Outdoor Air (vapors) by Residents and Workers (Industrial and Construction)

- Current/Future Ingestion of COPCs in Surface Water by Residents and Workers (Industrial and Construction)

- Current/Future Dermal Absorption of COPCs in Surface Water by Residents and Workers (Industrial and Construction)

- Current/Future Ingestion of COPCs in Sewer Water by Construction Workers

- Current/Future Dermal Absorption of COPCs in Sewer Water by Construction Workers

- Future Ingestion of Groundwater by Residents

- Future Dermal Absorption of COPCs in Groundwater by Residents

- Future Inhalation of Indoor Vapors Associated with Groundwater Use by Residents

- Future Inhalation of Vapors from Sewer Water and/or Groundwater Associated with an Open Excavation by Construction Workers

7.1.6 Toxicity Assessment

The purpose of the toxicity assessment is to identify the types of adverse health effects that a COPC may potentially cause and to define the relationship between the dose of a compound and the likelihood and magnitude of an adverse effect (response). Adverse effects are characterized as carcinogenic or noncarcinogenic. Dose-response relationships are defined by EPA for oral and inhalation exposures. Oral dose-response values were used to derive appropriate dermal toxicity values.

The dose-response assessment evaluates the available toxicity information and quantitatively describes the relationship between the level of exposure (either from animal or human epidemiological studies) and the occurrence of an adverse health effect. This relationship is described by a cancer slope factor (CSF) or unit risk factor (URF) for carcinogens and a reference dose (RfD) or reference concentration (RfC) for systemic toxicants—collectively called toxicity values.

Toxicity values were obtained from the following hierarchy of sources in accordance with the EPA Office of Superfund Remediation and Technology Innovation:

- Tier 1 – Integrated Risk Information System

- Tier 2 – Provisional Peer-Reviewed Toxicity Values

- Tier 3 – Other (Peer-Reviewed) Values including: Agency for Toxic Substances and Disease Registry Minimal Risk Levels, California Environmental Protection Agency (CalEPA), and EPA Health Effects Assessment Summary Tables Values

7.1.7 Summary of Toxicity Data

The available EPA oral/dermal and inhalation health effects criteria for COPCs at OU4 are presented in Tables 7-1A and 7-1B, respectively. The chronic and subchronic oral RfDs, oral to dermal adjustment factors, adjusted dermal RfDs, primary target organ, combined uncertainty/modifying factors, and source of the information are shown in Table 7-1A. The chronic and subchronic inhalation RfCs and RfDs, primary target organ, combined uncertainty/modifying factors and source information are shown in Table 7-1B. The oral CSFs, oral to dermal adjustment factors, adjusted dermal CSFs, weight of evidence cancer classification, and source information are presented in Table 7-2A. The inhalation CSFs, unit risk, weight of evidence cancer classification, and source information are presented in Table 7-2B.

7.1.8 Risk Characterization

Risk characterization integrates the results of the exposure and toxicity assessments to derive quantitative and qualitative estimates of the potential cancer risk and noncancer hazards that may occur due to exposure to site-related contaminants. This section presents the methods and results of the risk characterization. The results of the risk characterization are presented in Tables 5-1 through 5-5 of the HHRA. The estimates of hazards and risks are expressed numerically in spreadsheets in Appendix H (RAGS D Tables 7.1 through 7.8 and 8.1 through 8.8) of the HHRA. The hazard and risk estimates are also summarized in Appendix I (RAGS D Tables 9.1 through 9.3 and 10.1 through 10.3).

<u>Method for Noncancer Hazard Estimation</u>

The potential for chronic noncarcinogenic health effects due to chemical exposure was evaluated by comparing intake (expressed as milligrams per kilogram per day [mg/kg/day]) with an RfD (expressed in mg/kg/day). This comparison or unitless ratio is called the Hazard Quotient (HQ) and is expressed by the following equation:

Noncancer HQ = CDI/RfD

Where: CDI = Chronic Daily Intake (mg/kg/day)/RfD = Reference Dose (mg/kg/day)

CDI and RfD are expressed in the same units and represent the same exposure period (i.e., chronic, subchronic, or short term). The CTE HQs were quantified using the average CTE exposure intake values. The RME HQs were quantified using the RME exposure intake values. HQs were summed for each chemical across multiple exposure pathways to produce a total Hazard Index (HI) for a receptor for a given chemical. HIs were summed across multiple chemicals and multiple pathways to provide a total HI of

noncancer risks under an assumption of additivity of toxic effects. The assumption of additivity is applicable to COPCs that induce the same type of effect. If the total HI was greater than one (1), COPCs were reevaluated by critical effect. Separate HIs were calculated by type of effect (target organ-specific HI) because health effects from exposure to different chemicals are only additive if they have the same toxic effect (effect the same target organ system).

Method for Cancer Risk Estimation

For chemicals that are potential carcinogens, risk was estimated as the incremental probability of a receptor developing cancer over a lifetime as a result of exposure via each identified exposure pathway. The slope factor converts estimated daily intakes to the incremental risk of a receptor developing cancer. The following equation (i.e., the linear low-dose cancer risk equation) was used to compute chemical-specific cancer risk:

Risk = CDI x SF

Where: Risk = Chronic Daily Intake (mg/kg/day) x Slope Factor ($mg/kg/day^{-1}$)

Above cancer risks of 1.0×10^{-2}, the model is no longer linear, and the following equation (i.e., the one-hit equation) must be used:

Risk = 1 -exp (-CDI or Dose x Slope Factor)

The one-hit equation was used to calculate the RME and cancer risks for the future adult and child resident associated with ingestion, dermal absorption, and inhalation of PCE and TCE in groundwater.

Total incremental lifetime cancer risks for residential exposure scenarios were calculated by combining the estimated cancer risk for the adult and child.

The CTE risk estimate was quantified using the average CTE exposure intake parameters. The RME was quantified using the RME exposure intake parameters. The total cancer risk for each exposure pathway was quantified by summing the chemical-specific cancer risks.

To provide a perspective on the potential risks associated with OU4, the magnitude of the potential risks associated with the known or suspected carcinogens detected were compared to the EPA acceptable cancer risk range of $1x10^{-4}$ to $1x10^{-6}$. A cancer risk of $1x10^{-4}$ is equivalent to one cancer case in 10,000 exposed people while a cancer risk of $1x10^{-6}$ is equivalent to one cancer case in one million exposed people. EPA considers acceptable exposure levels to be the residual concentration levels that represent an excess cancer risk to an individual of between $1x10^{-4}$ to $1x10^{-6}$ based on dose and response information for the particular chemical.

7.1.9 Site-Specific Hazard and Risk Estimates

Cancer risks and noncancer hazards were evaluated for human exposures to soil, vapors, groundwater, and surface water. Cancer risks and noncancer hazards for the construction worker were also evaluated for exposure to sanitary sewer water and vapors. For residential exposures, the cancer risk for the child was combined with the cancer risk for the adult to estimate lifetime cancer risk.

The following is a discussion of the calculated potential health risks associated with OU4.

Current Residential Exposures for Soil, Surface Water, and Indoor Air Exposures

Current residential exposures to COPCs at OU4 were evaluated for soil, indoor and outdoor air, and the surface water pathways. Exposures may occur through ingestion of soil, inhalation of indoor and outdoor vapors, and through incidental ingestion and dermal contact with surface water. Cancer risks associated with exposure to TCE were evaluated using oral and inhalation slope factors derived by both the National Center for Environmental Assessment (NCEA) and CalEPA. Since the inhalations of indoor and outdoor vapors were both estimated for continuous daily exposures (24 hours), the total cancer risk and noncancer hazards were calculated separately for exposures to indoor and outdoor vapors. This procedure avoided double accounting for the inhalation pathway. The summaries of estimated cancer risk and noncancer hazards associated with current residential exposures including outdoor vapors are presented in Table 7-3a (NCEA) and Table 7-3b (CalEPA).

The total adult and child residential HIs for all current exposure pathways combined (ingestion, dermal, and inhalation of indoor vapors) range from $2x10^{-2}$ (for CTE) to $5\ x10^{-2}$ (for RME) and from $4x10^{-2}$ (for CTE) to $1x10^{-1}$ (for RME), respectively. Since the HIs associated with these current exposure pathways are less than one, there is no concern for potential noncarcinogenic health effects. There are no noncancer COCs for these current residential exposures (including inhalation of indoor vapors).

The total current lifetime carcinogenic risk levels for residents (adult and child) for all exposure pathways combined (ingestion, dermal, and inhalation of indoor vapors) range from $2.1x10^{-5}$ (for CTE) to $9.1x10^{-5}$ (for RME) based on the NCEA slope factor for TCE. These cancer risk estimates are within the acceptable risk management range ($1x\ 10^{-4}$ to $1x10^{-6}$). There are no carcinogenic COCs for current residential exposures. The highest lifetime cancer risk estimate (adult and child combined) is associated with exposure to TCE through inhalation of indoor vapors ($6.9x10^{-5}$). The exposure to TCE through inhalation accounts for approximately 75 percent of the total lifetime cancer risk estimate for the current resident.

Current Residential Exposures for Soil, Surface Water, and Outdoor Air Exposures

The total adult and child residential HIs for all current exposure pathways combined (ingestion, dermal, and inhalation of outdoor air vapors) range from $2x10^{-1}$ (for CTE) to

one (for RME) and from $4x10^{-1}$ (for CTE) to three (for RME), respectively. Since the HIs associated with these current residential exposure pathways were found to exceed one, further evaluation of the potential for noncarcinogenic effects is required. In accordance with EPA guidance, the potential noncarcinogenic hazards for these current residents were evaluated separately for each target organ system. The results of this analysis indicate that the target organ HI for the kidney exceeds one. PCE is the COC for these current residential exposures (including inhalation of outdoor vapors).

The total current lifetime carcinogenic risk levels for residents (adult and child) for all exposure pathways combined (ingestion, dermal, and inhalation of outdoor vapors) range from $2.0x10^{-4}$ (for CTE) to $2.5x10^{-3}$ (for RME) based on the NCEA slope factor for TCE. These cancer risk estimates exceed the EPA acceptable risk management range ($1x10^{-4}$ to $1x10^{-6}$). The carcinogenic COCs for these current residential exposures include PCE and TCE in outdoor air. The highest lifetime cancer risk estimate (adult and child combined) is associated with exposure to PCE through inhalation of outdoor vapors ($2.4x10^{-3}$). The exposure to PCE through inhalation of outdoor air accounts for approximately 95 percent of the total lifetime cancer risk estimate for the current resident.

Using the CalEPA slope factor for TCE, the total current lifetime carcinogenic risk levels for residents (adult and child) for all exposure pathways combined (ingestion, dermal, and inhalation of outdoor vapors) range from $1.7x10^{-4}$ (for CTE) to $2.4x10^{-3}$ (for RME). These cancer risks exceed the EPA acceptable risk management range ($1x10^{-4}$ to $1x10^{-6}$). The carcinogenic COC for these current residential exposures is PCE in outdoor air. The highest lifetime cancer risk estimate (adult and child combined) is associated with exposure to PCE through inhalation of outdoor vapors.

Future Residential Exposures for Soil, Groundwater, Surface Water, and Indoor Air Exposures

Future residential exposures to COPCs at OU4 were evaluated for soil, groundwater, indoor and outdoor air, and the surface water pathways. Exposures may occur through ingestion and dermal absorption with soil and groundwater, inhalation of indoor and outdoor vapors, and through incidental ingestion and dermal contact with surface water.

Cancer risks associated with exposure to TCE were evaluated using the oral and inhalation slope factors derived from both NCEA and CalEPA. Since the inhalations of indoor and outdoor vapors were both estimated for continuous daily exposures (24 hours), the total cancer risk and noncancer hazards were calculated separately for exposure to indoor and outdoor vapors.

The total adult and child residential HIs for all future exposure pathways combined (ingestion, dermal, and indoor inhalation) range from $4x10^{1}$ (for CTE) to $4x10^{2}$ (for RME) and from $8x10^{1}$ (for CTE) to $9x10^{2}$, respectively. Since the HIs associated with these future residential exposure pathways were found to exceed one, a further evaluation of the potential for noncarcinogenic effects is required. In accordance with EPA guidance, the potential noncarcinogenic hazards for the future residents were evaluated

separately for each target organ system. The results of this analysis indicate that the target organ/critical effect HIs for the liver, kidney, body weight, central nervous system, endocrine system, blood, and developmental effects all exceed one. The noncancer COCs for future residential exposures (including inhalation of indoor vapors) include PCE in soil; cis-1,2-dichloroethene; and PCE and TCE in groundwater.

The total lifetime carcinogenic risk levels for residents (adult and child) for all future exposure pathways combined (ingestion, dermal, and inhalation of outdoor air) range from 2.2×10^{-2} (for CTE) to 5.4×10^{-1} (for RME) based on the NCEA slope factor for TCE. These cancer risk estimates exceed the EPA acceptable risk management range (1×10^{-4} to 1×10^{-6}). The carcinogenic COCs for the future resident include PCE in soil as well as PCE and TCE in groundwater. The highest lifetime cancer risk estimates (adult and child combined) are associated with exposure to PCE and TCE in groundwater. The exposure to PCE through ingestion, dermal contact, and inhalation of indoor vapors associated with groundwater use accounts for approximately 87 percent of the total lifetime cancer risk estimate for the future resident.

Using the CalEPA slope factor for TCE, the total future lifetime carcinogenic risk levels for residents (adult and child) for all exposure pathways combined (ingestion, dermal, and inhalation of indoor air) range from 1.7×10^{-2} (for CTE) to 4.8×10^{-1} (for RME). These cancer risk estimates exceed the EPA acceptable risk management range (1×10^{-4} to 1×10^{-6}). The carcinogenic COCs for the future resident include PCE in soil as well as PCE and TCE in groundwater. The highest lifetime cancer risk estimates (adult and child combined) are associated with PCE and TCE in groundwater. The exposure to PCE through ingestion, dermal contact, and inhalation of indoor vapors associated with groundwater use accounts for approximately 98 percent of the total lifetime cancer risk estimate for the future resident.

Future Residential Exposures for Soil, Groundwater, Surface Water, and Outdoor Air Exposures

The total adult and child residential HIs for all future exposure pathways combined (ingestion, dermal, and outdoor inhalation) range from 4×10^{1} (for CTE) to 4×10^{2} (for RME) and 8×10^{1} (for CTE) to 9×10^{2} (for RME), respectively. Since the HIs associated with these future residential exposure pathways were found to exceed one, a further evaluation of the potential noncarcinogenic effects is required. In accordance with EPA guidance, the potential noncarcinogenic hazards for the future residents were evaluated separately for each target organ system. The results of this analysis indicate that the target organ/critical effect HIs for the liver, kidney, body weight, central nervous system, endocrine system, blood, and developmental effects all exceed one. The COCs for future residential exposures (including inhalation of outdoor vapors) include PCE in soil; cis-1,2-dichloroethene; PCE and TCE in groundwater; and PCE in outdoor air.

The total lifetime carcinogenic risk levels for residents (adult and child) for all future exposure pathways combined (ingestion, dermal, and inhalation of outdoor air) range from 2.2×10^{-2} (for CTE) to 5.4×10^{-1} (for RME) based on the NCEA slope factor for TCE.

These cancer risk estimates exceed the EPA acceptable risk management range of $1x10^{-4}$ to $1x10^{-6}$. The carcinogenic COCs for the future resident include PCE in soil, PCE and TCE in groundwater, and PCE in outdoor air. The highest lifetime cancer risk estimates (adult and child combined) are associated with exposure to PCE and TCE in groundwater use accounts for approximately 87 percent of the total lifetime cancer risk estimate for the future resident.

Using the CalEPA slope factor for TCE, the total lifetime carcinogenic risk levels for residents (adult and child) for all future exposure pathways combined (ingestion, dermal, and inhalation of outdoor air) range from $1.7x10^{-2}$ (for CTE) to $4.8x10^{-1}$ (for RME). These cancer risk estimates exceed the EPA acceptable risk management range of $1x10^{-4}$ to $1x10^{-6}$. The carcinogenic COCs for the future resident include PCE in soil, PCE and TCE in groundwater, and PCE in outdoor air. The highest lifetime cancer risk estimates (adult and child combined) are associated with exposure to PCE and TCE in groundwater. The exposure to PCE through ingestion, dermal contact, and inhalation of outdoor vapors associated with groundwater use accounts for approximately 98 percent of the total lifetime cancer risk for the future resident.

Current/Future Residential Exposure Units

Current and future industrial worker exposures to COPCs at OU4 were evaluated for individual exposure units through indoor air vapor intrusion pathway (indoor air). Individual exposure units were defined based on indoor air sampling conducted to evaluate the vapor intrusion pathway at individual residential homes in the OU4 area. As defined, exposures may occur through inhalation of indoor vapors at Exposure Units A through F. Cancer risks associated with exposure to TCE were evaluated using the inhalation slope factors derived by both NCEA and CalEPA.

The total adult and child residential HIs for the inhalation of indoor vapors at all exposure units are below one. Since the HIs associated with these current/future exposure pathways are less than one, there is no concern for potential noncarcinogenic health effects. There are no noncancer COCs for current/future residential exposures (considering inhalation of indoor vapors) at these exposure units.

The total carcinogenic risk levels for residents (adult and child) for inhalation of indoor vapors at all exposure units range from a low of $8.1x10^{-6}$ (for CTE) at exposure units C up to $1.1x10^{-4}$ (for RME at exposure unit D) based on the NCEA slope factor for TCE. These cancer risk estimates are within the EPA acceptable risk management range ($1x10^{-4}$ to $1x10^{-6}$). There are no carcinogenic COCs for these current/future residential exposures.

Using the CalEPA slope factor for TCE, the total lifetime carcinogenic risk levels for residents (adult and child) for inhalation of indoor vapors at all exposure units range from a low of $3.6x10^{-7}$ (for CTE at exposure unit D) up to $3.5x10^{-5}$ (for RME at exposure unit

F). These cancer risk estimates are within the EPA acceptable risk management range ($1x10^{-4}$ to $1x10^{-6}$). There are no carcinogenic COCs for these current/future residential exposures.

Current/Future Industrial Worker Exposure

Current and future industrial worker exposures to COPCs at OU4 were evaluated for soil, indoor and outdoor air, and the surface water pathways. Exposures may occur through ingestion of soil, inhalation of indoor and outdoor vapors, and through incidental ingestion and dermal contact with surface water. Cancer risks associated with exposure to TCE were evaluated using the oral and inhalation slope factors derived by both NCEA and CalEPA. Since inhalation of indoor and outdoor vapors were both estimated for continuous daily exposures (24 hours), the total cancer risk and noncancer hazards were calculated separately for exposures to indoor and outdoor vapors. This procedure avoided double accounting for the inhalation pathway.

Current/Future Industrial Worker Exposures for Soil, Surface Water, and Indoor Air

The total industrial worker HIs for all current/future exposure pathways combined (ingestion, dermal, and inhalation of indoor vapors) range from $1x10^{-2}$ (for CTE) to $3x10^{-1}$ (for RME). Since the HIs associated with these current/future exposure pathways are less than one, there is no concern for potential noncarcinogenic health effects. There are no noncancer COCs for current/future industrial worker exposures (including inhalation of indoor vapors).

The total carcinogenic risk level for industrial workers for all current/future exposure pathways combined (ingestion, dermal, and inhalation of indoor vapors) range from $2.5x10^{-5}$ (for CTE) to $5.2x10^{-4}$ (for RME) based on the NCEA slope factor for TCE. These cancer risk estimates exceed the EPA acceptable risk management range ($1x10^{-4}$ to $1x10^{-6}$). The carcinogenic COC for the current/future industrial worker is PCE in soil. The highest cancer risk estimates for the industrial worker are associated with the exposure to PCE in soil. The exposure to PCE in soil accounts for approximately 98 percent of the total cancer risk estimate for the current/future industrial worker.

Using the CalEPA slope factor for TCE, the total carcinogenic risk levels for industrial workers for all current/future exposure pathways combined (ingestion, dermal, and inhalation of indoor vapors) range from $2.0x10^{-5}$ (for CTE) to $4.9x10^{-4}$ (for RME). These cancer risk estimates exceed the EPA acceptable risk management range ($1x10^{-4}$ to $1x10^{-6}$). The carcinogenic COC for the current/future industrial worker is PCE in soil. The highest cancer risk estimate for the industrial worker is associated with exposure to PCE in soil. The exposure to PCE in soil accounts for approximately 98 percent of the total cancer risk estimate for the current/future industrial worker.

Current/Future Industrial Worker Exposure for Soil, Surface Water, and Outdoor Air

The total industrial worker HIs for all current/future exposures pathways combined (ingestion, dermal, and inhalation of outdoor vapors) range from $2x10^{-1}$ (for CTE) to 1 (for RME). Since the HIs associated with these current/future exposure pathways are less than or equal to one, there is no concern for potential noncarcinogenic health effects. There are no noncancer COCs for current/future industrial worker exposures (including inhalation of outdoor vapors).

The total carcinogenic risk levels for industrial workers for all current/future exposure pathways combined (ingestion, dermal, and inhalation of outdoor vapors) range from $7.1x10^{-5}$ (for CTE) to $1.7x10^{-3}$ (for RME) based on the NCEA slope factor for TCE. These cancer risks exceed the EPA acceptable risk management range ($1x10^{-4}$ to $1x10^{-6}$). The carcinogenic COC for the current/future industrial worker is PCE in soil and outdoor air. The highest cancer risk estimate for the industrial worker is associated with exposure to PCE in outdoor air. The exposure to PCE in outdoor air accounts for approximately 69 percent of the total cancer risk estimate for the current/future industrial worker.

Using the CalEPA slope factor for TCE, the total carcinogenic risk levels for industrial workers for all current/future exposure pathways combined (ingestion, dermal, and inhalation of outdoor vapors) range from $6.4x10^{-5}$ (for CTE) to $1.6x10^{-3}$ (for RME). These cancer risks estimates exceed the EPA risk management range ($1x10^{-4}$ to $1x10^{-6}$). The carcinogenic COC for the current/future industrial worker is PCE in soil and outdoor air. The highest cancer risk estimate for the industrial worker is associated with exposure to PCE in outdoor air. The exposure to PCE in outdoor air accounts for approximately 69 percent of the total cancer risk estimate for the current/future industrial worker.

Current/Future Construction Worker Exposures for Soil and Sanitary Sewer System

Current/future construction worker exposures to COPCs at OU4 were evaluated for soil, outdoor air, surface water as well as sanitary sewer water, and vapor pathways. Exposures may occur through ingestion and dermal contact with soil, inhalation of vapors, incidental ingestion, and dermal contact with surface water and sanitary sewer water. Cancer risks associated with exposure to TCE were evaluated using the oral and inhalation slope factors derived by both NCEA and CalEPA. Since the inhalation of sewer water/excavation vapors and outdoor (ambient) vapors was estimated for continuous daily exposures, the total cancer risk and noncancer hazards were calculated separately for exposures associated with the sanitary sewer system and outdoor (ambient) vapors. This procedure avoided double accounting for the inhalation pathway.

The total construction worker HIs for all current/future exposure pathways combined (ingestion, dermal, and inhalation of sewer vapors) range from $2.9x10^{-6}$ (for CTE) to $5.1x10^{-5}$ (for RME). Since the HIs associated with the current/future exposure pathways are less than one, there is no concern for potential noncarcinogenic health effects. There are no noncancer COCs for current/future construction worker exposures (including inhalation of sewer vapors).

The total carcinogenic risk levels for construction workers for all current/future exposure pathways combined (ingestion, dermal, and inhalation of sewer vapors) range from $2.9x10^{-6}$ (for CTE) to $5.1x10^{-5}$ (for RME) based on the NCEA slope factor of TCE. These cancer risk estimates are within the EPA acceptable risk management range ($1x10^{-4}$ to $1x10^{-6}$). There are no carcinogenic COCs for current/future construction worker exposures (including inhalation of sewer vapors). The highest lifetime cancer risk estimate is associated with exposure to PCE through ingestion of soil ($2.3x10^{-5}$). The exposure of PCE through ingestion of soil accounts for approximately 45 percent of the total lifetime cancer risk estimate for the current/future construction worker.

Using the CalEPA slope factor for TCE, the total carcinogenic risk levels for construction workers for all current/future exposure pathways combined (ingestion, dermal, and inhalation of sewer vapors) range from $2.3x10^{-6}$ (for CTE) to $4.2x10^{-5}$ (for RME). These cancer risk estimates are within the EPA acceptable risk management range ($1x10^{-4}$ to $1x10^{-6}$). There are no carcinogenic COCs for current/future construction worker exposures (including inhalation of sewer vapors). The highest lifetime cancer risk estimate is associated with exposure to PCE through ingestion of soil ($2.3x10^{-5}$). The exposure to PCE through ingestion of soil accounts for approximately 55 percent of the total lifetime cancer risk estimate for the current/future construction worker.

Current/Future Construction Worker Exposures for Soil, Surface Water, and Outdoor Air

The total construction worker HIs for all current/future exposure pathways combined (ingestion, dermal, and inhalation of outdoor vapors) range from 2.0 (for CTE) to $1x10^{1}$ (for RME). Since the HIs associated with these current/future construction worker exposure pathways were found to exceed one, a further evaluation of the potential for noncarcinogenic effects is required. In accordance with EPA guidance, the potential noncarcinogenic hazards for the current/future construction workers were evaluated separately for each target organ system. The results of this analysis indicate that the target organ/critical effect HI for the kidney exceeds one. The noncancer COC for current/future construction worker exposures (including inhalation of outdoor vapors) is PCE in outdoor air.

The total carcinogenic risk levels for construction workers for all current/future exposure pathways combined (ingestion, dermal, and inhalation of outdoor vapors) range from $1.2x10^{-5}$ (for CTE) to $1.9x10^{-4}$ (for RME) based on the NCEA slope factor for TCE. These cancer risk estimates exceed the EPA acceptable risk management range ($1x10^{-4}$ to $1x10^{-6}$). The carcinogenic COC for the current/future construction worker is PCE in outdoor air. The highest cancer risk estimate is associated with exposure to PCE through inhalation of outdoor air ($1.6x10^{-4}$). The exposure to PCE through inhalation of outdoor air accounts for approximately 84 percent of the total lifetime cancer risk estimate for the current/future construction worker.

Using the CalEPA slope factor for TCE, the total carcinogenic risk level for construction workers for all current/future exposure pathways combined (ingestion, dermal, and

inhalation of outdoor vapors) range from 1.1×10^{-5} (for CTE) to 1.9×10^{-4} (for RME). These cancer risk estimates exceed the EPA acceptable risk management range (1×10^{-4} to 1×10^{-6}). The carcinogenic COC for the current/future construction worker is PCE in outdoor air. The highest lifetime cancer risk estimate is associated with exposure to PCE through inhalation of outdoor air (1.6×10^{-4}). The exposure to PCE through inhalation of outdoor air accounts for approximately 84 percent of the total lifetime cancer risk estimate for the current/future construction worker.

7.1.10 Summary of Risk Characterization

Risk characterization integrates the results of the exposure and toxicity assessment to derive quantitative and qualitative estimates of the potential cancer risk and noncancer hazards that may occur due to exposure to site-related contaminants. Cancer risks associated with exposure to TCE were evaluated using the oral and inhalation slope factors derived by NCEA and CalEPA. The results of the risk characterization and identified COCs are summarized in Tables 7-3a and 7-3b.

7.2 Summary of Ecological Risk Assessment

A screening level ecological risk assessment (ERA) was conducted to assess the potential for the existence of ecological receptors and pathways between those receptors and COPCs associated with the Site as a whole. There was not a separate ERA done for OU4 specifically. The ERA was conducted using the methodology described in the *Ecological Risk Assessment Guidance for Superfund: Process for Designing and Conducting Ecological Risk Assessments* (USEPA 1997). The screening level ERA was designed to assess the need for a follow-up baseline ERA. The results of the screening level ERA are discussed in detail in the Ecological Risk Assessment, Revision 0, prepared for EPA by Black & Veatch Special Projects Corp. The ERA concluded that OU4 poses minimal risk to ecological receptors. A May 2008 review of recent analytical results for surface water samples indicates that PCE concentrations in the OU4 tributaries did not exceed ecological screening values.

7.3 Risk Assessment Summary and Conclusion

This section summarizes the key information presented in the HHRA with specific attention focused on the COPCs selected, the approaches used for estimating exposure, the toxicological assumptions, and the total potential carcinogenic and noncarcinogenic risks to each receptor group at OU4.

7.3.1 Contaminants of Concern

Constituents at OU4 were identified from samples of soil, groundwater, surface water, sewer water, and indoor air. A screening of constituents was conducted during which constituents detected in blanks were eliminated, and maximum detected concentrations

were compared to risk-based screening levels. Through this process, a number of constituents were selected as COPCs for the Site. These COPCs are presented in Table 7-1 and are limited to VOCs.

Not every COPC was detected or selected in every environmental media sampled at OU4. Consequently, potential health risks and hazards are characterized based on the selected COPCs for each relevant medium.

7.3.2 Exposure Assessment

The exposure assessment in the HHRA included a characterization of the exposure setting and population demographics as well as an identification of exposure pathways and quantification of exposure intakes for each receptor group at OU4.

The characterization of the exposure setting included a description of the local climate, geology, soils, groundwater, and surface water conditions at OU4. Local population statistics and land/water uses were also presented.

A fate and transport analysis of the COPCs in conjunction with the source area characteristics identified the potential constituent migration and exposure pathways at OU4. The complete list of selected exposure pathways considered most applicable to OU4 can be found in Section 7.2 of the HHRA.

7.3.3 Toxicity Assessment

The toxicity assessment presents the available human health toxicological health effects criteria for each COPC and for each exposure route identified for OU4. For carcinogenic effects, the available oral and inhalation cancer slope factors and unit risk factors are identified and presented for each constituent classified as a carcinogen by EPA. In addition, dermal cancer slope factors are calculated by dividing the oral cancer slope factor by an oral-to-dermal adjustment factor. For chronic noncarcinogenic effects, the available oral and inhalation reference doses and reference concentrations are identified and presented for each constituent. In addition, dermal reference doses are calculated by multiplying the oral reference dose by an oral-to-dermal adjustment factor.

7.3.4 Risk Characterization

A summary of the final calculated cancer risks and HIs for each scenario is presented in Appendix H, Table 7-1 and Figures 7-1 and 7-2 in the HHRA, respectively.

However, the following provides a brief discussion of the potential for cancer risk and noncancer hazards associated with each affected media at OU4.

Soils

There are no chemicals present in the surface soils at OU4 that present an unacceptable cancer risk or noncancer hazard to human health. For total soil (surface and subsurface soil combined), PCE is at levels that present an unacceptable cancer risk and noncancer hazard to future residents at OU4. PCE is also at levels in OU4 soil that present a cancer risk to current/future industrial workers at OU4.

Surface Water

There are no chemicals present in the surface water that present an unacceptable cancer risk to human receptors. In addition, there are no chemicals present in the surface water that present a noncancer hazard to human receptors at OU4.

Sediment

There are no chemicals present in the sediments that present an unacceptable cancer risk to human receptors. In addition, there are no chemicals present in the sediments that present a noncancer hazard to human receptors at OU4.

Groundwater

In groundwater at OU4, PCE and TCE are at levels that present an unacceptable cancer risk to future residents. In addition, cis-1,2-dichloroethene; PCE; and TCE are at levels in groundwater that present a noncancer hazard to future residents.

Indoor Air

There are no chemicals present in the indoor air that present an unacceptable cancer risk to human receptors. In addition, there are no chemicals present in the indoor air that present a noncancer hazard to human receptors at OU4.

Outdoor Air

For outdoor air, PCE is predicted at levels that present an unacceptable cancer risk to current/future residents and current/future industrial workers at OU4. In addition, PCE is predicted at a level in outdoor air that presents an unacceptable cancer risk to current/future construction workers. PCE is also predicted at levels in OU4 outdoor air that present a noncancer hazard to future residents, current/future industrial workers, and current/future construction workers.

TCE was also predicted at levels in outdoor air that may present an unacceptable cancer risk to current/future residents at OU4 when evaluated using the NCEA slope factor for TCE. When using the CalEPA slope factor for TCE, the predicted levels of TCE in outdoor air are within the EPA acceptable risk range.

The predicted outdoor air concentrations associated with OU4 were based on measured soil and groundwater concentrations and conservative modeling. Generally, the models used are conservative and tend to predict higher concentrations than would likely occur over time. Consequently, modeled concentrations in outdoor air may have been overestimated. Uncertainty associated with the use of modeled data may be moderate to high. A complete discussion of uncertainty associated with data can be found in Section 6.0 of the HHRA.

Sewer Water

There are no chemicals present in the sewer water that present an unacceptable cancer risk to human receptors. In addition, there are no chemicals present in the sewer water that present a noncancer hazard to human receptors at OU4.

8.0 Remedial Action Objectives

Section 121(b) of CERCLA requires remedial actions that attain a degree of cleanup, that ensure protection of human health and the environment, are cost effective, and use permanent solutions and alternative treatment technologies or resource recovery technologies to the maximum extent practicable.

Remedial Action Objectives (RAOs) provide a general description of what the response action is expected to accomplish for OU4.

The RAOs developed for OU4 soils are:

- For protection of human health – prevent exposure to soils with contaminant concentrations which result in an excess cancer risk greater than $1x10^{-6}$ or an HQ greater than 1.0, whichever is less.

- For protection of the environment – reduce the soil contaminant levels and prevent/reduce migration of soil contaminants to the groundwater.

The RAOs developed for OU4 groundwater are:

- For protection of human health – prevent exposure to groundwater with contaminant levels greater than MCLs. For those contaminants without established MCLs, prevent exposure to groundwater with contaminant levels which result in an excess cancer risk greater than $1x10^{-6}$ or an HQ greater than 1.0, whichever is less.

- For protection of the environment – minimize further degradation of the local groundwater by the contaminants at OU4.

9.0 Description of Remedial Alternatives

The FS describes three alternatives developed to contain or remediate the contamination at OU4; these alternatives are presented below. The alternatives include a no action alternative which is required by the NCP as a baseline for alternative comparison purposes, plume containment, and active remediation. The groundwater portions of the remedial alternatives include the first two general types of response actions as to provide ranges in the time and costs required for practicable remediation activities. Alternatives are listed with the primary process option chosen for soil, followed by the process option chosen for groundwater. For cost-estimating purposes, each alternative was standardized to a 30-year time period unless indicated otherwise.

9.1 Alternative 1: No Action

Estimated Capital Cost:	$ 93,000
Present Worth O&M[4] Cost:	$ 28,100
Total Present Worth Cost:	$121,100
Estimated Time to Achieve RAOs:	Not Achievable

Alternative 1 would not involve any remedial actions other than closure of the existing monitoring wells. Under this alternative, OU4 would remain in its present condition. This alternative, required by the NCP, is a baseline alternative against which the effectiveness of the other alternatives can be compared. Under the no action alternative, OU4 would be left "as is" and no funds would be expended for monitoring, containment, or cleanup of the contaminated groundwater and soils. Five-year reviews of OU4 would be required under CERCLA so funds would have to be expended to conduct the OU4 portion of the five-year review.

9.2 Alternative 2: Capping, Sheet Piling, and Rock Grouting/Hydraulic Containment and Above-Ground Treatment

Estimated Capital Cost:	$ 825,000
Present Worth O&M Cost:	$1,738,000
Total Present Worth Cost:	$2,563,000
Estimated Time to Achieve RAOs:	Greater than 30 years

Alternative 2 would use hydraulic containment, above-ground groundwater treatment, monitored natural attenuation, and institutional controls (ICs) to address the potential health risks associated with contaminated groundwater. This alternative would minimize the migration of the heavily contaminated portions of the plume farther downgradient. The existing old garage would be removed and then sheet piling, rock grouting, and a cap would be used to create an enclosure around the contaminated soils to prevent groundwater flow from coming in contact with the contaminated soils. Water from within the enclosure would be pumped out creating an inward hydraulic gradient.

[4] Operation and maintenance.

Hydraulic containment wells would also be placed within the edge of the heavily contaminated portion of the plume to prevent further plume migration. Extracted groundwater would be treated with granulated activated carbon to remove VOCs. With the source area soils contained, natural attenuation processes should begin to reduce the contaminant levels in the plume. The contaminated groundwater would be monitored as described in Alternative 3. Monitoring the plume would allow EPA to track the migration of the plume.

ICs for soils would consist of proprietary controls in the form of environmental covenants on the properties where the containment structure was built. These controls would restrict activities that could damage the containment structure and would allow EPA, MDNR, and/or their contractors access. OU4 is within an area designated "Special Area 3" in MDNR, Division of Geology and Land Survey, Well Construction Code [10 C.S.R. 23-3.100(7)]. As a result of this designation, well drilling restrictions are in place that are designed to preclude the installation of any well within an area of groundwater contamination which may create an unacceptable exposure to humans. In addition to these restrictions, EPA intends to continue its efforts to inform and educate the owners of the properties where the groundwater contamination is located of the potential health hazards posed by the contaminants present at OU4 and the need to comply with the state well installation requirements.

9.3 Alternative 3: In Situ Chemical Oxidation/Groundwater Monitoring

Estimated Capital Cost:	$ 223,000
Present Worth O&M Cost:	$1,178,000
Total Present Worth Cost:	$1,401,000
Estimated Time to Achieve RAOs:	Less than 10 years for soils and greater than 30 years for groundwater

Alternative 3 would use in situ chemical oxidation to address the potential health risks associated with contaminated soil. An oxidizing chemical would be injected into the soil using direct push technology. As the chemical is released into the soil, it would mix with the contaminated soil and oxidize the contaminants. The injection of a chemical oxidant (permanganate) would create an in situ reactive zone where the residual PCE would be destroyed. An extensive soil sampling event will be conducted to pin point the residual "hot spots" remaining from the 2007 removal action. Depending on subsurface conditions and subsequent sampling results, multiple treatments may be needed.

Alternative 3 would include groundwater monitoring and the imposition of ICs at OU4 as described in Alternative 2 above. Alternative 3 would not actively restore the groundwater. The groundwater monitoring component will include the installation of four new monitoring wells. Two wells would be installed in or near the source area soils. One would be installed on the downgradient edge of the plume to determine the depth of the plume at that location. The final location and depths of the remaining wells will be

determined during the Remedial Design (RD) phase of the project. A total of 24 monitoring wells would sample the COC-impacted groundwater. The groundwater samples would be sampled for VOCs.

10.0 Comparative Analysis of Alternatives

NCP sets forth nine criteria that EPA must use in evaluating remedial alternatives individually and against each other in order to select a remedy. A summary comparative analysis of alternatives for OU4 is presented in Table 5-1 of the FS Report. The nine criteria are (1) overall protection of human health and the environment; (2) compliance with ARARs; (3) long-term effectiveness and permanence; (4) reduction of toxicity, mobility, or volume of contaminants through treatment; (5) short-term effectiveness; (6) implementability; (7) cost; (8) state acceptance; and (9) community acceptance. This section profiles the relative performance of each alternative against the nine criteria, noting how it compares to the other options under consideration. A detailed comparative analysis of these alternatives can be found in Section 5.0 of the Final FS Report.

10.1 Overall Protection of Human Health and the Environment

This criterion determines whether an alternative provides adequate protection of human health and the environment and describes how risks posed through each exposure pathway are eliminated, reduced, or controlled through engineering controls and/or ICs.

Alternative 1 would not provide additional protection from the contaminants in the groundwater. Currently, the state's "Special Area " designation and the fact that municipal water is readily available to all residences/businesses at OU4, help ensure that human health is protected from the contaminated groundwater at OU4. However, the potential for future ingestion or direct contact with contaminated groundwater would remain. Because no remedial actions would occur under Alternative 1, the groundwater contaminants would continue to migrate and increase the size of the plume and ultimately continue to discharge contaminants into the Missouri River. While the MCLs for the groundwater would not be met with either Alternatives 2 or 3, these alternatives would be adequately protective of human health and the environment.

10.2 Compliance with ARARs

This criterion evaluates whether the alternative meets applicable or relevant and appropriate federal and state environmental statutes, regulations, and other requirements that pertain to the Site. Section 121(d) of CERCLA and the NCP [40 CFR § 300.430(f)(1)(iii)(B)] require that remedial actions at CERCLA sites at least attain legally applicable or relevant and appropriate federal and state requirements, standards, criteria, and limitations (collectively referred to as ARARs) unless such ARARs are waived as provided for in section 121(d)(4) of CERCLA.

Applicable requirements are those cleanup standards, standards of control, and other substantive requirements, criteria, or limitations promulgated under federal

environmental or state environmental or facility siting laws that specifically address a hazardous substance, pollutant, contaminant, remedial action, location, or other circumstance found at a CERCLA site. Only those state standards that are identified by a state in a timely manner and that are more stringent than federal requirements may be applicable.

Relevant and appropriate requirements are those cleanup standards, standards of control, and other substantive requirements, criteria, or limitations promulgated under federal environmental or state environmental or facility siting laws that specifically address a hazardous substance, pollutant, contaminant, remedial action, location, or other circumstance found at a site, address problems or situations sufficiently similar to those encountered at the site that their use is well suited to the particular site. Only those state standards that are identified by a state in a timely manner and that are more stringent than federal requirements may be applicable.

Alternative 1 would not comply with the chemical-specific ARARs because groundwater with contaminant levels in excess of the MCLs would remain unremediated and unmonitored. Alternative 2 includes containment of the heavily contaminated head of the groundwater plume, treatment of extracted groundwater, and groundwater monitoring, while Alternative 3 would include groundwater monitoring to monitor the location and contaminant levels in the plume. However, both Alternatives 2 and 3 would still not comply with ARARs. A waiver for those specific ARARs would be required. Waivers and grounds for invoking them are set forth in section 121(d)(4) of CERCLA and in NCP [40 CFR § 300.430(f)(1)(ii)(C)]. As discussed above, due to the geology at OU4, EPA has determined that it is technically impracticable from an engineering perspective to achieve MCLs within the contaminated groundwater plume. Accordingly, all three alternatives would have to have this chemical-specific ARAR waived.

Alternatives 2 and 3 would comply with all federal and state location- and action-specific ARARs.

10.2.1 Identification of ARARs/Target Cleanup Levels

This section presents the ARARs for the COCs for which a Technical Impracticability (TI) waiver is sought. Chemical-specific ARARs were identified in the FS and included MCLs and nonzero maximum contaminant level goals (MCLGs).

MCLs are established drinking water standards for public drinking water supply systems. The federal MCLGs are nonenforceable health goals for public water systems. MCLGs are set at levels that should result in no known or anticipated adverse health effects and that provide an adequate margin of safety. MCLGs for substances considered to be probable human carcinogens are set at zero. MCLGs for other substances are based upon chronic toxicity and are often set at levels equivalent to MCLs.

Target Cleanup Levels (TCLs) for OU4, as developed in the FS Report, were chosen to be equivalent to MCLs (for COCs which have established MCLs) because they are legally enforceable standards for drinking water. For COCs for which no MCLs have been established, the nonzero MCLG was chosen.

The COC and the chemical-specific ARARs/TCLs for which a waiver is provided are all chemicals which were included as COPCs in the HHRA for OU4 and presented in Table 10-1.

10.3 Long-term Effectiveness and Permanence

Long-term effectiveness and permanence refer to expected residual risk and the ability of a remedy to maintain reliable protection of human health and the environment over time once cleanup levels have been met. This criterion includes the consideration of residual risk that will remain on-site following remediation and the adequacy and reliability of controls.

Because there is no remedial action component to Alternative 1, there would be a long-term risk associated with Alternative 1 as the cleanup goals are not met. Under Alternative 1, it is probable that the contaminant plume would continue to migrate downgradient, ultimately discharging into the Missouri River. Any untreated source area soils still above the soil cleanup goals could continue to release contaminants into the groundwater.

Alternative 2 would have the least long-term risk because it would contain the source area soils with capping, sheet piling, and rock grouting and the heavily contaminated portion of the plume would be hydraulically contained. This alternative would include monitoring to determine if groundwater contaminant concentrations are increasing or decreasing and if the plume was migrating toward new receptors. Alternative 2 would also provide additional long-term effectiveness through the well construction and certification requirements under the state's Special Area designation and through public education/information.

Alternative 3 would have less long-term risk than Alternative 1 because it would treat the source area soils with in situ chemical oxidation until the cleanup goals are achieved and the groundwater plume would be monitored. The monitoring provided in this alternative also would indicate whether groundwater contaminant concentrations are increasing or decreasing, if the plume was migrating toward new receptors, and the effect that the remediation of the contaminated soils has on the groundwater. Alternative 3 would also provide additional long-term effectiveness through the well construction requirements under the state's Special Area designation and through public education/information.

As required by CERCLA, five-year reviews would be required for all three alternatives. Alternatives 1, 2, and 3 would require at least six five-year reviews because each of these alternatives takes at least 30 years to reach the RAOs.

10.4 Reduction of Toxicity, Mobility, or Volume of Contaminants through Treatment

This criterion evaluates an alternative's use of treatment to reduce the harmful effects of principal contaminants, their ability to move in the environment, and the amount of contaminants present. Reduction of toxicity, mobility, or volume through treatment refers to the anticipated performance of the treatment technologies that may be included as part of a remedy.

Alternative 1 does not include any treatment or source removal so no decreases in the toxicity, mobility, or volume of the soil and groundwater contamination are anticipated. Also, Alternative 1 would not provide any mechanism (such as monitoring) to determine if any reductions are occurring due to natural attenuation processes, to ensure that the plume is not migrating toward sensitive receptors, or to confirm that the soils have been remediated.

Alternative 2 would significantly reduce the mobility of the contaminants in the soils and shallow bedrock by containing the contamination in the cap/sheet pile/rock grouting enclosure. Alternative 2 would provide reduction of the mobility and volume of some of the groundwater contaminants by extraction and treatment within the source area. Reductions in the volume of the downgradient groundwater contaminants should occur as natural attenuation processes begin to remove more contaminant mass from the downgradient portion of the plume than is added from the isolated source area soils or through desorption from the downgradient aquifer rock.

Alternative 3 would reduce the volume and toxicity of the soil contaminants by using in situ chemical oxidation to degrade the contaminants to their harmless constituents. Alternative 3 would include monitoring to determine if the plume is migrating toward sensitive receptors and soil sampling to confirm the remediation of the soils. Only Alternative 3 meets the statutory preference for treatment as a principal element although Alternative 2 does treat the groundwater that is extracted to contain the head of the plume.

10.5 Short-term Effectiveness

This criterion considers the length of time needed to implement an alternative. It also evaluates the risks the alternative poses to workers, residents, and the environment during implementation.

Alternative 1 would not pose an increased risk to the community or to workers. Minimal increased risk would occur with Alternative 3 from installation of additional monitoring wells and the soil monitoring and treatment. The risks from Alternative 2 would be moderately low, mainly due to the installation of the sheet piling around the source area soils and the demolition of the old garage.

Alternative 3 would treat in situ the remaining contaminated soils, which should remove the source of the groundwater contamination and allow groundwater cleanup levels to be reached through natural attenuation earlier than Alternative 1. Because Alternative 2 would contain the heavily contaminated groundwater at the head of the plume as well as the source area soils, it may reach the groundwater cleanup levels before Alternative 3. Based on the history of the plume, no estimate of the time to achieve the groundwater environmental protection RAO under Alternatives 1, 2, and 3 can be accurately projected.

10.6 Implementability

Implementability addresses the technical and administrative feasibility of a remedy from design through construction and operation. Factors such as availability of services and materials, administrative feasibility, and coordination with other governmental entities are also considered.

Implementation of Alternative 1 would be easy to complete. Closure of the existing monitoring wells and five-year reviews would be required; services, material, and personnel needed to close the wells and complete the reviews are readily available.

Alternative 2 would be the most difficult to implement because it would require the installation of extraction wells, soil enclosure elements (especially the sheet piling and cap), and the groundwater treatment system as well as a comparable number of monitoring wells as Alternative 3.

Implementation of Alternative 3 would be relatively easy to accomplish but slightly more difficult than Alternative 1. In situ chemical oxidation treatment of the contaminated soils has already been conducted twice so it is known that that component of the remedy can be readily implemented. The installation of monitoring wells is a common practice which has been done before at OU4, and technical assistance for health and safety concerns for both the soil treatment and well installation is readily available. The soil remediation technology—in situ chemical oxidation—is a proven and reliable method for remediation of the COCs found at OU4.

10.7 Cost

This criterion evaluates the estimated capital and operation and maintenance (O&M) costs as well as present worth costs. Present worth costs are the total cost of an alternative over time in terms of today's dollars (i.e., present worth costs corrected for expected inflation). The cost estimates are order-of-magnitude estimates which are expected to be accurate within a range of +50 to -30 percent.

The estimated present worth costs for the alternatives described in the FS are $121,000 (Alternative 1); $2,563,000 (Alternative 2); and $1,401,000 (Alternative 3). The cost of each alternative varies with the amount of treatment and the type of treatment technology. The cost comparisons for the alternatives include the detailed cost estimates for each

alternative and the sensitivity analysis which evaluates the impact of changes on the present worth of each alternative. For any remedial action alternative, the actual cost of the project would depend on the final scope of the remedial action to be determined in the RD and as the action is implemented over time. The final FS contains the breakdown of the costs for each alternative presented as well as the assumptions used to develop cost figures. Cost summaries are found in Tables 5-2 and 5-3 of the final FS.

10.8 State/Support Agency Acceptance

This criterion considers whether the state agrees with EPA's analyses and preferred alternative as contained in the RI/FS and the Proposed Plan.

As indicated by MDNR, the state of Missouri supports the preferred alternative—Alternative 3—selected by EPA.

10.9 Community Support

This criterion considers whether the state agrees with EPA's analyses and preferred alternative as contained in the RI/FS and the Proposed Plan. Comments received on the Proposed Plan are important indicators of community acceptance.

During the Proposed Plan public comment period (December 31, 2008, through January 29, 2009), no written comments were received that opposed EPA's choice of Alternative 3; in addition, no comments were received by EPA during a public meeting on the Proposed Plan that was held in New Haven on January 6, 2009.

11.0 Principal Threat Wastes

The NCP establishes an expectation that EPA will use treatment to address principal threats posed by a site whenever practicable [NCP § 300.430(a)(1)(iii)(A)]. The principal threat concept is applied to the characterization of source materials at a Superfund site. A source material is material that includes or contains hazardous substances, pollutants, or contaminants that acts as a reservoir for migration of contamination to groundwater, surface water, air, or acts as a source for direct exposure. Contaminated groundwater generally is not considered to be a source material; however, nonaqueous phase liquids (NAPLs) in groundwater may be viewed as source materials. Identifying principal threat wastes combines concepts of both hazard and risk. In general, principal threat wastes are those source materials considered to be highly toxic or highly mobile which generally cannot be contained in a reliable manner or would present a significant risk to human health or the environment should exposure occur. Conversely, nonprincipal threat wastes are those source materials that generally can be reliably contained and would present only a low risk in the event of exposure. The manner in which principal threats are addressed generally will determine whether the statutory preference for treatment as a principal element is satisfied.

Wastes that generally will be considered to constitute principal threats include but are not limited to the following:

- Liquid source material – waste contained in drums, lagoons, or tanks, free product in the subsurface (i.e., NAPLs) groundwater containing COCs.
- Mobile source material – surface soil or subsurface soil containing high concentrations of COCs that are (or potentially are) mobile due to wind entrainment, volatilization (e.g., VOCs), surface runoff, or subsurface transport.
- Highly toxic source material – buried drummed nonliquid wastes, buried tanks containing nonliquid wastes, or soils containing significant concentrations of highly toxic materials.

Wastes that generally will not constitute principal threats include but are not limited to the following:

- Nonmobile contaminated source material of low to moderate toxicity – surface soil containing COCs that generally are relatively immobile in or near groundwater (i.e., nonliquid, low volatility, low-leachability contaminants such as high molecular weight compounds) in the specific environmental setting.
- Low-toxicity source material – soil and subsurface soil concentrations not greatly above reference dose levels or that present an excess cancer risk near the acceptable range were exposure to occur.

The contaminated soils in the OU4 source area are considered to be a principal threat waste because the COCs are considered to be mobile source materials. Although contaminated groundwater also poses a risk, it is not considered a principal threat as defined by EPA guidance. A removal action consisting of the injection of a chemical oxidant has been conducted by EPA in two phases. These treatments partially addressed the high levels of COCs in the soil. Alternative 3 will address any remaining residual source materials located at OU4.

12.0 Selected Remedy

The preferred remedy for addressing OU4 is Alternative 3 which includes the injection of a chemical oxidant to address soil contamination and ICs. Because this alternative would not actively restore the groundwater, it does not comply with chemical-specific ARARs (Section 10.2.1). Therefore, a TI Evaluation Report (TI Report) was developed to analyze and support the issuance of a TI waiver.

12.1 Fractured Bedrock Technical Impracticability Evaluation Report

This TI Report was prepared using information obtained from key Site documents including but not limited to the following:

- Final Feasibility Study, Operable Unit, The Orchard Street/Maiden Lane Site, Riverfront Superfund Site, New Haven, Missouri, 2008
- Final Focused Remedial Investigation of Operable Unit 4, Riverfront Superfund Site; Franklin County, Missouri, 2008

The TI Report forms the part of the phased Site environmental investigation which includes the preparation of the FS Report and assists in rendering a decision on the practicabilty of achieving certain identified ARARs within a reasonable time frame for groundwater in bedrock impacted from sources at OU4.

Under CERCLA, an alternative selected to address contamination at a site must achieve the ARARs identified for the action or provide the basis for an ARAR waiver. ARARs may be waived for any of six reasons set forth in section 121(d)(4) of CERCLA including where compliance with the requirement is technically impracticable from an engineering perspective. The term "engineering perspective" refers to factors such as feasibility, reliability, scale or magnitude of a project, and safety.

EPA's *Guidance for Evaluating the Technical Impracticability of Ground-Water Restoration* (OSWER 9234.2-25, September 1993) specifies the following components as necessary for a TI evaluation:

1. Specific ARARs or media cleanup standards for which TI determinations are sought
2. Spatial area over which the TI decision will apply
3. Conceptual model that describes site geology, hydrology, groundwater contamination sources, transport, and fate
4. An evaluation of the restoration potential of the site
5. Proposed remedy option cost estimates
6. Any additional information or analyses EPA deems necessary for the TI evaluation

In developing the TI Report, the range of remedial alternatives for the groundwater evaluated in the FS was considered. The FS evaluated feasible bedrock groundwater remedial alternatives against the set of nine criteria as prescribed in the NCP in Section 300.430(e)(9)(iii). This evaluation demonstrated that of the groundwater remedial alternatives developed and retained for detailed evaluation, none fully satisfied the NCP criteria, "Compliance with ARARs." The FS determined that the evaluated remedial alternatives for bedrock groundwater would not be able to reduce COC concentrations below chemical-specific ARARs/TCLs within a reasonable time frame.

12.1.1 Technically Impracticable Zone

This section describes the vertical and horizontal extent of the TI zone. The TI zone includes contaminated groundwater in the fractured bedrock that will require excessive time, effort, and cost to remediate to federal and state cleanup standards.

Key factors in setting the TI zone are the unpredictability of the movement of the COCs through fractures in the bedrock (Section 5.1.4) and the distribution of the fractures in the bedrock. The selection of the TI zone was based on the available contaminant and geologic data in the RI Report. The suggested TI zone is comprised of a block of fractured bedrock that is approximately 5,000 feet in length; 2,000 feet wide at the upgradient edge; 4,500 feet wide at the downgradient edge; and between 20 and 450 feet deep (Figures 5-2 and 12-1). The ground surface over this block is a heavily developed residential area with steep topography.

The top of the bedrock and depth of the plume at the upgradient edge is approximately 20 feet bgs at BM-11; the downgradient plume depth is approximately 500 feet bgs at BW-02 and 400 feet bgs at BW-01 (Figure 5.2).

Bedrock units in the region have a regional dip to the northeast which is consistent with the flow direction of the plume. Potentiometric maps also support the northeasterly groundwater flow (Figure 5-5). A structural contour map (Figure 5-3) on top of the upper sandstone unit in the Cotter Dolomite indicates a dip of about 60 feet to the northeast over about 2.5 miles (0.5 percent) in the New Haven area. Fractures or joints in the bedrock are common and typically trend southeast-northwest and southwest-northeast.

The lateral and vertical extent of the TI zone is also based on groundwater PCE sampling results above PCE's MCL of 5 μg/L. The areas contaminated above the MCLs for the other three COCs are located within the PCE zone so no additional extension of the TI zone is necessary.

12.2 Summary of the Rationale for the Selected Remedy

The selected remedy is Alternative 3: In Situ Chemical Oxidation (Sodium Permanganate/Groundwater Monitoring). The goal of the selected remedy is to reduce contamination in the soils to levels that will prevent continued migration of COCs to groundwater. This alternative uses ICs to safeguard against exposures to the contaminated groundwater. It also uses monitoring to evaluate any fluctuations in contaminant levels.

This remedial action provides for the overall protection of human health and the environment, a "threshold" criterion for remedy selection as set forth in Section 300.430(f) of the NCP; however, it does not meet the second NCP threshold criterion of compliance with ARARs. Due to the highly complex and variable bedrock conditions found at the Site, compliance with all ARARs through containment, collection, treatment, or other technologies will be extremely uncertain and costly. As a result, a waiver for certain chemical-specific ARARs (Section 10.2.1) is hereby provided as compliance with such requirements is technically impracticable from an engineering perspective.

The selected remedy reduces toxicity, mobility, and volume through treatment in the source area soils using in situ chemical oxidation—an innovative but proven technology. Short-term risk will be reduced given that oxidant injection activities are generally short-

duration events (3 to 5 days per event). Workers and residents will be protected as the workers will follow appropriate health and safety protocol. No air emissions or treatment system discharges are anticipated to be generated as a result of the operation of this remedy. Noise levels and any emissions from well/injection point installation can be mitigated through appropriate health and safety measures. The implementability of the remedy for source area soils is technically and administratively feasible from design through construction and operation. The required material and supplies are readily available.

EPA expects the selected remedy to satisfy the following statutory requirements of CERCLA section 121(b): (1) that it is protective of human health and the environment, (2) that it is cost effective, and (3) that it utilize permanent solutions and alternative treatment technologies or resource recovery technologies to the maximum extent practicable. Unacceptable short-term or cross-media impacts are not expected to occur.

The preferred alternative presented in EPA's Proposed Plan is the selected remedy and did not change in response to public comment or new information.

12.3 Description of the Selected Remedy

This response action includes addressing PCE-contaminated source area soils to prevent continued contaminant migration to groundwater. For cost estimating purposes, the selected remedy involves the use of in situ chemical oxidation by injection of sodium permanganate into remaining hotspot areas identified by discrete interval soil sampling. It is expected that multiple injections will be need to address the residual contamination. The RD will include additional site characterization and field tests to determine the best locations for the in situ injections. Soil and groundwater monitoring will be conducted to evaluate the remediation progress.

The selected remedy also utilizes ICs. OU4 is within an area designated as Special Area 3 in the MDNR, Division of Geology and Land Survey, Well Construction Code [10 C.S.R. 23-3.100(7)]. As a result of this designation, well drilling restrictions are in place that are designed to preclude the installation of any well within an area of groundwater contamination which may create an unacceptable exposure to humans to such contamination. In addition to this restriction, EPA intends to continue its efforts to inform and educate the owners of the properties where the groundwater contamination is located of the potential health hazards posed by the contaminants present at OU4 and the need to comply with state well installation requirements.

It is unlikely that new wells would be installed in the vicinity of OU4 since municipal water is readily available in that area. The state regulations will ensure that if any new well construction or well deepening is planned, state officials will be informed and can prescribe methods for ensuring that no exposures to hazardous substances occur. These regulations should also be effective in preventing the construction of substandard wells

which could spread contamination at or near OU4. The regulations are considered to be durable as revocation would require the affirmative action of the state with notification to interested parties.

It is expected that EPA will also provide public education through the preparation and distribution of fact sheets and/or a newsletter on the Site and by providing informational meetings which may be held every five years. The public education campaign would be intended to inform citizens of the potential health hazards associated with exposure to contaminated groundwater and would remind the city officials and residents of the restrictions on OU4.

12.4 Summary of the Estimated Costs

Estimated Total Capital Costs:	$ 223,000
Estimated Present Worth O&M Costs:	$1,178,000
Estimated Present Worth Cost:	$1,401,000

A complete description of costs related to Alternative 3 can be found in Appendix A, Table A-3 of the Final FS Report.

The values in this cost estimate are based on the best available information regarding the expected scope of the remedy. Changes in the cost elements are likely to occur as a result of new information and data collected during the engineering design of the selected remedy. Any major changes will be in the form of a memorandum in the Administrative Record file, an Explanation of Significant Differences, or an amendment to this ROD. This estimate is an order-of-magnitude engineering cost estimate. It is expected to be within +50 to -30 percent of the actual costs of the remedy.

12.5 Expected Outcomes of the Selected Remedy

The selected remedy was chosen over the other alternatives because it will be protective of human health and the environment by actively remediating the residual source area soils to levels that will prevent continued migration of PCE from soils to groundwater. It is anticipated that as the source area soils are remediated, hydrodynamic dispersion will reduce PCE concentrations in groundwater through mechanical dispersion and chemical diffusion processes. These hydrodynamic dispersion processes will be the primary natural attenuation processes affecting the reduction of PCE concentrations in the plume over time.

The selected remedy is expected to achieve cleanup levels for the source area soils within approximately 10 years. Because of the technical impracticability from the engineering perspective of achieving the chemical-specific groundwater ARAR (MCLs), it is estimated that the time required to achieve groundwater cleanup levels would be approximately 100 years.

13.0 Statutory Determinations

Pursuant to section 121 of CERCLA and the NCP, the lead agency must select remedies that are protective of human health and the environment, comply with ARARs (unless a statutory waiver is justified), are cost effective, and utilize permanent solutions and alternative treatment technologies or resource recovery technologies to the maximum extent practicable. The selected remedy is designed and expected to be a final cleanup action at OU4 and represents the balance of trade-offs among alternatives with respect to pertinent criteria given the scope of the action. In addition, CERCLA includes a preference for remedies that employ treatment that permanently and significantly reduces the volume, toxicity, or mobility of hazardous wastes as a principal element and a bias against off-site disposal of untreated wastes. This preference is addressed in the selected remedy. The following sections discuss how the selected remedy meets these statutory requirements.

13.1 Protection of Human Health and the Environment

The selected remedy is protective by actively remediating the source area soils. Human health RAOs are currently met as the state's Special Area designation and the fact that municipal water is readily available to all residences/businesses at OU4 helps ensure that human health is protected from the contaminated groundwater at OU4. Monitoring would allow determination of whether soil environmental protection RAOs had been met and if the groundwater plume was threatening new receptors.

13.2 Compliance with Applicable or Relevant and Appropriate Requirements

Section 121(d)(2) of CERCLA, the NCP, and EPA guidance and policy require that:

> remedial actions conducted under CERCLA achieve a degree or level of cleanup which at a minimum attains any standard, requirement, criteria, or limitation under federal environmental law...or any promulgated standard, requirement, criteria, or limitation under a state environmental or facility siting law, that is more stringent than any federal standard . . .[which] is legally applicable to the hazardous substance or pollutant, or contaminant concerned or is relevant and appropriate under the circumstances of the release or threatened release of such hazardous substance or pollutant or contaminant. . . The identified standards, requirements, criteria, or limitations thus adopted from other environmental laws, which govern on-site cleanup activities at this site, are referred to as applicable or relevant and appropriate requirements or ARARs.

As discussed above, the selected remedy would not meet chemical-specific ARARs (Section 10.2.1). Accordingly, as set forth herein, a TI waiver is invoked. The selected remedy would otherwise comply with all federal and state location-specific and action-specific ARARs.

13.3 Cost Effectiveness

The selected remedy, Alternative 3, is cost effective and represents a reasonable value for the money. In making this determination, EPA refers to the following definition of cost effectiveness contained in the NCP: "[a] remedy shall be cost-effective if its costs are proportional to its overall effectiveness." 40 CFR § 300.430(f)(1)(ii)(D). This determination was accomplished by evaluating the "overall effectiveness" of those alternatives that satisfied the threshold criteria (i.e., were both protective of human health and the environment and ARAR compliant). Overall effectiveness was evaluated by assessing three of the five balancing criteria in combination (long-term effectiveness and permanence; reduction in toxicity, mobility, and volume through treatment; and short-term effectiveness). Overall effectiveness was then compared to costs to determine cost effectiveness. The relationship of the overall effectiveness of this remedial alternative was determined to be proportional to its costs; hence, this alternative represents a reasonable value for the money to be spent. The estimated present worth cost of the selected remedy is $1,401,000. This section provides a summary of how cost effectiveness is defined and provides an analysis of the selected remedy and the other two remedial alternatives.

The information in this cost estimate is based on the best available information regarding the anticipated remedial alternative. Changes in the cost elements are likely to occur as a result of new information and data collected during the implementation of the remedial alternative. Major changes may be documented in the form of a memorandum in the Administrative Record file, an Explanation of Significant Differences, or a ROD amendment. This is and order-of-magnitude engineering cost estimate that is expected to be within +50 to -30 percent of the actual project costs.

13.4 Utilization of Permanent Solutions and Alternative Treatment Technologies to the Maximum Extent Practicable

EPA has determined that the selected remedy represents the maximum extent to which permanent solutions and treatment technologies can be utilized in a practicable manner at OU4. The selected remedy is the final remedy decision currently planned at OU4. EPA has determined that the selected remedy is the best balance of trade-offs in terms of the balancing criteria given the scope of this action while also considering the statutory preference for treatment as a principal element, preference against off-site treatment and disposal, and considering state and community acceptance. The in situ chemical oxidation remedy treatment provides for the destruction of COCs to prevent continued migration to groundwater. Once the source area soils are remediated, it is estimated that

it would take approximately 20 to 80 years for groundwater to migrate from the Maiden Lane source area to the Missouri River. During this time frame, hydrodynamic dispersion will reduce PCE concentrations through mechanical dispersion and chemical diffusion processes. These processes will be the primary natural attenuation processes affecting the reduction of PCE concentrations in the plume.

13.5 Preference for Treatment Which Reduces Toxicity, Mobility, or Volume

The preference for treatment is addressed in this ROD. The treatment components that support the OU4 final remedy include in situ chemical oxidation of residual contamination in the source area soils. Treatment is the principal element for the OU4 final remedy as the COCs will be removed from the source area soils when oxidized and destroyed by in situ chemical oxidants.

13.6 Five-Year Review Requirements

Because this remedy will result in hazardous substances, pollutants, or contaminants remaining on-site above health-based levels, a statutory review will be conducted to ensure that the remedy continues to provide adequate protection of human health and the environment within five years after the initiation of the remedial actions. The schedule of the five-year reviews will be triggered by the remedial action implemented at OU1 and will include all OUs at the Site. The five-year reviews will continue until it has been determined that no hazardous substances, pollutants, or contaminants remain on-site above levels that allow for unlimited use and unrestricted exposure. The basis for this finding will be documented in the final Five-Year Review Report.

14.0 Documentation of Significant Changes from Preferred Alternative of Proposed Plan

The Proposed Plan was released for public comment on December 31, 2008. The Proposed Plan identified Alternative 3: In Situ Chemical Oxidation/Groundwater Monitoring as the preferred alternative. EPA has determined that no significant changes to the remedy, as originally identified in the Proposed Plan, were necessary or appropriate.

PART III RESPONSIVENESS SUMMARY

1.0 Stakeholder Issues and EPA Responses

On December 31, 2008, EPA released the Proposed Plan with regards to response actions at the Site, OU4. The Proposed Plan discussed EPA's proposed actions to address contaminated residual source area materials and groundwater contamination at OU4. The public comment period on the Proposed Plan for OU4 was held from December 31, 2008, through January 29, 2009. EPA held a public meeting in New Haven on January 6, 2009; presented the Proposed Plan to the public; apprised the public of the comment period; and recorded the concerns of the community expressed during the meeting. A copy of the transcript from the public meeting is included in the Administrative Record file. No oral or written comments were received during the public comment period.

2.0 Technical and Legal Issues

2.1 Technical Issues

None.

2.2 Legal Issues

None.

Figures

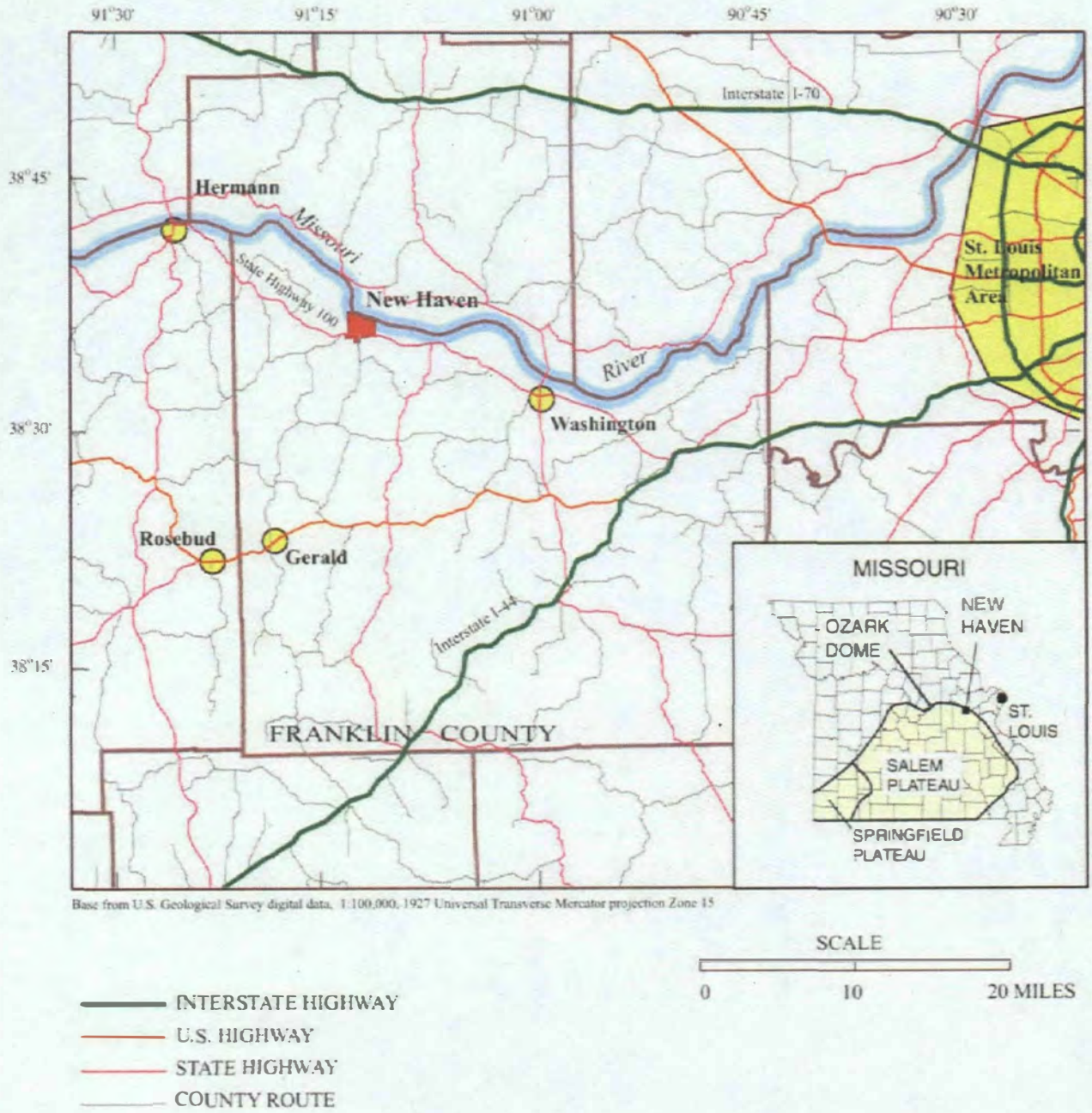


Figure 1-1. The location of the City of New Haven, Missouri.

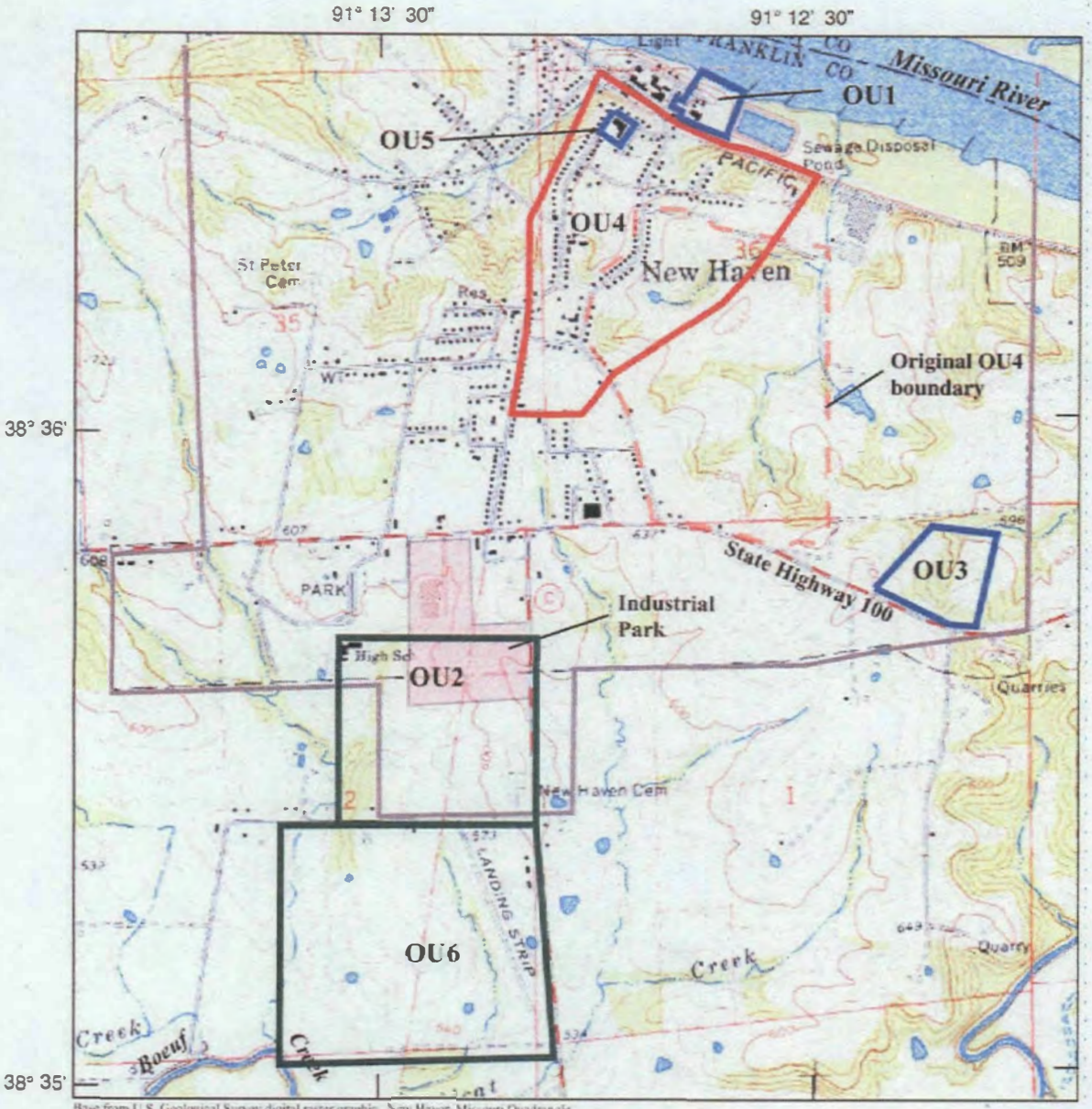


Figure 1-2 Topography in the New Haven Remedial Investigation (RI) study area and location of RI Operable Units (●Us).

Base from U.S. Geological Survey digital orthophoto, 1:24,000, 1927 Universal Transverse Mercator projection Zone 15

SCALE

0 250 500 1,000 Feet

EXPLANATION

STREAM

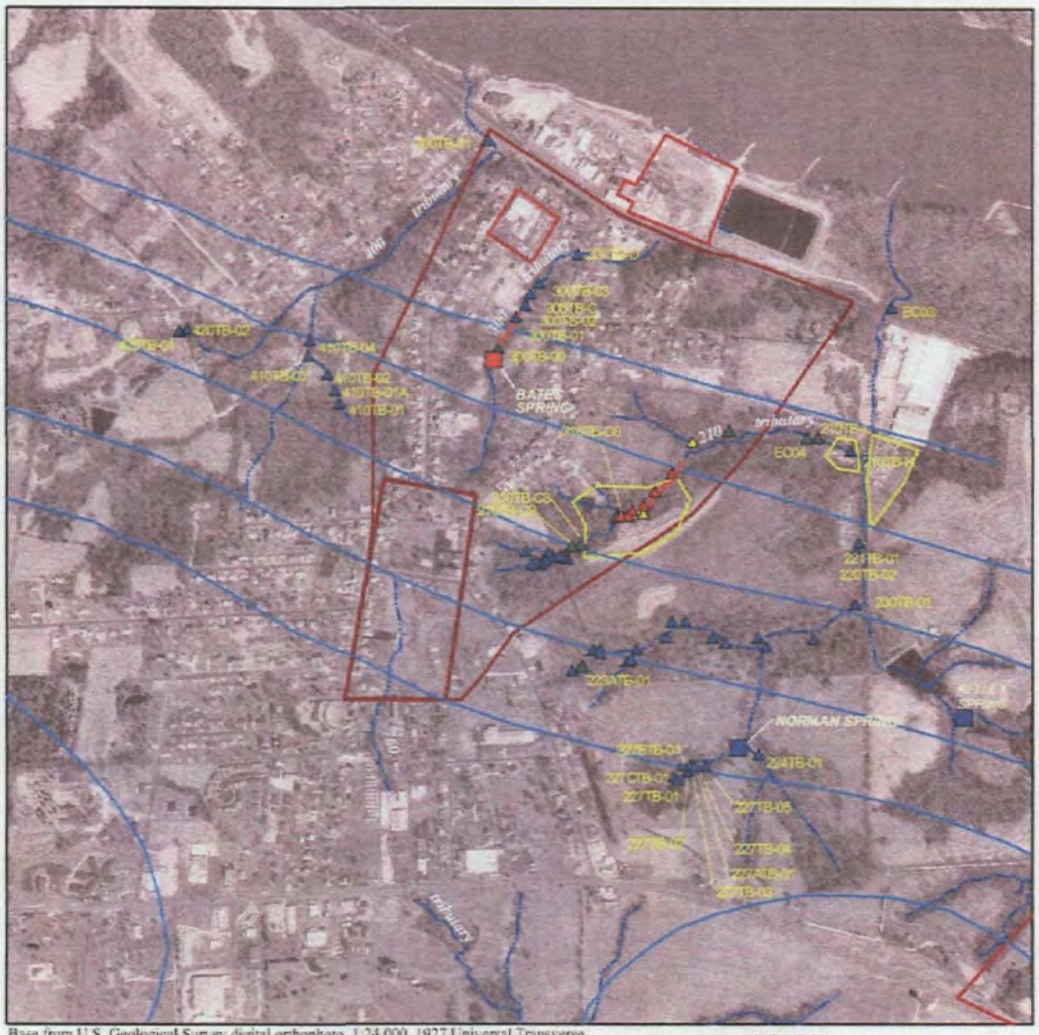
SANITARY SEWER FORCE MAIN

SANITARY SEWER GRAVITY MAIN

ESTIMATED MAXIMUM PCE CONCENTRATION IN TREE-CORE SAMPLE. CONCENTRATIONS IN MICROGRAMS PER KILOGRAM OF WET CORE.

- LESS THAN 0.1
- 0.1 to 4.99
- 5.0 to 49.9
- 50.0 to 117

Figure 2-1. Locations of Round 3 tree-core samples collected from the Maiden Lane area of OU4, October 2003.



Base from U.S. Geological Survey digital orthophoto, 1:24,000, 1927 Universal Transverse Mercator projection Zone 15

SCALE

0 625 1,250 2,500 Feet

EXPLANATION

STREAM

SHALLOW GROUND-WATER CONTOUR (USEPA, 2003)

ESTIMATED MAXIMUM PCE CONCENTRATION IN SURFACE WATER OR SPRING SAMPLE. CONCENTRATIONS IN MICROGRAMS PER LITER. *UNLABELED SITES LISTED ON FIGURE 3-05.

- LESS THAN 0.1
- 0.1 to 0.99
- 1.0 to 4.99
- 5.0 to 30.3

Figure 2-2. Location of surface-water and spring sample sites at OU4 and vicinity. Maximum estimated (PCE) concentrations determined by the portable gas-chromatograph.

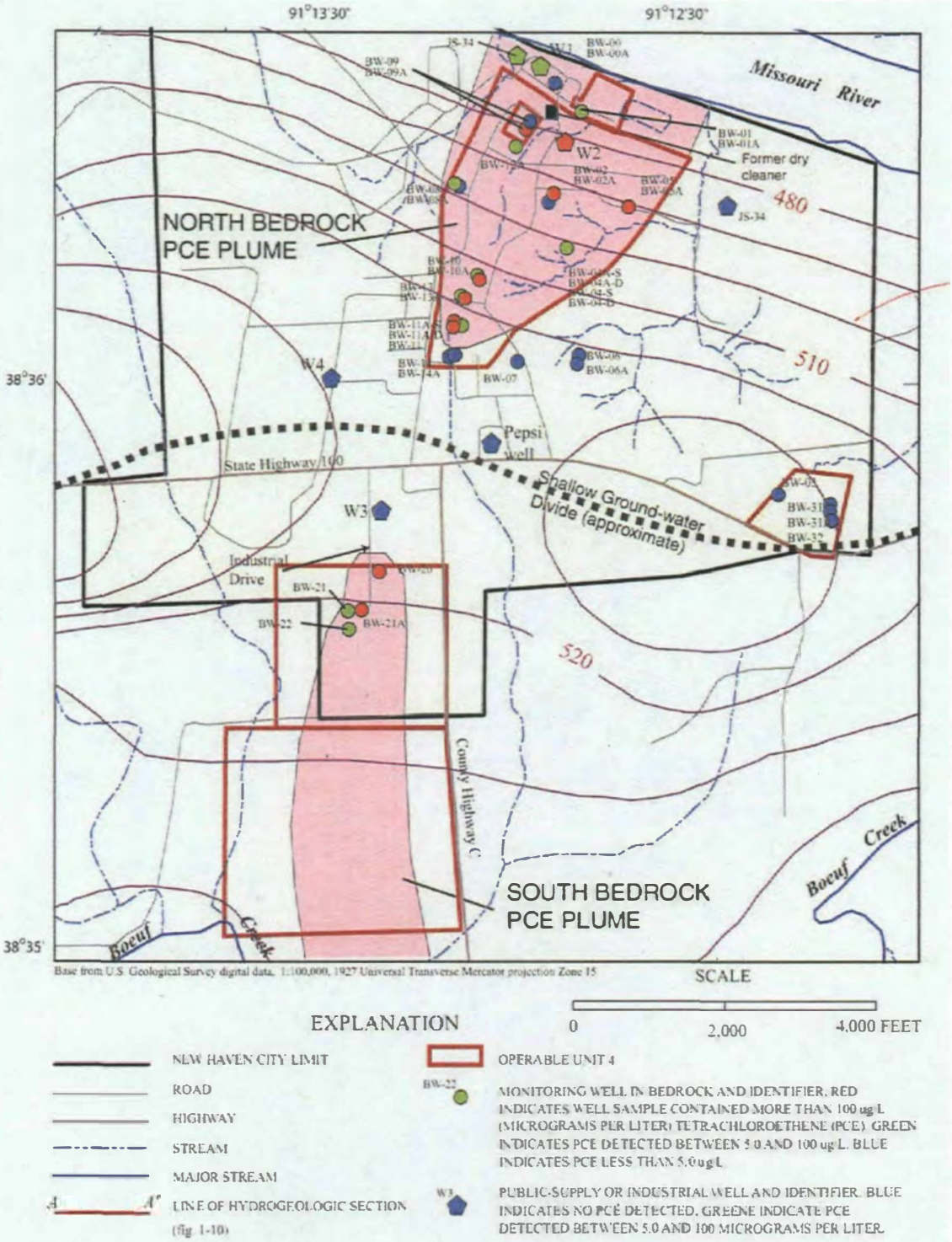


Figure 2-3. Location of U.S. Environmental Protection Agency (USEPA) monitoring wells in bedrock in New Haven, Missouri.

Base from U.S. Geological Survey digital orthophoto, 1:24,000, 1927 Universal Transverse Mercator projection Zone 15

SCALE

0 75 150 300 Feet

EXPLANATION

GRAVITY SANITARY SEWER LINE

FORCE MAIN SANITARY SEWER LINE

SOIL BORING NUMBER AND MAXIMUM PCE CONCENTRATION DETECTED IN SAMPLES FROM BORING. CONCENTRATIONS ESTIMATED IN MICROGRAMS PER KILOGRAM BY THE PORTABLE GAS CHROMATOGRAPH.

A607

- NOT DETECTED
- 1 TO 239.9
- 240 TO 479.9
- 480 TO 479,999
- 479,999 TO 8,000,000

Figure 2-4. Maximum PCE concentrations detected in soil borings from Phase II in the Maiden Lane Area. Unlabled points are Phase I borings.

Base from U.S. Geological Survey digital orthophoto, 1:24,000, 1927 Universal Transverse Mercator projection Zone 15, 1999 photograph

SCALE

0 75 150 300 Feet

EXPLANATION

GRAVITY SANITARY SEWER LINE

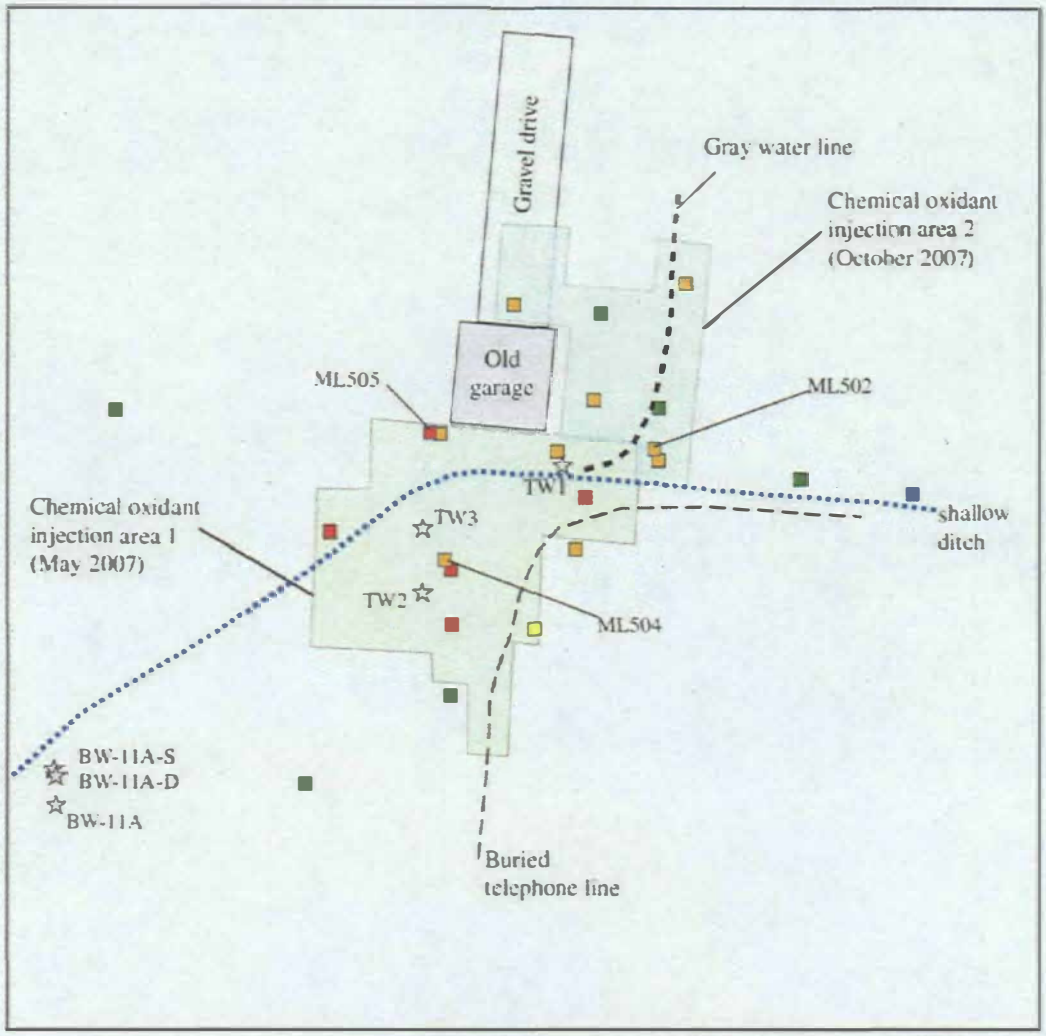
FORCE MAIN SANITARY SEWER LINE

SOIL BORING NUMBER AND MAXIMUM PCE CONCENTRATION DETECTED IN SAMPLES FROM BORING. CONCENTRATIONS ESTIMATED IN MICROGRAMS PER KILOGRAM BY THE PORTABLE GAS CHROMATOGRAPH.

AB07

- NOT DETECTED
- 1 TO 239.9
- 240 TO 479.9
- 480 TO 479.999
- 479.999 TO 8.000.000

Figure 2-5. Maximum PCE concentrations detected in soil borings from the Phase 3 soil borings in the Maiden Lane area.



EXPLANATION

BW-11A ☆ MONITORING WELL AND NUMBER

SOIL BORING NUMBER AND MAXIMUM PCE CONCENTRATION DETECTED IN SAMPLES FROM BORING. CONCENTRATIONS ESTIMATED IN MICROGRAMS PER KILOGRAM BY THE PORTABLE GAS CHROMATOGRAPH

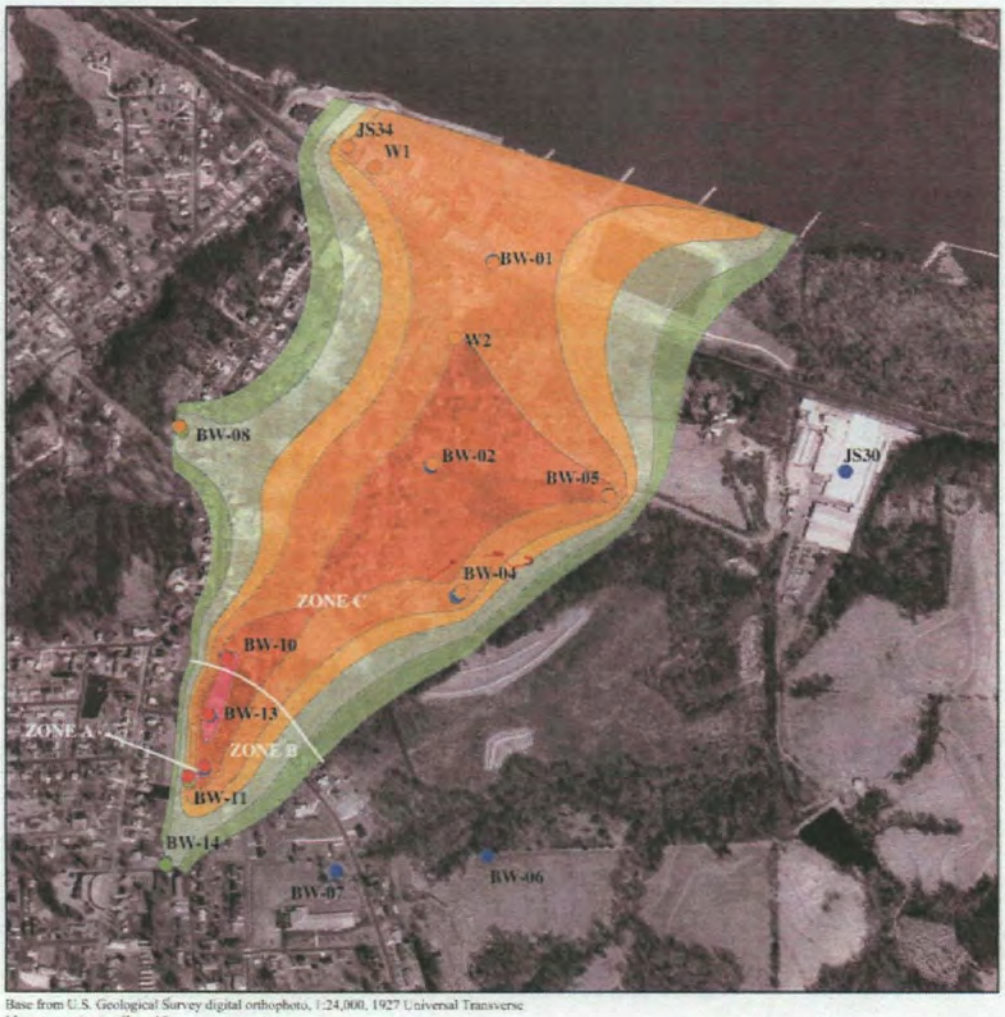
ML502

- NOT DETECTED
- 1 TO 239.9
- 240 TO 479.9
- 480 TO 479.999
- 479.999 TO 8,000,000

SCALE

0 15 30 60 Feet

Figure 2-6. Locations of Phase IV Maiden Lane soil borings, temporary overburden wells and chemical oxidant injection areas.



Base from U.S. Geological Survey digital orthophoto, 1:24,000, 1927 Universal Transverse Mercator projection Zone 15

0 375 750 1,500 Feet

EXPLANATION

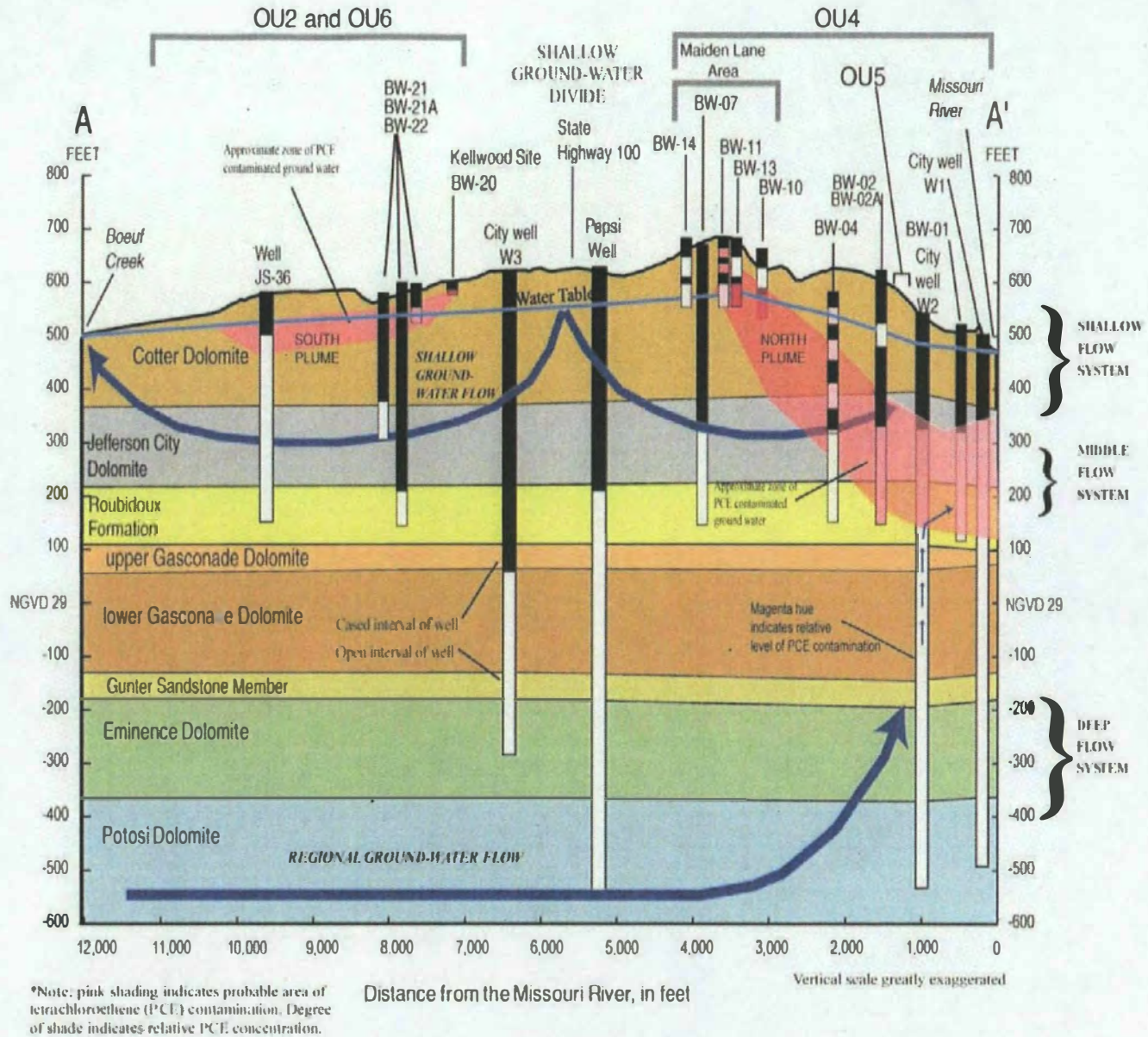
MAXIMUM TETRACHLOROETHENE (PCE) CONCENTRATION IN MONITORING WELL CLUSTER. CONCENTRATIONS IN MICROGRAMS PER LITER

- NOT DETECTED
- LESS THAN 5.0 UG/l
- 5.0 TO 499
- GREATER THAN 500

ESTIMATED TETRACHLROETHENE (PCE) CONCENTRATION IN GROUND-WATER. CONCENTRATIONS IN MICROGRAMS PER LITER

- LESS THAN 0.1
- 0.1 TO 0.99
- 1.0 TO 4.99
- 5.0 TO 49.9
- 50 TO 499
- 500 TO 4,999
- GREATER THAN 5,000

Figure 5-1. Estimated spatial distribution of PCE concentrations in groundwater at OU4 and assigned contaminant thickness zones.



*Note: pink shading indicates probable area of tetrachloroethene (PCE) contamination. Degree of shade indicates relative PCE concentration.

Figure 5-2. Generalized hydrogeologic section in the New Haven area. Location of section is shown on Figure 2-4.

Base from U.S. Geological Survey digital raster graphic, New Haven, Missouri Quadrangle.

Modified from Starbuck, 2002

EXPLANATION

FAULT

INFERRED FAULT

OPERABLE UNIT (OU)

ST. PETER SANDSTONE EXPOSURE. ALL OTHER AREAS UNDERLAIN BY THE UNDIFFERENTIATED POWELL AND COTTER DOLOMITES

FOLD

SCALE

0 2,000 4,000 FEET

— 560 — STRUCTURAL CONTOUR ON TOP OF THE UPPER SAND UNIT IN THE COTTER DOLOMITE. CONTOUR INTERVAL 20 FEET. DATUM IS NGVD 29

A —— A' LINE OF HYDROGEOLOGIC SECTION (fig. 1-17)

Figure 5-3. Generalized geologic map of the New Haven area and structural contours on the top of the upper sandstone unit of the Cotter Dolomite. Modified from Starbuck (2002).

Base from U.S. Geological Survey digital orthophoto, 1:24,000, 1927 Universal Transverse Mercator projection Zone 15

SCALE

0 250 500 1,000 Feet

EXPLANATION

STREAM

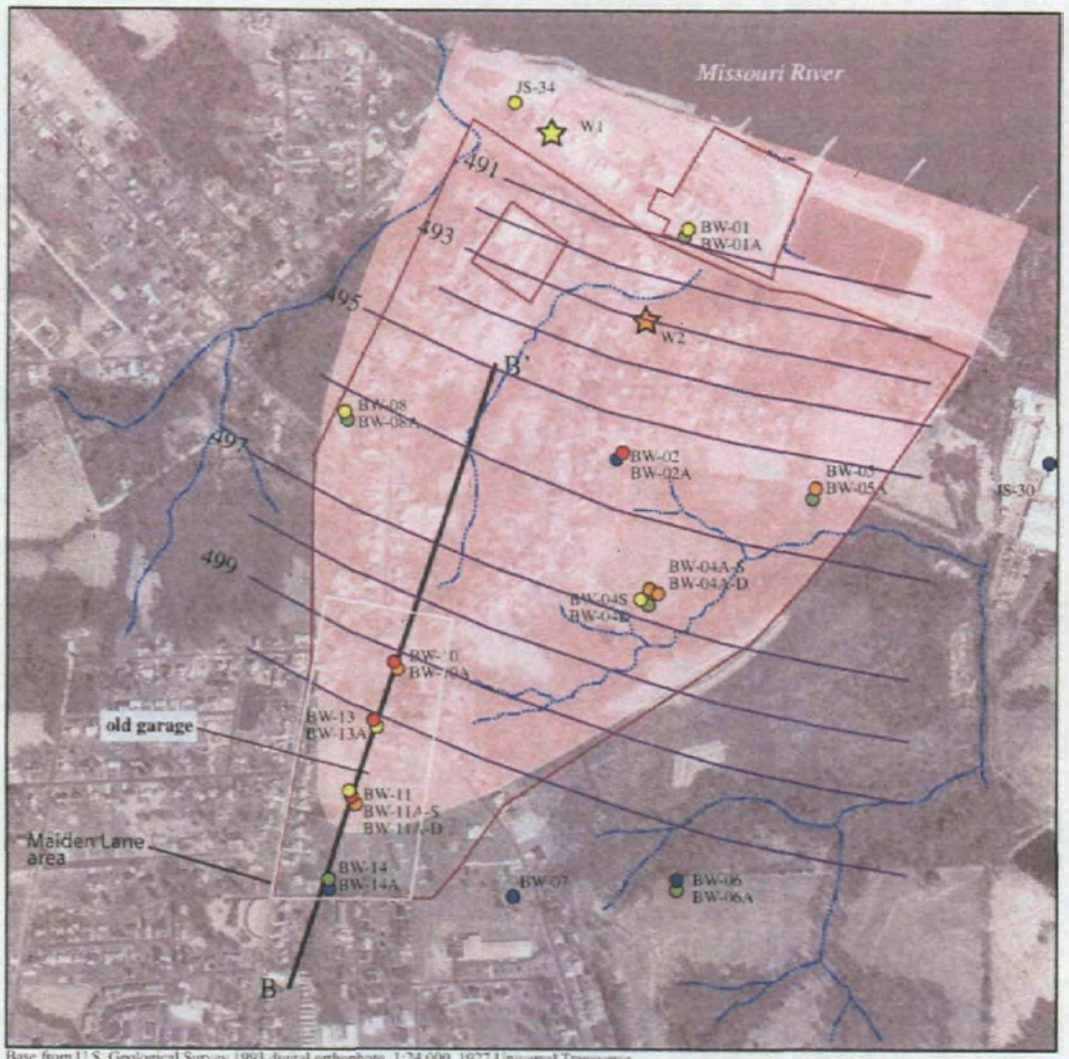
SANITARY SEWER FORCE MAIN

SANITARY SEWER GRAVITY MAIN

ESTIMATED PCE CONCENTRATION IN TREE-CORE SAMPLE. CONCENTRATIONS IN MICROGRAMS PER KILOGRAM OF WET CORE.

- LESS THAN 0.1
- 0.1 to 4.99
- 5.0 to 49.9
- 50.0 to 117

Figure 5-4. Estimated PCE concentrations in tree-core samples from the Maiden Lane area.



Base from U.S. Geological Survey 1993 digital orthophoto, 1:24,000, 1927 Universal Transverse Mercator projection Zone 15

SCALE

0 750 1,500 FEET

EXPLANATION

ESTIMATED EXTENT OF PCE CONTAMINATED GROUND WATER AT OPERABLE UNIT 4

Bedrock monitoring well cluster and maximum PCE concentration detected in micrograms per liter

- Not detected
- Less than 5
- 5 to 49.99
- 50 to 499
- Greater than 500

493 POTENTIOMETRIC CONTOUR JUNE 21, 2007. INTERVAL IS 1 FOOT. DATUM NGVD29.

Figure 5-5. Extent of PCE contamination in the bedrock aquifer and maximum PCE contamination detected in moitoring and supply wells at OU4 and vicinity.

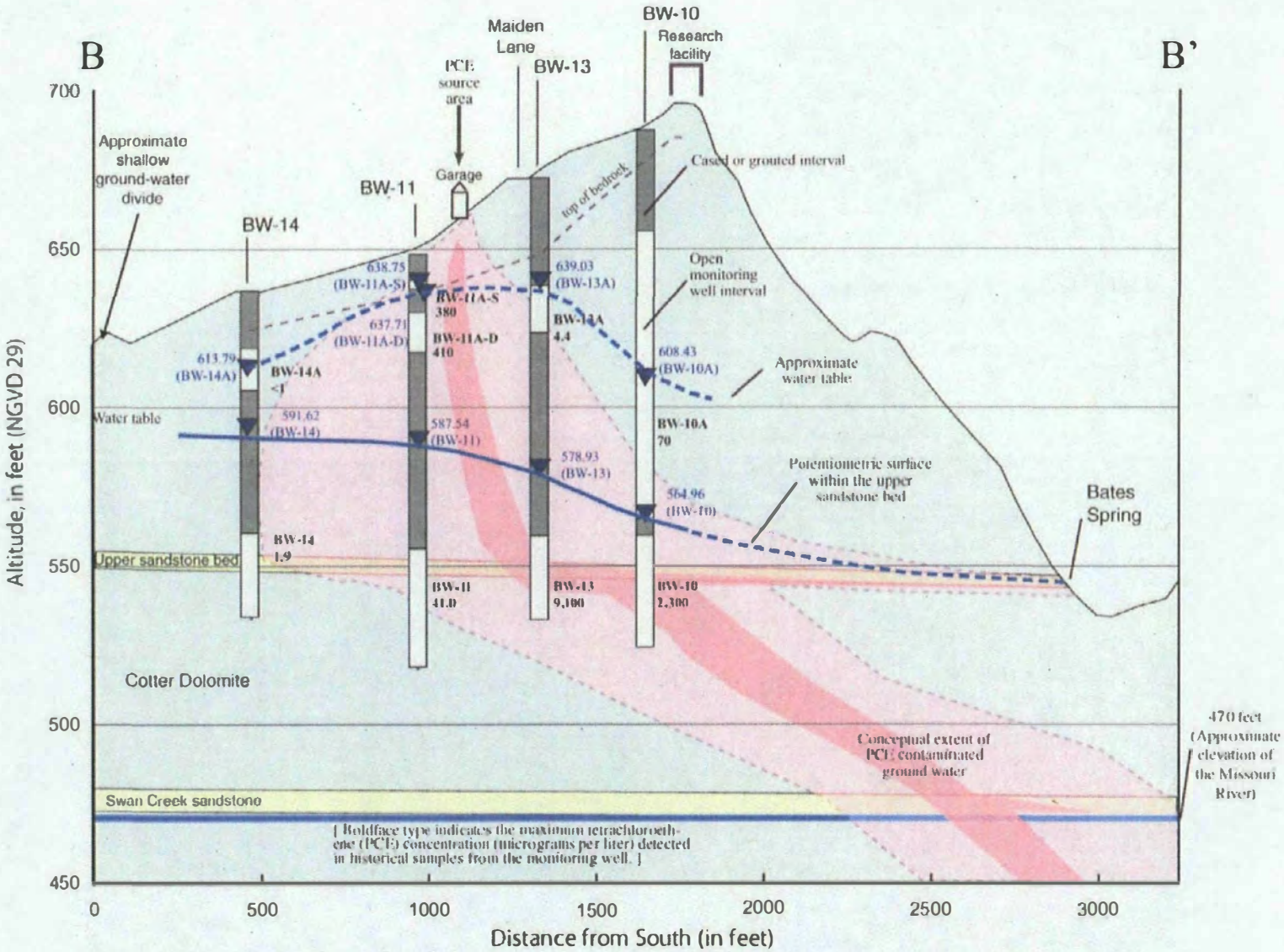


Figure 5-6. Generalized schematic south-north cross section through the Maiden Lane area showing completion depths of monitoring wells, water levels, and PCE concentrations during September 2005. Cross section line shown on figure 4-05.

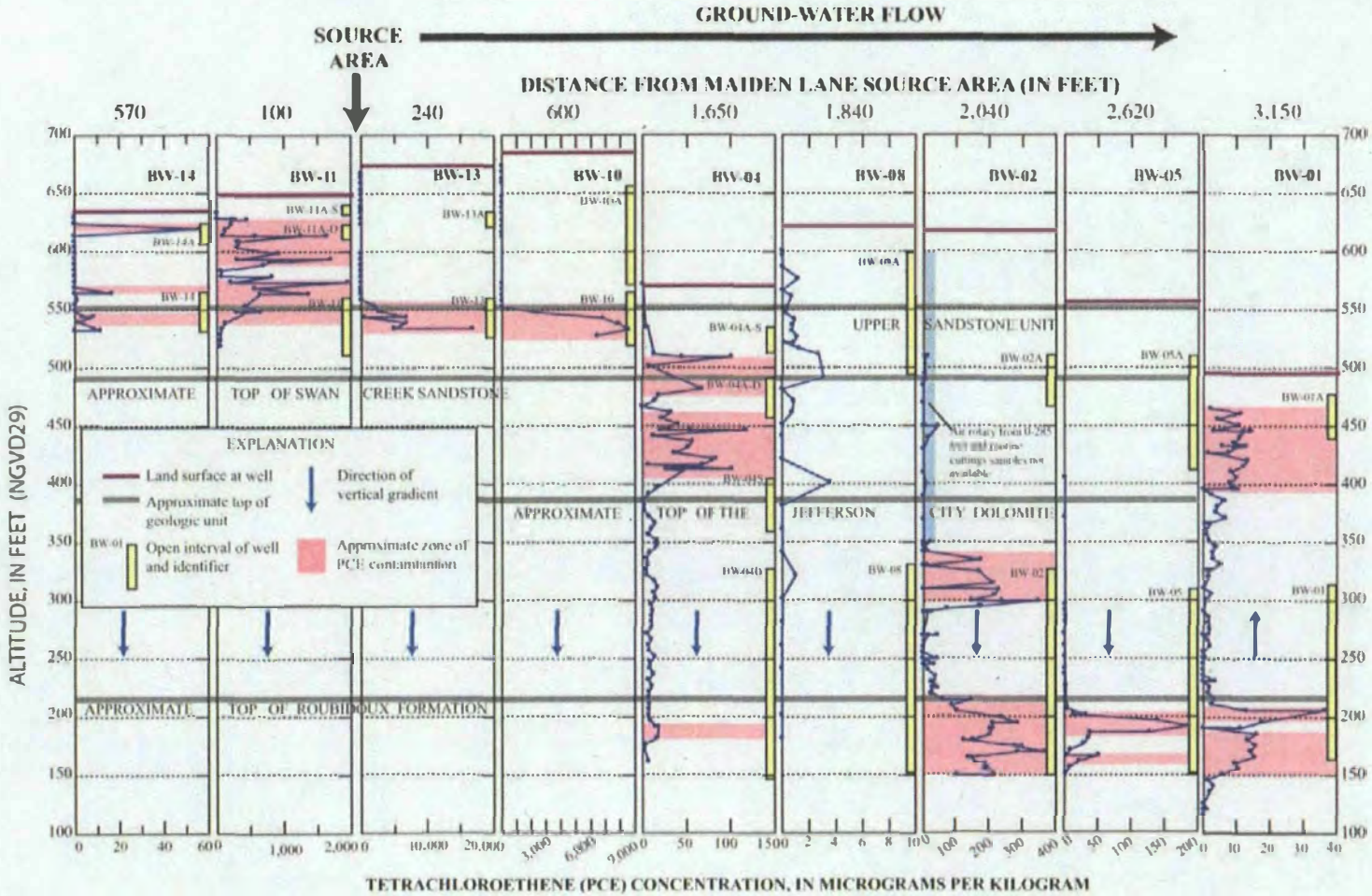


Figure 5-7. Verticle profiles of PCE concentrations estimated by the portable gas chromatograph in drill cuttings from bedrock monitoring wells at OU4.

Base from U.S. Geological Survey digital orthophoto, 1:24,000, 1927 Universal Transverse Mercator projection Zone 15, 2003 photograph

0 250 500 1,000 Feet

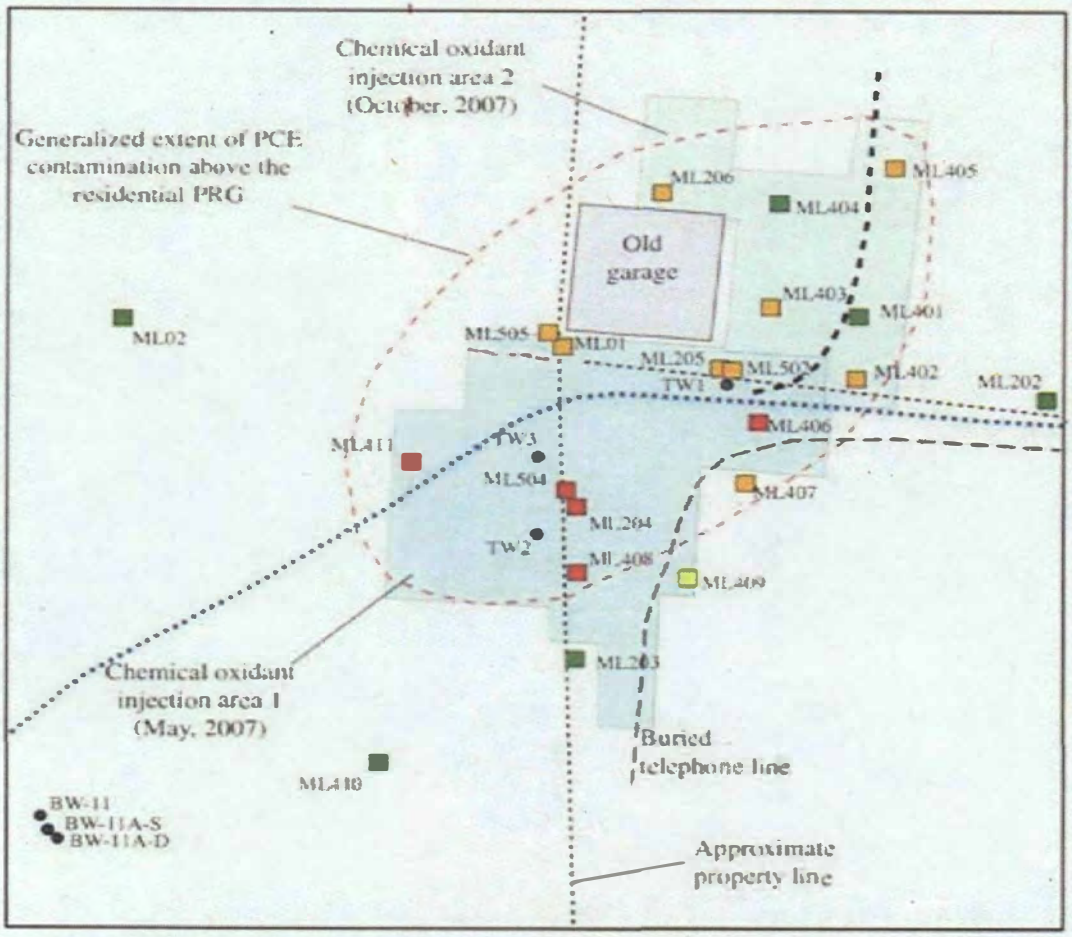
EXPLANATION

○ Soil boring location, no sample data

Maximum PCE concentration detected by the laboratory or portable gas-chromatograph in samples from soil boring. Concentrations in micrograms per kilogram

- Less than 1
- 1.0 to 239.9
- 240 to 479.9
- 480 to 479,999
- 480,000 to 8,000,000

Figure 5-8. Summary of maximum PCE concentration detected by the laboratory or portable gas-chromatograph in soil samples at Operable Unit 4.



EXPLANATION

0 12.5 25 50 Feet

TW3 ● Monitoring well and number

Maximum PCE concentration detected by the laboratory or portable gas-chromatograph in samples from soil boring. Concentrations in micrograms per kilogram

- Less than 1
- 1.0 to 239.9
- 240 to 479.9
- 480 to 479,999
- 480,000 to 8,000,000

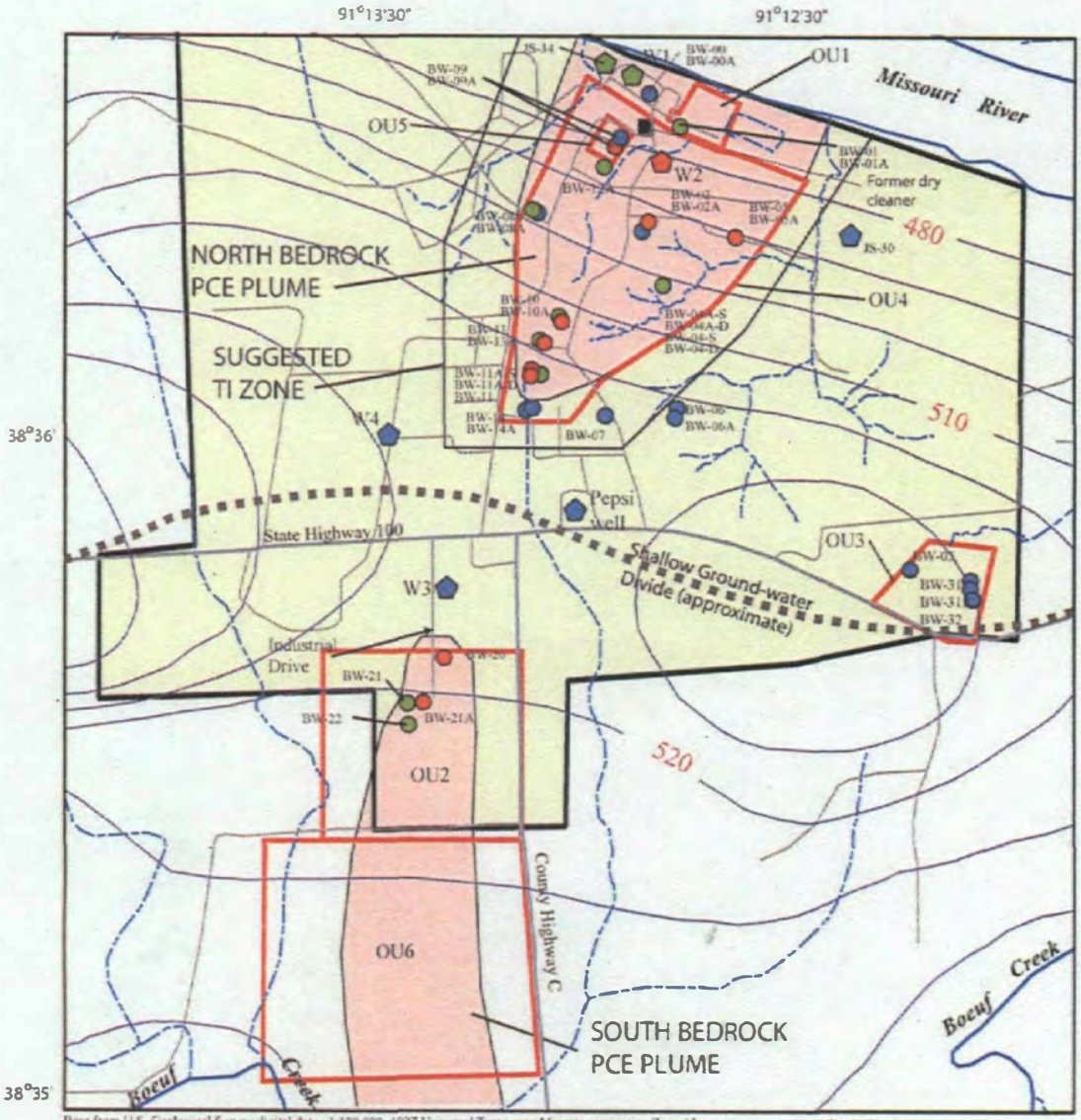
Figure 5-9. Maximum PCE concentration detected by the laboratory or portable gas-chromatograph in soil samples from borings at the Maiden Lane source area.

RECEPTORS

MEDIA	EXPOSURE PATHWAYS	Construction Worker (Adult)	Industrial Worker (Adult)	Resident (Adult/ Child)
Soil (Surface and/or Total)	Dermal Absorption, Ingestion	C/F (Total)	C/F (Total)	C (SS only) F (total)
Groundwater	Dermal Absorption, Inhalation of Vapors, Ingestion	NA	NA	F
Surface Water	Dermal Absorption, Ingestion	C/F	C/F	C/F
Sewer Water	Dermal Absorption, Inhalation of vapors, Ingestion	C/F	NA	NA
Air (Dust and/or Vapors)	Inhalation	C/F	C/F	C/F

C – Current Use Scenario
F– Future Use Scenario
NA – Not applicable to this media/receptor
SS – Surface Soil
Total – Combined Surface and Subsurface Soil

Figure 7-1
Conceptual Exposure Model (Exposure Pathways)
Riverfront OU4 Site



Base from U.S. Geological Survey digital data, 1:100,000, 1927 Universal Transverse Mercator projection Zone 15

SCALE

0 2,000 4,000 FEET

EXPLANATION

NEW HAVEN CITY LIMIT

ROAD

HIGHWAY

STREAM

MAJOR STREAM

A A' LINE OF HYDROGEOLOGIC SECTION (fig. 1-10)

OPERABLE UNIT 4

BW-22 MONITORING WELL IN BEDROCK AND IDENTIFIER. RED INDICATES WELL SAMPLE CONTAINED MORE THAN 100 ug/L (MICROGRAMS PER LITER) TETRACHLOROETHENE (PCE). GREEN INDICATES PCE DETECTED BETWEEN 5.0 AND 100 ug/L. BLUE INDICATES PCE LESS THAN 5.0 ug/L.

W3 PUBLIC-SUPPLY OR INDUSTRIAL WELL AND IDENTIFIER. BLUE INDICATES NO PCE DETECTED. GREENE INDICATE PCE DETECTED BETWEEN 5.0 AND 100 MICROGRAMS PER LITER

FIGURE **12-1**
SUGGESTED TI ZONE
RIVERFRONT SUPERFUND SITE
OPERABLE UNIT 4 TI EVALUATION REPORT

SOURCE: USGS OU4 RI. 2008
Z:\0447/05\C0008351.ai 10/17/2008

Tables

Table 2-1. Summary of Field Investigation Activities at OU4

Date	Activity
1999-2000	ESI/RI well inventory and water level map, geophysical investigation and packer testing of city wells W2, and installation of monitoring well clusters BW-01 and BW-02.
2000	Interview area residents on possible waste dumping on Orchard Street and east of Miller Street.
April-May 2000	Initial tree-core sampling east of Miller Street.
Nov 2000-Feb 2001	Installation of well clusters BW-05, BW-06, and BW-07.
Dec 2000	NPL listing and delineation of original OU4 area.
	Initial tree-core reconnaissance across central part of city and along several sanitary sewer lines.
Sept 2001	PCE detected in several trees outside the original OU4 area, south of Maiden Lane.
Sept 2001	Reconnaissance of sanitary sewer system indicates PCE in sewers downstream from OU2, including OU4 –likely residual PCE emanating from OU2.
Dec 2001-June 2002	Investigation of possible dump areas in the original OU4 area east of Miller Street using aerial photography, metal detector survey, tree-core, and surface water sampling.
Dec 2001	Phase 1 soil borings and sampling east of Miller Street (alleged dump Area A).
July-Sept 2002	Installation of BW-04 well cluster to examine vertical extent of PCE plume upgradient from monitoring well BW-02.
Dec 2002	Installation of well cluster BW-08 to define western extent of bedrock PCE plume.
June 2003	Interviews with former Kellwood employees.
June 2003	Ground penetrating radar (GPR) survey and Phase I soil borings at Assumption Catholic Church parking lot.
July 2003	Tree-core sampling at the former Kellwood research facility.
June-Aug 2003	Well cluster BW-10 installed at alternate location, southeast of Research facility (original location was northeast corner of Research facility property).
Oct 2003	Tree-core sampling focusing on the Maiden Lane area to confirm previous PCE detection in trees south of Maiden Lane and to confirm interview with former area resident about waste PCE used as a drain cleaner.
April 2004	Well Cluster BW-11 installed south of Maiden Lane, adjacent to PCE contaminated trees.
Sept 2004	Phase II soil borings along Maiden Lane sewer and upslope of well cluster BW-11.
June 2005	Well Cluster BW-13 installed north (downgradient) of probable PCE source area upslope of well cluster BW-11.
July 2005	BW-14 installed south (upgradient) of probable PCE source area.
Nov 2005	Phase III soil borings to define extent of PCE contamination in probable source area upslope from well cluster BW-11 and investigation of potential PCE contamination in soils at the former Kellwood research facility.
May 2007	Phase I EPA removal action at PCE source area – injection of chemical oxidant into contaminated soils.
Oct 2007	Phase II EPA removal action at PCE source area – injection of chemical oxidant into contaminated soils.
Nov 2008	Limited confirmatory soil sampling collection from chemical oxidant injection area.

Table 7-1. Chemicals of Potential Concern at OU4

Exposure Medium	Analyte	Exposure Points
Surface Water	Tetrachloroethene (PCE)	Onsite Tributaries
	Trichloroethene (TCE)	Onsite Tributaries
	Vinyl Chloride (VC)	Onsite Tributaries
Sediment	NONE*	
Soil	Tetrachloroethene (PCE)	Surface Soil and Total Soil
	Trichloroethene (TCE)	Surface Soil and Total Soil
	Vinyl Chloride (VC)	Surface Soil and Total Soil
Groundwater	cis-1,2-dichloroethene	OU4 Groundwater
	trans-1,2-dichloroethene	OU4 Groundwater
	Total 1,2-dichloroethene	OU4 Groundwater
	Tetrachloroethene (PCE)	OU4 Groundwater
	Trichloroethene(TCE)	OU4 Groundwater
Sanitary Sewer Water	Bromomethane	OU4 Sanitary Sewer
	Chloroform	OU4 Sanitary Sewer
	Tetrachloroethene (PCE)	OU4 Sanitary Sewer
Indoor Air	Chloroform	OU4 Indoor Air
	Tetrachloroethene (PCE)	OU4 Indoor Air
	Trichloroethene (TCE)	OU4 Indoor Air

* No COPCs were selected for OU4 sediment.

Table 7-2
EXPOSURE POINT CONCENTRATION SUMMARY
RIVERFRONT OU4

Scenario Timeframe: Current/Future
Medium: Surface Water
Exposure Medium: Surface Water

Exposure Point	Chemical of Potential Concern	Units	Arithmetic Mean	95% UCL (Distribution)	Maximum Concentration (Qualifier)	Reasonable Maximum Exposure			Central Tendency Exposure		
						EPC Value	EPC Statistic	EPC Rationale	EPC Value	EPC Statistic	EPC Rationale
210 Tributary	Tetrachloroethene (PCE)	ug/L	13.1	18.1 (N)	35	18.1	UCL-N	(1)	13.1	Mean	(2)
	Trichloroethene (TCE)	ug/L	1.01	1.26 (N)	2.1	1.26	UCL-N	(1)	1.01	Mean	(2)
	Vinyl Chloride	ug/L	0.883	1.08 (NP-C_{95})	0.55 J	0.55	Max	(3)	0.55	Max	(4)

Notes:

EPC = Exposure Point Concentration

J = estimated value

UCL = upper confidence limit

ug/L = micrograms per liter

Statistical methods selected for 95% UCL were as recommended by EPA's ProUCL software. If a constituent was not detected in a sample, one half of the detection limit was used in the calculations.

(1) 95% UCL computed based on normal data using EPA's ProUCL Student's t.
(2) The arithmetic mean concentration was used for the Central Tendency EPC.
(3) In accordance with guidance and ProUCL recommendations, the maximum concentration was used because the calculated UCL exceeds the maximum detected concentration.
(4) In accordance with guidance, the maximum concentration was used because the calculated mean exceeds the maximum detected concentration.

(C_{95}) Recommended UCL was computed using EPA's ProUCL 95% Chebyshev method.
(N) The data are normal at 5% significance level.
(NP) The data are nonparametric. A nonparametric UCL was computed using EPA's ProUCL software.

Table 7-3

EXPOSURE POINT CONCENTRATION SUMMARY
RIVERFRONT OU4

Scenario Timeframe: Current
Medium: Surface Soil
Exposure Medium: On-site Surface Soil

Exposure Point	Chemical of Potential Concern	Units	Arithmetic Mean	95% UCL (Distribution)	Maximum Concentration (Qualifier)	Reasonable Maximum Exposure			Central Tendency Exposure		
						EPC Value	EPC Statistic	EPC Rationale	EPC Value	EPC Statistic	EPC Rationale
On-Site Surface Soil	Tetrachloroethene (PCE)	ug/kg	354	2633 (NP-C_{99})	1500	1500	Max	(1)	354	Mean	(2)
	Trichloroethene (TCE)	ug/kg	52	416 (NP-C_{99})	400	400	Max	(1)	52	Mean	(2)
	Vinyl Chloride	ug/kg	50.6	361 (NP-C_{99})	180 J	180	Max	(1)	50.6	Mean	(2)

Notes:

EPC = Exposure Point Concentration
J = estimated value
UCL = upper confidence limit
ug/kg = micrograms per kilogram

Statistical methods selected for 95% UCL were as recommended by EPA's ProUCL software. If a constituent was not detected in a sample, one half of the detection limit was used in the calculations.

(1) In accordance with guidance and ProUCL recommendations, the maximum concentration was used because the calculated UCL exceeds the maximum detected concentration.
(2) The arithmetic mean concentration was used for the Central Tendency EPC.

(C_{99}) Recommended UCL was computed using EPA's ProUCL 99% Chebyshev method.
(NP) The data are neither normal or lognormal. A nonparametric UCL was computed using EPA's ProUCL software.

Table 7-4
EXPOSURE POINT CONCENTRATION SUMMARY
RIVERFRONT OU4

Scenario Timeframe: Future
Medium: Groundwater
Exposure Medium: Groundwater

Exposure Point	Chemical of Potential Concern	Units	Arithmetic Mean	95% UCL (Distribution)	Maximum Concentration (Qualifier)	Reasonable Maximum Exposure			Central Tendency Exposure		
						EPC Value	EPC Statistic	EPC Rationale	EPC Value	EPC Statistic	EPC Rationale
Riverfront OU4	Acetone	ug/L	728	3570 (NP-C_{99})	2100	2100	Max	(1)	728	Mean	(2)
	cis-1,2-Dichloroethene	ug/L	309	1710 (NP-C_{99})	6000	1710	UCL-C_{99}	(3)	309	Mean	(2)
	trans-1,2-Dichloroethene	ug/L	69.4	353 (NP-C_{99})	14 J	14	Max	(1)	14	Max	(4)
	1,2-Dichloroethene (total)	ug/L	273	1560 (NP-C_{99})	4800	1560	UCL-C_{99}	(3)	273	Mean	(2)
	Tetrachloroethene (PCE)	ug/L	3350	36400 (T-$C_{97.5}$)	71000	34600	UCL-$C_{97.5}$	(5)	3350	Mean	(2)
	Trichloroethene (TCE)	ug/L	323	1800 (NP-C_{99})	7900	1800	UCL-C_{99}	(3)	323	Mean	(2)

Notes:
EPC = Exposure Point Concentration
J = estimated value
UCL = upper confidence limit
ug/L = micrograms per liter

Statistical methods selected for 95% UCL were as recommended by EPA's ProUCL software. If a constituent was not detected in a sample, one half of the detection limit was used in the calculations.

(1) In accordance with guidance and ProUCL recommendations, the maximum concentration was used because the calculated UCL exceeds the maximum detected concentration.
(2) The arithmetic mean concentration was used for the Central Tendency EPC.
(3) 95% UCL computed based on nonparametric data using EPA's ProUCL 99% Chebyshev method.
(4) In accordance with guidance, the maximum concentration was used because the calculated mean exceeds the maximum detected concentration.
(5) 95% UCL computed based on lognormal data using EPA's ProUCL 97.5 Chebyshev method.

($C_{97.5}$) Recommended UCL was computed using EPA's ProUCL 97.5% Chebyshev method.
(C_{99}) Recommended UCL was computed using EPA's ProUCL 99% Chebyshev method.
(NP) The data are neither normal or lognormal. A nonparametric UCL was computed using EPA's ProUCL software.
(T) The data follow the Lognormal Distribution.

Table 7-5

EXPOSURE POINT CONCENTRATION SUMMARY
RIVERFRONT OU4

Scenario Timeframe: Current/Future
Medium: Total Soil (Surface + Subsurface Soil)
Exposure Medium: Total Soil (Surface + Subsurface Soil)

Exposure Point	Chemical of Potential Concern	Units	Arithmetic Mean	95% UCL (Distribution)	Maximum Concentration (Qualifier)	Reasonable Maximum Exposure			Central Tendency Exposure		
						EPC Value	EPC Statistic	EPC Rationale	EPC Value	EPC Statistic	EPC Rationale
On-Site	Tetrachloroethene (PCE)	ug/kg	444000	2550000 (NP-HB)	6100000	2550000	UCL-HB	(1)	444000	Mean	(2)
	Trichloroethene (TCE)	ug/kg	3750	9507 (NP-HB)	7700	7700	Max	(3)	3750	Mean	(2)
	Vinyl Chloride	ug/kg	6761	15100 (NP-HB)	200	200	Max	(3)	200	Max	(4)

Notes:
EPC = Exposure Point Concentration
UCL = upper confidence limit

ug/kg = micrograms per kilogram

Statistical methods selected for 95% UCL were as recommended by EPA's ProUCL software. If a constituent was not detected in a sample, one half of the detection limit was used in the calculations.

(1) 95% UCL computed based on non-parametric data using EPA's ProUCL 95% Hall's Bootstrap method.
(2) The arithmetic mean concentration was used for the Central Tendency EPC.
(3) In accordance with guidance and ProUCL recommendations, the maximum concentration was used because the calculated UCL exceeds the maximum detected concentration.
(4) In accordance with guidance, the maximum concentration was used because the calculated mean exceeds the maximum detected concentration.

(HB) The UCL was computed using EPA's ProUCL 95% Hall's Bootstrap method.
(NP) The data are neither normal or lognormal. A nonparametric UCL was computed using EPA's ProUCL software.

Table 7-6
EXPOSURE POINT CONCENTRATION SUMMARY
RIVERFRONT OU4

Scenario Timeframe: Current/Future
Medium: Water
Exposure Medium: Sanitary Sewer Water

Exposure Point	Chemical of Potential Concern	Units	Arithmetic Mean	95% UCL	Maximum Concentration (Qualifier)	Reasonable Maximum Exposure			Central Tendency Exposure		
						EPC Value	EPC Statistic	EPC Rationale	EPC Value	EPC Statistic	EPC Rationale
Sanitary Sewer System Manhole Inflow	Bromomethane	ug/L	1.7	3.88 (NP-C_{95})	2.2	2.2	Max	(1)	1.7	Mean	(2)
	Chloroform	ug/L	2.09	6.01 (G)	7.5	6.01	UCL-G	(3)	2.09	Mean	(2)
	Tetrachloroethene (PCE)	ug/L	1.98	3.28 (N)	5	3	UCL-N	(4)	1.98	Mean	(2)

Notes:

EPC = Exposure Point Concentration
ug/l = micrograms per liter
UCL = upper confidence limit

Statistical methods selected for 95% UCL were as recommended by EPA's ProUCL software. If a constituent was not detected in a sample, one half of the detection limit was used in the calculations.

(1) In accordance with guidance and ProUCL recommendations, the maximum concentration was used because the calculated UCL exceeds the maximum detected concentration.
(2) The arithmetic mean concentration was used for the Central Tendency EPC.
(3) UCL computed based on gamma distribution using EPA's ProUCL Approximate Gamma.
(4) 95% UCL computed based on normal data using EPA's ProUCL Student's t.

(C_{95}) Recommended UCL was computed using EPA's ProUCL 95% Chebyshev method.
(G) The data follow the gamma distribution. Recommended UCL was computed using EPA's ProUCL Approximate Gamma
(N) The data are normal at 5% significance level.
(NP) The data are neither normal or lognormal. A nonparametric UCL was computed using EPA's ProUCL software.

Table 7-7

EXPOSURE POINT CONCENTRATION SUMMARY
RIVERFRONT OU4

Scenario Timeframe: Current/Future
Medium: Indoor Air
Exposure Medium: Indoor Air

Exposure Point	Chemical of Potential Concern	Units	Arithmetic Mean	95% UCL	Maximum Concentration (Qualifier)	Reasonable Maximum Exposure			Central Tendency Exposure		
						EPC Value	EPC Statistic	EPC Rationale	EPC Value	EPC Statistic	EPC Rationale
Indoor Air	Choroform	ug/m^3	0.27	0.469 (G)	1.2	0.469	UCL-G	(1)	0.27	Mean	(2)
	Tetrachloroethena (PCE)	ug/m^3	1.19	1.96 (G)	11	1.96	UCL-G	(1)	1.19	Mean	(2)
	Trichloroethene (TCE)	ug/m^3	0.665	1.16 (T-H)	7.6	1.16	UCL-H	(3)	0.665	Mean	(2)

Notes:

EPC = Exposure Point Concentration
ug/m^3= micrograms per cubic meter

UCL = upper confidence limit

Statistical methods selected for 95% UCL were as recommended by EPA's ProUCL software. If a constituent was not detected in a sample, one half of the detection limit was used in the calculations.

(1) UCL computed based on gamma distribution using EPA's ProUCL Approximate Gamma.
(2) The arithmetic mean concentration was used for the Central Tendency EPC.
(3) 95% UCL computed based on lognormal data using EPA's ProUCL H statistic

(G) The data follow the gamma distribution. Recommended UCL was computed using EPA's ProUCL Approximate Gamma
(H) Recommended UCL was computed using EPA's ProUCL H statistic.
(T) The data follow the Lognormal Distribution.

Table 7-8a

EXPOSURE POINT CONCENTRATION SUMMARY
RIVERFRONT OU4

Scenario Timeframe: Current
Medium: Outdoor Air
Exposure Medium: Outdoor Air

Exposure Point	Chemical of Potential Concern	Units	Arithmetic Mean	95% UCL	Maximum Concentration (Qualifier)	Reasonable Maximum Exposure			Central Tendency Exposure		
						EPC Value	EPC Statistic	EPC Rationale	EPC Value	EPC Statistic	EPC Rationale
Outdoor Air	Acetone	ug/m^3	3.03E-04	8.74E-04	NA	8.74E-04	UCL	(1)	3.03E-04	Mean	(2)
	cis-1,2-Dichloroethene	ug/m^3	5.09E-03	2.82E-02	NA	2.82E-02	UCL	(1)	5.09E-03	Mean	(2)
	trans-1,2-Dichloroethene	ug/m^3	4.39E-04	4.39E-04	NA	4.39E-04	UCL	(1)	4.39E-04	Mean	(2)
	Tetrachloroethene	ug/m^3	1.80E-02	1.86E+00	NA	1.86E+00	UCL	(1)	1.80E-02	Mean	(2)
	Trichloroethene	ug/m^3	2.41E-02	1.85E-01	NA	1.85E-01	UCL	(1)	2.41E-02	Mean	(2)
	Vinyl Chloride	ug/m^3	2.35E-02	8.34E-02	NA	8.34E-02	UCL	(1)	2.35E-02	Mean	(2)

Notes:

EPC = Exposure Point Concentration
NA = Not Applicable (no measured data)
UCL = upper confidence limit
ug/m^3= micrograms per cubic meter

(1) The RME concentration was based on the highest predicted vapor or dust concentration modeled from the RME/UCL groundwater or soil data (See Appendix C)
(2) The CTE concentration was based on the highest predicted vapor or dust concentration modeled from the CTE groundwater or soil data (See Appendix C).

Current dust and vapors from soil were modeled from surface soil data.

Table 7-8b
Exposure Point Concentration Summary
Riverfront OU4

Scenario Timeframe: Future
Medium: Outdoor Air
Exposure Medium: Outdoor Air

Exposure Point	Chemical of Potential Concern	Units	Arithmetic Mean	95% UCL	Maximum Concentration (Qualifier)	Reasonable Maximum Exposure			Central Tendency Exposure		
						EPC Value	EPC Statistic	EPC Rationale	EPC Value	EPC Statistic	EPC Rationale
Outdoor Air	Acetone	ug/m^3	3.03E-04	8.74E-04	NA	8.74E-04	UCL	(1)	3.03E-04	Mean	(2)
	cis-1,2-Dichloroethene	ug/m^3	5.09E-03	2.82E-02	NA	2.82E-02	UCL	(1)	5.09E-03	Mean	(2)
	trans-1,2-Dichloroethene	ug/m^3	4.39E-04	4.39E-04	NA	4.39E-04	UCL	(1)	4.39E-04	Mean	(2)
	Tetrachloroethene	ug/m^3	1.84E+03	1.05E+04	NA	1.05E+04	UCL	(1)	1.84E+03	Mean	(2)
	Trichloroethene	ug/m^3	1.35E+01	2.77E+01	NA	2.77E+01	UCL	(1)	1.35E+01	Mean	(2)
	Vinyl Chloride	ug/m^3	8.34E-01	8.34E-01	NA	8.34E-01	UCL	(1)	8.34E-01	Mean	(2)

Notes:

EPC = Exposure Point Concentration
NA = Not Applicable (no measured data)
UCL = upper confidence limit
ug/m^3= micrograms per cubic meter

(1) The RME concentration was based on the highest predicted vapor or dust concentration modeled from the RME/UCL groundwater or soil data (See Appendix C)
(2) The CTE concentration was based on the highest predicted vapor or dust concentration modeled from the CTE groundwater or soil data (See Appendix C).

Future dust and vapors from soil were modeled from total soil (surface + subsurface) data.

Table 7-9
EXPOSURE POINT CONCENTRATION SUMMARY
RIVERFRONT OU4

Scenario Timeframe: Current/Future
Medium: Sewer Trench Air
Exposure Medium: Sewer Trench Air

Exposure Point	Chemical of Potential Concern	Units	Arithmetic Mean	95% UCL	Maximum Concentration (Qualifier)	Reasonable Maximum Exposure			Central Tendency Exposure		
						EPC Value	EPC Statistic	EPC Rationale	EPC Value	EPC Statistic	EPC Rationale
Sewer Trench Air	Acetone	ug/m^3	5.41E-02	1.56E-01	NA	1.56E-01	UCL	(1)	5.41E-02	Mean	(2)
	Bromomethane	ug/m^3	1.45E+01	1.87E+01	NA	1.87E+01	UCL	(1)	1.45E+01	Mean	(2)
	Chloroform	ug/m^3	1.58E+01	4.54E+01	NA	4.54E+01	UCL	(1)	1.58E+01	Mean	(2)
	cis-1,2-Dichloroethene	ug/m^3	1.43E+00	7.92E+00	NA	7.92E+00	UCL	(1)	1.43E+00	Mean	(2)
	trans-1,2-Dichloroethene	ug/m^3	1.44E-01	1.44E-01	NA	1.44E-01	UCL	(1)	1.44E-01	Mean	(2)
	Tetrachloroethene	ug/m^3	6.86E+01	7.08E+02	NA	7.08E+02	UCL	(1)	6.86E+01	Mean	(2)
	Trichloroethene	ug/m^3	4.06E+00	2.26E+01	NA	2.26E+01	UCL	(1)	4.06E+00	Mean	(2)

Notes:

EPC = Exposure Point Concentration
NA = Not Applicable (no measured data)
UCL = upper confidence limit
ug/m^3= micrograms per cubic meter

(1) The RME concentration was based on the highest predicted vapor concentration modeled from the RME/UCL groundwater or sewer water data (See Appendix C)
(2) The CTE concentration was based on the highest predicted vapor or dust concentration modeled from the CTE groundwater or sewer water data (See Appendix C).

Table 7-1A

NON-CANCER TOXICITY DATA – ORAL/DERMAL

Riverfront OU4

Chemical of Potential Concern	Chronic/ Subchronic	Oral RfD		Oral to Dermal Adjustment Factor (1)	Adjusted Dermal RfD (2)		Primary Target Organ(s)	Combined Uncertainty/Modifying Factors	RfD:Target Organ(s)	
		Value	Units		Value	Units			Source(s) (3)	Date(s) (MM/DD/YYYY)
Acetone	Chronic	9E-01	mg/kg-day	1	9E-01	mg/kg-day	Nephropathy (Kidney)	1000	IRIS	1/14/2008
Acetone	Subchronic	1E+00	mg/kg-day	1	1.0E+00	mg/kg-day	Liver/Kidney	100	HEAST	7/31/1997
Bromomethane	Chronic	1.4E-03	mg/kg-day	1	1.4E-03	mg/kg-day	stomach hyperplasia (GI)	1000	IRIS	1/14/2008
Bromomethane	Subchronic	5.0E-03	mg/kg-day	1	5.0E-03	mg/kg-day	stomach hyperplasia (GI)	300	PPRTV	6/13/2008
Chloroform	Chronic	1E-02	mg/kg-day	1	1E-02	mg/kg-day	Liver	1000	IRIS	1/14/2008
Chloroform	Subchronic	1E-02	mg/kg-day	1	1E-02	mg/kg-day	Liver	1000	HEAST	7/31/1997
cis-1,2-Dichloroethylene	Chronic	1E-02	mg/kg-day	1	1E-02	mg/kg-day	Blood	3000	PPRTV	5/13/2008
cis-1,2-Dichloroethylene	Subchronic	1E-01	mg/kg-day	1	1E-01	mg/kg-day	Blood	300	PPRTV	5/13/2008
trans-1,2-Dichloroethylene	Chronic	2E-02	mg/kg-day	1	2E-02	mg/kg-day	Blood	1000	IRIS	1/14/2008
trans-1,2-Dichloroethylene	Subchronic	2E-01	mg/kg-day	1	2E-01	mg/kg-day	Blood	100	HEAST	7/31/1997
1,2-Dichloroethylene (Total)	Chronic	1E-02	mg/kg-day	1	1E-02	mg/kg-day	Blood	3000	PPRTV	1/14/2008
1,2-Dichloroethylene (Total)	Subchronic	9E-03	mg/kg-day	1	9E-03	mg/kg-day	Liver	1000	HEAST	7/31/1997
Tetrachloroethylene (PCE)	Chronic	1E-02	mg/kg-day	1	1E-02	mg/kg-day	Liver/Body Weight	1000	IRIS	1/14/2008
Tetrachloroethylene (PCE)	Subchronic	1E-01	mg/kg-day	1	1E-01	mg/kg-day	Liver	100	HEAST	7/31/1997
Trichloroethylene (TCE)	Chronic	3E-04	mg/kg-day	1	3E-04	mg/kg-day	Liver/Kidneys/Fetus	3000	NCEA	1/14/2008
Trichloroethylene (TCE)	Subchronic	NA	mg/kg-day	NA	NA	mg/kg-day	NA	NA	NA	NA
Vinyl Choride	Chronic	3E-03	mg/kg-day	1	3E-03	mg/kg-day	Liver Cell Polymorphism	30	IRIS	1/14/2008
Vinyl Choride	Subchronic	NA	mg/kg-day	NA	NA	mg/kg-day	NA	NA	NA	NA

HEAST - Health Effects Assessment Summary Tables
IRIS - Integrated Risk Information System
NA - Not Available
NCEA - National Center for Environmental Assessment
PPRTV - Provisional Peer Reviewed Toxicity Value
GI - Gastrointestinal
mg/kg-day - milligrams per kilogram per day
RfD - Reference Dose

(1) Refer to RAGS Part E (2004) and text for explanation. Note: Oral to Dermal Adjustment Factors from Exhibit 4-1, RAGS Part E, 2004
(2) See RAGS Part E (2004), Page 4-3. Note: Dermal RfD (mg/kg) = Oral RfD (mg/kg) x Oral to Dermal Adjustment Factor
(3) IRIS values obtained from the IRIS database (Date Indicated); NCEA values obtained from NCEA (Date Indicated); PPRTV values obtained from EPA (Date Indicated)

Table 7-1B

NON-CANCER TOXICITY DATA – INHALATION

Riverfront OU4

Chemical of Potential Concern	Chronic/ Subchronic	Inhalation RfC (1)		Extrapolated RfD (2)		Primary Target Organ(s)	Combined Uncertainty/Modifying Factors	RfC Target Organ(s)	
		Value	Units	Value	Units			Source(s) (3)	Date(s) (MM/DD/YYYY)
Acetone	Chronic	3E+01	mg/m^3	8.8E+00	mg/kg-day	Neurologic	100	ATSDR-MRL	5/9/2008
Acetone	Subchronic	3E+01	mg/m^3	8.8E+00	mg/kg-day	Neurologic	100	ATSDR-MRL	5/9/2008
Bromomethane	Chronic	5E-03	mg/m^3	1.4E-03	mg/kg-day	Olfactory epithelium (Nasal)	100	IRIS	1/14/2008
Bromomethane	Subchronic	1E-01	mg/m^3	2.9E-02	mg/kg-day	Respiratory	30	PPRTV	5/13/2008
Chloroform	Chronic	5E-02	mg/m^3	1.3E-02	mg/kg-day	CNS/Liver/Kidney	100	PPRTV	1/14/2008
Chloroform	Subchronic	2E-01	mg/m^3	6.9E-02	mg/kg-day	Liver	300	ATSDR-MRL	5/9/2008
cis-1,2-Dichloroethylene	Chronic	NA	mg/m^3	NA	mg/kg-day	NA	NA	NA	NA
cis-1,2-Dichloroethylene	Subchronic	NA	mg/m^3	NA	mg/kg-day	NA	NA	NA	NA
trans-1,2-Dichloroethylene	Chronic	6E-02	mg/m^3	1.7E-02	mg/kg-day	Lung	3000	PPRTV	1/14/2008
trans-1,2-Dichloroethylene	Subchronic	8E-01	mg/m^3	2.3E-01	mg/kg-day	Liver	1000	ATSDR-MRL	5/9/2008
1,2-Dichloroethylene (Total)	Chronic	6E-02	mg/m^3	1.7E-02	mg/kg-day	Lung	3000	PPRTV	1/14/2008
1,2-Dichloroethylene (Total)	Subchronic	8E-01	mg/m^3	2.3E-01	mg/kg-day	Liver	1000	ATSDR-MRL	5/9/2008
Tetrachloroethylene (PCE)	Chronic	6E-01	mg/m^3	1.7E-01	mg/kg-day	Kidney (Tubular cell karyomegaly)	30	NCEA	1/14/2008
Tetrachloroethylene (PCE)	Subchronic	NA	mg/m^3	NA	mg/kg-day	NA	NA	NA	NA
Trichloroethylene (TCE)	Chronic	4E-02	mg/m^3	1.1E-02	mg/kg-day	CNS/Liver/Endocrine System	1000	NCEA	1/14/2008
Trichloroethylene (TCE)	Subchronic	5E-01	mg/m^3	1.5E-01	mg/kg-day	Neurologic	300	ATSDR-MRL	5/9/2008
Vinyl Choride	Chronic	1E-01	mg/m^3	2.9E-02	mg/kg-day	Liver Cell Polymorphism	30	IRIS	1/14/2008
Vinyl Choride	Subchronic	8E-02	mg/m^3	2E-02	mg/kg-day	Liver	30	ATSDR-MRL	5/9/2008

ATSDR - Agency for Toxic Substances and Disease Registry
IRIS - Integrated Risk Information System
MRL - Minimal Risk Level
NA - Not Available
NCEA - National Center for Environmental Assessment
PPRTV - Provisional Peer Reviewed Toxicity Value
CNS - Central Nervous System
RfC - Reference Concentration
RfD - Reference Dose
mg/m^3 - milligrams per cubic meter
mg/kg-day - milligrams per kilogram per day

(1) Refer to RAGS, Part A and text for an explanation
(2) Adjusted Inhalation RfD (mg/kg/day) = Inhalation RfC (mg/m3) x 20 (m3/day) / 70 kg
(3) IRIS values obtained from the IRIS database (Date Indicated); NCEA values obtained from NCEA (Date Indicated), PPRTV values obtained from EPA (Date Indicated); ATSDR-MRL values obtained from ATSDR (Date Indicated)

Table 7-2A

CANCER TOXICITY DATA – ORAL/DERMAL

Riverfront OU4

Chemical of Potential Concern	Oral Cancer Slope Factor		Oral to Dermal Adjustment Factor (1)	Adjusted Dermal Slope Factor (2)		Weight of Evidence/ Cancer Guideline Description	Oral CSF	
	Value	Units		Value	Units		Source(s) (3)	Date(s) (MM/DD/YYYY)
Acetone	N/A	$(mg/kg\text{-}day)^{-1}$	N/A	N/A	$(mg/kg\text{-}day)^{-1}$	Inadequate (D)	IRIS	1/14/2008
Bromomethane	N/A	$(mg/kg\text{-}day)^{-1}$	N/A	N/A	$(mg/kg\text{-}day)^{-1}$	Inadequate (D)	IRIS	1/14/2008
Chloroform *	N/A	$(mg/kg\text{-}day)^{-1}$	N/A	N/A	$(mg/kg\text{-}day)^{-1}$	B2	IRIS	1/14/2008
cis-1,2-Dichloroethylene	N/A	$(mg/kg\text{-}day)^{-1}$	N/A	N/A	$(mg/kg\text{-}day)^{-1}$	D	IRIS	1/14/2008
trans-1,2-Dichloroethylene	N/A	$(mg/kg\text{-}day)^{-1}$	N/A	N/A	$(mg/kg\text{-}day)^{-1}$	Incomplete Evaluation	IRIS	1/14/2008
1,2-Dichloroethylene (Total)	N/A	$(mg/kg\text{-}day)^{-1}$	N/A	N/A	$(mg/kg\text{-}day)^{-1}$	D	IRIS	1/14/2008
Tetrachloroethylene (PCE)	5.40E-01	$(mg/kg\text{-}day)^{-1}$	1	5.40E-01	$(mg/kg\text{-}day)^{-1}$	B2	CalEPA	1/14/2008
Trichloroethylene (TCE)	4.0E-01	$(mg/kg\text{-}day)^{-1}$	1	4.0E-01	$(mg/kg\text{-}day)^{-1}$	B2	NCEA	1/14/2008
Trichloroethylene (TCE)	1.3E-02	$(mg/kg\text{-}day)^{-1}$	1	1.3E-02	$(mg/kg\text{-}day)^{-1}$	B2	CalEPA	6/12/2008
Vinyl Chloride	1.4E+00 **/7.2E-01 ***	$(mg/kg\text{-}day)^{-1}$	1	1.4E+00**/7.2E-01***	$(mg/kg\text{-}day)^{-1}$	A	IRIS	1/14/2008

* = For chloroform, available evidence indicates that chloroform-induced carcinogenicity is secondary to cytotoxicity and regenerative hyperplasia; hence, the Agency relies on a nonlinear approach and the use of a margin-of-exposure analysis for cancer risk. The Agency has also chosen not to rely on a mathematical model to estimate a point of departure for cancer risk the mode of action indicates that cytotoxicity is the critical effect and the reference dose value is considered protective for this effect (IRIS, 2008).

**=Lifetime exposure from birth. Note that because all the exposures in this BLRA are less than lifetime, the vinyl chloride slope factors for "lifetime exposure from birth" will not be used. Rather, only the low slope factors are used, but exposure during early life incorporates a non-pro-rated risk as well as the more typical pro-rated risk (EPA, 2000; *Toxicological Review of Vinyl Chloride*).

***=Lifetime exposure during adulthood

CSF - Cancer Slope Factor
N/A - Not Available
IRIS - Integrated Risk Information System
mg/kg-day - milligrams per kilogram per day
NCEA - National Center for Environmental Assessment

EPA Group:
A - Human carcinogen
B2 - Probable human carcinogen - Indicates sufficient evidence in animals and inadequate or no evidence in humans
C - Possible human carcinogen
D -Not Classified

(1) RAGS A (1989); RAGS E (2004); see explanation of derivation provided in the text. Note: Oral to Dermal Adjustment Factor from Exhibit 4-1, RAGS E 2004
(2) Adjusted Dermal Slope Factor (1/mg/kg/day) = Oral Cancer Slope Factor (1/mg/kg/day) divided by Oral to Dermal Adjustment Factor
(3) IRIS values obtained from the IRIS database (Date Indicated). NCEA values obtained from NCEA (Date Indicated); CalEPA values obtained from EPA (Date Indicated)

Table 7-2B

CANCER TOXICITY DATA – INHALATION

Riverfront OU4

Chemical of Potential Concern	Unit Risk		Inhalation Cancer Slope Factor (1)		Weight of Evidence/ Cancer Guideline Description	Unit Risk. Inhalation CSF	
	Value	Units	Value	Units		Source(s) (2)	Date(s) (MM/DD/YYYY)
Acetone	N/A	$(ug/m^3)^{-1}$	N/A	$(mg/kg/-day/)^{-1}$	Inadequate (D)	IRIS	1/14/2008
Bromomethane	N/A	$(ug/m^3)^{-1}$	N/A	$(mg/kg/-day/)^{-1}$	Inadequate (D)	IRIS	1/14/2008
Chloroform	2.3E-05	$(ug/m^3)^{-1}$	8.1E-02	$(mg/kg/-day/)^{-1}$	B2	IRIS	1/14/2008
cis-1,2-Dichloroethylene	N/A	$(ug/m^3)^{-1}$	N/A	$(mg/kg/-day/)^{-1}$	D	IRIS	1/14/2008
trans-1,2-Dichloroethylene	N/A	$(ug/m^3)^{-1}$	N/A	$(mg/kg/-day/)^{-1}$	Incomplete Evaluation	IRIS	1/14/2008
1,2-Dichloroethylene (Total)	N/A	$(ug/m^3)^{-1}$	N/A	$(mg/kg/-day/)^{-1}$	D	IRIS	1/14/2008
Tetrachloroethylene (PCE)	5.9E-06	$(ug/m^3)^{-1}$	2.1E-02	$(mg/kg/-day/)^{-1}$	B2	CalEPA	1/14/2008
Trichloroethylene (TCE)	1.1E-04	$(ug/m^3)^{-1}$	4.0E-01	$(mg/kg/-day/)^{-1}$	B2	NCEA	1/14/2008
Trichloroethylene (TCE)	2.0E-06	$(ug/m^3)^{-1}$	7.0E-03	$(mg/kg/-day/)^{-1}$	B2	CalEPA	5/12/2008
Vinyl Choride	8.8E-06 */4.4E-06 **	$(ug/m^3)^{-1}$	3.0E-02*/1.5E-02**	$(mg/kg/-day/)^{-1}$	A	IRIS	1/14/2008

*=Lifetime exposure from birth. Note that because all the exposures in this BLRA are less than lifetime, the vinyl chloride slope factors for "lifetime exposure from birth" will not be used. Rather, only the lower slope factors are used, but exposure during early life incorporates a non-pro-rated risk as well as the more typical pro-rated risk (EPA, 2000; Toxicological Review of Vinyl Choride).

**=Lifetime exposure during adulthood

CSF - Cancer Slope Factor

N/A - Not Available

IRIS - Integrated Risk Information System

mg/kg-day - milligrams per kilogram per day

NCEA - National Center for Environmental Assessment

ug/m^3 - micrograms per cubic meter

EPA Group

A - Human carcinogen

B1 - Probable human carcinogen - Indicates limited human data are available

B2 - Probable human carcinogen - Indicates sufficient evidence in animals and inadequate or no evidence in humans

C - Possible human carcinogen

D - Not Classified

(1) RAGS A (1989); see explanation of derivation provided in the text.

(2) IRIS values obtained from the IRIS database (Date Indicated); NCEA values obtained from NCEA (Date Indicated); CalEPA values obtained from EPA (Date Indicated).

Table 7-3a
Summary of Human Health Risk Characterization (NCEA Slope Factor for TCE)
All Scenarios (Chemicals of Concern)
Riverfront OU4

Scenario	Receptor	Cancer Risk		Hazard Index		COCs
		RME	CT	RME	CT	
Current Residential - (Surface Water, Sediment, Surface Soil and Indoor Vapor Pathways Combined)	Adult Resident	5.5E-05	7.9E-06	5E-02	2E-02	None
	Child Resident	3.6E-05	1.3E-05	1E-01	4E-02	
	Total Adult and Child	9.1E-05	2.1E-05			
Current Residential - (Surface Water, Sediment, Surface Soil and Outdoor Vapor Pathways Combined)	Adult Resident	1.6E-03	7.6E-05	1E+00	2E-01	Cancer risk due to PCE and TCE in outdoor air. Noncancer hazard due to PCE in outdoor air.
	Child Resident	9.4E-04	1.2E-04	3E+00	4E-01	
	Total Adult and Child	2.5E-03	2.0E-04			
Future Residential - (Surface Water, Sediment, Groundwater, Total Soil and Indoor Vapor Pathways Combined)	Adult Resident	3.4E-01	6.7E-03	4E+02	4E+01	Cancer risk due to PCE in soil; PCE and TCE in groundwater. Noncancer hazard due to PCE in soil; cis-1,2-DCE, PCE and TCE in groundwater.
	Child Resident	2.0E-01	1.3E-02	9E+02	8E+01	
	Total Adult and Child	5.4E-01	2.2E-02			
Future Residential - (Surface Water, Sediment, Groundwater, Total Soil and Outdoor Vapor Pathways Combined)	Adult Resident	3.4E-01	8.8E-02	4E+02	4E+01	Cancer risk due to PCE in soil; PCE and TCE in groundwater; PCE in outdoor air. Noncancer hazard due to PCE in soil; cis-1,2-DCE, PCE and TCE in groundwater; PCE in outdoor air.
	Child Resident	2.0E-01	1.3E-02	9E+02	8E+01	
	Total Adult and Child	5.4E-01	2.2E-02			
Industrial Worker - (Combined Surface Water, Sediment, Total Soil and Indoor Vapor Pathways)	Adult Worker	5.2E-04	2.5E-05	3E-01	7E-02	Cancer risk due to PCE in soil.
Industrial Worker - (Combined Surface Water, Sediment, Total Soil and Outdoor Vapor Pathways)	Adult Worker	1.7E-03	7.1E-05	1E+00	2E-01	Cancer risk due to PCE in soil; PCE in outdoor air.
Construction Worker - (Combined Surface Water, Sediment, Total Soil, Sewer Water and Vapors)	Adult Worker	5.1E-05	2.9E-06	1E+00	3E-01	None
Construction Worker - (Combined Surface Water, Sediment, Total Soil, Outdoor Vapors)	Adult Worker	1.9E-04	1.2E-05	1E+01	2E+00	Cancer risk due to PCE in outdoor air. Noncancer hazard due to PCE in outdoor air.

Notes
cis-1,2-DCE = cis-1,2-dichloroethene
CT = central tendency
PCE = tetrachloroethylene
RME = reasonable maximum exposure
TCE = trichloroethene

Table 7-3b

Summary of Human Health Risk Characterization (CalEPA Slope Factor for TCE)
All Scenarios (Chemicals of Concern)
Riverfront OU4

Scenario	Receptor	Cancer Risk		Hazard Index		COCs
		RME	CT	RME	CT	
Current Residential - (Surface Water, Sediment, Surface Soil and Indoor Vapor Pathways Combined)	Adult Resident	1.2E-05	1.7E-06	5E-02	2E-02	None
	Child Resident	1.1E-05	3.9E-06	1E-01	4E-02	
	Total Adult and Child	2.3E-05	5.6E-06			
Current Residential - (Surface Water, Sediment, Surface Soil and Outdoor Vapor Pathways Combined)	Adult Resident	1.5E-03	6.7E-05	1E+00	2E-01	Cancer risk due to PCE outdoor air. Noncancer hazard due to PCE in outdoor air.
	Child Resident	9.0E-04	1.0E-04	3E+00	4E-01	
	Total Adult and Child	2.4E-03	1.7E-04			
Future Residential - (Surface Water, Sediment, Groundwater, Total Soil and Indoor Vapor Pathways Combined)	Adult Resident	3.0E-01	6.8E-03	4E+02	4E+01	Cancer risk due to PCE in soil; PCE and TCE in groundwater. Noncancer hazard due to PCE in soil; cis-1,2-DCE, PCE and TCE in groundwater.
	Child Resident	1.8E-01	1.0E-02	9E+02	8E+01	
	Total Adult and Child	4.8E-01	1.7E-02			
Future Residential - (Surface Water, Sediment, Groundwater, Total Soil and Outdoor Vapor Pathways Combined)	Adult Resident	3.0E-01	6.9E-02	4E+02	4E+01	Cancer risk due to PCE in soil; PCE and TCE in groundwater; PCE in outdoor air. Noncancer hazard due to PCE in soil; cis-1,2-DCE, PCE and TCE in groundwater; PCE in outdoor air.
	Child Resident	1.8E-01	1.0E-02	9E+02	8E+01	
	Total Adult and Child	4.8E-01	1.7E-02			
Industrial Worker - (Combined Surface Water, Sediment, Total Soil and Indoor Vapor Pathways)	Adult Worker	4.9E-04	2.0E-05	3E-01	7E-02	Cancer risk due to PCE in soil.
Industrial Worker - (Combined Surface Water, Sediment, Total Soil and Outdoor Vapor Pathways)	Adult Worker	1.6E-03	6.4E-05	1E+00	2E-01	Cancer risk due to PCE in soil; PCE in outdoor air.
Construction Worker - (Combined Surface Water, Sediment, Total Soil, Sewer Water and Vapors)	Adult Worker	4.2E-05	2.3E-06	1E+00	3E-01	None
Construction Worker - (Combined Surface Water, Sediment, Total Soil, Outdoor Vapors)	Adult Worker	1.9E-04	1.1E-05	1E+01	2E+00	Cancer risk due to PCE in outdoor air. Noncancer hazard due to PCE in outdoor air.

Notes:
cis-1,2-DCE = cis-1,2-dichloroethene
CT = central tendency
PCE = tetrachloroethylene
RME = reasonable maximum exposure
TCE = trichloroethene

Table 10-1
Numerical Values of Chemical-Specific ARARs for
Groundwater and Soil Contaminants of Concern
Operable Unit 4, Orchard Street/Maiden Lane Subsite
New Haven, Missouri

Groundwater				
	Contaminant	ARAR Value		Maximum Detection
	Volatile Organic Compounds			
*	cis-1,2-Dichloroethene	70 ug/L	1	210 ug/L
*	trans-1,2-Dichloroethene	100 ug/L	1	30 ug/L
*	Tetrachloroethene	5 ug/L	2	9,100 ug/L
*	Trichloroethene	5 ug/L	2	100 ug/L
Soils				
	Contaminant	Soil Cleanup Goal Value		Maximum Detection
	Volatile Organic Compounds			
*	Tetrachloroethene	550 ug/kg	3	8,000,000 ug/kg
*	Trichloroethene	43 ug/kg	3	42,800 ug/kg
*	Vinyl Chloride	43 ug/kg	3	NAF

Notes:

* Contaminant of Concern (COC).

1 National Primary Drinking Water Standards, 40 CFR Part 141, Subpart F, Maximum Contaminant Levels Goals. These standards are ARARs because non-zero MCLGs for these contaminants have been promulgated.

2 National Primary Drinking Water Standards, 40 CFR Part 141, Maximum Contaminant Levels. These standards are ARARs because non-zero MCLGs for these contaminants have not been promulgated.

3 EPA Region 6 Human Health Medium-Specific Screening Levels, 2008.

NAF – Not Analyzed For