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October 20, 2010

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SUBJECT: START 3, EPA Region 8, Contract No. EP-W-05-050, TDD No. 0805-11 Removal Report, Billings PCE Removal Site, Billings, Yellowstone County, Montana

Dear Mr. Guy:

Attached are two copies of the final Removal Report for the Billings PCE Removal Site in Billings, Yellowstone County, Montana. This document is submitted for your review and approval.

If you have any questions, please call me at 303-291-8313.

Very truly yours,

URS OPERATING SERVICES, INC.

John Noto, P.G.
Project Manager

cc: Charles W. Baker/UOS (w/o attachment)
File/UOS

START 3

Superfund Technical Assessment and Response Team 3 - Region 8

United States
Environmental Protection Agency
Contract No. EP-W-05-050

REMOVAL REPORT

BILLINGS PCE REMOVAL SITE
Billings, Yellowstone County, Montana

TDD No. 0805-11

OCTOBER 20, 2010

URS
OPERATING SERVICES, INC.

In association with:
Garry Struthers Associates, Inc.
LT Environmental, Inc.
TechLaw, Inc.
Tetra Tech EM, Inc.
TN & Associates. Inc.

REMOVAL REPORT

BILLINGS PCE REMOVAL SITE
Billings, Yellowstone County, Montana

EPA Contract No. EP-W-05-050
TDD No. 0805-11

Prepared By:
John Noto, P.G.
Project Manager

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U.S. ENVIRONMENTAL PROTECTION AGENCY

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BILLINGS PCE REMOVAL REPORT

Billings, Yellowstone County, Montana

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LIST OF ACRONYMS

°C	Degrees Celsius
µg/L	Micrograms per liter
µg/m^3	Micrograms per cubic meter
ASTM	ASTM International
BCS	Billings Construction Supply
bgs	Below ground surface
BMP	Best Management Practices
BSL	Big Sky Linen
CCV	Continuing calibration verification
DNAPL	Dense nonaqueous phase liquid
ECD	Electron capture detector
EPA	U.S. Environmental Protection Agency
ER	Environmental Restoration LLC
ERRS	Emergency and Rapid Response Services
ES&T	Environmental Science & Technology
GC/MS	Field portable gas chromatograph/mass spectrometer
GC/PID	Gas chromatograph/photoionization detector
HVAC	Heating/ventilation/air conditioning
ISCO	In situ oxidation
ISOTEC	In-Situ Oxidative Technologies, Inc.
Mass TURI	Massachusetts Toxics Use Reduction Institute
MCL	Maximum Contaminant Level
MDEQ	Montana Department of Environmental Quality
mg/kg	Milligrams per kilogram
mg/L	milligrams per liter
mm	Millimeters
MNA	Monitored natural attenuation
msl	Mean sea level
NIH	National Institutes of Health
NLM	National Library of Medicine
NPDES	National Pollution Discharge Elimination System
OSC	On-Scene Coordinator

LIST OF ACRONYMS, cont.

PA	Preliminary Assessment
PCE	Tetrachloroethylene
PID	Photoionization detector
ppb	Parts per billion
PPE	Personal protective equipment
ppm	Parts per million
PVC	Polyvinyl chloride
RCRA	Resource Conservation and Recovery Act
SDWA	Safe Drinking Water Act
TCLP	Toxicity characteristic leaching procedure
START	Superfund Technical Assessment and Response Team
TCE	Trichloroethene
TDD	Technical Direction Document
Terracon	Terracon Consultants, Inc.
UOS	URS Operating Services, Inc.
VOCs	Volatile organic compounds
WIC	Yellowstone County Women, Infants, and Children Program
yds^3	Cubic yards

EXECUTIVE SUMMARY

This report describes the removal action conducted by the U.S. Environmental Protection Agency (EPA) at the Billings PCE site in Billings, Montana. The removal was conducted from July 2008 through December 2008. The removal action addressed contaminated soil and groundwater in the source area. The goal of the source area removal was to reduce downgradient groundwater contamination and, as a result, reduce vapor intrusion into structures.

The EPA Emergency Response Removal Services contractor, Environmental Restoration, LLC, (ER), coordinated and conducted the physical aspects of the removal. ER provided pre-removal logistical planning; hired specialized subcontractors; excavated, stockpiled, treated, and disposed of contaminated soil; and restored work areas. The EPA Superfund Technical Assessment and Response Team (START) contractor, URS Operating Services, Inc. (UOS), evaluated and coordinated testing of remediation technologies and ranked and recommended technologies to the EPA. UOS also characterized source area contamination, developed a removal plan, collected and analyzed soil and groundwater samples, planned and guided *in situ* treatment and excavation, and designed a procedure for treating excavated soil to allow for disposal at the local Subtitle D municipal landfill.

Site assessment activities are described in the draft Site Assessment and Remediation Alternatives Report that was prepared by UOS and submitted to the EPA in May 2009. The site is located in Billings, Montana, in Sections 3, 4, and 5, T. 1 S., R. 26 E. The site encompasses residential, commercial, and light industrial use neighborhoods.

A tetrachloroethylene (PCE) groundwater contaminant plume approximately 8,500 feet long (within the 100 micrograms per liter [µg/L] concentration contour) was mapped at the site. PCE vapors from the contaminated groundwater had a measured impact on homes and other structures. The 10^{-4} risk-based action level for PCE of 41 micrograms per cubic meter ($\mu g/m^3$) was exceeded in 6 of the 74 residential properties sampled. The 10^{-5} screening level was exceeded at 38 properties, and the 10^{-6} target screening level was exceeded at 58 of the 74 properties sampled.

PCE contamination originated from Big Sky Linen (BSL), which had a dry cleaning operation from approximately 1967 through 1992. The area addressed in the removal action (source area) was between the BSL property at 715 Central Avenue and the intersection of Central Avenue and 7th Street West. The source area had highly contaminated soil and groundwater, including free-phase PCE. The PCE leaked from pipelines connected to BSL floor drains and the from the adjoining storm sewer line. PCE-contaminated soil was observed under approximately 380 linear feet of combined pipeline and storm sewer line.

Although dry cleaning and PCE use was discontinued at BSL in approximately 1992, the groundwater plume was persistent (and possibly growing) due to the nature of source area contamination. The PCE contamination was trapped and held by the fine-grained soils under the pipelines. This fine-grained soil was a continuous source of contamination to the underlying gravel aquifer.

A comprehensive evaluation of remediation alternatives was conducted before the removal began. The nature of contamination, site geology, hydrogeology, logistical considerations (buildings, utilities, etc.), and potential impact on residents were factored into the evaluation. The evaluation included many technologies that were initially ranked based on potential effectiveness, feasibility, and cost. Based on the screening criteria, testing, and modeling scenarios, the EPA selected aggressive source area soil removal/remediation with monitored natural attenuation (MNA) to address the BSL contamination. Because the thickness and characteristics of the fine-grained material (and corresponding depth of the gravel aquifer) differed in the source area, different removal/remediation technologies were used in different parts of the source area. The specific removal plan included *in situ* chemical oxidation, soil excavation, and the installation of a sheet piling containment cell. The sheet piling was proposed to enclose/isolate an area of extremely contaminated soil that could not be treated *in situ* and was not suitable for excavation because it was below the water table.

Extensive preliminary work was required before the contaminated materials could be removed. This included:

- Installing a heating/ventilation/air conditioning (HVAC) bypass system in the building adjacent to the BSL alley/driveway;
- Closing Central Avenue and rerouting traffic around the planned removal area;
- Bypassing or rerouting the water, sanitary sewer, storm sewer, electrical, and natural gas lines around the planned removal area; and
- Installing a flowable-fill (concrete) buttress wall adjacent to the BSL building to allow deep excavation close to the shallow footings.

In-Situ Oxidative Technologies, Inc.(ISOTEC) conducted *in situ* chemical oxidation (ISCO) using Modified Fenton's reagent to treat PCE-contaminated soil in the BSL alley and along the storm drain under Central Avenue between 715 Central Avenue and the intersection of 7th Street West. The reagent was applied during four separate events from June through October 2008.

The first two ISCO events were conducted from June 19 through 20, 2008 and June 23 through 24, 2008 in the BSL alley and along Central Avenue. The events were prior to excavation activities for the purpose of reducing contamination that might be liberated during source area excavation. The reagent was injected into holes spaced 25 feet apart through screened intervals from 14 to 19 feet below ground surface (bgs).

The third ISCO event treated contaminated soil in the BSL alley excavation pits from August 19 through 24, 2008. The purpose of the application was to treat contaminated soil below the water table that could not be excavated. The reagent was sprayed directly into the open pits that were excavated to the water table (approximately 15 to 16 feet bgs). The reagent was stirred/mixed into the soil via a trackhoe bucket.

The forth ISCO event was conducted from October 28 through 30, 2008 in the BSL alley and along Central Avenue. The event was conducted to treat residual/remaining contamination in the areas that were excavated/backfilled and in areas that were not excavated. In addition to excavated/backfilled areas, the reagent was injected into the highly contaminated soils under the storm drain at the intersection of 7th Street and Central Avenue and between the flowable fill wall and the BSL building. The injection intervals at all locations were 10 to 15 and 15 to 20 feet bgs. Reagent was also injected into the 20 to 25 foot bgs interval at three locations.

A sheet piling containment cell was permanently installed to enclose, isolate, and allow excavation of the thick sequence of highly contaminated fine-grained source area soils with confirmed dense nonaqueous phase liquid (DNAPL) under the groundwater table below Central Avenue. The enclosed area had unique characteristics (including the presence of free-phase PCE below the water table) that eliminated other remediation alternatives from consideration. The low-permeability fine-grained soil was not conducive to contaminant extraction via pumping. The fine-grained material also prevented the use of treatment technologies that required injection such as ISCO. The DNAPL below the water table could not be safely excavated without the protection provided by the enclosure and the capability to dewater the enclosure.

Approximately 330 linear feet of sheet piling was driven approximately 30 feet bgs into bedrock to isolate an approximately 5,330 square foot area. A joint sealant was used to improve the watertightness of the sheet piling containment cell. The sheet piling was also braced and functioned as shoring for deep excavation within the enclosure. The enclosure was successfully dewatered for the excavation. The extracted water was processed through an on-site carbon treatment system and discharged into the sanitary sewer with the approval of the City of Billings.

The soil excavation in the BSL alley and under Central Avenue (outside the sheet piling containment cell) generally addressed the contaminated soil above and just below the water table. Assessment data was used to plan the preliminary excavation boundaries and planned depths. A high sample density was necessary due to the numerous release points along the pipelines through joints and cracks. The pre-removal sampling program in the alley allowed accurate excavation boundaries to be drawn. The pre-defined excavation boundaries were used to plan engineering controls (i.e., building foundation support), maximize effectiveness, and minimize the excavation footprint.

Samples collected from pit sidewalls and bottoms during the removal action were analyzed with a gas chromatograph/mass spectrometer (GC/MS) instrument in a field laboratory. The sample results were used to guide the excavation and to determine the PCE concentrations of the final excavated surfaces.

Approximately 6,600 tons (4,440 cubic yards [yds^3]) of soil were excavated during the removal. The excavated soil was initially segregated based on relative PCE concentrations and stockpiled in an on-site staging area. Many of the stockpiles had toxicity characteristic leaching procedure (TCLP) PCE concentrations that exceeded 0.7 milligrams per liter (mg/L) and were, therefore, hazardous waste as defined in the Resource Conservation and Recovery Act (RCRA). The sample results also revealed that the PCE was highly leachable.

Approximately 600 tons (400 yds^3) of the most contaminated soil, (greater than 500 milligrams per kilogram [mg/kg] PCE) was shipped to a RCRA Subtitle C hazardous waste facility for incineration. An additional 1,320 tons (880 cubic yards) of soil that was not hazardous waste (PCE concentrations less than 14 mg/kg)[1] were shipped directly to the local RCRA Subtitle D municipal landfill.

Approximately 4,680 tons (3,120 yds^3) of contaminated soil with PCE concentrations between 14 mg/kg and 500 mg/kg remained in the staging area. As a cost-saving alternative for transporting to and disposal at a RCRA Subtitle C hazardous waste facility, on-site soil treatment options were pursued. Sodium permanganate was selected to treat the soil based on favorable treatment study results. The treatment process successfully reduced the PCE concentrations to less than 14 mg/kg. All treated soil was disposed at the local RCRA Subtitle D landfill as nonhazardous waste. The on-site treatment and disposal of

1 The 14 ppm PCE non-hazardous classification was a conservative value based on the TCLP concentration for hazardous waste of 0.7 mg/L multiplied by 20. The TCLP method uses a 20x dilution. For example, a sample with 14 ppm PCE that has 100 percent leachable PCE would have a TCLP result of 0.7 mg/kg.

treated soil at the regional landfill saved an estimated $700,000 compared to disposal at a Subtitle C facility

Restoration activities included:

- Backfilling the excavation with engineered fill that was compacted to required specifications;
- Cutting the sheet piling below grade;
- Installing new water, storm sewer, sanitary sewer, gas, and electric lines, and new manholes;
- Paving Central Avenue and installing new curb/gutter and sidewalk; and
- Grading and filling the stockpile area with a gravel cover.

1.0 INTRODUCTION

START was tasked by EPA, Region 8, under Technical Direction Document (TDD) No. 0805-11, to provide technical assistance for the removal activities at the Billings PCE Removal Site in Billings, Montana (CERCLIS ID MTD986073252). The site location is shown in Figure 1.

EPA tasked UOS to conduct a site assessment at the Billings PCE site to investigate PCE-contaminated groundwater, soil, and indoor air under TDD No. 0605-09. The investigation was initiated in May 2006. The assessment activities were documented in the draft Site Assessment and Remediation Alternatives Report, which was prepared by UOS and submitted to the EPA in August 2009 (UOS 2009).

The physical removal, treatment, and transportation of contaminated soils to disposal facilities, and the site restoration were conducted or contracted by the EPA Emergency and Rapid Response Services (ERRS) contractor, Environmental Restoration LLC, (ER).

This Removal Activities Report describes pre-removal planning, contaminant removal and mitigation, treatment and disposal of contaminated materials, and site restoration. UOS documented the removal activities with photographs, which are in Appendix B. The removal was conducted from July through December 2008.

2.0 OBJECTIVES

EPA selected aggressive source area soil removal/remediation with MNA to address the contamination. EPA selected methods of excavation, isolation, and *in situ* treatment of PCE contaminated soil to accomplish this. A thorough source area remediation significantly reduced the extent and magnitude of the groundwater contaminant plume and reduced the associated potential for vapor intrusion into overlying structures. Source area remediation and the resulting attenuation of the groundwater plume subsequently eliminated the potential for harmful concentrations of PCE to migrate into overlying homes and other structures.

PCE contamination originated from BSL, which had a dry cleaning operation from approximately 1967 through 1992. The PCE-contaminated soil addressed during the removal action was located under the alley adjacent to Big Sky Linen (at 715 Central Avenue) and under Central Avenue between Big Sky Linen and 7th Street West.

The scope of the removal included: ISCO of source area soil in the vadose zone and below the water table, excavating accessible source area soil above the water table to the extent practicable, and installing a sheet piling containment cell to isolate source area soil contaminated with DNAPL. The containment cell was necessary due to DNAPL/high PCE concentrations in the fine-grained soil below the water table. Key aspects of the removal action included:

- Removal assessment data was used to plan initial excavation boundaries prior to the removal action. Pit sidewall and pit bottom samples were collected and analyzed on site to advance the excavation and document final surfaces.

- EPA focused on the accessible highly contaminated soil in the source area to maximize the cost/benefit of the removal action. This approach was accomplished by using the information about the extent and magnitude of soil and groundwater contamination obtained during the site assessment.

- The removal was conducted in a densely populated area. Monitoring and engineering controls were implemented to minimize the impact of PCE vapors on the nearby population. A clean air intake/bypass system was installed in the commercial building adjacent to the BSL alley excavation area.

- Controlling factors included the presence of contamination above or below the water table, the nature of contamination (i.e., DNAPL presence), lithologies, buildings, utilities, and other potential obstacles.

- Central Avenue, a major thoroughfare and utility corridor had to be closed to address the highly contaminated soil under Central Avenue, a major thoroughfare and utility corridor. EPA reduced the impact on nearby residences and businesses by rerouting/bypassing utilities and redirecting traffic.

- Contaminated soil was either disposed as hazardous waste at a regulated landfill or treated on site, allowing it to be disposed of as non-hazardous material.

- The sheet piling containment cell was installed to isolate contaminated soil and to provide shoring for excavating soil inside the cell. The cell was partially dewatered to allow deep excavation. The water was treated on site prior to discharge.

3.0 SITE BACKGROUND AND HISTORY

3.1 SITE LOCATION AND DESCRIPTION

The Billings PCE Removal Site is located in Billings, Montana, in Sections 3, 4, and 5, T. 1 S., R. 26 E. (Figure 1). The source area (area where releases from pipelines occurred) is on the BSL property at 715 Central Avenue, and along the portion of Central Avenue between BSL and 7th Street West. BSL is an active laundry facility that conducted dry cleaning operations from approximately 1967 through 1992.

The terrain across the site is generally flat, with runoff and storm water generally flowing toward the east-northeast.

3.2 SITE HISTORY

Field investigations were first initiated at the site by the Montana Department of Environmental Quality (MDEQ) in 1992, with subsequent investigation in 1994, 1999, and 2001.

A detailed history of the site is in the Site Assessment and Remediation Alternatives Report prepared by UOS for EPA Region 8 (UOS 2009). The site assessment conducted by UOS for the EPA under TDD No. 0605-09 was initiated in May 2006. The Site Assessment Report includes a description of the MDEQ investigations and findings. The report also includes descriptions of the extent and magnitude of soil, groundwater, and indoor air contamination and an analysis of remediation alternatives.

3.3 CONTAMINANTS OF CONCERN

The primary contaminant of concern at the site is PCE, which was released into the environment from the former dry cleaning operations at BSL. PCE is a halogenated solvent that is usually clear and colorless. PCE is commonly used in the dry cleaning industry and less commonly for cold cleaning and vapor degreasing of metals. PCE is an ingredient in many common automotive products, hobby products, and household products, including brake cleaners and lubricants, cleaners, degreasers/solvents, hobby adhesives, polishes, and sealants (National Institutes of Health [NIH]and the National Library of Medicine [NLM] 2007).

The Safe Drinking Water Act (SDWA) Maximum Contaminant Level (MCL) for PCE is 5 micrograms per liter (µg/L). The molecular formula of PCE is $Cl_2C{=}CCl_2$. PCE is relatively volatile with a vapor pressure of 18.47 millimeters (mm) of mercury at 25 degrees Celsius (°C) and has a relatively high density with a specific gravity of 1.626 at 20°C. PCE has low to moderate mobility in soil with a soil sorption coefficient (K_{oc}) of 238 (est). The solubility of PCE in water is 150 milligrams per liter (mg/L) at 25°C (EPA 2009a).

The reduction reaction daughter product of PCE is trichloroethene (TCE). TCE is also a common solvent primarily used for metal cleaning and degreasing; as a chemical intermediate for hydrogen-based fluorocarbon, flame retardant chemical, and polyvinyl chloride (PVC) manufacture; and as a solvent in adhesives and aerosols (Massachusetts Toxics Use Reduction Institute [Mass TURI] 2009).

TCE is denser than water with a specific gravity of 1.465 at 20°C. The solubility of TCE in water is 1,000 mg/L at 25°C. TCE is a volatile chemical with a relatively high vapor pressure of 57.8 mm of mercury at 25°C. TCE is very mobile in soil with a sorption coefficient (log K_{oc}) of 2. The SDWA MCL for TCE is 5 μg/L (EPA 2009b).

The degradation products of TCE are cis-dichloroethene, trans-dichloroethene, and 1,1-dichloroethene. Vinyl chloride and ethylene are the final products of the reduction reactions (Environmental Science & Technology [ES&T] 1987).

3.4 GEOLOGY/HYDROGEOLOGY

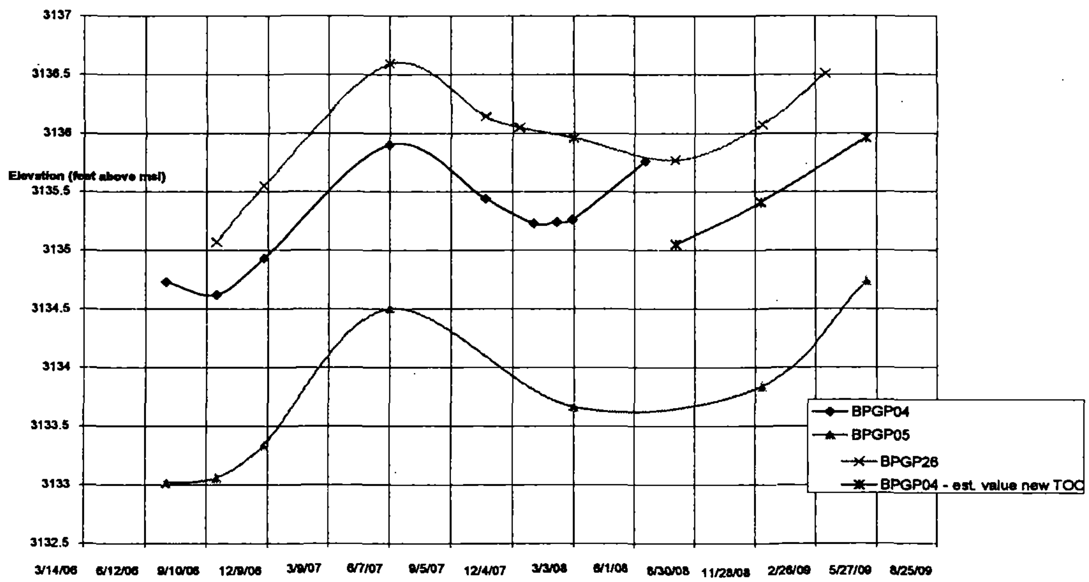
Soil cores were collected with the Geoprobe® to map the lithologies in the removal area. Cross-sections of the removal area are in Appendix D. Lithologic logs are in Appendix E. The general sequence of the lithologic units in the removal area was:

Asphalt and Silty/Sandy fill
Silt/Clayey Silt
Clay and Silt
Sand and Silty Sand — fine grained
Sand — fine grained to medium grained
Gravel and Sand
Shale bedrock

The thickness and composition of the units varied across the site. Lithologic descriptions of each removal sub-area are in the respective sections of this report.

The depth to groundwater in the source area ranged from approximately 14 to 16 feet bgs. The groundwater elevations in wells near the source area are shown in the chart below. The groundwater elevations in well BPGP04 (NW corner 7th and Central) ranged from 3,134.62 feet above mean sea level (msl) in September 2006 to 3,135.9 feet above msl in June 2006. There is not enough temporal data to thoroughly illustrate season patterns (if present). There may be other factors related to water elevation changes that include infiltration from canals and irrigaton.

FIGURE A
Groundwater Elevations in Selected Wells (feet above mean sea level)



4.0 PRE-REMOVAL ASSESSMENTS AND STUDIES

An evaluation of remediation alternatives conducted by UOS during the site assessment is described in the UOS Site Assessment Report (UOS 2009). The alternatives were judged based on potential effectiveness, feasibility/implementability, low risk, cost, and timeliness. The technologies in the initial screening were categorized by different applications:

- Source area,
- Plume containment, and

- Dissolved phase remediation.

Because the contaminated soil in the source area was actively contributing to groundwater contamination, the EPA determined that source area remediation or permanent containment was the highest priority. Dissolved phase remediation was a potential follow-up to source area removal.

5.0 HEALTH AND SAFETY

Health and safety considerations that were addressed during removal activities included PCE exposure, heavy equipment, open excavations, oxidant handling and exposure, adverse weather, and other factors. UOS prepared a site-specific Health and Safety Plan for the removal activities. The plan included task/hazard analysis, monitoring procedures, action levels, response actions, and personal protective equipment (PPE) guidelines. PCE action levels and planned responses are listed in Appendix A, Table 1.

UOS prepared an Air Monitoring and Control Plan for Removal Activities (UOS 2008b) and an Addendum to Air Monitoring and Control Plan for Removal Activities (UOS 2008c). These documents included descriptions of work zones and specified monitoring equipment and procedures, action levels, and vapor mitigation and engineering controls. The plans are attached as Appendix H.

6.0 PRE-REMOVAL LOGISTICS AND ENGINEERING CONTROLS

6.1 HVAC SYSTEM BYPASS AT 711 CENTRAL AVENUE

The EPA determined that constructing an HVAC bypass system for the commercial building at 711 Central Avenue was necessary to protect building occupants from the elevated PCE vapors expected to be generated during soil excavation. The PCE action levels and mitigation actions are in Appendix A, Table 1 and Figure 3. The monitoring equipment and procedures, action levels, and engineering controls are described in the Air Monitoring and Control Plan (Appendix H).

An HVAC bypass system was chosen rather than relocating tenants, restricting excavation times, or implementing vapor control or capture measures. The air inside the 711 Central Avenue building was deemed to be at risk and a HVAC bypass system was necessary because:

- The proximity of the building to the BSL alley and Central Avenue excavations,
- The air intakes on the pre-existing HVAC system were close to the ground where high vapor concentrations were anticipated during the excavation; and

- Visitors to the building included clients of the Yellowstone County Women, Infants, and Children (WIC) program. The infants, children, and pregnant women may have had heightened sensitivity to PCE vapors.

UOS contracted with URS to design the HVAC bypass. The EPA Decontamination Team was also involved with planning and design. The design plan is shown in Appendix C. Photos of the system bypass installation and final system are in Appendix B (Photos 1049, 1116, 1123, and 1126). The two intake systems at each end of the building were modified by attaching ductwork stacks with open ends just above the roof line. A supplemental intake/cooling system was constructed on the north side of building with a swamp cooler.

6.2 RUNOFF AND STORM WATER MANAGEMENT PRACTICES

UOS prepared a draft Storm Water Protection Plan that described measures to prevent sediment and contaminated soil from entering the storm drain system. The plan is attached as Appendix F. The removal activities that could have impacted the quality of runoff and discharge to the storm water systems include:

- Stripping asphalt and sidewalk from a portion of Central Avenue and the right-of-way along Central Avenue,
- Closing and bypassing utilities under Central Avenue,
- Installing sheet piling on Central Avenue to enclose contaminated soil,
- Dewatering the sheet piling containment cell and treating the water prior to discharge,
- Excavating contaminated soil from a property adjacent to Central Avenue,
- Storing excavated soil in temporary stockpiles and in a stockpile staging/holding area, and
- Loading soil into trucks for transport to designated off-site disposal facilities.

Best Management Practices (BMP) were used at the Billings PCE site to reduce or eliminate potential pollutants from entering storm water conveyance systems or waters of the state. The BMPs for construction of site storm water runoff control are provided in the EPA National Pollution Discharge Elimination System (NPDES) Web site:
http://cfpub.epa.gov/npdes/stormwater/menuofbmps/bmp_background.cfm

Although formal NPDES compliance at the site was not required, the NPDES Construction BMPs were used at the site.

6.3 UTILITY BYPASSES AROUND THE PLANNED REMOVAL AREA

Central Avenue is a major utility corridor with natural gas, water, sanitary sewer, and storm sewer lines. The BSL alley also had electrical, natural gas, water, and storm sewer lines in the planned work area. The utility lines in the removal area are shown in Figure 2. Rerouting/bypassing the utility lines that traversed the planned excavation and sheet piling containment cell was necessary. The utility work was conducted by contractors hired by ER. All utility work was coordinated with the City of Billings and the respective utility companies.

The water line work was planned and conducted by Curb Box Specialists, Inc. The water main under Central Avenue was closed at the valves above and below the work areas. Temporary feeder lines were installed to provide service to the properties impacted by the closed line. The water service to BSL was closed and rerouted because the line was in the alley excavation area.

The storm sewer and sanitary sewer bypass work was conducted by Rain for Rent, Inc. An 18-inch diameter sanitary sewer line under Central Avenue was bypassed around the planned removal area. The section of sewer line was closed by plugging the line at the manholes west (upstream) and east of the planned excavation area. A surface bypass line was installed from manhole to manhole adjacent to the removal area. A high-capacity pump was used to pump the sewage through the bypass line.

The 36-inch diameter storm sewer line was also bypassed around the planned removal area. The section of line through the removal area was plugged at manholes upstream (west) and downstream. A surface bypass line was installed from manhole to manhole adjacent to the removal area. The intermittent flow through the storm sewer was pumped through the bypass line.

The natural gas line under the east-bound lane of Central Avenue was left in place during the removal and service was not interrupted. The service line to BSL through the alley and Central Avenue removal area had to be closed and rerouted. The gas line work was conducted by the gas utility, Montana Power Company.

The underground electrical line to BSL in the BSL alley was bypassed with an aboveground line. A temporary utility pole was installed near the northeast corner of the BSL building for the power line.

6.4 STRUCTURE SURVEYS AND SEISMIC MONITORING

ER contacted with Terracon Consultants, Inc. (Terracon) to conduct pre-construction surveys involving the inspection and evaluation of structures adjacent to the planned removal areas. Terracon used instruments to measure and record the vibrations from heavy equipment and the sheet piling installation.

6.5 ENGINEERING CONTROLS TO ALLOW EXCAVATION NEXT TO BIG SKY LINEN BUILDING

The removal action included excavating highly contaminated soil adjacent to the BSL building. ER contracted Terracon to prepare a plan and design a procedure to excavate soil as close to the BSL building as possible without undermining or damaging the building. A custom plan was necessary because limited access and space prevented the use of conventional shoring methods. Terracon prepared a plan that was described in the "Special Study Report for the Proposed Excavation in the Alley Near Big Sky Linen." The report is attached as Appendix G. Terracon's general engineering recommendations were:

- Excavate the upper 3 feet of soil in the alley, and
- Install a subsurface flowable concrete fill wall adjacent to the BSL building.

The wall was installed in stages to limit the length of the open excavation along the BSL foundation. The final wall consisted of five 20-foot long segments (100 feet total) of flowable fill concrete installed approximately 3 feet from the BSL foundation. The wall was 3 feet wide and 8 feet bgs (11 feet below original ground surface).

6.6 CENTRAL AVENUE ROAD CLOSURE/DETOUR

Central Avenue was closed between 7th Street West and 8th Street West while the removal was conducted. The section of road was closed from July 2009 through November 2009. The road closure and detour plan was coordinated with the City of Billings by ER's contractor Billings

Construction Supply (BCS). BCS supplied and maintained signage and barriers for the closure. Access to the properties within the closed area was available via Cline Avenue.

6.7 REMOVAL SITE SECURITY

ER contracted with a security firm to provide on-site security guards at night. Temporary fencing was placed around the work areas to restrict entry by unauthorized people.

7.0 SAMPLE COLLECTION, SCREENING, AND ANALYSIS

This section describes the sample collection, field screening/monitoring, and analytical procedures conducted during the removal action, including;

- Real-time ambient air sampling and screening for PCE inside of the building at 711 Central Avenue,
- Sample collection and VOC laboratory analysis of ambient air inside of the building at 711 Central Avenue,
- Monitoring of outside ambient air for volatile organic compounds (VOCs) in the removal area with portable field instruments,
- Passive monitoring badge sampling and laboratory analysis to measure PCE vapor exposures to removal workers,
- Groundwater sample collection and on-site analysis to evaluate PCE concentrations before and after ISCO and for on-site water treatment and discharge, and
- Soil sample collection and on-site analysis to support all phases of removal activities including excavation/removal planning, excavation confirmation, and stockpile treatment and disposal.

7.1 INDOOR AIR MONITORING, SAMPLING, AND ANALYSIS

Indoor air monitoring and sampling was conducted in the commercial building at 711 Central Avenue during removal activities. The sampling and monitoring procedures are described in the Air Monitoring and Control Plan for Removal Activities and Addendum to the plan (UOS 2008b, UOS 2008c) (Appendix H). The action levels for PCE in ambient air and potential control actions are in Appendix A, Table 1 and Figure 3. Real-time indoor air analysis was conducted and indoor air samples were collected for commercial laboratory analysis during the removal.

The 711 Central Avenue building was constantly monitored because of its location adjacent the source area investigation, the potentially sensitive workers and visitors, and the building's ventilation system, which was modified for the removal. Real-time sampling and analysis was conducted with Photovac, Inc. Voyagers®. The Voyager is a gas chromatograph/photoionization detector (GC/PID) and electron capture detector (ECD) instrument. As many as four Voyagers, three rented and one owned by EPA, were used to monitor various parts of the building. The Voyagers have several characteristics that make them suitable for indoor air monitoring. They can be used to specifically identify PCE; they have a low detection limit of approximately 1 ppb for PCE; and the Voyagers are self-contained with built-in carrier gas tanks and batteries and can be operated remotely. A photo of a Voyager is in Appendix B (Photo 1425).

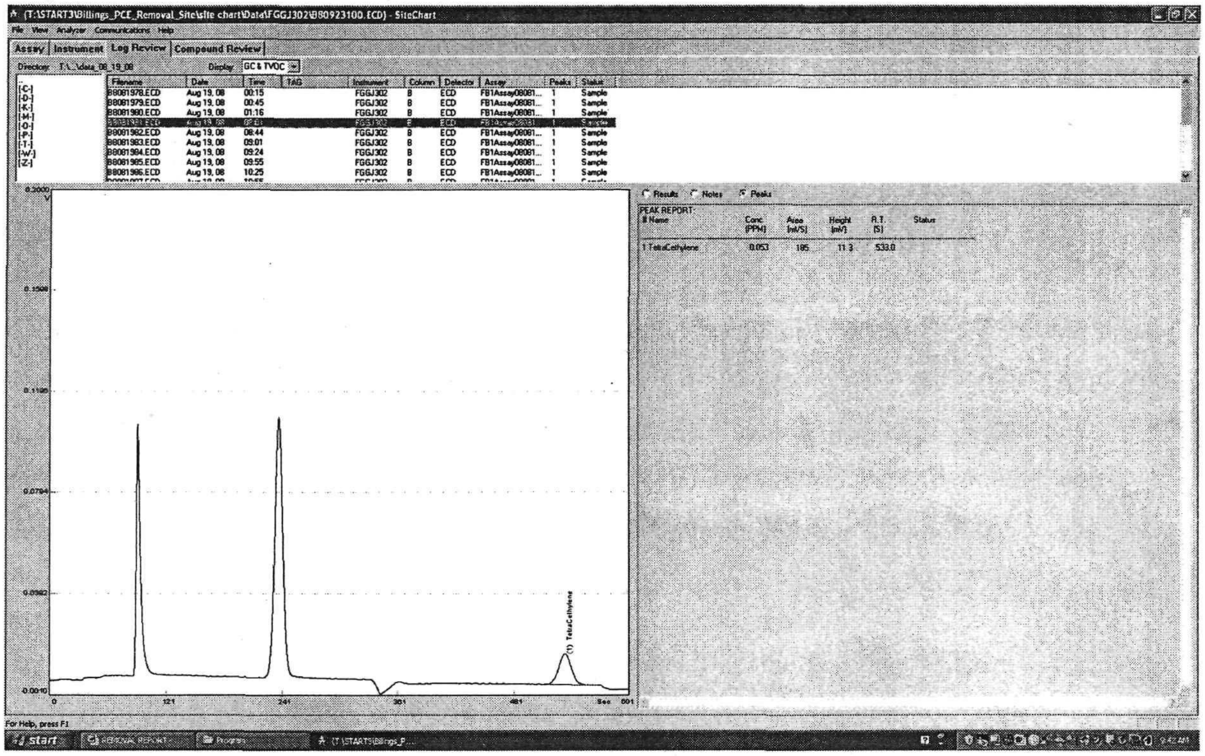
PhotoVAC Voyager PCE concentrations exceeded 500 parts per billion (ppb) on August 20 with the highest PCE concentration in a public area (2nd floor hallway) of 751 ppb during the 0915 to 0935 sample interval. Elevated PCE concentrations (greater than 200 ppb) were also measured in the building on August 21, August 22, and September 14. Graphs that display the PCE concentrations on August 20, September 14, and September 15, and response actions taken are in Appendix I. The complete listing of Voyager PCE results is also in Appendix I.

The Voyagers were set up to transmit and receive data to a central computer in the field laboratory. A null modem and antenna were attached to each unit, which sent data to a receiving antenna attached to the computer. The configuration allowed UOS to monitor the real-time status of the Voyagers and PCE concentrations in different parts of the 711 Central Avenue building.

The Voyagers were calibrated before initial use and as necessary afterwards. A continuing calibration verification (CCV) was conducted on each instrument before and after each day's use. The Voyagers were recalibrated if the CCV failed. The PCE calibration standards were prepared in Tedlar® bags with a laboratory-certified calibration gas. Calibration blanks were also prepared with a zero- VOC air standard. The calibration standards had a range of PCE concentrations from 5 ppb to 500 ppb.

The Voyagers were usually programmed for 20 minute sampling intervals. Each sampling event was composed of a measured amount of air being pulled into the sample chamber and analyzed for approximately 10 minutes. An individual data file was created for each sample. The Perkin-Elmer Photovac SiteChart® software was used to process the data and calculate the PCE concentration from the area under the peak. An example screen shot from the SiteChart software is shown in Figure B below.

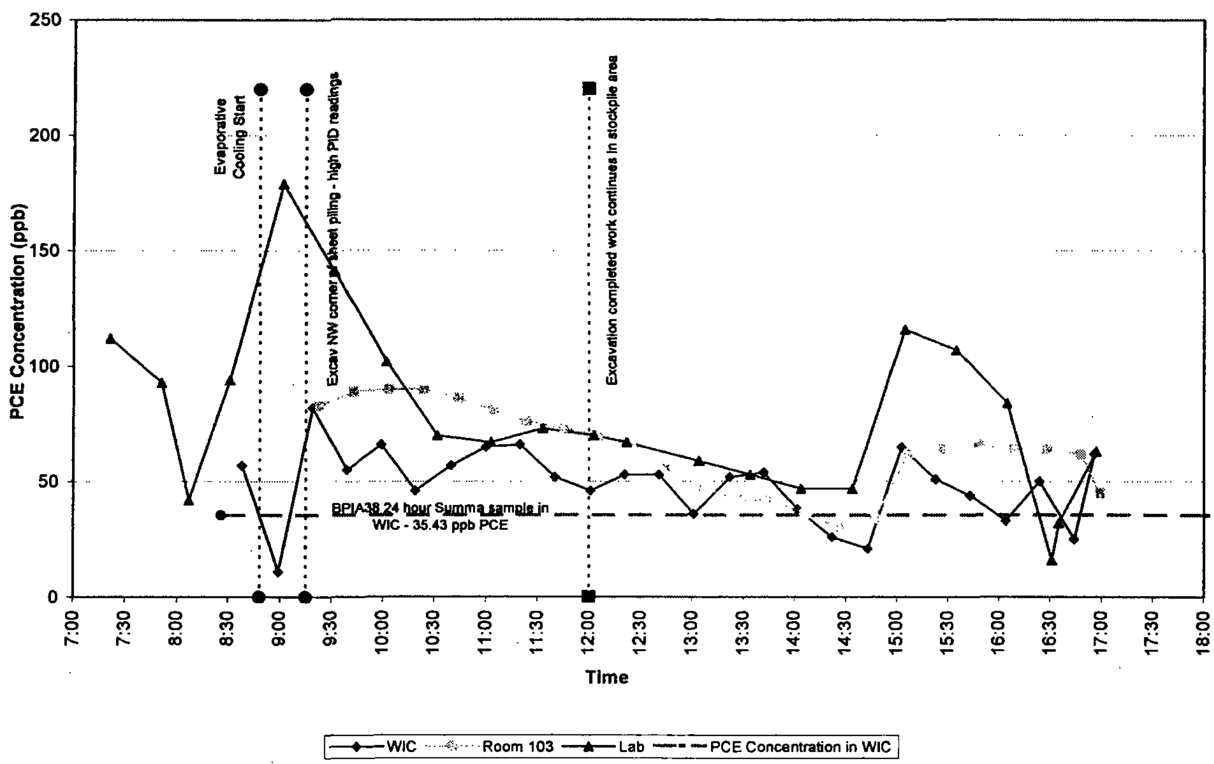
FIGURE B
SiteChart Screen Shot



A graph of the indoor air PCE concentrations and the control actions taken on September 15, 2008, is shown below. During the excavation of highly contaminated soil in the sheet piling containment cell, high PCE concentrations were measured with the Voyagers in 711 Central Avenue. The HVAC bypass system was turned on and a rapid decrease in the indoor air PCE concentrations resulted.

Indoor air samples were collected from inside the 711 Central Avenue building. The sample results are in Appendix A, Table 2. Two samples were collected just prior to the removal, and two were collected during the removal. The samples were collected using Summa canisters, which were submitted to a commercial laboratory for analysis via Method TO-15A. The samples were collected through a regulator over an approximate 24-hour period. The samples were collected on June 19, 2008, August 21, 2008, and September 15, 2008. The highest reported PCE concentration was 240 μg/m^3 in sample BPIA38, collected on September 15, as shown in Figure C below.

FIGURE C
PCE Concentrations in Building During Central Avenue Excavation on September 15, 2008



7.2 OUTDOOR AMBIENT AIR MONITORING AND BADGE SAMPLES

Different instruments and media were used for outdoor air monitoring. The choice of instrument and media depended on the planned use for the data and the PCE concentrations in the area being monitored. The samples were collected per the procedures described in the Air Monitoring and Control Plan and the Addendum to the Plan (UOS 2008b, UOS 2008c).

A hand-held MultiRAE® PID was used to monitor the excavation and stockpile areas. The readings were used for PPE and other health and safety decisions, and to measure VOC concentrations at the site perimeter. The PID has a detection limit of approximately 1,000 ppb.

Photovac Voyagers were used for occasional air sampling/PCE analysis east of the stock pile area. The instruments were used to measure the impact of the treatment/handling work on the nearby neighborhood. The Voyager placement included the northwest fenced parking lot at 711 Central and just outside of the northern stockpile staging area fence. The Voyager PCE results are in Appendix I. The highest PCE concentrations were recorded north of the stockpiles on September 18 and 22 at 981 $\mu g/m^3$ and 2,855 $\mu g/m^3$, respectively.

Passive monitoring badges were used to measure PCE concentrations and worker exposure (Appendix A, Table 3). The badges were worn by ER removal contactor personnel who were working in the excavation and stockpile areas. The badges were 3M Passive Diffusion Badges, which have an approximate detection limit of 1.8 ppb. A commercial laboratory analyzed the badges and reported the total PCE concentrations. The 8-hour exposure limits were calculated by dividing 8 hours by the hours that the badges were worn and multiplying by the total PCE concentrations. The highest reported 8-hour adjusted PCE badge concentration was 10,560 ppb on September 15th. The badge was worn for approximately 3 hours by an equipment operator while working in the stockpile/staging area

7.3 GROUNDWATER SAMPLES AND SAMPLING PROCEDURES

Groundwater samples were collected before, during, and after removal/treatment activities. The samples were collected from wells, temporary sampling points, and from the treatment system tanks of pre-treated and post-treated water. Sample results were used to evaluate areas pre- and post-ISCO and for water treatment evaluation. The groundwater samples and results are in Appendix A, Table 4.

The groundwater samples were collected and identified per the procedures described in the Field Sampling Plan for the Billings PCE Removal Site (UOS 2008a), attached as Appendix K.

The groundwater samples were analyzed for VOCs in the UOS field laboratory via EPA Method 8260; a portion of the samples were also submitted to a commercial laboratory for analysis. To comply with the City of Billings requirements for discharge, a post-treated water sample was analyzed by a Northern Analytical Laboratory for VOCs, metals, and cyanide, via EPA Methods 8260B, 200.8/200.2, and 4500, respectively. City of Billings water disposal requirements and laboratory data are attached in Appendix N. The treated water was in compliance with the City's requirements; analytical results are in Appendix Q.

7.4 SOIL SAMPLES AND SAMPLING PROCEDURES

Soil samples were collected to support all phases of removal activities, including pre-removal planning, excavation confirmation, and stockpile treatment and disposal. The soil samples were collected and identified per the procedures described in the Field Sampling Plan (Appendix K). Soil samples collected from the excavation were named "BPSO" with a sequential numeric identifier. The excavation (BPSO) soil sample log and PCE results are in Appendix A, Table 6.

The samples collected from the initial excavated soil stockpiles were designated with "BPST" and a sequential numeric identifier. The stockpile (BPST) sample log and PCE results are in Appendix A, Table 6.

The samples collected during the sodium permanganate treatment process were designated "BPUS" for untreated soil and "BPTS" for treated soil with a sequential numeric identifier. The untreated and treated soil (BPUS and BPTS) sample log and PCE results are in Appendix A, Table 9.

The collection of representative soil samples from stockpiles and the trackhoe buckets presented challenges due to unequal contamination, volatilization, and mixed lithologies. Individual samples had to accurately represent contamination in stockpiles with up to an estimated 40 yds^3 of soil. The sampling procedure also had to return consistent results when multiple samples were collected from the same stockpile. The samples were quickly prepared and analyzed to minimize volatilization and improve accuracy. To verify the samples were accurate and representative, UOS devised the following sampling preparation procedures for site soils:

- A dedicated 0.75-inch diameter by 3-inch long acetate tube was used for each sample.
- A minimum of five aliquots were packed into the tube from different locations of soil on the stockpile, trackhoe bucket, or other surfaces. A higher number of aliquots were used for larger stockpiles.
- The composite samples were representative of the entire stockpile by including aliquots spaced across the stockpile and from different lithologies.
- Aliquots were collected from "fresh" surfaces dug into the stockpile, trackhoe bucket, excavation walls, and other locations.
- The ends of each sample tube were sealed with caps and/or GLAD Press'n Seal® wrap.

- Most of the sample tubes were immediately analyzed; otherwise, they were placed on ice or refrigerated.

UOS collected soil samples from boreholes installed with the Geoprobe and PowerProbe® to characterize and define excavation areas and boundaries and for planning the ISCO injection points. Core samples that were collected from boreholes not associated with well installations or groundwater samples were identified by "BPBH", the respective borehole number, and the upper and lower depth interval. Core samples collected from well locations or temporary groundwater sample locations were designated "BPGP" or "BPSP," the respective well/sample point number, and the depth interval. The borehole sample log and PCE results are in Appendix A, Table 7.

The soil cores were collected into dedicated acetate liners. Each soil sample was collected by cutting a segment from the soil core/liner. Most of the samples were less than 2 inches thick to represent a narrow depth interval. The soil was kept undisturbed in the acetate liner to minimize VOC loss. Each core segment was immediately wrapped in GLAD Press'n Seal wrap, placed in a plastic bag, and placed in a cooler with ice.

7.5 FIELD LABORATORY SAMPLE PREPARATION AND ANALYSIS

UOS used a sample preparation technique in the field laboratory that was designed to represent all soil in the sample container and minimize VOC loss though volatilization:

- A scupula (small coring tool) was used to collect soil from the entire length of the tube or core section. The coring technique allowed collection of soil in the tube to include all aliquots that were sampled (Appendix B, Photo 823).
- Five grams of soil were quickly weighed, immediately placed in a vial, and immersed in methanol extraction fluid to minimize volatilization.

VOC analysis was performed on-site in a field laboratory (Appendix B, Photos 1064, 1065, and 1066). The field laboratory was self-contained and included the sample preparation and analytical equipment for definitive analysis. Two different methods were employed for VOC analysis depending on the necessary reporting limits and required analyte list.

Waters and soils were analyzed by SW-846 method 8260B (VOCs by GC/MS). Aqueous samples were analyzed via SW-846 method 5030B (Purge-and-Trap for Aqueous Samples). Soil and waste samples were analyzed via SW-846 method 5035 (Closed-System Purge-and-Trap and

Extraction for Volatile Organics in Soil and Waste Samples) for extraction of medium-level soils. This method reported 24 target analytes, 4 internal standards, and 3 system monitoring compounds (surrogates).

Soils requiring analysis for PCE only were analyzed using a hybrid method, which consisted of analyzing the SW-846 method 5035 extract by SW-846 method 8270D injection, and a Method 8260B analysis (semivolatile organic compounds by GC/MS) using direct cool-on column injection. This was a performance-based method, which was verified against the purge-and-trap method, an independent laboratory, and second source standards. This method allowed for a 9-minute run time, compared with a 32-minute run time for the full purge-and-trap method. This method reported PCE, one internal standard, and one system monitoring compound (surrogate).

The GC/MS system included an Agilent 6890 series GC coupled to an Agilent 5973 series MS. Purge-and-trap process was performed by a Tekmar 3100 series sample concentrator. Direct injection was achieved using an Agilent 6890 series automatic liquid sampler.

8.0 RADON-TYPE SYSTEM INSTALLATIONS IN RESIDENTIAL AND COMMERCIAL PROPERTIES

Radon-type venting systems were installed in three residential properties and in a commercial building in February and May 2008. The system installations are described in Appendix O. The radon-type systems were installed at the following addresses:

- 342 Miles Avenue,
- 311 Howard Avenue,
- 632 St. Johns Avenue No. 2, and
- 711 Central Avenue commercial property.

UOS collected indoor air and subslab air samples from the properties before and after the radon system installations. The sample results are in Appendix A, Table 2. The radon systems were installed by ER contractor, Radon Busters (Les Keibler). UOS and ER provided technical support and documented the installations. Radon system standards and procedures referenced for the installations included:

- ASTM International (ASTM) E2121-03 – Standard Practice for Installing Radon Mitigation Systems in Existing Low-Rise Residential Buildings (ASTM 2003), and

- EPA 402-R-93-078 – Radon Mitigation Standards (EPA 1994).

The general radon system steps were:

- Collect pre-installation 24-hour indoor air and subslab air samples,
- Measure pre-installation carbon monoxide concentrations in indoor air,
- Select location for initial vent pipe and pump system,
- Drill hole through slab and excavate soil under slab for sump pit,
- Install radon system, and
- Run radon system and measure vacuum pressures in test ports drilled through the slab.

9.0 SOURCE AREA REMOVAL AND MITIGATION ACTIVITIES

The source area removal/remediation action was conducted from July through December 2008. Climate data from the National Weather Service is attached in Appendix P. Photographs of the field activities are in Appendix B.

Soil in the source area was contaminated by PCE that leaked through joints and cracks in pipelines and the storm sewer line extending from the BSL facility to the intersection of 7th Street West and Central Avenue. The source area is described in detail in the Site Assessment Report (UOS 2009). The thickness and characteristics of the fine-grained soil (and corresponding depth of the gravel aquifer) differed across the source area. Due to these differences in geology and multiple release points from pipeline joints and cracks, different removal/remediation technologies were used in different parts of the source area.

The source area was divided into three removal sub-areas shown in Figure 2:

- Storm Sewer Line Treatment/Excavation Area – East Section of Central Avenue,
- Sheet Piling Containment Cell Installation and Excavation Area – West Section of Central Avenue, and
- BSL Alley – Excavation and Treatment Area.

9.1 STORM SEWER LINE TREATMENT/EXCAVATION AREA – EAST SECTION OF CENTRAL AVENUE

The storm sewer treatment/excavation area was located on Central Avenue extending from the east end of the sheet piling containment cell to 7th Street West (Figure 2). The treatment/excavation area was approximately 160 feet long by 15 feet wide. The excavation depths varied depending on the depths of contamination.

The storm sewer excavation area differed from the sheet piling area section of Central Avenue and the BSL alley in geology and contaminant distribution. Core samples collected during the site assessment were used to develop the general lithologic description shown in the table below.

TABLE A
General Lithology of the Storm Sewer Line Treatment/Excavation Area

Top	Bottom	Description
0	1	Asphalt and Road Base Fill
1	8	Gravel Base Fill (in utility corridor)
1	8	Silty Clay/Clayey Silt
		Silty Sand
		Clay
8	9	Silt
9	14	Silty Sand
14	15	Sand
15	30	Sandy Gravel
30		Shale Bedrock

The nature of the contamination in this area was as follows:

- Contamination apparently leaked through the joints where sections of the storm sewer are connected.
- The highest PCE concentrations in soil were primarily below the storm sewer to the sand/gravel contact (approximately 8 to 15 feet bgs).
- Samples from wells screened in the deep part of the aquifer (25 to 30 feet bgs) had relatively low PCE concentrations, indicating that DNAPL was not present in bedrock.

- The highest PCE concentrations in groundwater were in samples collected closest to the source (BSL), and the concentrations dropped sharply past the 7th Avenue West and Central Avenue intersection.
- The localized hot spots of PCE soil and groundwater contamination indicated that certain joints in the storm sewer had gaps, failed tar seals, and/or points of accumulation where larger quantities of PCE leaked.

The following removal activities were conducted in the storm sewer line treatment/excavation area:

- ISCO treatment before excavation with Modified Fenton's reagent;
- Excavation of uncontaminated soil above the storm sewer and removal of the storm sewer line;
- Excavation of contaminated soil from under the storm sewer line to just below the water table;
- Backfilling with clean fill and replacement of the storm sewer line; and
- Post-excavation *in situ* treatment of area with Modified Fenton's reagent.

Modified Fenton's reagent is hydrogen peroxide with an iron catalyst that is used to destroy chlorinated compounds via ISCO. The Modified Fenton's reagent was applied by ER Contractor, ISOTEC (Appendix B, Photos 1023, 1024, and 1025). The field activities are described in the *In Situ* Chemical Oxidation Remediation Program Report (ISOTEC 2008) (Appendix L). ISOTEC conducted three separate reagent applications, two before and one after excavation.

The first two ISCO events were conducted from June 19 through 20, 2008 and June 23 through 24, 2008 along Central Avenue. The events were prior to excavation activities for the purpose of reducing contamination that might be liberated during source area excavation. The reagent was injected into holes spaced 25 feet apart through slotted Geoprobe screen at 14 to 19 foot bgs screened intervals. The reagent was applied to treat the contamination in the fine-grained sand and gravel within the vadose zone and below the water table.

The excavation was initiated on July 19, 2008 (Appendix B, Photo 1060). The excavation footprint is shown in Figure 4. The initial step was to remove the asphalt from the entire excavation area. The excavation was advanced in segments from east to west. Each segment consisted of an excavation approximately 10 feet long by 16 feet deep, and the width of the storm and sanitary sewer line corridor. UOS laid out a grid along the street that was used to identify the coordinates of each segment and sample locations (Figure 9). The top 5 to 6 feet of uncontaminated soil was excavated and disposed of as non-hazardous material at the Billings Regional Landfill, a RCRA Subtitle D facility. The concrete storm sewer line, clay sewer line, and underlying soil were stockpiled in the staging area. The soil was excavated to the gravel contact at approximately 16 feet bgs (approximately 1 foot below the water table). Soil samples were collected from sidewalls of the excavation to guide and confirm the removal (Appendix A, Table 5). Final surface samples are shown on Figure 4. Samples were identified by a chronological numerical identifier and depth. The grid coordinates were also noted for each sample (Appendix A, Table 5).

Each open segment was backfilled while excavation began on the next segment. Only a small area was kept open because of the instability of the non-native fill present from ground surface to approximately 11 feet bgs. The sidewalls of the excavation pit were unstable and prone to collapse in the non-native fill.

ER coordinated the site restoration work with the City of Billings. Specifically, ER contracted the reinstallation of the storm and sanitary sewer lines; backfill and compaction of the excavation; paving of Central Avenue, sidewalk, and curb; and gutter reinstallation. The work was completed in accordance with the City of Billings requirements and approved by City of Billings inspectors.

The third application of Modified Fenton's reagent was performed on October 28, 29, and 30, 2009. The application was focused in the intersection of 7th Street West and Central Avenue where elevated PCE concentrations were found near a storm sewer manhole. The injection intervals at all locations were 10 to 15 and 15 to 20 feet bgs. Reagent was also injected into the 20 to 25 foot bgs interval adjacent to the storm sewer manhole.

9.2 SHEET PILING CONTAINMENT CELL INSTALLATION AND EXCAVATION AREA – WEST SECTION OF CENTRAL AVENUE

The sheet piling installation and excavation area was located on Central Avenue beginning at the BSL facility and extending eastward to the approximate center of the 711 Central Avenue property (Figure 2). This area had a relatively thicker sequence of clay and silt, a deeper gravel contact, and relatively higher PCE concentrations. Sheet piling was installed to enclose the highly DNAPL-contaminated soil and to allow dewatering and deep excavation of the soil.

The approximate 5,330 square foot area enclosed by sheet piling was approximately 140 feet by 60 feet and had a perimeter of about 330 linear feet (Figure 5). The sheet piling was driven into weathered shale bedrock approximately 29 feet to 31 feet bgs. The sheet piling was also for long-term/permanent enclosure and isolation of the contaminated soil and groundwater.

A sheet piling containment cell in the west section of Central Avenue was deemed necessary for the following reasons:

- Free-phase PCE/DNAPL was present in the fine-grained sediments below the water table.
- The low permeability of the strata was not conducive to injection of a chemical oxidizer or amendments for bioremediation.
- Sheet piling would isolate the area and allow it to be dewatered prior to excavation.
- Sheet piling functioned as shoring to support the sidewall during excavation of the enclosure.
- Disturbing the fine-grained sediments during a wet excavation (without dewatering) could have caused the dense free-phase PCE to migrate into the gravel and onto the bedrock surface.
- The remaining contaminated soil and groundwater inside the sheet piling containment cell will be isolated and no longer a source for downgradient contamination.
- The remaining contaminated soil and groundwater within the enclosure will be a static environment that can be remediated under controlled conditions. This allows more time and more options (such as bioremediation), and a potential cost savings.

Groundwater in the sheet piling area was approximately 14 feet bgs; free-phase PCE/DNAPL was discovered at a depth of about 19 feet; and bedrock is about 30 feet bgs. Soil cores were collected with a Geoprobe to log the lithologies along Central Avenue and along the BSL alley. The investigation revealed a thick sequence of fine-grained material associated with a bowl-shaped depression in the underlying gravel layer. The strata in the sheet piling area are shown in the N-S and E-W cross sections attached in Appendix D. Soil Boring Logs/Monitoring Well Construction Diagrams are in Appendix E. Core samples were collected from borehole MIP14-BH (near the junction of the BSL pipeline and storm sewer), and other boreholes were used for the general lithologic descriptions presented below:

TABLE B
General Lithology of the Sheet Piling Containment Area

Top	Bottom	Description
0	1	Asphalt and Road Base Fill
1	8	Gravel Base Fill (in utility corridor)
8	18	Silty Clay
		Silty Sand
		Clay
		Silty Sand
		Clay
18	19	Silty Sand
19	25	Sand
25	30	Sandy Gravel
30		Shale Bedrock

The following removal activities were conducted in the sheet piling installation and excavation area:

- Installed a permanent sheet piling containment cell,
- Dewatered the enclosure,
- Treated the water for discharge to the City of Billings sanitary sewer,
- Excavated accessible shallow and deep highly contaminated soil,
- Backfilled the enclosure, and
- Trimmed and notched the sheet piling below the ground surface to allow utility line passage and re-paving of Central Avenue.

Work began in the area in July 2008 with the truncating/rerouting of utility lines and stripping of asphalt (Appendix B, Photo 1030). The sheet piling installation began on July 10, 2008. The sheet piling was installed by the ER contractor, Copp Construction. Each sheet was 36 feet long by 2.5 feet wide. The sheet piling was ASTM A572 Grade 50 with ball/socket type connections.

WADIT® joint sealant was applied to each sheet prior to installation (Appendix B, Photos 1028 and 1091). WADIT is an elastomer, which is modified with styrene butadiene (rubber) (PilePro 2008). The WADIT was pre-applied to the sheet piling interlocks prior to delivery to the site. A sample of WADIT was provided to UOS for cursory testing. The WADIT dissolved in neat (100 percent) PCE, but remained intact in a PCE-saturated water (>150 parts per million [ppm]) solution.

Copp Construction installed an H beam framework to guide the sheet piling during installation (Appendix B, Photos 1036 through 1038). The sheet piling was driven into the ground with a crane-mounted hydraulic hammer or vibrator (Appendix B, Photos 1050 and 1054). The type of equipment depended on the lithology. Vibration was less effective in clayey soil. Hammering was used in low-clay soil and bedrock. The piling sheets were advanced incrementally to prevent binding and keep them vertical. The sheet piling installation was completed on August 25, 2008. All sheets were driven into the upper part of the weathered shale bedrock, and the approximate depths of each sheet are in Appendix M. Soil core samples were collected from various locations adjacent to the sheet piling to identify bedrock depth.

Copp Construction installed braces and cross beams to strengthen the sheet piling walls and allow it to shore the excavation (Appendix B, Photos 1202, 1203, 1207, and 1236). ER began contaminated soil excavation within the sheet piling on September 3, 2008. The excavation was started on the east end of the sheet piling containment cell (Appendix B, Photos 1301, 1302, and 1303). The excavation at the east end was advanced to a depth of approximately 16 feet bgs, to the gravel contact, just below the water table. Due to the thicker sequence of fine-grained soil and deeper gravel contact, soil was excavated to a greater depth in the western part of the sheet piling containment cell.

ER installed an 8-inch diameter PVC pipe inside the sheet piling containment cell for potential use as a dewatering well (Appendix B, Photos 1291 and 1292). A submersible pump provided by Rain for Rent was placed in the well for a pump/capacity test. The well could not produce sufficient volume for a practical dewatering operation.

UOS installed six 2-inch monitoring wells inside the sheet piling containment cell to measure water levels and for potential use as dewatering wells (Figure 5). Pump/capacity tests revealed that the tested wells had the capacity to produce sufficient volumes for dewatering. However, the self-priming centrifugal pump purchased for the operation did not produce a sufficient volume to effectively dewater the containment cell.

After the unsuccessful attempts at dewatering using conventional wells and pumps, ER and UOS devised a method for installing a well that could be used with a high capacity "trash" pump at the floor of the excavation. The dewatering well was constructed of 6-inch diameter threaded steel pipe that was slotted. A PowerProbe® solid expendable point was attached to the bottom of the pipe. ER used a trackhoe with a hammer/vibrator pad to drive the pipe into the gravel. The well was placed into the 15-foot deep excavation pit inside the enclosure (Appendix B, Photos 1236, 1240, 1241, and 1245). Pumping was initiated on September 11, 2008. The water was piped to a treatment system provided by ER contractor, Rain for Rent. The water table within the sheet piling containment cell was successfully lowered prior to the deep excavation. The 2-inch wells installed by UOS were used to monitor the water table during the dewatering operation. Water levels are in Figure 6. The successful dewatering of the sheet piling containment cell indicated that the base and seams of the enclosure were relatively watertight. The highly contaminated soil in the western part of the enclosure was excavated to a depth of approximately 24 feet bgs.

The Rain for Rent water treatment system is shown in Appendix B, Photos 1247, 1306, and 1307. The water treatment system consisted of frac tanks for holding pre- and post-treated water, a sand filter battery, and a carbon treatment unit. UOS collected pre- and post-treated water samples, which were submitted to a commercial laboratory and analyzed at the site field laboratory. The water was treated to reduce chemical concentrations to meet the City of Billings discharge specifications (Appendix N). Sample results were provided to the City of Billings for discharge approval. Treated water was discharged into the city sanitary sewer. Analytical results of pre- and post-treated water are in Appendix A, Table 8.

Soil samples and PCE concentrations collected from the sheet piling containment cell are in Appendix A, Table 5. The sample locations were based on the grid coordinates shown on Figure 9. The final surface sample location and PCE concentrations are shown on Figure 5.

After the excavation of accessible heavily contaminated soil, ER filled the sheet piling containment cell with engineered sandy gravel backfill. The backfill was compacted to meet specifications required by the City of Billings. Copp Construction cut and notched the sheet piling below grade to allow utility line installation, backfilling, and repaving (Appendix B, Photo

1357). The work in the sheet piling containment cell area was completed on September 15, 2008. The sheet piling construction diagrams are attached as Appendix M.

9.3 BSL ALLEY – EXCAVATION AND TREATMENT AREA

The BSL alley excavation and treatment area was located between the BSL building and the 711 Central Avenue property line (Figure 2). The excavation and treatment area extends from the north end of the BSL building to the sheet piling wall. Photos of the excavation activities are in Appendix B. A general lithologic description near the center of the area is presented in Table C below:

TABLE C
General Lithology of the BSL Alley Area

Top	Bottom	Description
0	1	Asphalt and Road Base Fill
1	5	Silt
5	11	Clay
11	14	Silty Sand
14	17	Sand
17	30	Sandy Gravel
30		Shale Bedrock

The investigation in the BSL alley revealed that:

- The contamination leaked from the pipelines connected to floor drains in the facility.
- The highest PCE concentrations were primarily in the soil below pipelines connecting BSL floor drains to the storm sewer. PCE sludge was found in the floor drain pipeline.
- Samples from wells screened in the deep part of the aquifer (25 to 30 feet bgs) had relatively low PCE concentrations, indicating that DNAPL was not present in the deep part of the aquifer or bedrock.
- The majority of contaminated soil was from about 5 to 16 feet bgs — under the pipelines to the gravel contact.
- The highly contaminated soil did not extend beyond the BSL eastern property line.

The following removal activities were conducted in the BSL alley:

- *In situ* treatment before excavation with Modified Fenton's reagent,
- Excavation of uncontaminated soil above the pipelines from the facility,
- Installation of a flowable fill concrete wall below grade to support the BSL building foundation during excavation,
- Excavation of contaminated soil,
- Backfilling with clean fill and replacement of the pipeline from the BSL facility, and
- Post-excavation *in situ* treatment of the area with Modified Fenton's reagent.

The Modified Fenton's reagent was applied by ER Contractor, ISOTEC (Appendix B Photos 1016 through 1022). The field activities are described in the *In Situ* Chemical Oxidation Remediation Report (ISOTEC 2008) (Appendix L). ISOTEC conducted four separate reagent application events, before, during, and after excavation activities. The first and second application events were in June 2008, the third application was in August 2008, and the fourth event was in October 2008.

The first two ISCO events were conducted from June 19 through 20, 2008 and June 23 through 24, 2008 in the BSL alley. The events were prior to excavation activities for the purpose of reducing contamination that might be liberated during source area excavation. The reagent was injected into holes spaced 25 feet apart through 14 to 19 foot screened intervals. The reagent was injected from slotted Geoprobe screen at 10 to 15 feet bgs and 15 to 20 feet bgs, respectively.

UOS collected core samples, installed monitoring wells, and collected groundwater samples from the alley prior to excavation activities. The alley investigation is described in the Site Assessment Report (UOS 2009). The extent of soil contamination was observed to be within the BSL property boundary. The soil core samples revealed that contamination migrated laterally in thin (less than 1-foot thick) layers of relatively permeable soil. Highly contaminated soil was identified in the alley adjacent to the BSL building where the pipelines connected to the floor drains emerge from the building.

The excavation began on August 6, 2008. The initial step was to remove the upper 3 feet of uncontaminated asphalt and soil from the entire alley area. The uncontaminated soil was disposed of as non-hazardous material at the Billings Regional Landfill. Trenches were excavated adjacent to the BSL building and filled with flowable fill concrete, creating a subterranean wall (Appendix B, Photo 1149). The concrete wall was installed to protect and support the BSL foundation during the excavation. Most of the wall was approximately 3 feet wide and 8 feet deep (11 feet below original ground surface). The wall was constructed in 5-foot long sections approximately 4 feet from the BSL footer. Due to heavy contamination where the pipeline was connected to the north floor drain, the soil was excavated to approximately 14 feet below original surface and adjacent to that part of the building. The soil adjacent to the building's other drain pipeline was also contaminated; however, an electric transformer pad prevented excavation close to the building (Appendix B, Photos 1131 and 1133).

The alley excavation was advanced in segments from north to south. Each segment consisted of an excavation approximately 10 feet long by 12 feet wide. UOS laid out a grid in the alley that was used to identify the coordinates of each segment (Figure 9). The soil was excavated to a depth of approximately 15 to 16 feet below original ground surface (just below the top of the gravel and the water table). The lateral extent of the excavation was guided by sidewall samples, which were analyzed by UOS in the field laboratory. Sample PCE concentrations are in Appendix A, Table 5. Samples were identified by a chronologic numerical identifier and depth. The grid coordinates were also noted for each sample. Final surface samples and PCE concentrations are shown on Figure 7.

Each open segment was backfilled and compacted before the next segment was excavated. This practice kept a limited portion of the flowable fill support wall exposed at any one time.

PCE sludge was present in the pipeline that connected the floor drain in the BSL building to the manhole in the alley (Appendix B, photos 1171, 1172, 1173, 1175, 1176, and 1181). A sample of the sludge, BPSLUDGE02, had a PCE concentration of 181,567 mg/kg (Appendix A, Table 5).

Samples collected from the floors of certain excavated cells revealed that elevated PCE concentrations were present in the gravel. The contaminated soil below the water table could not be excavated due to the instability of the gravel and the potential of disturbing and liberating entrained contamination. *In situ* treatment was selected as an alternative to deeper excavation. ER contracted ISOTEC to conduct the treatment. ISOTEC mobilized to the site and began applying Modified Fenton's reagent, which was mixed into soil near water table depth in the open excavation on August 22, 2008 (Appendix B, Photos 1191 to 1199). The reagent was applied between the 75 to 95 south grid coordinates (Figure 7). The area between 8 and 18 south was re-excavated on August 23, 2008 for Fenton's reagent application. The Fenton's reagent was mixed with a trackhoe into the soil at the base of the 14-foot excavation.

After the excavation and backfilling were completed, additional Modified Fenton's reagent was injected into the BSL alley from October 28 to 30, 2008. The Modified Fenton's reagent was applied to the entire alley. An additional quantity was applied to the area between the flowable fill wall and the BSL building by the BSL electric transformer pad where contaminated soil could not be excavated The reagent injection depth intervals were 10 to 15 feet bgs, 15 to 20 feet bgs, and 20 to 25 feet bgs adjacent to the transformer pad.

The BSL drainage pipe, water, gas, and electric lines were reinstalled in the alley after backfilling was completed. The drainage line was eventually reconnected to the storm sewer line because, although the floor drain inside the BSL building was plugged, the pipelines were still needed to discharge water from the roof drain.

10.0 SOIL STAGING TREATMENT AND DISPOSAL

The excavated soil was initially separated into one of three groups in the staging area; highly, moderately, or slightly contaminated. This initial segregation was based on field screening with a PID and other observations. The stockpiles were sampled and analyzed in the on-site laboratory to determine PCE concentrations for disposal. The non-hazardous soil, with PCE concentrations less than 14 mg/kg, was transported and disposed of at the Billings Regional Landfill. The most contaminated soil, with PCE concentrations greater than 500 mg/kg, was transported and disposed of at Clean Harbors, a RCRA Subtitle C facility. On site soil treatment was selected as a cost saving alternative to disposal at a RCRA Subtitle C facility for the remaining soil.

START conducted bench and pilot scale treatment studies and determined that sodium permanganate would be used based on effectiveness and efficiency. All soil was successfully treated to reduce final PCE concentrations to below 14 mg/kg. The treated soil was transported to the Billings Regional Landfill for disposal as non-hazardous waste.

Detailed descriptions of soil staging, handling, treatment, and disposal are in the following sections.

10.1 EXCAVATED SOIL – INITIAL STOCKPILING, CLASSIFICATION, AND DISPOSAL

A general procedure for soil screening and categorization was implemented to minimize handling and disposal costs, and included the following steps:

- Each trackhoe bucket of excavated soil was screened with a MultiRAE PID to determine the relative VOC concentration.
- The soil was staged in the storage area into high, medium, or low concentration stockpiles, designated BPST##, which were approximately 40 yds^3.
- Each stockpile was sampled and analyzed by UOS on the field GC/MS.
- The stockpiles were classified based on their respective PCE concentrations for future treatment or immediate transportation and disposal.

ER prepared a site soil stockpile, treatment, and storage area in the vacant lot west of and adjacent to the BSL facility. The lot, which is owned by BSL, had a pre-existing perimeter fence. ER prepared the area by grading it and laying out a HDPE plastic liner in the northern part of the lot. A soil layer was placed on the liner to protect it from tears/damage. The stockpile area had gated entrances at the north and south ends.

Excavated soil was classified by relative PCE concentration by using monitoring/screening instruments and by the location of the excavation. UOS used a MultiRAE PID to screen vapors emitted from freshly excavated soil in the trackhoe bucket. Depending on the vapor concentration, each dump truck load of contaminated soil was placed into high, medium, or low concentration piles. Each stockpile was approximately 40 yds^3. UOS collected composite samples from each stockpile and analyzed the stockpile samples in the field laboratory. Stockpile PCE concentrations sample results are in Appendix A, Table 6.

When the excavation reached the planned depths and lateral boundaries, confirmation samples were collected from sidewalls and excavation floors. The samples were usually collected directly from the trackhoe bucket into 3-inch long acetate tubes using the procedures described below. These samples were identified by "BPSO," a sequential number, and the upper and lower depth interval. For example, a soil sample collected from the 13- to 16-foot depth interval that is the

56th sequential sample will be labeled BPSO56_13_16. The sample locations were based on a site-specific grid layout (Figures 4 and 5).

Approximately 6,600 tons (4,440 yds^3) of soil was excavated during the removal. All excavated soil was staged in or adjacent to the stockpile area (Figure 2). UOS developed a soil segregation and stockpile management procedure based on relative contamination. Composite samples were collected from the soil stockpiles for analysis by UOS in the field laboratory with the Agilent GC/MS. The samples collected from these stockpiles were identified as "BPST" and a numerical identifier. Clean Harbors, Inc., the RCRA Subtitle C Disposal Facility, provided a concentration/cost schedule that was used to define the Tier I through Tier III PCE concentrations designations:

- <14 ppm was below the threshold for disposal as RCRA hazardous waste,
- 14 ppm to <59 ppm was designated Tier I,
- 60 ppm to 499 ppm was designated Tier II, and,
- 500 ppm or greater was designated Tier III.

The disposal costs differed for each category, and the Tier III cost of approximately $600/ton was much higher than the other categories. The goal of the initial segregation was to minimize the amount of Tier III soil by not mixing highly contaminated soil with less contaminated soil.

The 14 ppm PCE non-hazardous classification was a conservative value based on the TCLP concentration for hazardous waste of 0.7 mg/L multiplied by 20. The TCLP method uses a 20x dilution. For example, a sample with 14 ppm PCE that has 100 percent leachable PCE would have a TCLP result of 0.7 mg/kg.

Soil samples were also collected from selected stockpiles that had PCE concentrations greater than 14 ppm for TCLP analysis. TCLP analysis performed on samples collected from many of the remaining stockpiles revealed that the PCE was highly leachable. Samples with relatively low total PCE concentrations exceeded the 0.7 mg/L threshold concentration for RCRA hazardous waste (Appendix A, Table10).

The non-hazardous soil with PCE concentrations <14 ppm and/or TCLP PCE concentrations <0.7 mg/l was disposed of at the Billings Regional Landfill. Approximately 1,320 tons (880 yds^3) of non-hazardous soil was disposed of at the landfill.

The Tier III stockpiles (PCE concentrations >500 ppm) were disposed of at the Clean Harbors facility. ER loaded the soil into containers supplied by Clean Harbors and the soil was transported to the facility. Approximately 600 tons of Tier III soil was sent to Clean Harbors for disposal (Appendix A, Table 6).

The EPA tasked UOS to explore on-site treatment alternatives for the approximately 4,680 tons (3,120 yds^3) of remaining soil with PCE concentrations greater than 14 mg/kg. These remaining stockpiles were consolidated into large Tier I and Tier II stockpiles in the staging area.

10.2 BENCH-SCALE AND PILOT-SCALE TREATMENT TESTS

The EPA On-Scene Coordinator (OSC) tasked UOS to investigate on-site treatment as a cost-saving alternative to disposal at the Clean Harbors RCRA Subtitle C disposal facility. The goal of on-site treatment was to reduce the PCE concentrations to less than 14 mg/kg for disposal at the local Billings Regional Landfill. The tests are detailed in Appendix J. Bench- and pilot-scale tests were conducted to evaluate the feasibility, practicality, effectiveness, and cost of various treatment chemicals.

UOS conducted a series of bench-scale treatment studies and a pilot test. The tests included:

- Soil drying/volatilization test,
- Sodium permanganate bench test,
- Potassium permanganate bench test,
- RegenOX oxidant bench test,
- Sodium persulfate bench test, and
- Sodium permanganate pilot test.

Based on these studies, UOS recommended sodium permanganate as the most practical and effective chemical for soil treatment. The benefits of sodium permanganate were:

- Effective PCE reduction,
- Fast reaction time,
- Soil not liquefied,

- No pH adjustment necessary,
- Ease of handling, and
- Fewer mixing steps.

Pilot-scale tests were conducted on small batches of soil (12 to 15 yds^3) to refine the sodium permanganate treatment process for planning the treatment mixtures/quantities. The pilot tests generally revealed that most of the reduction in PCE concentrations occurred within 24 hours of applying the sodium permanganate.

10.3 SOIL TREATMENT AND DISPOSAL

ER constructed a below-grade concrete vat for soil treatment in the stockpile area on October 8, 2008 (Appendix B, Photo 1421).

The general soil treatment procedure was:

1. Extract 12 or 15 yds^3 of soil from the main stockpile to create a treatment stockpile.
2. Assign a numerical ID to the stockpile and place an ID flag in the pile (the flag remains with the pile before and after treatment).
3. Collect a composite sample from the stockpile and analyze it with the field laboratory GC/MS.
4. Determine the amount of sodium permanganate and water for treatment based on the PCE concentration of the pile (this information is written on the flag).
5. Place soil in treatment vat and mix in the sodium permanganate and water.
6. Allow treated soil to sit a minimum of 24 hours, or until the purple color has faded.
7. Collect composite sample from stockpile and analyze it on the field laboratory GC/MS.
8. Ship the treated soil with a PCE concentration <14 mg/kg to the Billings Regional Landfill.
9. Re-treat and re-analyze soil with a PCE concentration >14 mg/kg.

Photos of the soil treatment process are in Appendix B. The initial treatment was conducted on 17 soil piles that were 12 yds^3 in size (approximately 204 yds^3) from October 23 through 29, 2008

(Appendix A, Table 9). The observations and sample data from this initial period were used to refine the treatment procedure and quantities.

Full-scale treatment of 15 yd^3 soil batches was initiated on October 29, 2008 and completed on December 9, 2008. The initial quantities of sodium permanganate and water added to soil were based on the treatment study and initial treatment data. Observations and PCE results were used to continually refine the mixture to arrive at the treatment matrix show in Table D below.

TABLE D
Sodium Permanganate Quantities for Soil Treatment

PCE Conc. (PPM)	Pile (cubic yards)	Initial Quantitiy of 20% NaMnO4 (gal)	90% of Initial (gal)	80% of Initial (gal)	70% of Initial (gal)	60% of Initial (gal)	50% of Initial (gal)
14 to 50	15	56	51	45	39	34	28
51 to 100	15	79	71	63	55	47	39
101-150	15	101	91	81	71	61	51
151-200	15	135	122	108	95	81	68
201-250	15	169	152	135	118	101	84
251-300	15	203	182	162	142	122	101
301-400	15	236	213	189	165	142	118

Excessive NaMnO4 observed
Excessive NaMnO4 inferred
Correct NaMnO4 observed
Correct NaMnO4 inferred

Insuffiecient NaMnO4

The ideal quantities of sodium permanganate for each range of PCE concentrations are shaded green. If an excessive quantity of permanganate was used, the soil remained purple and didn't fade to brown. Insufficient sodium permanganate resulted in PCE concentrations remaining above the 14 mg/kg goal.

Most of the permanganate-treated soil was allowed to react for at least 24 hours prior to sampling and analysis. The color change from purple to brown/natural was used as an indication of the progress of the permanganate reaction. The soil was usually not sampled until the purple faded. Treated soil that remained purple was either rehydrated with water and stirred or combined with untreated/undertreated soil.

The approximate quantity of soil treated from October 23, 2008 to December 9, 2008 was 3,600 tons (2,400 yds^3) (146 piles x 15 yds^3 plus 17 piles x 12 yds^3) (Appendix A, Table 9).

The approximate quantity of soil that was sampled and not treated because the PCE concentration was below 14 ppm was 1,080 tons (720 yds^3) (48 piles x 15 yds^3). Soil stockpiles with a PCE concentration less than 14 ppm were non-hazardous and were disposed of at the Billings Regional Landfill. The final shipment of soil was transported to the Billings Regional Landfill on December 9, 2008.

ER removed the concrete treatment vault and backfilled the hole. The stockpile/treatment area was scraped, and confirmation samples were collected to test for residual contamination. Final surface sample results are in Appendix A, Table 5. The area was filled to grade with clean backfill.

The on-site treatment and disposal of treated soil at the regional landfill saved an estimated $700,000 compared to disposal at a Subtitle C facility (Figure 8).

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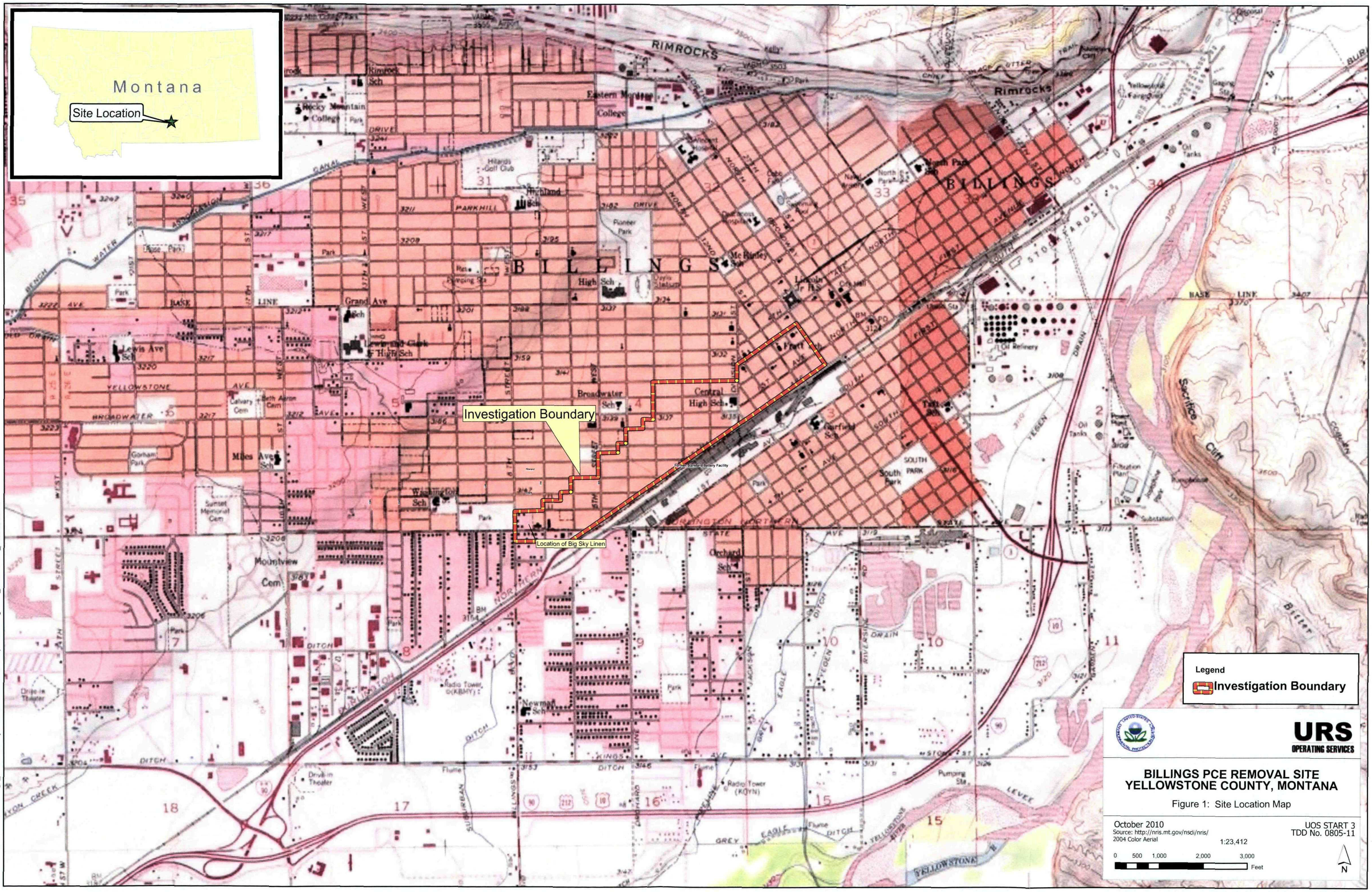

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PCE Action Levels

100,000 ppb — Occupational Safety and Health Administration Permissible Exposure Limit (PEL)

"The concentration of a substance to which most workers can be exposed without adverse effect averaged over a normal 8 hour per day, 40 per work week."

25,000 ppb — American Conference of Government Industrial Hygienists (ACGIH) Threshold Limit Value (TLV)

"The TLV represents the concentration at which most workers can be exposed without adverse effects it is expressed as a time weighted average."

10,000 ppb — EPA Upper Recommended Exposure Limit

Potential Response Actions:
-Apply Vapor Suppression
-Shift Excavation schedule
-Evacuate Building
-Shut Down Excavation

2000 ppb — Odor Threshold

Potential Response Actions:
-Temporarily Suspend Excavation
-Work to Bring Concentration Down

500 ppb — Safe Short Term Office Worker Exposure Limit

Potential Response Actions:
- HVAC Controls
- Increase Monitoring

18 ppb — Safe Long Term Office Worker Exposure Limit

Ppb = Parts per Billion

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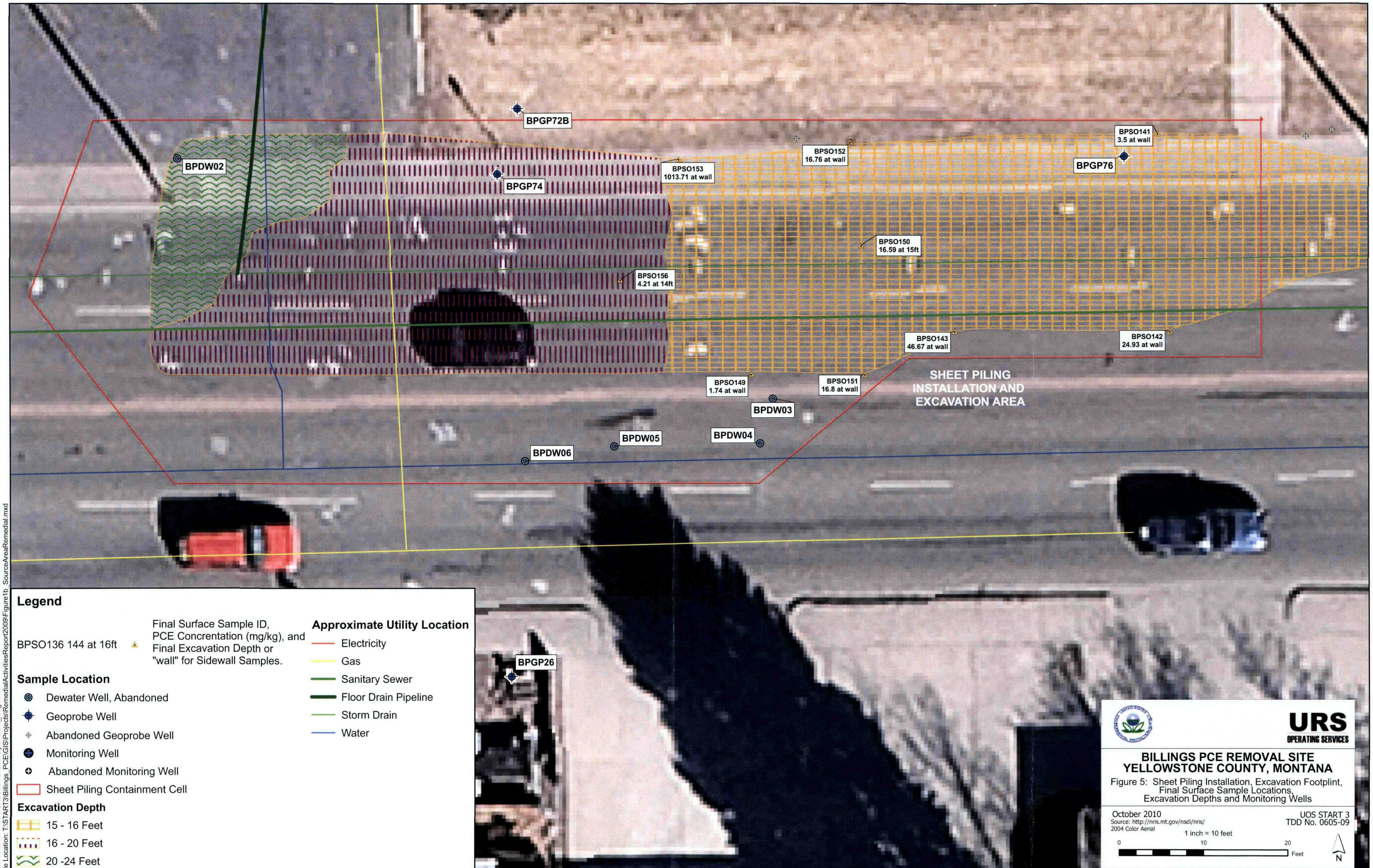

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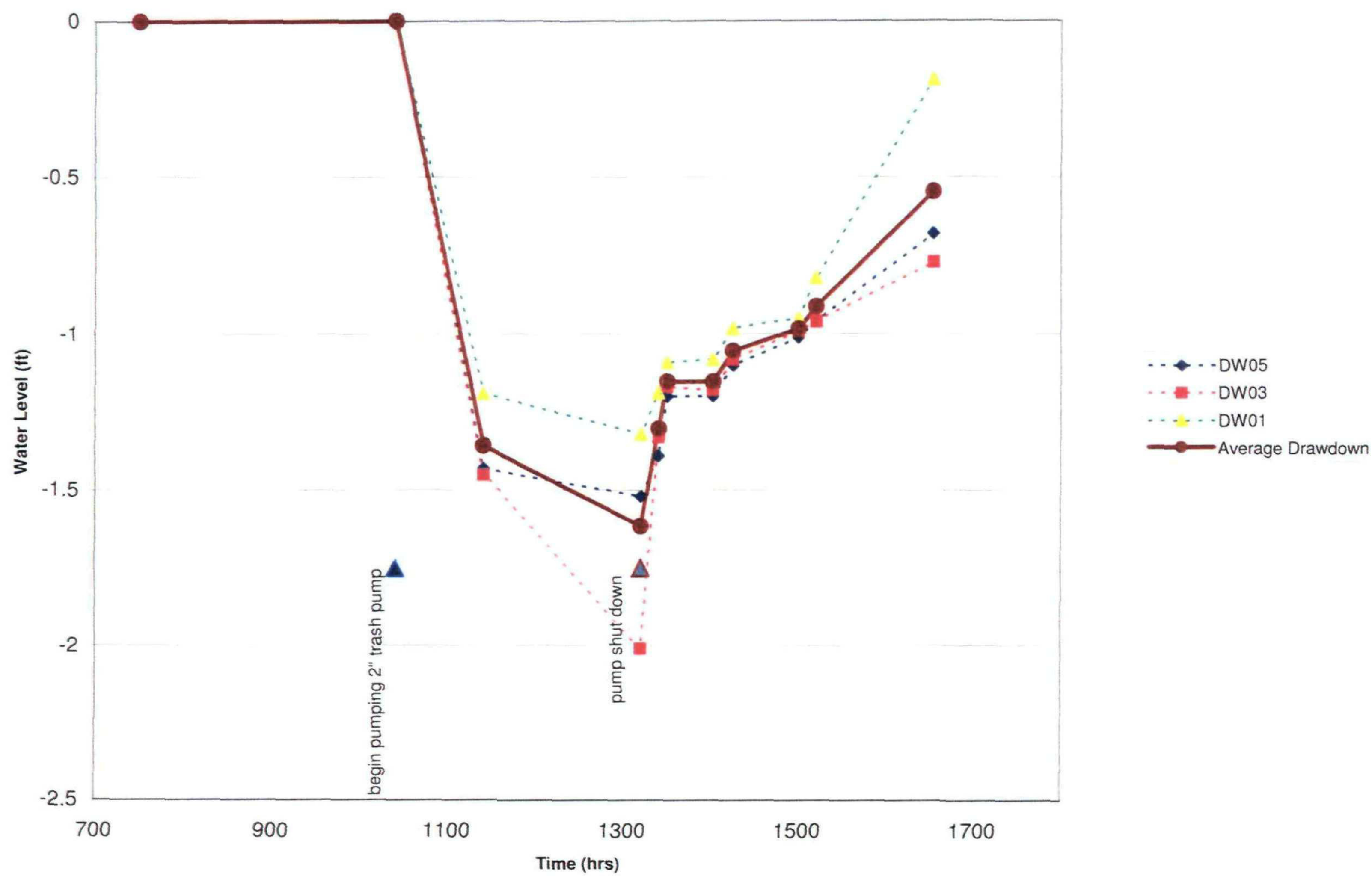
Figure 6 - Sheet Piling Containment Cell Drawdown Test



Legend

BPSO136 144 at 16ft — *Final Surface Sample ID, PCE Concentration (µg/kg), and Final Excavation Depth or "wall" for Sidewall Samples.*

Sample Location
- Dewater Well, Abandoned
- Geoprobe Well
- Abandoned Geoprobe Well
- Monitoring Well
- Abandoned Monitoring Well
- Sheet Piling Containment Cell

FinalExcavation2009

Depth
- Main Excavation
- Trench Cell 3
- Trench Cells 1,2 4, and 5

Approximate Utility Location
- Electricity
- Gas
- Sanitary Sewer
- Floor Drain Pipeline
- Storm Drain
- Water

URS
OPERATING SERVICES

BILLINGS PCE REMOVAL SITE
YELLOWSTONE COUNTY, MONTANA
Figure 7: BSL Alley Excavation Footprint, Final Surface Sample Locations, and Excavation Depths

October 2010
Source: http://nris.mt.gov/nsdi/nris/
2004 Color Aerial

UOS START 3
TDD No. 0805-11

1 inch = 10 feet
0 10 20 Feet
N

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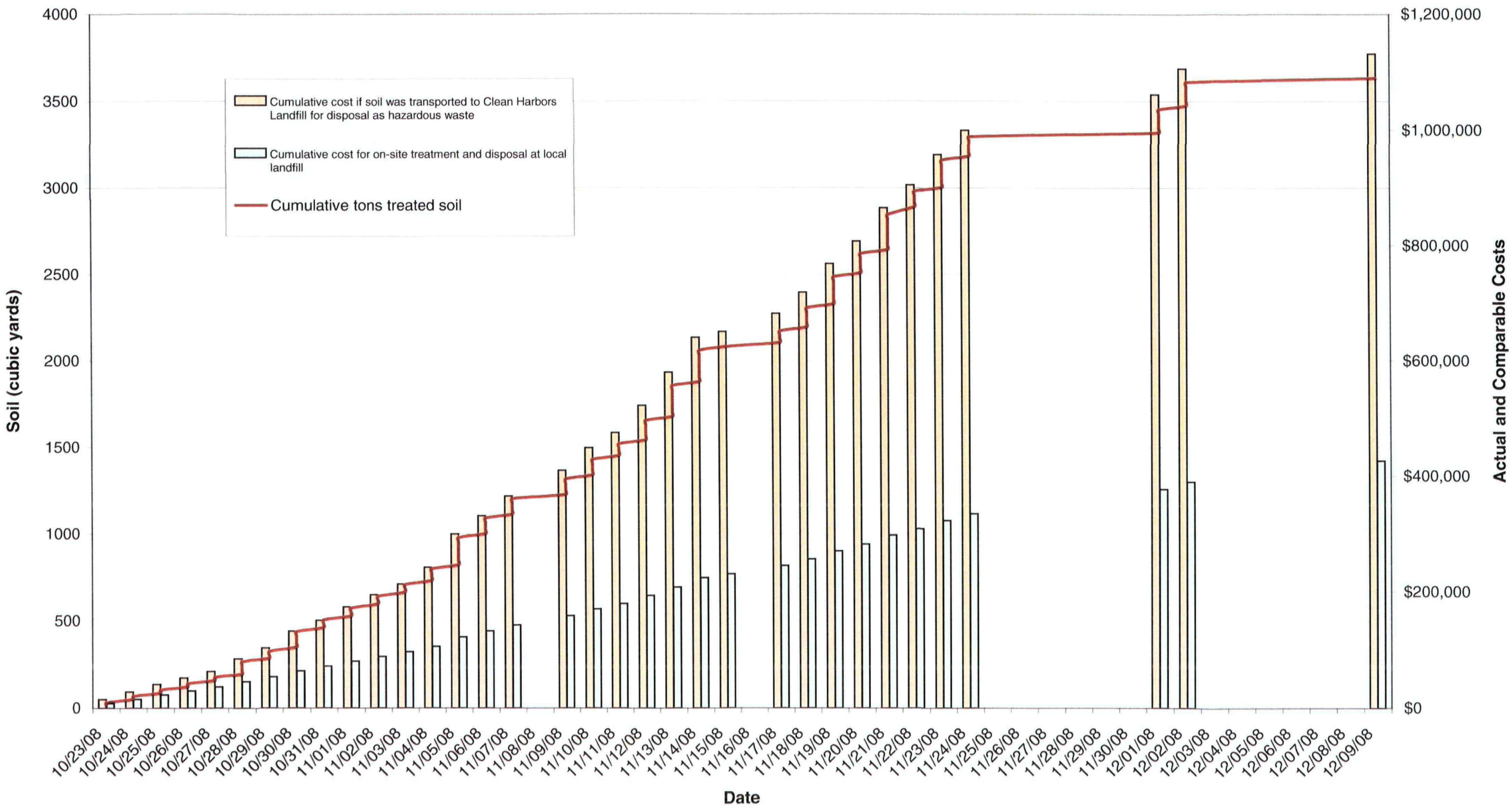
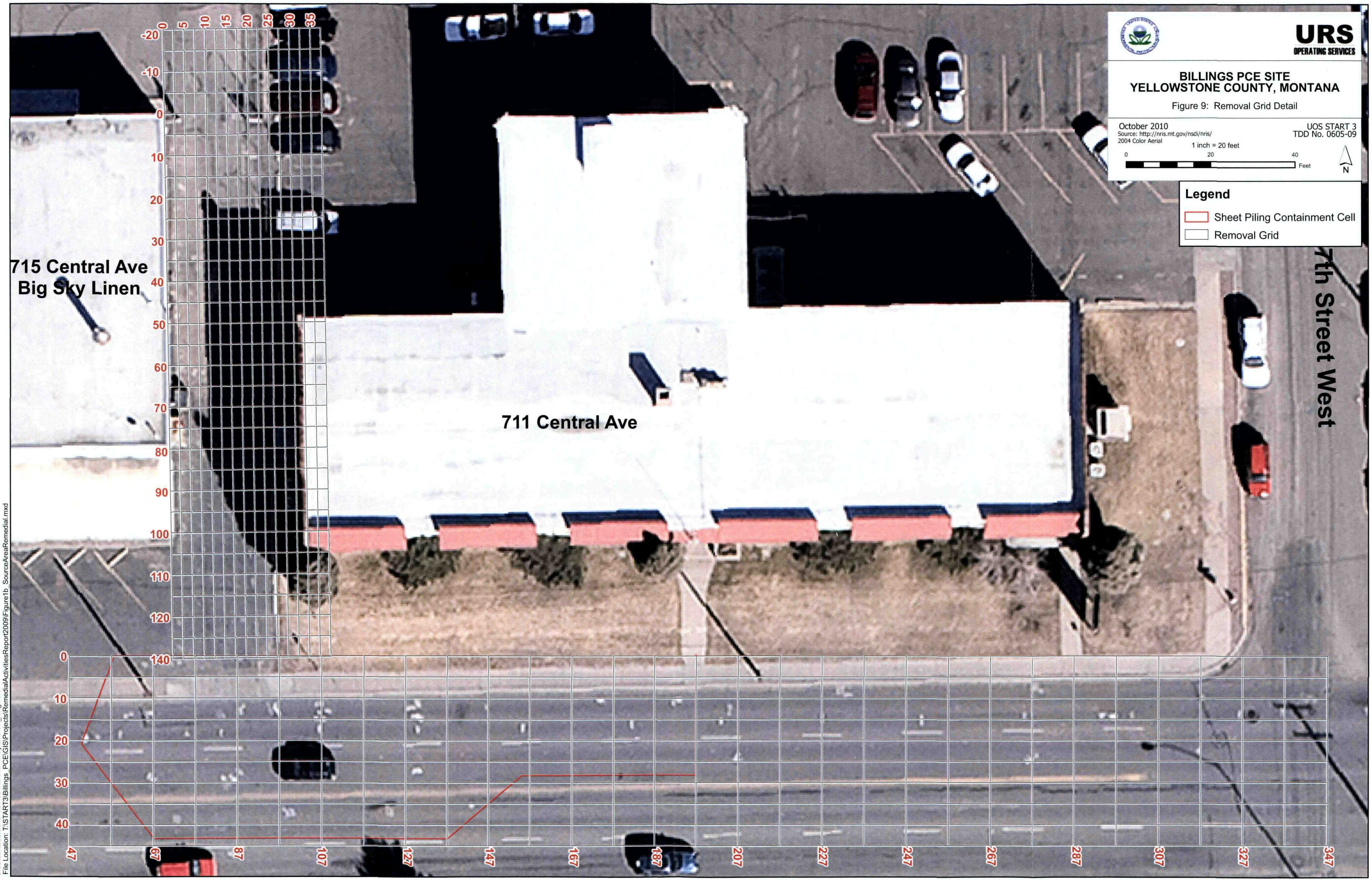
Figure 8 - Soil Treatment Cost Comparison and Volume Chart





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