Feasibility Study

Brenntag Mid-South, Inc.
Chemical Distribution Facility
2235 W. Battlefield Road
Springfield, Missouri
EPA ID No. MOD0002325298

P R E P A R E D F O R:

Brenntag Mid-South, Inc.
Pottsville & Huller Lane
Reading, Pennsylvania 19605
December 17, 2010
Revised July 20, 2011

ARCADIS

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Appendices

A Summary of Comparative Analysis of Soil Remedial Alternative Costs

B Comparative Analysis of Groundwater Remedial Alternative Costs

Acronyms and Abbreviations

ARARs	Applicable or Relevant and Appropriate Requirements
bgs	below ground surface
BTEX	benzene, toluene, ethylbenzene, and xylene
CAA	Clean Air Act
CERCLA	Comprehensive Environmental Response, Cleanup, and Liability Act
CH_4	Methane
CO_2	Carbon Dioxide
COCs	chemicals of concern
CVOCs	chlorinated volatile organic compounds
CWA	Clean Water Act
DCE	dichloroethene
DNAPL	Dense Non-Aqueous Phase Liquid
DO	dissolved oxygen
ELCR	excess lifetime cancer risk
EPC	Exposure Point Concentration
ERA	Ecological Risk Assessment
ERD	Enhanced reductive dechlorination
Fe^{2+}	Ferrous Iron
Fe^{3+}	Ferric Iron
GAC	granular activated carbon
H_2S	Sulfide/Hydrogen Sulfide
HHRA	Human Health Risk Assessment
HI	hazard index
HQ	hazard quotient
HVE	High Vacuum Extraction

Acronyms and Abbreviations (continued)

IRZ	in-situ reactive zone
lbs	pounds
LNAPL	Light Non-Aqueous Phase Liquid
MCLGs	Maximum Contaminant Level Goals
MCLs	Maximum Contaminant Levels
MDNR	Missouri Department of Natural Resources
MMCLs	Missouri Maximum Contaminant Levels
Mn^{2+}	Mangenous Manganese
Mn^{4+}	Mangenic Manganese
MNA	Monitored natural attenuation
MPE	Multi-phase extraction
MWQS	Missouri Water Quality Standards
NAPL	Non-Aqueous Phase Liquid
NCP	National Contingency Plan
NO_2^-	Nitrite
NO_3^-	Nitrate
O&M	operations and maintenance
ORP	oxidation reduction potential
OSWER	Office of Solid Waste and Emergency Response
PAH	polynuclear aromatic hydrocarbon
PCB	polychlorinated biphenyl
PCE	perchloroethene or tetrachloroethene
POTW	Publicly-Owned Treatment Works
PRGs	Preliminary Remediation Goals
RAOs	remedial action objectives
RCRA	Resource Conservation and Recovery Act

Acronyms and Abbreviations (continued)

RI	Remedial Investigation
RI/FS	Remedial Investigation/Feasibility Study
ROD	Record of Decision
SDWA	Safe Drinking Water Act
SO_4^{2-}	Sulfate
SVE	Soil vapor extraction
SVOC	semi-volatile organic compound
TBC	to-be-considered
TCE	trichloroethene
THQ	Target hazard quotient
TOC	total organic carbon
TR	Target Risk
TSCA	Toxic Substances Control Act
µg/L	micrograms per liter
USEPA	U.S. Environmental Protection Agency
VOCs	volatile organic compounds

1. Introduction

This document presents a Feasibility Study (FS) to evaluate potential remedial activities at the Brenntag Mid-South, Inc (Brenntag) Chemical Distribution Facility (Brenntag site or Site), located at 2235 West Battlefield Road, Springfield, in Greene County, Missouri (Figure 1-1). Brenntag owns and operates a chemical distribution business at this facility that encompasses approximately 3.75 acres within the Missouri Pacific Industrial Park (Figure 1-2). The geographic location of the Brenntag site is the SE ¼ of the SE ¼ of the NW ¼ of Section 3, Township 28 North, and Range 22 West.

The FS process is a requirement of the Administrative Order on Consent for Removal Action and Remedial Investigation and Feasibility Study that was signed in September 2001 by representatives of Brenntag and the United States Environmental Protection Agency (USEPA) Region 7. The Brenntag site is jointly regulated by USEPA Region 7 and the State of Missouri Department of Natural Resources (MDNR). The findings presented in the Remedial Investigation Report (ARCADIS 2007a) and the Human Health Risk Assessment (HHRA, included as Appendix K of the Remedial Investigation) were used as the basis for the development of the remedial action strategy presented in this FS.

1.1 Purpose of Report

The purpose of the FS is to utilize the findings of the Remedial Investigations (RI) for the Brenntag site to develop and evaluate potential remedial action alternatives that address identified areas of environmental impact that represent a risk to human health and the environment. Remedial action alternatives were developed and screened based on federal and state regulations that are Applicable or Relevant and Appropriate Requirements (ARARs), and on the findings of the HHRA. In accordance with USEPA protocols, this document will provide sufficient information for the decision-makers “to adequately compare alternatives, select an appropriate remedy for the site, and demonstrate satisfaction of the Comprehensive Environmental Response, Cleanup, and Liability Act (CERCLA) remedy selection requirements in the Record of Decision (ROD, USEPA, 1988a).” Final remedy selection is recommended in the ROD.

1.2 Report Organization

This FS for the Brenntag site is divided into nine sections. A brief description of the sections is presented below:

- Section 1, Introduction – Discusses the purpose and organization of the FS for the Brenntag site.

- Section 2, Background – Presents a Site description and history, summary of historical Site Operations, a summary of Site Geology, a summary of the RI and HHRA, a discussion of Site source areas identified in the RI, and a summary of the ongoing Interim Measures being performed at the Site.

- Section 3, Objectives and Requirement for Remediation – Defines the remedial action objectives (RAOs); discusses chemical, location, and action-specific ARARs for the site; identifies media of concern and chemicals of concern (COCs); provides Preliminary Remediation Goals (PRGs); and identifies the areas of contamination.

- Section 4, Identification and Preliminary Screening of Remedial Technologies and Process Options – Identifies applicable remedial action technologies and process options and presents the results of the remedial technology screening. These remedial technologies are then screened with respect to effectiveness, implementability, and cost.

- Section 5, Technology Descriptions – Presents a general description of remedial technologies screened in Section 3 as they relate to the Brenntag site.

- Section 6, Development of Remedial Action Alternatives – Alternatives for soil and the source area are developed from the technologies described in Section 4.

- Section 7, Detailed Analysis of Remedial Action Alternatives – Presents a detailed evaluation of each of the remedial alternatives retained and developed in Section 6. A detailed evaluation of each alternative is presented with respect to seven of the nine evaluation criteria. The remaining two criteria, State and community acceptance, will be addressed after completion of the FS process.

- Section 8, Comparative Analysis of Remedial Action Alternatives and Development of the Brenntag site – Presents a comparative analysis for each group of alternatives developed (surface soil and source areas) and then develops the site-wide alternatives.

- Section 9, References – Provides complete citations for all documents used in the preparation of this FS.

2. Background

The following sections provide a brief discussion of the relevant environmental setting specific to the Brenntag Site. This information is excerpted from the RI Report (ARCADIS, 2007a).

2.1 Brenntag Site Description and History

Brenntag owns and operates a chemical distribution facility which is located in the southwest side of Springfield. Brenntag AG acquired Holland Chemical International (HCI) in December of 2000 and currently operates the facility under their subsidiary Brenntag Mid-South, Inc. Holland Chemical International (HCI) - Chemtech acquired the site from Chemtech Industries, Inc. (CII) in 1992 and operated under the name HCI-Chemtech Distribution, Inc. CII initiated operations at the facility in 1975. Previously, the Site had been agricultural land used for farming and grazing until 1975.

Two undeveloped land tracts located north of the Brenntag site are presently owned by the Back 3, LLC (western tract) and Battlefield Business Center, LLC (eastern tract). ACME Brick is located to the west of the facility. A light industrial business complex owned by Dennis Blake Properties is located east of the site. The southern boundary of the site is adjacent to West Battlefield Road. On the south side of West Battlefield Road are a residential trailer park and Foster Manufacturing, Inc. (Figure 1-2).

The Brenntag facility occupies approximately 3.75 acres and is comprised of structures, including:

- A 2,000 square foot office;
- A 12,000 square foot warehouse and loading dock;
- A 1,250 square-foot bag storage building (former drum rinsing area);
- A 2,000 square-foot drum storage building;
- A 700 square-foot storage shed, an inactive tank farm; and
- An inactive rail car spur.

The rail spur enters the site from the north along the eastern property boundary (Figure 1.3). A six-foot chain link fence surrounds the property with an electronic entry gate along the front that adjoins the office building. This gate is locked during non-

business hours. The parking lot, loading dock, and rail spur are approximately five feet (ft) lower in elevation than the remaining portion of the facility (front lawn, office, warehouse, and northern portion).

The site is located in an area of gently rolling hills, dissected by local streams that contribute to the James River, located south of Springfield. The general topographic gradient at the site is to the north and south as the site is located on a gentle east – west trending ridgeline. This ridgeline separates two westerly flowing drainage channels that represent the headwaters of South Creek. These westerly flowing channels appear approximately 3,000 ft north and 2,500 ft south of the site. Several nearby wetlands were identified along the South Branch of South Creek (Figure 1-1).

In general, the surface water drainage system at the northern portion of the Brenntag site consists of overland flow to the north. Engineered drains in the southern portion of the facility direct surface water drainage to the storm sewer along Battlefield Road. Locations of overhead and buried utilities at the Site are provided on Figure 1-4.

2.1.1 Site Operations

Presently, the facility only stores and distributes pre-packaged chemical products. The facility also distributes dry chemicals including caustic, surfactants, desiccants, and pharmaceutical and food-grade chemicals. The facility never manufactured chemicals and the amount of chlorinated solvents stored at the facility has decreased considerably since bulk storage was discontinued.

Caustics, aromatic solvents, acids, ketones, alcohols, glycols, petroleum based hydrocarbons, and chlorinated solvents were handled and stored at the facility.

In general, the former operations and practices conducted at the facility fall within two areas (Figure 2-1);

- The Former Drum Rinse Area - Includes both the Acid and Caustic Drum Rinse Area, and the Solvent Drum Rinse Area in the northwest portion of the Site.

- The Former Bulk Chemical Handling Area – Includes the Blend Tank, Drum Filling Room (in the warehouse), Bulk Tank Truck Loading Area, and Drum Filling Area (near the new tank farm).

2.2 Site Geology and Hydrogeology

The site is underlain by reddish-brown silts, clays, and residuum which overlays a hard, limestone bedrock. The reddish-brown silts and clays show localized variations throughout the site. Discontinuous thin lenses of chert, white crystalline sands, and oolites of varying thickness are present throughout the site. The soil/residuum becomes firmer with depth, except in the interval immediately above the limestone, where it is weathered and less firm. The soil/residuum thickness varies from approximately 12 to 24 ft on site and up to approximately 30 ft off site to the north, depending on the depth to the irregular limestone bedrock surface.

The limestone bedrock (Springfield Plateau Aquifer) is lightly fractured, medium crystalline, hard limestone. Bedrock permeability appears to be primarily through secondary features such as sediment filled voids near the bedrock surface, fractures and bedding planes.

A shallow unconfined water table is present in the soil/residuum and underlying upper limestone bedrock. The groundwater elevations vary seasonally and respond quickly during periods of precipitation. Depths to groundwater range from 0.5 ft bgs to approximately 5 ft bgs onsite and as deep as 25 ft bgs in offsite wells to the north. Water levels in the shallow bedrock are similar to the water levels in adjacent wells completed in the soil/residuum and indicate that there is no significant vertical gradient between the soil/residuum and the shallow bedrock.

The groundwater flow direction beneath the site is generally to the north-northeast reflecting the east-west trending ridge at the surface and may also be influenced by the irregular subsurface bedrock elevation and secondary permeability pathways such as fractures, bedding planes and minor solution features. The results of hydraulic testing (slug tests) at the site, and the relatively low yield of the dual phase HVE remediation system appear consistent with the fine grained lithology described during the installation of site monitoring wells, recovery wells, and soil borings. Overall, it appears the primarily permeability within the fine grained soil/residuum is low, but that secondary features allow flow velocities and VOC travel times significantly higher than anticipated from the lithologic descriptions and the hydraulic testing.

The deep Springfield Plateau Aquifer wells generally exhibit the following characteristics: slow rates of groundwater recovery; lack of observed fracturing or solution features in the bedrock borings; low rate of groundwater recovery; and a low hydraulic conductivity. Static water levels range from 15 ft -25 ft below water levels in

nearby shallow bedrock and soil/residuum wells, indicating a downward vertical gradient.

Monitoring wells SAW-2 and SAW-4 through SAW-8 are completed in the deep portion of the Springfield Plateau Aquifer. Potentiometric surface maps of the groundwater elevations in the deep portion of the Springfield Plateau Aquifer indicate that flow direction is to the west-southwest. The slow rate of groundwater recovery in the deep wells (SAW-2 and SAW-4 through SAW-8), and the lack of fracturing or solution features observed during deep well installation indicate hydraulic conductivity of the deeper limestone bedrock is low.

2.3 Summary of the Remedial Investigation

This RI Report has summarized previous environmental investigations and RI activities conducted at the Site. As a result of the RI activities, soil and groundwater impacts associated with the Brenntag facility have been delineated. Constituents of potential concern (COPC) were identified and evaluated in the Human Health Risk Assessment. The Human Health Risk Assessment concluded that site-related impacts may result in unacceptable risk and that a Feasibility Study to address remediation of these impacts is warranted.

A conceptual site model was developed following the collection and evaluation of the RI data, and is summarized in Figure 2-2 and discussed below. Additional discussion of the conceptual site model is contained in the RI (ARCADIS, 2007a).

Two soil source areas, related to previous site operations, have been identified to facilitate discussion of the nature and extent of impacts and their fate and transport:

- The Former Bulk Chemical Handling Area located in the central portion of the Brenntag facility.
- The Former Drum Rinse area is located in the northwest portion of the Brenntag facility. Soil and groundwater impacts associated with this area are primarily related to the historic practices of cleaning and recycling drums.

Dissolved VOCs have migrated downgradient from the identified source areas towards the north in the direction of groundwater flow. CVOCs have been detected downgradient of the facility, but the distribution of CVOC compounds changes with distance from the source area. PCE and TCE are the primary COPC's in the Former Drum Rinse Area, although elevated concentrations of degradation products (cis-

1,2-DCE and vinyl chloride) are also present. In downgradient wells, overall concentrations of CVOCs decline, concentrations of PCE and TCE markedly decline, and the dominant CVOCs consist of degradation products. This is in contrast to the dominant concentrations of aromatic hydrocarbons and ketones (typically toluene and acetone) observed in the offsite monitoring wells (MW-17). Based on the presence of dissolved degradation products of PCE and TCE, it appears that a significant amount of reductive dechlorination is occurring at the site. The aromatic hydrocarbons and ketones are likely providing the necessary organic carbon to generate reducing conditions that are fueling the reductive dechlorination of the CVOCs.

Monitoring well SAW-2 contains dissolved VOCS. As initially constructed, SAW-2 acted as a conduit for shallow groundwater to migrate vertically downward. Based on the reduction in VOC concentrations observed in SAW-2 since the modification and intermittent baildown of the well, it is concluded that the VOCs present in SAW-2 migrated vertically via the previously uncased well bore, driven by the downward hydraulic gradient. Thus the vertical transport method at the site has likely been eliminated.

2.4 Summary of the Risk Assessment

The HHRA for the site was prepared consistent with USEPA guidance. The HHRA quantified potential risks and hazards associated with chemicals of potential concern (COPCs) in soil and groundwater at the site. In addition, potential exposure to indoor air via vapor intrusion from groundwater was also evaluated using the USEPA vapor intrusion model and Site-specific soil-gas and sub-slab vapor data. The entire HHRA report is in Appendix K of the RI report (ARCADIS, 2010b).

Using the human exposure and toxicity information, potential human health risks for each COPC and selected exposure pathway were evaluated. Upper-bound excess lifetime cancer risks and non-cancer hazards were quantified. In addition, cumulative risks and hazard indices were estimated by summing the upper-bound excess lifetime cancer risks or hazards across exposure pathways for individual receptors. Several exposure scenarios were evaluated, including:

- Future onsite worker;
- Potential current offsite worker; and
- Hypothetical future onsite resident.

The calculated excess lifetime cancer risks for future site worker (ELCR = 3 x 10^{-2}) and hypothetical future resident (ELCR = 2 x10^{-1}) exposure to soil and groundwater are greater than the USEPA target risk of 10^{-4} prescribed by the National Contingency Plan (USEPA, 1991a). In addition, the cumulative HIs for a future site worker (HI = 128), and a hypothetical future resident (HI = 1063) are greater than the benchmark of 1. Therefore, chemicals of concern (COCs) have been identified based on the results of the HHRA for each medium of concern (groundwater and soil) as presented below:

- Groundwater
  - Hypothetical future resident exposure scenario: benzene, bromodichloromethane, carbon tetrachloride, chloroform, 1,1-dichloroethane, 1,1-dichloroethene, 1,2-dichloroethane, cis-1,2-dichloroethene, 1,2-dichloropropane, ethylbenzene, methylene chloride, naphthalene, 1,1,1,2-tetrachloroethane, 1,1,2,2-tetrachloroethane, tetrachloroethene (PCE), toluene, 1,1,2-trichloroethane, trichloroethene (TCE), 1,2,3-trichloropropane, 1,2,4-trimethylbenzene, 1,3,5-trimethylbenzene, vinyl chloride, and xylenes (total).
- Soil:
  - Hypothetical future resident exposure scenario - 1,2,4-trimethylbenzene, and 1,3,5-trimethylbenzene.

2.5 Potential Soil Source Areas

Based on the results of the historical and recent RI efforts, two soil source areas were identified within the Brenntag site (Figure 2-1):

- The Former Bulk Chemical Handling Area, located in the central portion of the Brenntag facility.
- The Former Drum Rinse area, located in the northwest portion of the Brenntag facility.

2.6 VOC Occurrence and Distribution

There are two primary groups of VOCs detected at the Site:

- Chlorinated solvents and degradation products, typically used as degreasers and resistant to aerobic degradation;
- Petroleum based hydrocarbons consisting primarily of toluene, ethylbenzene, and xylenes.

Ketones widely used as commercial solvents, volatile and aerobically degradable are also present.

The highest concentrations of VOCs were detected in three primary areas, the Former Bulk Chemical Handling Area, the Former Drum Rinse Area, and an off site portion of the groundwater plume near MW-17 (Figure 2-3).

Constituents released from the source areas have moved generally vertically by gravity though the soil/residuum until groundwater is encountered. Constituents are then dissolved in the groundwater and migrate laterally through the weathered bedrock zone. Over time, releases of mixed petroleum and chlorinated compounds have co-mingled into a single groundwater plume that has migrated offsite to the north-northwest approximately 700 ft. The groundwater analytical data suggests that a significant reduction of BTEX and CVOCs has occurred as a result of the continued operation of the existing Interim Measures dual-phase, high-vacuum extraction system (HVE) in conjunction with ongoing very active reductive dechlorination.

Dissolved VOCs were detected in deep monitoring well SAW-2. As initially constructed, SAW-2 acted as a conduit for shallow groundwater to migrate vertically downward.

SAW-2 was installed on the Brenntag facility during previous investigations in July 2000. It was completed as a deep Springfield Aquifer open-hole monitoring well to a total depth of 208 ft bgs. Originally constructed open hole with surface casing to a depth of 35 ft bgs, the well was modified in September 2002 due to concerns about the potential for shallow impacted groundwater to enter the open borehole. Two-inch diameter well materials were installed with the screen set from 188 to 208 ft bgs and a high-solids bentonite grout seal to the surface. A program to bail down the SAW-2 was initiated in 2002 to verify that the potential downward vertical migration of shallow impacted groundwater was eliminated.

Based on the reduction in VOC concentrations observed in SAW-2 since the modification of the well, and the start of the groundwater bailing program, it is concluded that the VOCs present in SAW-2 migrated vertically via the previously uncased well bore, driven by the downward hydraulic gradient. Thus the vertical transport method at the site has likely been eliminated. In addition, none of the detected VOC concentrations in the five other Deep Springfield Plateau Aquifer wells (SAW-4 through SAW-8) exceeded the RSL for tap water. These results further suggest that the VOC impacts are adequately delineated and are localized in the vicinity of SAW-2.

2.7 Summary of Interim Measures implemented at the Brenntag Site

Several ongoing Interim Measures have been implemented at the Brenntag Site, including:

- The installation and operation of a dual-phase, high-vacuum extraction (HVE) system.
- Quarterly groundwater monitoring.
- The implementation of an Enhanced Reductive Dechlorination (ERD) pilot test.
- Completion of soil vapor and sub-slab vapor sampling.
- Pilot testing and installation of a sub-slab vapor extraction system.
- Hydraulic testing of soils and upper bedrock.

These Interim Measures are discussed in the following sections.

2.7.1 High-Vacuum Extraction System

RI activities for the Brenntag site were completed between 1999 and 2007. Results of the RI have assisted in the enhancement of the Interim Removal Action Plan (IRAP) implemented in accordance with the Compliance Agreement signed in November 1997. Brenntag voluntarily installed a dual-phase, high-vacuum extraction (HVE) system in July 1999. Operation of the HVE system was initiated in March 2000 to reduce the volatile organic compound (VOC) impacts in both the soil and groundwater. The removal action called for the prevention of impacted groundwater from migrating offsite and to reduce the overall mass of contaminants in onsite soil and groundwater.

The dual-phase HVE treatment system at the Brenntag site consists of five major components:

- Four groups of HVE wells referred herein as units;
- Dual phase HVE equipment;
- A groundwater aeration treatment system;
- A granular activated carbon polish, and
- A permitted outfall to the publicly owned treatment works (POTW) via the sanitary sewer.

Currently, there are 51 dual-phase HVE wells screened in the silt and clay soil/residuum portion of the aquifer and 4 HVE wells screened in bedrock. Two HVE wells (Wells E51 and E52) are screened across the soil/residuum and upper bedrock (Figure 2-4). The well construction information and lithology in which each of the HVE wells is constructed is presented in the RI. Each of the 57 HVE wells is constructed of 2-inch diameter materials and was installed using a hollow stem auger or an air rotary drilling rig.

Each of the 57 HVE wells are located within one of the four HVE well units. Each HVE unit has a trunk line to which each of the wells in that unit is connected via a shutoff valve.

As designed, the HVE system induces a vacuum at the recovery wells to withdraw both soil vapors and groundwater from the subsurface. Constituents are removed as a dissolved component in the groundwater, as vapors from the soil, and in the case of the petroleum hydrocarbons, through in-situ biodegradation.

The objectives of the HVE interim measure were to:

- Remove the COPCs from unsaturated soils and the dewatered smear zone through vapor extraction;
- Reduce the overall mass of COPCs from the groundwater by extraction and treatment;

- To prohibit the vertical migration of COPCs; and
- Provide hydraulic control to mitigate impacted groundwater from migrating offsite.

The interim dual-phase HVE system has proven to be protective of human health and the environment by capturing soil vapor and impacted groundwater in the extraction wells and treating groundwater prior to discharge to the POTW. Plume capture at the northern property boundary of the Brenntag site has limited the offsite migration of groundwater containing COPCs.

2.7.2 Quarterly Groundwater Monitoring

On-going groundwater monitoring is conducted quarterly to assess whether offsite migration of impacted groundwater containing COPCs is being prevented. These reports include a record of the dual-phase HVE treatment system operation parameters such as flow rate, contaminant discharge concentrations, removal efficiency, and VOC reduction trends. These data are used to evaluate and/or adjust system configurations. Maintenance is performed on the groundwater treatment and extraction system as required.

2.7.3 ERD Pilot Test

An enhanced reductive dechlorination (ERD) pilot test was conducted in 2005 in the vicinity of MW-1 (Figure 2-4). Injection wells IW-1 through IW-5 were installed between monitoring well MW-1 and HVE well E42B in April 2005. These injection wells were used to conduct an initial ERD pilot test that was started in August 2005.

The objective of the pilot test was to assess the feasibility of enhancing the ongoing reductive dechlorination of the CVOCs in the vicinity of the Former Drum Rinse Area. Results of the ERD pilot test were provided in the August 2006 ERD Pilot Test Report (ARCADIS, 2006). In general, the results of the pilot test indicated that the ongoing reductive dechlorination can be effectively enhanced through the injection of a carbon source. As a result, an expanded ERD pilot test proposal was approved and injection wells IW-6, IW-7, and IW-8 were installed in January 2007. The expanded ERD pilot test was initiated on March 5, 2007.

Based on the results of the pilot testing, several conclusions can be drawn regarding the implementation of ERD to address site impacts of chlorinated VOCs in groundwater:

- Results indicate that the ongoing reductive dechlorination can be further enhanced through the addition of a carbon source.

- The presence of dissolved gases in groundwater, such as methane, ethene, and ethane, which are the final reductive dechlorination products of chlorinated VOCs, are consistent with the reductive process being driven to completion.

- Due to the presence of secondary permeability pathways, mainly bedding planes, chert zones, and solution features, uniform delivery of carbon through the use of traditional vertical wells will be problematic.

- The results of the pilot test indicate distribution of organic carbon and accompanying reductive dechlorination does occur in the subsurface once the carbon source is injected.

- Enhancing and sustaining an accelerated rate of dechlorination will be dependent upon designing and implementing a more robust carbon delivery method.

- Based on the results of the long term pilot test, ERD is an appropriate approach to remediate dissolved CVOCs at the Site, however, delivery systems other than vertical injection wells will be evaluated prior to full-scale implementation.

2.7.4 Soil Vapor and Sub-slab Vapor Activities

Analytical results of the onsite soil vapor survey exceed EPA screening levels in one sample located near the northwest corner of the Brenntag warehouse. As a result, four sub-slab vapor samples were collected on June 15, 2007.

With the exception of three constituents (trichloroethene, 1,3,5-trimethylbenzene and 1,2,4-trimethylbenzene) detected in one of the four samples, the detected concentrations for the other constituents were all less than the 1×10^{-4} target risk level. The sub-slab vapor concentrations of 1,3,5-trimethylbenzene and 1,2,4-trimethylbenzene exceed the screening levels. However, even though concentrations of these constituents exceed screening levels, it is likely that elevated air concentrations in the building would not be observed. The foundation appears to be intact with no visible cracks or floor drains that could act as a conduit for sub-slab vapors to migrate into the building. Also, there are large loading dock access doors

open most of the year and circulation of ambient air with indoor air is likely to be significant.

However, to remove the vapor concentration beneath the northwestern portion of the slab, an Interim Measure Vacuum Extraction System has been installed. The sub-slab system installation was completed in November 2009 and the installation report was submitted to the USEPA and MDNR on April 7, 2010.

The SSVE system consists of nine extraction points located in the facility warehouse. These extraction points are configured as follows: three vapor extraction points (VE-1, VE-4 and VE-9) in the Former Drum Filling Room, three vapor extraction points (VE-2, VE-3 and VE-5) in the Warm Room and three vapor extraction points (VE-6, VE-7 and VE-8) in the Main Warehouse near the Warehouse Office. A 3.5 horsepower (hp) regenerative blower is used to apply the vacuum to the extraction points via collection piping. Extracted vapors are discharged above the roof line via a 2-inch steel exhaust stack.

2.7.5 Hydraulic Testing

Hydraulic testing within the shallow unconsolidated soils and upper bedrock was conducted in May 2010 as proposed in the Data Gap Study Work Plan (February 2010). Testing was conducted to evaluate 1) hydraulic characteristics of the shallow unconsolidated soils and upper bedrock, and 2) the ability to achieve hydraulic control using groundwater extraction. Hydraulic testing conducted as part of the Data Gap Study indicated that despite the relatively steep groundwater gradient at the site, groundwater extraction results in overlapping capture zones and can be an effective containment method preventing offsite migration of VOCs in the unconsolidated sediments and shallow bedrock.

3. Objectives and Requirements of Remediation

This section identifies and evaluates the objectives and requirements of remediation as a preparatory step to developing and screening remedial alternatives.

3.1 Remedial Action Objectives

RAOs are site-specific clean-up objectives established for protecting human health and the environment. RAOs specify contaminants and media of concern, potential exposure pathways and receptors, and PRGs [40 CFR 300.430 (e)(2)(i)]. RAOs indicate a contaminant level and an exposure route, rather than a contaminant level alone, because protection of human and ecological receptors may be achieved by reducing or eliminating exposure pathways as well as by reducing contaminant concentrations (USEPA, 1988a). The RAOs were developed based on the results of the Human Health Risk Assessment (Appendix K, RI Report, ARCADIS 2007b) and based on ARARs (Section 3.2).

RAOs may be qualitative (e.g., to prevent exposure to contaminated groundwater) or quantitative (e.g., to specify the maximum contaminant concentration in groundwater). The following subsections discuss qualitative RAOs for each media of concern within the Brenntag site; quantitative RAOs are presented in Section 3.3. RAOs are specified for two major groupings of impacted media: unsaturated (i.e., vadose zone) soil; source area residual COCs adsorbed to saturated soils below the water table (i.e., smear zone) and groundwater. These two groupings will be used throughout the FS and are further defined for the FS in Section 3.4.

3.1.1 Soil

As summarized in Section 2, and as fully presented in Risk Assessment (Appendix K of the RI Report – ARCADIS, 2010b), soil was identified as a medium of concern at the Former Bulk Chemical Handling Area and the Former Drum Rinse Area, based on potential direct impacts to human health. The chemicals of concern for soil, under the hypothetical future resident exposure scenario, include:

- 1,2,4-trimethylbenzene; and
- 1,3,5-trimethylbenzene.

Remedial Action Objectives were developed for impacted soil and include the following:

- Prevent ingestion and dermal contact (future site workers) with onsite soil exceeding the risk-based Preliminary Remediation Goals (identified below) for the identified COCs developed for the hypothetical future onsite resident exposure scenario.
- Mitigate potential for COCs in soil to impact groundwater.
- Mitigate potential future vapor intrusion.
- Achieve risk-based Preliminary Remediation Goals for COCs in soil.

3.1.2 Groundwater

The groundwater plume is defined as COC-impacted groundwater in the soil/residuum and upper-most limestone aquifer, and extends offsite to the north as shown on Figure 2-3. Since the groundwater plume extends beyond the Site boundaries, a hypothetical future resident exposure scenario was used to develop Risk-based COCs for groundwater, including those constituents for which an unacceptable risk is present, as presented in Section 2.4 and further developed in Section 3.3.

The RAOs for groundwater include the following:

- Prevent ingestion and dermal contact (future workers) with onsite groundwater containing COCs above risk-based preliminary remediation goals;
- Prevent groundwater, with COCs exceeding MCLs, from migrating offsite (protective of current and future offsite residents) through treatment or hydraulic containment; and
- Achieve remediation goals for COCs in groundwater.

3.2 Applicable or Relevant and Appropriate Requirements

This section describes the ARARs and to-be-considered (TBC) guidance that may be applied to actions at the Brenntag site. The ARARs and TBC guidance are divided into three categories: chemical-specific, action-specific, and location-specific requirements. ARARs are defined as cleanup standards, standards of control, and other substantive environmental protection requirements, criteria, or limitations promulgated under

federal or state law that specifically address a hazardous substance, pollutant, contaminant, remedial action, location, or other circumstance at a site. The ARARs are used to develop quantitative RAOs, determine the appropriate extent of site cleanup, and govern the implementation and operation of the selected action. The TBC guidance is comprised of non-promulgated advisories or guidance issued by federal or state governments that are not legally binding (USEPA, 1988b).

3.2.1 Definition of ARAR Categories

The National Contingency Plan (USEPA, 1990), defines two ARAR components: (1) applicable requirements, and (2) relevant and appropriate requirements. Requirements under federal or state law may be either applicable or relevant and appropriate to CERCLA clean-up actions, but not both. However, requirements must be both relevant and appropriate for compliance to be necessary. The definitions of these types of requirements are as follows:

- Applicable requirements are "cleanup standards, standards of control, and other substantive requirements, criteria, or limitations promulgated under federal environmental, state environmental, or facility siting laws that specifically address a hazardous substance, pollutant, contaminant, removal action, location, or other circumstance found at a CERCLA site" (40 CFR 300.5).

- Relevant and appropriate requirements are "cleanup standards, standards of control, and other substantive requirements, criteria, or limitations promulgated under federal environmental, state environmental, or facility siting laws that, while not 'applicable' to a hazardous substance, pollutant, contaminant, removal action, location, or other circumstance at a CERCLA site, address problems or situations sufficiently similar to those encountered at the CERCLA site that their use is well suited to the particular site" (40 CFR 300.5).

Substantive requirements pertain directly to the actions or conditions at a site, while administrative requirements facilitate their implementation. USEPA recognizes that certain administrative requirements, such as consultation with state agencies and reporting, are accomplished through the state involvement and public participation requirements of the NCP. The CERCLA program has its own set of administrative procedures that ensure proper implementation of CERCLA. The application of additional or conflicting administrative requirements could result in delay or confusion in the implementation of a remedial action. To ensure that CERCLA response actions proceed as rapidly as possible, USEPA has reaffirmed this position in the final NCP (USEPA, 1988b).

CERCLA onsite remedial response actions must only comply with the substantive requirements of an ARAR and not the administrative requirements to obtain federal, state, or local permits [CERCLA §121(e)]. The NCP defines onsite as "the areal extent of contamination and all areas in very close proximity to the contamination necessary for implementation of the response action." Offsite actions need only comply with applicable requirements, not relevant and appropriate requirements. However, offsite actions must comply fully with both substantive and administrative requirements (USEPA, 1988b).

In the absence of federal- or state-promulgated regulations, there are many criteria, advisories, and guidance values that are not legally binding, but may serve as useful guidance for remedial actions. These are not potential ARARs, but are TBC guidance. These guidelines or advisory criteria should be identified if used to develop clean-up goals or if they provide important information needed to properly design or perform a remedial action. Two categories of TBC information are (1) technical information on how to perform or evaluate remedial or response actions; and (2) regulatory policy or proposed regulations (USEPA, 1988b).

3.2.2 Identification of ARARs

Because of their site-specific nature, identification of ARARs requires evaluation of federal, state, and local environmental and health regulations regarding chemicals of concern, site characteristics, and proposed remedial alternatives. The USEPA provides guidance on three categories of ARARs specific to the contaminant, location, or action as discussed below (USEPA, 1988b):

- Chemical-specific requirements set health- or risk-based concentration limits or ranges for specific substances in various environmental media.
- Location-specific requirements set restrictions on activities according to characteristics of the site or its immediate environs (e.g., regulations pertaining to development in a 100-year floodplain). These requirements may apply if the CERCLA site is located in such a restricted area.
- Action-specific requirements set controls or restrictions on specific activities related to the management of hazardous substances (e.g., Resource Conservation and Recovery Act (RCRA) standards for design and operation of hazardous waste management facilities). These requirements are not chemical-specific, but are specific to remedial actions.

The following subsections provide an overview of these ARARs categories.

3.2.2.1 Chemical-Specific ARARs

Chemical-specific ARARs generally involve health- or risk-based numerical values or methodologies that establish site-specific acceptable chemical concentrations or amounts. They govern the extent of site remediation by providing either actual clean-up levels, or the basis for calculating such values. Table 3-1 presents a summary of identified chemical-specific ARARs and TBC guidance. The following subsections provide an overview of chemical-specific ARARs and TBC guidance for each impacted media.

3.2.2.1.1 Soil

As discussed in Section 2.4, the HHRA identified regulatory unacceptable human health risks resulting from site soil for a hypothetical future resident exposure scenario. PRGs for COCs present in soil were developed using appropriate risk models and inputs for both non-cancer and cancer risks. A full discussion of the risk-based development of PRGs is contained in the HHRA (Appendix K of the RI, ARCADIS, 2010b).

An ecological risk assessment was not conducted for the site due to the presence of on-going commercial operations, the lack of ecological habitat, and the absence of complete exposure pathways for wildlife at the site.

3.2.2.1.2 Groundwater

The HHRA identified potential human health risks resulting from site groundwater conditions.

As discussed in the HHRA, PRGs were developed for COCs present in groundwater that pose potential health risks based on four exposure scenarios:

- future site worker direct contact and ingestion of COCs in groundwater used as potable water, and inhalation of volatile organic compounds (VOCs) migrating to indoor air from groundwater;

- Hypothetical future adult resident direct contact, inhalation and ingestion of COCs in groundwater used as potable water, and inhalation of VOCs migrating to indoor air from groundwater; and

- Hypothetical future child resident direct contact, inhalation and ingestion of COCs in groundwater used as potable water, and inhalation of VOCs migrating to indoor air from groundwater.

The calculated PRGs should be considered relevant and appropriate for groundwater remedial activities at the Brenntag site. Calculated PRGs specify the maximum concentration at which no known or anticipated adverse effect on humans will occur. The calculated PRGs for site COCs in groundwater are discussed fully in the HHRA (Appendix K of the RI, ARCADIS, 2010b) and summarized in Section 3.3.

3.2.2.2 Location-Specific ARARs

Location-specific ARARs may affect site activities and represent restrictions placed on the concentration of hazardous substances or the conduct of activities because of the location or characteristics of a site. These ARARs set restrictions relative to the presence of specific natural or manmade features or potentially affected resources at a disposal or clean-up site (Table 3-2).

3.2.2.2.1 Floodplains and Wetlands

The Brenntag site is not located within a flood plain.

3.2.2.2.2 Fish and Wildlife Resources

As a commercial property in a predominantly industrial area, the Brenntag site is not a wildlife resource.

3.2.2.2.3 Groundwater Protection

The site is located within a groundwater protection area that prevents construction of new drinking water wells in the Springfield Plateau Aquifer within Greene County and the northern half of Christian County. Missouri regulation 10 CSR 23-3.100(3), which is part of the Missouri Well Construction Code requires that well casing on new wells extend through the Northview Shale and that water produced comes from the Ozark Aquifer. This regulation has been in effect since 1987.

3.2.2.3 Action-Specific ARARs

Action-specific ARARs set controls or restrictions on particular kinds of activities related to the management of hazardous waste and are triggered by the type of remedial action being considered. Action-specific ARARs involve design, implementation, and performance requirements that are generally technology- or activity-based. Selection of a particular remedial action may invoke appropriate action-specific ARARs that may specify particular performance standards or technologies, as well as specific environmental levels for discharged or residual chemicals. Action-specific ARARs may be established under the Resource Conservation and Recovery Act (RCRA), the Clean Air Act (CAA), the Clean Water Act (CWA), the Safe Drinking Water Act (SDWA), the Toxic Substances Control Act (TSCA), or other laws. Action-specific ARARs for each assembled remedial alternative are identified and discussed as part of the detailed analysis of alternatives in Section 7.

3.3 Development of Chemical-Specific Remediation Goals

Numerical remediation goals are a subset of the RAOs and they provide the measurable goals that drive remedial actions for each medium. In the preamble to the final NCP, the USEPA explained that remediation goals are based on ARARs unless they are unavailable. In the cases where remediation goals are not based on ARARs, numerical PRGs were developed following the USEPA guidance document entitled *Risk Assessment Guidance for Superfund: Volume 1 - Human Health Evaluation Manual (Part B, Development of Risk Based Preliminary Remediation Goals)*, Interim, December 1991 (USEPA, 1991a) and USEPA's Office of Solid Waste and Emergency Response (OSWER) Directive 9355.0-30, *Role of the Baseline Risk Assessment in Superfund Remedy Selection Decisions* (USEPA, 1991b).

The development of site-specific risk-based preliminary remediation goals for soil and groundwater is fully discussed in the HHRA (Appendix K of the RI, ARCADIS, 2010b). The impacted media and COCs for which an unacceptable risk has been identified were discussed in Section 2.4

3.3.1 Chemicals of Concern and Risk-based Preliminary Remediation Goals

As discussed in the HHRA, COCs were identified for each media of concern (groundwater and soil). A chemical was considered a human-health COC if it contributed an excess lifetime cancer risk (ELCR) greater than $1x10^{-6}$ or a HQ greater than 1, under current and/or future land-use assumptions.

Based on the data analysis presented above, the COCs and respective risk-based preliminary remediation goals are presented in Table 3-3 for soil (for the hypothetical future resident exposure scenario) and for groundwater (for the future site worker and hypothetical future resident exposure scenario).

3.3.1.1 Selection of the Remediation Goals for Soil and Groundwater

For each COC in soil and groundwater, the overall Remediation Goal was selected after a comparison of risk-based PRGs (based on potential cancer and non-cancer effects) and applicable ARARs. ARARs dictated the determination of the overall Remediation Goal. One of the ARARs is a county-wide restriction on shallow wells completed within the Springfield Plateau Aquifer, thereby eliminating a current exposure pathway for groundwater. Due to this location specific ARAR and the fact that the affected groundwater is not currently used for potable or non-potable purposes, risk based PRGs calculated using a target cancer risk of 1×10^{-5} were considered for Remediation Goals in the absence of chemical specific ARARs rather than the PRGs calculated using the most conservative target cancer risk of 1×10^{-6}. The applicable ARARs and the resultant remediation goals for both soil and groundwater are presented in Table 3-3.

Table 3-3 compares that risk-based Remediation Goals (for cancer and non-cancer exposure scenarios) to several common regulatory standards, including the Safe Drinking Water Act Maximum Contaminant Levels (MCLs) and the Tap Water Regional Screening Level.

The Remediation Goals for soil were determined using the following rationale:

- The most-protective (either cancer or non-cancer) of the site-specific risk-based levels were selected as the soil Remediation Goal.

Based on the above discussion, the Remediation Goals for soil are shown in Table 3-3 and can be summarized as:

- Prevent ingestion and dermal contact (hypothetical future residents) with onsite soil for 1,2,4-trimethylbenzene at concentrations exceeding 50 mg/kg; and

- Prevent ingestion and dermal contact (hypothetical future residents) with on site soil for 1,3-5-trimethylbenzene at concentrations exceeding 104 mg/kg.

The Remediation Goals for groundwater were determined using the following rationale:

- The list of COCs from the hypothetical residential exposure scenario was used. The residential exposure scenario was selected to account for potential future offsite receptors.
- The MCL value was selected for those constituents for which MCLs are available.
- For the remaining groundwater COCs, the most protective (either cancer or non-cancer) of the site-specific risk-based PRGs was selected as the Remediation Goal.

The list of COC and their associated Remediation Goals are summarized in Table 3-3.

3.4 Areas and Volumes to be Remediated

The areal and vertical extent of soil and groundwater contamination exceeding PRGs at Brenntag are presented in this section. A more detailed description of the nature and extent is described in the Remedial Investigation Report (ARCADIS 2007a). The delineation is based on RAOs, available site analytical data, site history, and professional judgment. The delineation of areas exceeding PRGs and the estimates of COC mass are used as the basis for developing remedial alternatives and evaluating their ability to achieve the RAOs. The two groupings of soil source area and groundwater are defined as:

- Source area soil – Source area soil describes the surface and subsurface soil in the Former Bulk Chemical Handling Area and the Former Drum Rinse Area (Figure 2-1).
- Groundwater – describes groundwater impacted with dissolved COCs in both the onsite and offsite plumes shown on Figure 2-3.

3.4.1 Soil Source Areas

In the soils, elevated concentrations of residual VOCs are generally isolated in the two identified source areas. Although aerobic conditions are likely present within the unsaturated soil due to the operation of the HVE system, some near-surface unsaturated source area soils may not be influenced by the HVA system and could be a potential source of sub-slab vapors. These source area soils could also be located within the zone of water table fluctuation and could act as a source for the dissolved groundwater plume.

The shallow depth of the groundwater at the site suggests that soil remedial activities at the site will be limited to the surface and near sub-surface depths. Below approximately 5 ft, the presence of chemicals of concern will be managed as a groundwater remediation issue. Additionally, the onsite worker exposure scenario would reasonably expect any potential exposure to occur at depths less than 5 ft below ground surface.

3.4.2 Groundwater

Groundwater analytical data collected and reported quarterly indicate the spatial distributions of constituents in site groundwater. Dissolved COCs are present within the groundwater, which extends into the limestone bedrock (approximately 11 to 32 feet bgs). Figures depicting the extent of selected constituents in groundwater are presented in the RI (ARCADIS, 2007a).

3.5 General Response Actions

General response actions are categories of remedial actions that may be used to satisfy the RAOs by either reducing the COC concentration in each medium to a level that is below the PRG or by preventing receptor exposure to the impacted medium. General response actions provide the basis for identifying specific remedial technologies and process options. General response actions are developed for each medium of interest defining remedial actions that may, singly or in combination, be taken to satisfy the RAOs for the Brenntag site. General response actions that will be considered for each source area include:

<u>Source Areas</u>

- No action;
- Institutional controls;
- Monitored natural attenuation;
- Capping;
- Containment of impacted soil/groundwater;
- Removal and disposal of impacted soil;
- Removal, ex-situ treatment, and disposal of impacted soil;
- Removal, ex-situ treatment, and discharge of impacted groundwater; and

- In-situ treatment of impacted soil/groundwater.

4. Identification and Preliminary Screening of Remedial Technologies and Process Options

This section identifies and evaluates potential remedial technologies and process options associated with the general response actions presented in Section 3.5. Remedial technologies are defined as general categories of remedies under each general response action (e.g. capping is a remedial technology under the general response action of containment). Process options are defined as specific categories of remedies within each remedial technology that are used to implement the remedial technology (e.g. vegetative cover is a process option under the remedial technology of capping - USEPA, 1988b).

The purpose of initially considering all potentially applicable technologies and process options is to ensure that such possibilities are not overlooked early in the FS process. Additionally, this initial comprehensive screening process eliminates those technologies or process options that are not applicable based on the COCs and site characteristics identified at the site prior to developing comprehensive remedial alternatives or conducting a more detailed analysis. The following sections describe the preliminary screening of remedial technologies and process options for the general response actions presented in Section 3.5. The technologies/process options that are retained through this screening process summarized in Section 5 and are later combined into specific remedial alternatives and presented in Section 6. The preliminary screening includes:

- Technical Implementability Screening;
- Evaluation of Process Options; and
- Selection of Representative Process Options.

4.1 Technical Implementability Screening

One of the preliminary screening criteria (or evaluation criteria) for remedial technologies and process options is technical implementability. This screening is based on technical implementability itself; the site-specific RAOs and ARARs developed in Section 3; site-specific conditions, such as the geologic setting and contaminant distribution; and, contaminant characteristics. Technical implementability refers to the ability of a remedial technology or process option to meet an RAO or PRG, including calculated PRGs and USEPA PRGs. The preliminary screening process for the site considered available technologies and the final result of this

screening is a list of retained technologies and process options that are technically capable of addressing contaminant types found at the site under the current site conditions.

Tables 4-1 and 4-2 present the technical implementability screening of remedial technologies and process options for soil and groundwater at the site, respectively. These tables briefly describe potentially applicable technologies and process options associated with the general response actions and provide detailed screening information. Technologies and process options that were eliminated from further consideration on the basis of technical implementability are shaded for clarity.

4.2 Evaluation of Process Options

After the technical implementability screening, the retained remedial technologies and process options are evaluated in greater detail using the following criteria:

- Effectiveness;
- Implementability; and
- Relative Cost.

In terms of effectiveness, remedial technologies and process options are evaluated by the following:

- Potential effectiveness in addressing the estimated areas and volumes of media and meeting the RAOs or PRGs;
- Potential impacts to human health or the environment during construction and implementation; and
- How proven and reliable the process is with respect to the types of contamination and site conditions that will be encountered.

Implementability refers primarily to the administrative aspects of using a process option, such as the ability to obtain necessary permits; the availability and capacity of treatment, storage, and disposal services; and the availability of necessary equipment and workers to implement the technology.

Cost plays a limited role in the evaluation of process options at this step. Relative capital and operations and maintenance (O&M) costs are used rather then detailed

estimates. Each process option is evaluated on the basis of engineering judgment as to whether costs are high, moderate, or low relative to the other process options of the same remedial technology type.

Tables 4-1 and 4-2 present the evaluation of process options for soil and groundwater, respectively. Technologies and process options that are screened out (i.e., not retained) on the bases of effectiveness, implementability, and/or cost are shaded in the tables.

In order to develop the final suite of retained process options and remedial technologies, an evaluation of relevant technologies was performed for soil and groundwater, as summarized in Tables 4-1 and 4-2, respectively. For each area, these tables provide a comprehensive list of general response actions, remedial technologies, and specific process options, along with a description of each process option and the basis for either retaining the technology or screening the technology from further consideration. The various process options were considered independently through the preliminary screening process. For instance, two process options (impermeable cover and vegetative cover) were considered under the "Containment" general response action and the "Capping" remedial technology (Table 4-1). The following sections provide the basis for whether a specific remedial technology was retained through the preliminary analysis. Retained technologies were evaluated in greater detail, as described in Section 5.

4.3 Selection of Representative Process Options

Following the evaluation of process options based on effectiveness, implementability, and relative cost, representative process options are selected for each remedial technology type. The representative process options are selected by considering those that are the most well-established, proven, and reliable over a range of site conditions. One or more representative process options are selected for each technology type to simplify the subsequent development and detailed analysis of remedial alternatives. More than one process option may be selected for a technology type if the processes are sufficiently different in their performance that one would not adequately represent the other.

The process options retained are discussed in detail in Section 5. The process options screened out and the reason(s) for being screened out are briefly summarized in the following sections.

4.3.1 Soil

The preliminary screening of alternatives to treat impacted soil at the site resulted in the removal of six of the technologies evaluated from further consideration. Technologies that were removed from further evaluation include site-wide capping, in-situ treatment of soil by chemical oxidation using ozone, ex-situ treatment of excavated soil by soil washing, stabilization/soil mixing, UV/chemical oxidation and composting as described in Table 4-1. Site-wide capping is inappropriate given the fact that the Site is an operational facility and the wide fluctuation in groundwater levels. In-situ chemical oxidation using ozone was not applicable to the treatment of soil, as the low permeability and heterogeneous nature of the site sediments and bedrock would prevent effective distribution of ozone within the relatively short period of time that the ozone is an effective oxidant. Ex-situ treatment of excavated soil by using UV/chemical oxidation was not applicable as the volatility of the COCs makes additional treatment in addition to aeration unnecessary. Soil washing is inappropriate given the fine grained nature of the soil. Volume reduction from soil washing would be minimal. Stabilization is ineffective with VOCs. Composting is impracticable given the mix of VOCs present at the site. A detailed analysis of each technology considered for soil treatment is summarized in Table 4-1.

4.3.2 Groundwater

The preliminary screening of alternatives to treat groundwater at the site resulted in the removal of eight of the technologies evaluated from further consideration, as described in Table 4-2. Specifically, technologies that were removed from further evaluation include the following: barrier technologies (grout injection, trenched cut-off wall, and sheet piling); ex-situ chemical and biological treatment processes (UV/chemical oxidation, constructed wetland treatment, and bioreactors); and onsite discharge options (reinjection and surface water discharge). The technologies removed during the preliminary screening process were primarily screened based on effectiveness related to the ability of the technology to meet remediation goals within the hydrogeologic setting, which consists of shallow groundwater present in heterogeneous low permeability sediments overlying limestone bedrock. For example, the barrier technologies are either technically inapplicable within the impacted bedrock (sheet piling and trenched cut-off wall), and/or technically inappropriate given the potential for unpredictable effects on groundwater flow due to the heterogeneous nature of the saturated materials (grout curtain, sheet piling, and trenched cut-off wall). The low volumes of groundwater that can potentially be withdrawn at the Brenntag site make ex-situ chemical and biological treatment inappropriate given the complexity

required by the mix of COCs at the site, when compared to the proven effectiveness of air stripping and carbon adsorption. Onsite discharge by reinjection would not be feasible given the low permeability of the saturated materials, and surface water discharge of treated groundwater is unnecessary given the existing POTW discharge permit for the currently operating HVE system.

5. Description of Retained Process Options

The following sections describe retained process options for soil and groundwater.

5.1 Soil Process Options

The following process option descriptions relate to remediation of soil at the site.

5.1.1 No Action

The NCP and USEPA's current guidance for conducting Remedial Investigation/ Feasibility Studies (RI/FS) investigations requires that the "No Action" option be developed and examined as a potential remedial action for all sites. The "No Action" option is retained and examined as a baseline to which other remedial actions are compared (Table 5-1).

5.1.2 Institutional Controls

Institutional controls affect site management and/or activities occurring at the site. Institutional controls do not physically alter conditions at the site and do not, or are not intended to, reduce the mobility, toxicity, or volume of contamination at the site as part of the remedial alternative. Institutional controls limit potential for exposure to site contamination.

5.1.3 Deed Notification

Deed notifications are descriptions about the property built into the property deed to convey information about the land to future buyers. RCRA also requires deed notifications to explain that the property has been used to manage hazardous or mixed wastes. The deed notification would, in perpetuity, notify any potential purchaser that the property has been used for the management and disposal of hazardous materials as part of site operations. Deed notification received "moderate" effectiveness, "high" implementability, and "low" cost evaluations (Table 5-1).

5.1.3.1 Deed Restriction

Deed restrictions are provisions built into a property deed prohibiting certain uses of the property. The deed would include deed restrictions precluding residential use of the property. The underlying assumption is that the facility will remain an industrial property for the foreseeable future. Deed restriction received “moderate” effectiveness, “high” implementability, and “low” cost evaluations (Table 5-1).

5.1.4 Removal – Excavation

Excavation involves the physical removal of impacted soil using standard excavation practices and technology. Typical equipment used includes backhoes, drag lines, clamshells, vacuum trucks, and front-end loaders.

Materials handling is a major concern which affects the implementability of excavation. Staging areas would be used to prepare wastes for disposal or treatment and should be graded to reduce ponding, lined to prevent groundwater contamination, and bermed to prevent runoff. The offsite transportation of wastes resulting from excavation must meet Federal and State shipping and manifesting regulations. Backfilling, grading, and revegetation after excavation would be necessary to prevent large open areas that would collect rainwater. Dewatering would be required for excavation below the groundwater table. Sampling of remaining soil would confirm the removal of contaminants. The excavated area would be backfilled with clean soil.

Excavation and removal of impacted soil eliminates the environmental and health concerns associated with direct contact of contaminated soil. However, consideration must be given to the health and safety of remedial workers. Onsite air monitoring and dust, vapor, and odor control provisions would be necessary during excavation operations. Excavation activities can result in the release of fugitive dusts and runoff from disturbed soil. Dust controls could include water sprays or application of chemical dust suppressants. Surface water controls may also be required. Excavation at the site would likely create significant disturbance of the overall operational activities of the facility**.** Excavation received “high” effectiveness, “low to moderate” implementability, and “high” cost evaluations (Table 5-1).

5.1.4.1 Disposal – Offsite Landfill

This disposal option would involve transporting the material to an approved landfill for disposal. The two nearest Subtitle C facilities are located in Peoria, Illinois and Waynoka, Oklahoma. Labor and materials for transportation of the material are

generally available. This technology is considered in conjunction with the excavation technology. Offsite landfill received “high” effectiveness, “moderate” implementability, and “high” cost evaluations (Table 5-1).

5.1.4.2 Disposal – Onsite Consolidation

Onsite consolidation of COC impacted soil would involve excavating and combining different areas to one central location to make application of a vegetative cover or other in-situ treatment option such as stabilization more cost effective. Onsite consolidation received “low to moderate” effectiveness, “low” implementability, and “low to moderate” cost evaluations (Table 5-1).

5.1.5 In-Situ Physical Treatment – Soil Vapor Extraction

Soil vapor extraction (SVE) is an accepted, recognized, and cost-effective technology for remediating soils contaminated with volatile and semivolatile organic compounds. This technology is known in the industry by various other names, such as soil venting and vacuum extraction. The process involves inducing air flow in the subsurface with an applied vacuum, and thus enhancing the in situ volatilization of contaminants. Depending on the depth of soil being remediated, extraction of air laden with contaminant vapors can be achieved with vertical extraction wells or horizontal extraction pipes. The SVE process takes advantage of the volatility of the contaminants to allow mass transfer from adsorbed, dissolved, and free phases in the soil to the vapor phase, where it is removed under vacuum and treated above ground. In order for this process to be effective, the chemicals of concern must be volatile enough and have a low enough water solubility to be drawn into the soil gas for removal.

In addition to removal of VOCs as vapor, operation of an SVE system provides oxygen to impacted soils by drawing atmospheric air into the subsurface. Where aerobically degradable compounds are present, operation of an SVE system can increase the rate of aerobic biodegradation of COCs.

SVE involves passing large volumes of air through or close to a contaminated media using an air circulation system. The organic compounds or various fractions of a mixture of organic compounds volatilize or evaporate into the air and are transported to the surface. A typical in situ soil vapor extraction system couples vapor extraction wells with blowers or vacuum pumps to remove contaminant vapors from zones permeable to airflow. The components of an in situ soil vapor extraction system are usually readily available as off-the-shelf products. The choices available to treat the

contaminants present in the effluent air are many, and will primarily depend on the type of contaminants and the mass loading rate. A typical soil vapor extraction system consists of one or more extraction wells, one or more air inlet or injection wells (optional), piping or air headers, vacuum pumps or air blowers, flow meters and controllers, vacuum gauges, sampling ports, air-water separator (optional), vapor treatment (optional), and a cap (Suthersan, 1997).

Pilot testing and operation of the HVE system at the site have indicated that permeabilities of the impacted soils, and other site conditions such as the shallow groundwater table and unsealed ground surface limit the effectiveness of SVE as a stand alone system. However, as a component of multiphase extraction (MPE) which allows for higher extraction vacuums, it can be effective in site conditions such as those that exist at the site.

An MPE pilot test was conducted at the site in 2000. Results of the pilot testing indicated that the soil vapor extraction component of the MPE was an effective means of site remediation. An interim remediation system consisting of 54 extraction wells, extraction piping, a vacuum extraction module, and a groundwater treatment system was installed in late 2000, and has been in operation since June 2001. Operation of the system has resulted in a significant reduction in dissolved phase COCs within the treatment area, but concentrations of dissolved COCs remain.

Soil vapor extraction received “moderate” effectiveness, “high” implementability, and “moderate” cost rating and would be implemented with other source area treatment technologies (Table 5-1).

5.1.6 In-Situ Physical Treatment – Chemical Oxidation

Chemical oxidation is a common and proven treatment process that consists of the addition of strong oxidants to the subsurface that react chemically with the contaminants which, if carried to completion, ultimately results in carbon dioxide and water. Common oxidants include peroxide, permanganate and persulfate, all of which can oxidize a wide variety of organic compounds including halogenated and non-halogenated aliphatic and aromatic compounds, including those VOCs present at the site. Successful remediation using chemical oxidation results occurs quickly, with treatment finished upon the completion of oxidant application.

There are a number of safety issues that will have to be addressed when considering chemical oxidation use in soil or groundwater remediation at the Site. Heat is released by the oxidation of the COCs. Organic vapors are also produced by the chemical

reactions and the increased vapor pressure due to heating of residual and NAPL VOCs.

In addition to the safety issues discussed above, implementation of chemical oxidation at the site would need to take into account site specific characteristics such as total oxidant demand, contaminant delineation, contaminant mass, and site hydrogeology. Given the low permeability of the soils at the site and as demonstrated during the ERD pilot test, injection of the oxidant as a liquid would require pneumatic fracturing, resulting in an uneven distribution of the oxidant and an uneven treatment of the residual VOCs. The most effective method of application would be by soil mixing. A typical soil mixing approach would be to use large diameter (up to 8 ft) soil augers to blend the oxidant reagent with the soils. The volume of oxidant required is then based on the oxidant demand of the soils due to non-target material as well as mass of VOCs. The soil mixing would be conducted in a manner to maximize the contact between the oxidant and the VOCs. Even with thorough application, the low permeability of the soils may result in a relatively modest mass reduction of VOCs.

Site specific technical limitations on implementing chemical oxidation include the following:

- Although high concentrations of residual VOCs have not been identified in the soil, the most likely “hot spots”, the former loading area and the inactive tank farm are inaccessible for the soil mixing approach to chemical oxidation.

- Aqueous chemistry cannot directly treat non-aqueous contaminants; the contaminants must dissolve to become available for oxidation reactions. Thus, effective chemical oxidation of the low permeability unsaturated sediments is limited to the soil mixing approach. Oxidation of residual VOCs in the saturated sediments may be effectively implemented by either injecting as a liquid or by soil mixing.

- Gases produced in the treatment will fill pore space, isolating contaminant from the aqueous chemistry, limiting mass reduction.

- Soil mixing will generate structure failure of the aquifer soil matrix, potentially generating preferred groundwater flow pathways which could increase the rate of mass transport out of the source zone.

Despite the inherent safety and performance concerns with implementing chemical oxidation, there are significant benefits to its use. Successful remediation using chemical oxidation occurs rapidly, with treatment finished upon completion of the final

oxidant application. Impacted soils are shallow and easily reached with soil mixing equipment, although site activities and facilities may limit access.

Chemical oxidation as applied at the Brenntag Site received “low to moderate” effectiveness, “moderate” implementability, and “med” cost evaluation (Table 5-1).

5.1.7 In-Situ Biological Treatment – Enhanced Reductive Dechlorination

Enhanced reductive dechlorination (ERD) is an engineered bioremediation technique in which chlorinated compounds are degraded under anaerobic conditions through a series of transformations. ERD involves the injection of an easily degradable carbohydrate solution (e.g., food-grade molasses) into the groundwater, which is metabolized by the naturally occurring bacteria in the subsurface. Consequently, the bacteria consume dissolved oxygen (DO) at a rate greater than it is recharged, creating an anaerobic environment.

ERD is primarily a groundwater treatment technology, but is retained here to address impacted constituents in the shallow saturated soil. Additional discussion of ERD is contained in Section 5.2.8.

An engineered ERD approach is synergistic with the existing reducing conditions at the site as demonstrated by the significant presence of degradation products in the groundwater.

The field demonstration study conducted within the saturated sediments of the site suggests that an engineered ERD is unlikely to be successful in unsaturated soils given the limited ability to inject solution. ERD is potentially a viable chlorinated VOC treatment technology within saturated soils provided an improved means of delivery (trench, excavation backfill) is utilized. ERD receives “low to moderate” effectiveness, “moderate” implementability, and “moderate” cost rating (Table 5-1).

5.1.8 In-Situ Thermal Treatment

In-Situ thermal enhancement is a treatment option used for the remediation of VOCs, that typically works by raising the soil and groundwater temperature sufficiently to to volatilize COCs which are then removed in the vapor phase. Some high temperature destruction of the COCs may also occur, through both abiotic and biotic degradation or destruction of COCs (USEPA, 2004b).

The principal methods of thermal enhancement are steam injection, thermal conduction heating, and electrical resistance heating (ERH), each of which increases temperatures in the subsurface using a different methodology. Implementation of steam injection is most effective in soils or fractured bedrock of moderate to high permeability where steam can enter the pore space of the impacted soil. The low permeability of the unconsolidated soils and bedrock of the site are not well suited for steam injection.

Thermal conductive heating uses subsurface electrical elements to heat the soil and soil vapor extraction to recover volatilized compounds. ERH is conducted by applying an electrical current through the soils between a series of subsurface electrodes. The electrical resistance of the soils results in energy being dissipated and generating heat. The heating of the soil causes the COCs to be volatilized, stripping them from the soil and groundwater and allowing collection using an SVE/MPE system. The technique and effect of implementing thermal conductive heating and ERH would be similar at the site. ERH will be discussed as the technique with a longer track record and more published information on implementation.

The implementation of ERH at the site would likely consist of a series of overlapping electrode arrays. Each of the electrode locations would also be constructed to allow for the withdrawal of soil vapors volatilized by the heating, and for the addition of sufficient water to maintain conductivity within the heated soils adjacent to the electrodes. In addition, due to the low permeability of the impacted soils, additional MPE extraction points may be required within the footprint of the array to ensure capture of the volatilized vapors. Extracted vapors would be cooled, the condensate removed, then discharged to the atmosphere or if necessary, treated using thermal oxidation.

The site conditions are such that if appropriately implemented, ERH would be effective in the removal of both residual COCs in the soil and dissolved VOCs within the groundwater. It is less clear that ERH would be effective in addressing dissolved VOCs within the upper bedrock.

In-Situ Thermal received “high” effectiveness, “moderate to high” implementability, and “high” cost rating ((Table 5-1) and would be potentially implemented as an aggressive source area treatment at the site.

5.1.9 Aerobic Bioremediation

Aerobic biodegradation is a bioremediation technique in which aerobically degradable organic compounds are microbially reduced using oxygen as an electron receptor. It is typically conducted by introducing oxygen and occasionally nutrients into the subsurface. Aerobically biodegradable compounds at the site include aromatic hydrocarbons and ketones. Chlorinated hydrocarbons are typically not considered aerobically biodegradable.

Air is a much more efficient carrier of oxygen than water, so is the most common delivery technique for unsaturated soil, where it is commonly referred to as bioventing. Bioventing is conducted either by drawing air into the subsurface as a consequence of SVE operation, or air is blown directly into the subsurface through vertical or horizontal deliver points.

Delivery of oxygen into saturated soils typically uses groundwater for distribution. Elevated DO concentrations are generated using a number of methodologies including air sparging, direct oxygen injection, or injection of oxygen releasing compounds (such as hydrogen peroxide, ORC) method. With all of these techniques, aerobic biodegradation is most effective where site conditions allow for efficient delivery and distribution of oxygen. Factors impacting delivery of oxygen include soil types, mineral content, soil permeability, groundwater flow velocities, soil pH, and COC concentrations.

Aerobic biodegradation of the aromatic hydrocarbons and ketones is likely ongoing (though undocumented) in the unsaturated soils as a result of the soil vapor extraction component of the MPE system. Aerobic biodegradation of aromatic hydrocarbons and ketones in the saturated soils is potentially an effective approach within the saturated soils given an effective delivery method. Aerobic biodegradation receives “moderate” effectiveness, “high” implementability, and “low to moderate” cost rating (Table 5-1).

5.1.10 Ex-situ Treatment - Aeration/Landfarming

Landfarming is an above-ground soil remediation technology where excavated soils are spread in a thin layer on the ground surface and aerobic microbial activity within the soils is stimulated through aeration and/or the addition of minerals, nutrients, and moisture. In addition, the process of excavating, spreading, and mixing enhances volatilization of VOCs. The enhanced microbial activity results in degradation of adsorbed aromatic hydrocarbons and ketones present at the site through microbial

respiration. The chlorinated hydrocarbons present in the soils would be addressed solely through volatilization.

Implementation of landfarming requires sufficient area to spread the soil in a thin layer (2 to 18 inches maximum). It is also necessary to contain and treat surface run off from the landfarm area to prevent the mobilization and off site discharge of COCs to surface water. Permitting requirements for implementation of land farming are significant, but routinely approved by the necessary agencies.

Landfarming can be an effective method to address all of the COCs present at the site. However, the lack of available space onsite prevented it from being cost-effective as a disposal method. Aerobic biodegradation receives “moderate to high” effectiveness, “moderate” implementability, and “moderate” cost rating (Table 5-1).

5.2 Groundwater Process Options

The following process options descriptions relate to remediation of groundwater at the site.

5.2.1 No Action

The NCP and USEPA’s current guidance for conducting RI/FS investigations requires that the “No Action” option be developed and examined as a potential remedial action for all sites. The “No Action” option is retained and examined as a baseline to which other remedial actions are compared (Table 5-2).

5.2.2 Institutional Controls

Institutional controls affect site management and/or activities occurring at the site. Institutional controls do not physically alter conditions at the site and do not, or are not intended to, reduce the mobility, toxicity, or volume of contamination at the site as part of the remedial alternative. Institutional controls limit potential for exposure to site contamination.

5.2.2.1 Deed Notification

Deed notifications are descriptions about the property built into the property deed to convey information about the land to future buyers. RCRA also requires deed notifications to explain that the property has been used to manage hazardous or mixed wastes (40 CFR 264.119(b) and 265.119(b)). The deed notification would, in

perpetuity, notify any potential purchaser that the property has been used for the management and disposal of hazardous materials as part of site operations. Deed notification received “moderate” effectiveness, “high” implementability, and “low” cost evaluations (Table 5-2).

5.2.2.2 Deed Restriction

Deed restrictions are provisions built into a property deed prohibiting certain uses of the property. The deed would include deed restrictions precluding residential use of the property, restrictions on groundwater usage, and restrictions on future construction activities restriction received “moderate” effectiveness, “high” implementability, and “low” cost evaluations (Table 5-2).

5.2.3 Monitored Natural Attenuation

Natural attenuation processes combine dispersion, sorption, volatilization, abiotic transformation, and biodegradation of anthropogenic contaminants, such as chlorinated ethenes (PCE, TCE, 1,2-DCE, vinyl chloride), petroleum hydrocarbons (polynuclear aromatic hydrocarbons [PAHs], aromatics – benzene, toluene, ethylbenzene, and xylenes [BTEX], and ketones – acetone) in groundwater systems. The time required for these processes to lower concentrations to levels protective of human health and the environment varies widely between different hydrologic systems and different chemical constituents.

Site specific data were used to evaluate natural attenuation at the site using several parameters including the compounds used at the site and their degradation products, historical VOC trends, site biogeochemical data, and distribution of VOCs on and off site.

Data presented in the RI including total VOC concentrations, distribution of VOCs between the parent compounds and degradation products, and biogeochemical parameters indicate that significant natural degradation of PCE and TCE is occurring in the source areas, and downgradient of the source areas. The natural degradation is likely enhanced by the presence of aromatic and ketone compounds that were co-released with the CVOCs. The reductive dechlorination process is dependent on the consumption of available electron acceptors through the oxidation of various organic carbon sources, resulting in a strongly reducing environment.

Monitored natural attenuation (MNA) for the source areas received “moderate” effectiveness, “high” implementability, and “low to moderate” cost rating for the source

area based on the current observed biodegradation and other natural attenuation processes (Table 5-2).

5.2.4 Barriers – Groundwater Extraction

Groundwater extraction is primarily used as a containment strategy although some benefit of mass removal can be realized for dissolved contaminants. In addition, when utilized as a component of MPE, it can increase the effectiveness of soil vapor extraction by dewatering previously saturated sediments sufficiently to allow air flow through impacted soils. Groundwater extraction can be used to control the migration of groundwater contaminants by altering the hydraulic gradient of the aquifer; they can also be used to withdraw contaminated groundwater for ex-situ treatment or offsite disposal. Extraction wells are wells screened at an appropriate depth to capture impacted groundwater. The wells are usually connected using a manifold, and the impacted groundwater is pumped through the manifold to an area where treatment occurs.

As discussed in Section 1.1, groundwater pump-and-treat is part of the HVE system implemented in 2001, and will likely remain as part of the selected remedy. Hydraulic testing conducted as part of the Data Gap Study indicated that despite the relatively steep groundwater gradient at the site, groundwater extraction testing conducted at three well locations resulted in hydraulic responses that indicate capture zones sufficient in size to overlap at the existing remediation well spacing. Where necessary (at all locations except previously reconstructed E47B), the extraction wells will be deepened to maximize drawdown and the resulting capture zone.

While performance of individual wells will need to be confirmed, the results from the testing indicate that properly designed and installed wells can be used to hydraulically contain shallow groundwater at the site either with or without applied vacuum. The results indicate that hydraulic containment can be effective in preventing offsite migration of VOCs in the unconsolidated sediments and shallow bedrock. Given the heterogeneous nature of the subsurface, performance evaluations of individual wells will be conducted at startup to ensure acceptable hydraulic performance.

On-going evaluation of the HVE/groundwater extraction system will be part of the long-term monitoring program under CERCLA. The most recent evaluation of the groundwater extraction system is that while it was not documented to have been wholly effective in containing the VOC plume onsite, it has contributed to a significant reduction in dissolved VOC concentrations on site. Performance monitoring will be conducted going forward to document capture of the VOC plume.

In addition to the impact of the HVE system on the shallow groundwater, groundwater withdrawal from the deeper SAW-2 well has resulted in a decrease in dissolved VOC concentrations. Inefficiencies or inadequacies in the existing groundwater extraction system will be addressed by modifications to the extraction system to meet the remediation goals.

Groundwater extraction received a “moderate to high” effectiveness rating, “high” implementability rating, and “moderate” cost rating for the groundwater implementation of this technology (Table 5-2).

5.2.5 In-Situ Treatment – Multi-Phase Extraction

MPE is a technique of applying a high vacuum or negative pressure on a recovery well and the formation in order to enhance the recovery of total fluids (i.e., water, NAPL, and vapor) from that well by increasing the net effective drawdown and, consequently, vapor flow through the formation. MPE also increases the mass removal of the volatile and semi-volatile contaminants, by maximizing dewatering and facilitating volatilization from previously saturated sediments via the increased air movement. In addition, mass removal of aerobically biodegradable contaminants will be enhanced by the resulting induced air movement through the treatment zone and an increase in oxygen available for aerobic microorganisms. The use of MPE systems in environmental remediation is unique because whereas most remediation methods rely on either water or air as the carrier, MPE relies on a combination of both fluids as carriers. Because of this characteristic to remove both liquids and vapors, MPE is also referred to as dual-phase extraction or vacuum-enhanced extraction.

MPE involves the extraction of water, gas, and possibly NAPL from the subsurface through the application of a vacuum to wells. MPE wells typically operate with all or a portion of the well screen completely dewatered, creating unsaturated pathways to the vadose zone. Thus, the vacuum applied creates vapor flow through the vadose zone to the MPE wells, thereby removing volatile organic vapors in the soil gas. The extraction of water creates a cone of depression, and therefore exposes a greater portion of the subsurface to vapor stripping. The extraction of groundwater also removes dissolved impacts from the subsurface.

An MPE pilot test was conducted at the site in 2000. Results of the pilot testing indicated that MPE was an effective means of site remediation. An interim remediation system consisting of 54 extraction wells, extraction piping, a vacuum extraction module, and a groundwater treatment system was installed in late 2000, and has been in operation since June 2001. Since being placed in operation, the HVE system has

had numerous maintenance issues that have had a significant impact on system runtime during the initial stage of operation. Significant equipment upgrades in 2002 and 2008 has resulted in a substantial increase in the system run time.

While concentrations of dissolved COCs remain, operation of the system has resulted in a significant reduction in dissolved phase COCs within the treatment area, including large reductions in petroleum hydrocarbon concentrations in the Central Unit area immediately following the installation of additional extraction wells.

An additional goal of the IRM system is to maintain hydraulic control of the on site dissolved phase COCs. Operating data has been inconclusive as to whether hydraulic containment was achieved. However, hydraulic testing conducted as part of the data gaps study indicated that hydraulic control of the dissolved phase plume within the unconsolidated sediments and shallow bedrock is readily achievable.

The primary means of removal for the MPE technology is extraction through the vapor-phase, as indicated by the calculated mass removal of COCs. As of August 2010 the mass of COCs removed as vapor is 950 lbs compared to total mass of 32 lbs removed in the dissolved phase.

MPE received “moderate” effectiveness, “high” implementability, and “moderate” cost rating and continued use of the interim remediation system would be as an aggressive source area treatment at the loading area (Table 5-2).

5.2.6 In-Situ Treatment – Chemical Oxidation

Chemical oxidation has been discussed in detail in Section 5.1.5 for use in source area soils. The method for application for groundwater would likely differ significantly.

Application of chemical oxidation for addressing groundwater impacts would involve the injection of liquid oxidant on close horizontal and vertical spacing to ensure even distribution of the oxidant within the area of impact. Given the low permeability of the soils, injection of the oxidant as a liquid could result in pneumatic fracturing, resulting in an uneven distribution of the oxidant and an uneven treatment of the residual VOCs. Thus, chemical oxidation via direct injection or the use of wells is likely to be most effective where used to address a predominantly groundwater component such as the offsite groundwater plume.

A potentially effective alternative is to inject the oxidant into excavation backfill or trenches and use the hydraulic head generated during the injection to push the oxidant

into native material. Given the relatively short half life of the reagents, chemical oxidation is likely to have the greatest effect within zones of higher permeability and modest or little effect in lower permeability zones. Thus, given the site hydrogeology, while chemical oxidation may result in a significant reduction in dissolved VOCs it is unlikely to result in complete destruction of COCs within the dissolved plumes.

Chemical oxidation as would be applied received “moderate” effectiveness, “moderate” implementability, and “moderate” cost evaluation (Table 5-2)**.**

5.2.7 In-Situ Treatment – Zero Valence Iron

Zero valence iron (ZVI) is an emerging technology for providing plume containment by chemical reduction of CVOCs, typically in permeable reactive barrier (PRB) applications,.

Implementation of ZVI would need to take into account site specific characteristics such as ZVI demand in groundwater, cross site flow volume of impacted groundwater, contaminant mass, and site hydrogeology. The lack of effectiveness with regards to the aromatic hydrocarbons and ketones make it unlikely that it could be effectively used to treat source area groundwater.

ZVI received “low to moderate” effectiveness, “moderate” implementability, and “high” cost evaluation (Table 5-2).

5.2.8 In-Situ Treatment – Enhanced Reductive Dechlorination

Enhanced reductive dechlorination (ERD) is an engineered bioremediation technique in which chlorinated compounds are degraded under anaerobic conditions through a series of transformations. ERD involves the injection of an easily degradable carbohydrate solution (e.g., food-grade molasses) into the groundwater, which is metabolized by the naturally occurring bacteria in the subsurface. Consequently, the bacteria consume dissolved oxygen (DO) at a rate greater than it is recharged, creating an anaerobic environment.

Following depletion of DO, the bacteria begin the successive utilization of alternative electron acceptors to support respiration. The general sequence of alternate electron acceptor utilization and respiration byproduct formation is as follows (from most thermodynamically favorable to least):

Nitrate (NO_3^-)	$\rightarrow$	Nitrite (NO_2^-)
Ferric Iron (Fe^{3+})	$\rightarrow$	Ferrous Iron (Fe^{2+})
Mangenic Manganese (Mn^{4+})	$\rightarrow$	Mangenous Manganese (Mn^{2+})
Sulfate (SO_4^{2-})	$\rightarrow$	Sulfide/Hydrogen Sulfide (H_2S)
Carbon Dioxide (CO_2)	$\rightarrow$	Methane (CH_4)

Microbial utilization of such alternate electron acceptors creates electrochemically reducing conditions. Consequently, by maintaining excess organic carbon in the groundwater environment, ERD technology drives the groundwater environment to anaerobic and strongly reducing conditions. The zone in which this environment is established becomes an in-situ reactive zone (IRZ).

ERD technology relies on an active delivery method, whereby the organic carbon source is periodically injected under low pressure through re-useable injection wells or injection trenches. This process ensures immediate and continued delivery of excess organic carbon to the formation. This allows microbial populations to flourish in a relatively short time frame, resulting in a highly reducing groundwater environment and supporting contaminant degradation at rates sufficient to meet remedial goals. Additional injections, natural dispersion, and advective groundwater transport also help maintain and propagate the ERD. Thus, ERD is most effective on saturated soils where the groundwater flow assists in the delivery and maintenance of the organic carbon solution. Effective treatment of unsaturated soils in-situ is more difficult, requiring development and maintenance of saturated conditions. This often results in the loss of bearing strength in the treated soils, and is inappropriate for many areas of the Site where activities are performed or surface structures are located.

During application of ERD, the increase in microbial populations also typically result in a natural surfactant effect caused by the generation of biosurfactants and bioemulsifiers that can promote desorption of residual and adsorbed phase contaminant mass, making it available for degradation (Suthersan, 2002). This effect is an important advantage of the ERD technology as it can aggressively access the adsorbed phase – and free-phase – mass that represents the bulk of chlorinated volatile organic compounds (CVOCs) that will need to be treated for successful remediation at the site including the Source Area. This will provide an advantage in a shortening of expected treatment duration as compared to other physical and chemical

treatment techniques which rely on the extremely slow process of diffusion to access the adsorbed phase mass (Nyer et al., 2001).

Assuming a sufficient population of naturally occurring bacteria and availability of sufficient nutrients and alternate electron acceptors, the primary technical challenges associated with the use of ERD for groundwater remediation include: (1) delivering the carbohydrate solution to the subsurface; and (2) controlling the groundwater biogeochemical environment.

An ERD field demonstration was conducted at the site to determine the effectiveness and implementability of the technology. The objectives of the field demonstration included the following:

- Determine site specific injection characteristics: Determined through monitoring of total organic carbon (TOC) in the performance monitoring wells. Successful performance will be demonstrated based on the presence of an increase in TOC concentrations in the performance monitoring wells. These data will be used to verify groundwater flow velocity, horizontal dispersion of injection solution, full-scale injection well spacing, and solution strength.

- Demonstrate ability to enhance reducing conditions in groundwater: Determined through monitoring of VOCs, field parameters (DO and oxidation reduction potential [ORP]), and various electron acceptors (nitrate, iron, manganese, sulfate, and carbon dioxide). Successful performance of the field demonstrations will be based on a combination of the following observations within the performance monitoring wells (1) increase in concentration of daughter products of trichloroethene (TCE), including dichloroethene (DCE), vinyl chloride, ethene, and ethane, relative to source material; (2) a decrease in electron acceptors (i.e., DO, nitrate and sulfate); (3) an increase in the reduced forms of the electron acceptors (i.e., nitrite, dissolved iron and manganese, sulfide, and methane); and, (4) a decrease in ORP.

- Demonstrate ability to maintain ERD proximate to source area: Determined through monitoring TOC and field parameters within the performance monitoring wells. Successful performance will be based on the ability to sustain anaerobic and reducing conditions through the field demonstration.

- Demonstrate ability to release adsorbed mass for degradation: Determined through monitoring VOCs and light hydrocarbons (ethene and ethane). Successful performance will be based on an increase in the summation of the molar concentrations of TCE, DCE, vinyl chloride, ethene, and ethane.

Typically, VOC concentrations may increase by 100 percent in performance monitoring wells located within the treatment zone.

Overall, the initial pilot test results indicated partially successful injection and distribution of the organic carbon solution and indicated development of enhanced reducing condition in the injection area. Results of the initial pilot test activities were sufficiently encouraging to extend the pilot study to more fully demonstrate effective reducing conditions and to collect the necessary information for a full-scale design of engineered ERD

An engineered IRZ approach is synergistic with the existing reducing conditions at the site as demonstrated by the presence of high concentrations of biodegradation products in the site groundwater. However, the site geology will make effective distribution of the reagent difficult.

ERD receives “moderate” effectiveness, “moderate to high” implementability, and “moderate to high” cost rating (Table 5-2).

5.2.9 In-Situ Treatment – Aerobic Bioremediation

In-situ aerobic biodegradation as discussed in detail in Section 4.1.7 is a remediation technique in which aromatic hydrocarbons and ketones can be degraded under aerobic conditions upon the successful delivery and distribution of oxygen into impacted media. Application to groundwater would be conducted in the same manner as previously discussed for saturated soils.

Aerobic biodegradation receives “moderate to high” effectiveness, “moderate to high implementability”, and “moderate” cost rating (Table 5-2).

5.2.10 Ex-Situ Treatment – Air Stripping

Air stripping is an ex-situ physical treatment process. Removing VOCs using packed-column air stripping is a common and established method for treating ground water. Air stripping is physical mass transfer process that is capable of high removal efficiencies for VOCs that have high Henry’s Law constants. It is a widely used groundwater treatment technology that is easy to install and operate. Two different air stripper configurations are common. The first is a countercurrent packed column, which resembles a cylindrical tower that contains a packing material. The diameter of the air stripper is a function of the groundwater flow rate, and the height of the tower is proportional to the contaminant concentrations. The second type is a shallow-tray (or

low-profile) air stripper, which is smaller than the countercurrent packed column and uses perforated trays to enhance contact between water and an air stream. Generally, influent groundwater enters the air stripper unit at the top and trickles down though trays or packing material. Air is injected upward through the stripping unit to remove VOCs from the groundwater. Due to their high Henry's Law constants, many VOCs are transferred from the groundwater to the air injected into the system, and exit the air stripper as a vapor. The effluent vapor stream discharges through the top of the air stripper, while the treated groundwater exits through the bottom of the air stripper. Due to elevated VOC concentrations in the source area groundwater, air emissions may require treatment prior to discharge.

An air stripper is currently used to treat groundwater that is extracted by the interim MPE system. The emissions do not require an air permit. Air stripping received "high" effectiveness, "high" implementability, and "moderate" cost rating for the treatment of extracted groundwater (Table 5-2).

5.2.11 Ex-Situ Treatment – Carbon Adsorption

Granular activated carbon (GAC) is a phase separation process which removes dissolved hydrophobic organic pollutants from water through adsorption. Both volatile (VOC) and semi-volatile (SVOC) organic compounds (including polychlorinated biphenyls [PCBs]) can be removed by the carbon adsorption process. As water passes through the porous granules in the carbon, molecules of organic compounds adhere to the surface of the carbon particle pores. Activated carbon has an extremely large total surface area to mass ratio thus providing numerous sites for adsorption to occur. Highly polar molecules cannot be effectively removed by carbon adsorption. Hydrophobic molecules (insoluble) are more readily adsorbed. As the compound is continuously loaded to the carbon, eventually all of the sorption sites become occupied with the contaminant. Saturated (or spent) activated carbon can be discarded or regenerated with a high-temperature process. Activated carbon adsorption can be used for vapor phase organics treatment as well as for liquid organics treatment.

Carbon adsorption is of limited effectiveness for vinyl chloride because of its poor adsorptive capacity for carbon (low K_{oc}). Carbon adsorption would be a very ineffective method by which to remove vinyl chloride in contaminated groundwater. As currently implemented, carbon adsorption of the treated groundwater extracted by the MPE system is conducted downstream of the air stripper and has proven effective in eliminating discharge of measurable dissolved VOCs. Carbon adsorption received "moderate" effectiveness, "moderate" implementability, and "moderate" cost rating for groundwater (Table 5-2).

5.2.12 Discharge – Publicly-Owned Treatment Works

The POTW can be used as a discharge technology for extracted groundwater. Treated (and in some cases untreated) groundwater can be discharged directly to a POTW which is currently the case with the interim remediation system at the site. In the case of extracted groundwater at the site, the treated water from the air stripper is discharged to the City of Springfield POTW. POTW discharge received “high” effectiveness, “high” implementability, and “moderate” cost rating (Table 5-2).

5.3 Screened Process Options

The process options screened out in Tables 5-1 and 5-2, and the reason(s) for being screened out, are briefly summarized in the following sections.

5.3.1 Soil

- Aeration/Landfarming – While some excavation is anticipated and although an effective treatment method of the COCs identified at the site, the inaccessibility to excavation of a large portion of the impacted soils, it is not anticipated that sufficient soils will be excavated to justify the construction of a landfarm. The volumes of soil that may be excavated will likely be transported for offsite disposal. Thus, aeration/landfarming was screened out.

5.3.2 Groundwater

- In-Situ Chemical Treatment – ZVI – this option was considered as a potential technology for containment of CVOC impacted groundwater. It was considered as a complementary methodology with other technologies being considered. At the current time, the largest component of offsite COC impacts are aromatic hydrocarbons (primarily toluene) and ketones that are not treated by ZVI. Thus, given the limited application, ZVI was screened out.

6. Development of Remedial Action Alternatives

Remedial technologies and process options retained during the preliminary technology evaluation and screening phases (Sections 4 and 5) are assembled in this section into remedial action alternatives for soil and groundwater. Each alternative includes a description of the alternative, including a conceptual design for implementation and a discussion of the assumptions made, which will provide a basis for detailed analysis and comparison to other alternatives. In some instances, remedial action alternatives are developed separately for a specific suspected source area; however, the potential affect or influence that one alternative may have upon alternatives for other suspected source area will be considered in the comprehensive site-wide alternative analysis. Section 7 presents a detailed analysis of the alternatives developed in this section. Section 8 presents a comparative analysis of alternatives as well as development of the site-wide alternatives.

The remedial action alternatives represent a broad spectrum of integrated approaches using combinations of multiple techniques that together are intended to satisfy the RAOs and comply with ARARs. Action-specific ARARs for the alternatives discussed in the following sections can be found in Tables 6-1 and 6-2. Upon selection of a preferred remedial alternative, the selected alternative will be thoroughly designed and evaluated during the Remedial Design phase in order to realize the optimal balance among the factors of effectiveness, the overall remedial timeframe, and cost. During this optimization, design modifications that address changes in the conceptual understanding of the fate and transport of the target constituents to be treated will be addressed.

6.1 Soil Remedial Action Alternatives

The following four remedial action alternatives (SR-1 through SR-4) were developed for impacts to unsaturated soils that would not be treated in conjunction with groundwater remedial actions. As discussed in Section 6 of the RI (ARCADIS, 2007a), the general extent of residual COC's was limited. Residual aromatic hydrocarbons and ketones were mainly detected in unsaturated soil samples in the Former Bulk Chemical Handling Area, and the Former Drum Rinse Area. Operation of the HVE system has resulted in the removal of a significant amount of VOC mass, and has likely enhanced the in-situ biodegradation of aromatic hydrocarbons and ketones in the unsaturated zone soils.

Uncertainties: The primary uncertainties associated with soil remediation include volume/aerial extent/depth of impacted soil, as existing soil data does not indicate significant residual mass; however, the size and persistence of the groundwater plume is indicative of an ongoing source. Additional uncertainties related to specific alternatives are incorporated in the alternative discussions.

The soil remedial action alternatives to be evaluated for the site are described in the following sections.

6.1.1 Alternative SR-1: No Action

Alternative SR-1 includes no remedial action for the reduction, control, or monitoring of potential human health or ecological risks associated with site soil impacts. "No Action" would be readily implementable. There would be no controls preventing land uses at the Site, potentially resulting in direct contact with impacted surficial soil. Also, there are no costs associated with "No Action". The "No Action" alternative is required by NCP and USEPA guidance as a baseline with which to compare other remedial action alternatives.

6.1.2 Alternative SR-2: Targeted Excavation, SVE, and Institutional Controls

Alternative SR-2 combines the use of a targeted excavation in the soil sources areas to remove accessible soil impacts and the use of a portion of the existing HVE system for SVE (Figure 6-1). The conceptual design assumptions for Alternative SR-2 are presented in Appendix A.

Implementation of Alternative SR-2 would involve the following specific components:

Targeted Excavation. Excavations would be conducted in two areas. In the Former Bulk Chemical Handling Area, shallow impacted soil (0-5 ft) would be excavated. In addition, shallow impacted soil adjacent to the northwest corner of the warehouse would also be excavated. In the Former Drum Rinse area, the soils surrounding MW-1 (both saturated and unsaturated) would be excavated to bedrock to remove source material. Excavated soils would be disposed of offsite as appropriate.

Disposal. Excavated soil would be characterized and then transported to a permitted offsite landfill facility for disposal. The final disposal of the material would be determined based on the characterization sampling results. It is generally assumed

that the excavated waste material would be classified as non-hazardous and would be manifested, transported, and disposed at an appropriate facility.

Soil Vapor Extraction. The existing HVE system was enhanced in 2005 with the addition of 3 recovery wells in the vicinity of the Former Bulk Chemical Handling Area (E-51, E-52, E-53) near the location of a suspected groundwater plume source. Additional wells would be added to maximize the effectiveness of the HVE system. These wells would be operated to address VOC impacts within the unsaturated soils in these areas. Operation of the SVE component of the HVE system has the associated impact of drawing fresh air into the subsurface, promoting aerobic biodegradation of the aromatic hydrocarbons and ketones present in the unsaturated soils.

Institutional Controls. Institutional controls would be implemented to restrict excavation in the vicinity of GP-23 as COC concentrations (greater than the PRG developed from soil data collected during RI activities) have been detected in the shallow soils beneath the concrete pad. The specific institutional controls implemented include deed restrictions, deed notifications, and development of an excavation management plan to be incorporated into the Site facility Management Plan. The excavation management plan would outline specific requirements for personal protective equipment (PPE) and material handling protocol should future excavation be required in the vicinity of GP-23. These restrictions would be applied to the areas of remediation, including enough area surrounding the impacted areas to ensure RAOs are satisfied. Institutional controls would be implemented to restrict future uses of the site to industrial uses.

Institutional controls would include: 1) filing an environmental covenant in accordance with the Missouri Environmental Covenants Act (MoECA), detailing the restrictions on site usage; 2) compliance with the provisions of CERCLA Section 120(h) (3) or other applicable statutory requirements in the event of property transfer; and 3) record the covenant at the local county recorder office. All land-use restrictions would be stated in full or by reference within zoning ordinances and/or deeds, easements, mortgages, leases, or other instrument of property transfer. They would be maintained in perpetuity or until the requirements of remediation are achieved.

6.1.3 Alternative SR-3: Target Excavation and Institutional Controls

Alternative SR-3 combines the use of targeted excavation in the soil source areas to remove accessible impacted unsaturated soils, as well as institutional controls in the form of deed notifications and deed restrictions to prevent direct contact with impacted soil (Figure 6-2). Aggressive groundwater remediation activities would effectively

address residual impacts within the saturated soils. The existing HVE System would be decommissioned. The conceptual design assumptions for Alternative SR-3 are presented in Appendix A**.**

Implementation of Alternative SR-3 would involve the following specific components:

Targeted Excavation. Excavations would be conducted in two areas. In the Former Bulk Chemical Handling Area, shallow impacted soil (0-5 ft) would be excavated. In addition, shallow impacted soil adjacent to the northeast corner of the warehouse would also be excavated. In the Former Drum Rinse area, the soils surrounding MW-1 (both saturated and unsaturated) would be excavated to bedrock. Excavated soils would be disposed of offsite as appropriate.

Disposal. Excavated soil would be characterized and then transported to a permitted offsite landfill facility for disposal. The final disposal of the material would be determined based on the characterization sampling results. It is assumed that the excavated waste material would be classified as non-hazardous and would be manifested, transported, and disposed at an appropriate facility.

Institutional Controls. Institutional controls would be implemented to restrict excavation in the vicinity of GP-23 as COC concentrations (greater than the PRG developed from soil data collected during RI activities) have been detected in the shallow soils beneath the concrete pad. The specific institutional controls implemented include deed restrictions, deed notifications, and development of an excavation management plan to be incorporated into the Site facility Management Plan. The excavation management plan would outline specific requirements for personal protective equipment (PPE) and material handling protocol should future excavation be required beneath the concrete pad. These restrictions would be applied to the areas of remediation, including enough area surrounding the impacted areas to ensure RAOs are satisfied. Institutional controls would be implemented to restrict future uses of the site to industrial uses.

Institutional controls would include: 1) filing an environmental covenant in accordance with the Missouri Environmental Covenants Act (MoECA), detailing the restrictions on site usage; 2) compliance with the provisions of CERCLA Section 120(h) (3) or other applicable statutory requirements in the event of property transfer; and 3) record the covenant at the local county recorder office. All land-use restrictions would be stated in full or by reference within zoning ordinances and/or deeds, easements, mortgages, leases, or other instrument of property transfer. They would be maintained in perpetuity or until the requirements of remediation are achieved.

6.1.4 Alternative SR-4: Targeted Excavation, In-Situ Thermal and Institutional Controls

Alternative SR-4 combines the use of targeted excavation in the Former Bulk Chemical Handling Area to remove accessible impacted unsaturated soils, in-situ thermal in the Former Drum Rinse Area, as well as institutional controls in the form of deed notifications and deed restrictions to prevent direct contact with impacted soil (Figure 6-3). The existing HVE System would not be retained for further soil remediation. The conceptual design assumptions for Alternative SR-4 are presented in Appendix A**.**

Implementation of Alternative SR-4 would involve the following specific components:

Targeted Excavation. Excavations would be conducted in two areas. In the Former Bulk Chemical Handling Area, shallow impacted soil (0-4 ft) would be excavated. In addition, shallow impacted soil adjacent to the northeast corner of the warehouse would also be excavated. Excavated soils would be disposed of offsite as appropriate.

Disposal. Excavated soil would be characterized and then transported to a permitted offsite landfill facility for disposal. The final disposal of the material would be determined based on the characterization sampling results. It is assumed that the excavated waste material would be classified as non-hazardous and would be manifested, transported, and disposed at an appropriate facility.

In-Situ Thermal. In-situ thermal would be implemented in the area surrounding MW-1 to the top of bedrock (a depth of approximately 22 ft bgs). The implementation of in-situ thermal at the site would consist of a series of overlapping electrode arrays. Each of the electrode locations would also be constructed to allow for the withdrawal of soil vapors volatilized by the heating, and for the addition of sufficient water to maintain conductivity within the heated soils adjacent to the electrodes. In addition, due to the low permeability of the impacted soils, additional MPE extraction points would likely be required within the footprint of the array to ensure capture of the volatilized vapors. Extracted vapors would be cooled; the condensate removed, then discharged to the atmosphere or if necessary, treated using thermal oxidation.

Institutional Controls. Institutional controls would be implemented to restrict excavation in the vicinity of GP-23 as COC concentrations (greater than the PRG developed from soil data collected during RI activities) have been detected in the shallow soils beneath the concrete pad. The specific institutional controls implemented include deed restrictions, deed notifications, and development of an excavation management plan to be incorporated into the Site facility Management Plan. The excavation management

plan would outline specific requirements for personal protective equipment (PPE) and material handling protocol should future excavation be required beneath the concrete pad. These restrictions would be applied to the areas of remediation, including enough area surrounding the impacted areas to ensure RAOs are satisfied. Institutional controls would be implemented to restrict future uses of the site to industrial uses.

Institutional controls would include: 1) filing an environmental covenant in accordance with the Missouri Environmental Covenants Act (MoECA), detailing the restrictions on site usage; 2) compliance with the provisions of CERCLA Section 120(h) (3) or other applicable statutory requirements in the event of property transfer; and 3) record the covenant at the local county recorder office. All land-use restrictions would be stated in full or by reference within zoning ordinances and/or deeds, easements, mortgages, leases, or other instrument of property transfer. They would be maintained in perpetuity or until the requirements of remediation are achieved.

6.2 Groundwater Remedial Action Alternatives

The following remedial action alternatives were developed for the site groundwater identified as having site-specific COC concentrations that exceed the Remediation Goals, as discussed in Section 3.

Groundwater impacts at the site have resulted from historical site operational activities. Groundwater impacts identified for the offsite groundwater plume are the result of impacted groundwater migrating offsite. Recognizing the difficulties in remediating these source zones given the site lithology and ongoing facility activities, groundwater alternatives were developed in order to satisfy the RAOs and provide a range of options with which to compare their applicability.

Uncertainties: The primary uncertainties associated with groundwater remediation include areas where facility operations reduce access, along with the geologic heterogeneities and the combination of chlorinated and non-chlorinated hydrocarbons. The combination of chlorinated and non-chlorinated constituents facilitated the need to utilize a combination of remedial technologies to address the groundwater impacts. For example, ERD is an effective technology to treat onsite groundwater impacted by chlorinated COCs but would not be effective in treating offsite groundwater impacted by hydrocarbon COCs.

These complications/uncertainties were mitigated through the RI process, literature reviews, professional experience, and conservative assumptions in this FS. Remedial alternatives were formulated and designed to achieve the RAOs. The assumptions used for development of the groundwater remediation alternatives are included in Appendix A. Additional uncertainties related to specific alternatives are incorporated in the alternative discussions.

Remedial Timeframes: Since beginning remediation activities at the site in 2000, there has been a substantial reduction dissolved VOC concentrations in groundwater samples collected from in both onsite and offsite monitoring wells. This is a result of a combination of factors including naturally occurring attenuation of COCs through degradation, adsorption and dispersion, enhanced reductive dechlorination of chlorinated VOCs where the VOC plume contains comingled petroleum hydrocarbon and chlorinated compounds, as well as the removal of VOC mass with the HVE system via SVE (residual VOCs in unsaturated soils) and extraction of impacted groundwater.

While it is not possible to precisely quantify the relative contribution of each of these factors, operational and monitoring data indicate that in general terms, the operation of the HVE system has been responsible for the majority of the onsite reduction in dissolved concentrations. The conclusion was reached based on the following observations:

- Modification of the system by the installation of additional extraction wells in April 2005 within the Central Unit resulted in an immediate and significant drop in VOC concentrations in dissolved hydrocarbons.

- Marked removal of VOCs in groundwater from the source area (Bulk Chemical Handling Area) has resulted in a decrease of VOCs in the Loading Dock Unit since start-up of the HVE system. Meanwhile, the relative change in concentrations of VOCs in SAW-2 (attributed to infiltration of shallow groundwater via an improperly completed well) which is not impacted by the HVE system is small.

- Significant mass removal via SVE and groundwater extraction from the four HVE units.

The uncertainty regarding the mass of residual COCs remaining in the subsurface inhibits the evaluation of projected remedial timeframes. However, a significant reduction in dissolved COC concentrations in the groundwater resulting from operation

of the HVE system indicate that where aggressive treatment technologies are employed (source area ERD, chemical oxidation), remedial time frames are likely to be relatively short. A maximum of three years of active remediation is anticipated followed by hydraulic containment and MNA.

6.2.1 Alternative GW-1: No Action

Alternative GW-1 includes no remedial action for the reduction, control, or monitoring of potential human health associated with onsite or offsite groundwater impacts. The "No Action" alternative is required by NCP and USEPA guidance as a baseline with which to compare other remedial action alternatives.

6.2.2 Alternative GW-2: Multiphase Extraction, SAW-2 Groundwater Extraction, Enhanced Reductive Dechlorination Source Treatment, Chemical Oxidation, Monitored Natural Attenuation, and Institutional Controls

Alternative GW-2 (Figure 6-4) includes a combination of the following technologies in the following locations:

- Continued operation of the MPE system in the Former Bulk Chemical Handling Area and Rail Spur Area.
- ERD in the Former Drum Rinse Area and at downgradient property boundary.
- Chemical Oxidation in the offsite groundwater plume.
- Continued groundwater extraction from the SAW-2 well.
- Monitored Natural Attenuation and Institutional controls.

The conceptual design assumptions for Alternative GW-2 are presented in Appendix B and discussed in more detail in the following sections.

<u>Multiphase Extraction:</u> Alternative GW-2 includes the continued operation of the MPE system in the Former Bulk Chemical Handling Area and the Former Rail Spur Area where the system has significantly reduced dissolved groundwater concentrations during operation. Additional wells would be installed and the system would continue to be operated to further reduce the dissolved groundwater concentrations and assist the additional site-wide groundwater remediation efforts.

ERD Treatment. Impacted groundwater in the vicinity of the Former Drum Rinse Area would be treated using ERD. During the ERD pilot testing, limitation on the effectiveness of injection wells were encountered including 1) surface breakout of injection fluids at very low injection pressures 2) low injection rates which required extensive injection periods, and 3) erratic distribution of the injection fluids as observed at test monitoring wells. Based on these results, it can be concluded that injection wells are not suited for uniform distribution of reagent. Thus, injection trenches would be utilized at each treatment line. Following source removal activities, injection trenches would be installed within and downgradient of the Former Drum Rinse Area. An additional treatment line would be installed near the downgradient property boundary for plume containment. These ERD treatment lines would extend near the top of bedrock in order to treat the full vertical extent of the dissolved-phase plume within the unconsolidated soils as well as smear zone soils. Routine injection of dilute organic carbon substrate solution would be used to stimulate naturally-occurring microorganisms, deplete oxygen and other available electron acceptors, and thereby establish and maintain anaerobic and reducing conditions.

Chemical Oxidation. Impacted groundwater in the offsite plume would be treated using a series of injection wells to deliver a chemical oxidant. Following the initial injection, monitoring would be conducted to determine if additional treatment was required. The injections would be limited to the unconsolidated soils and upper bedrock within the treatment area.

Groundwater Extraction. Groundwater extraction from the SAW-2 well has resulted in a significant decline in dissolved VOC concentrations. To maximize the removal efforts of dissolved phase VOCs from SAW-2, a groundwater extraction pump would be installed to allow for continuous recovery in place of the current groundwater withdrawal program (periodic bailing or pumping) Groundwater recovered from the SAW-2 well would be treated using the MPE groundwater treatment system and discharged to the POTW.

Monitored Natural Attenuation. MNA can be an acceptable groundwater remediation component where it can be documented to meet ARARs and where combined with source area removal. Alternative GW-2 includes monitoring of existing groundwater monitoring wells at the site (both on site and downgradient of the facility). Based on the review of available data, it appears that natural attenuation (via degradation of co-mingled degradable compounds such as petroleum hydrocarbons) is playing a significant role in contaminant mass reduction and plume control, especially for the CVOCs. Groundwater monitoring to support the MNA remedy would be performed

annually to confirm the effectiveness of MNA following the completion of active remediation activities. Groundwater samples would be collected from a network of monitoring wells and analyzed for VOCs, including aromatic hydrocarbons (BTEX), ketones (acetone, MEK), CVOC parent compounds (PCE, TCE) and degradation products (DCE, vinyl chloride, and ethene), electron donors (carbon sources), biogeochemical indicators, and water quality parameters. These parameters include:

- VOCs;
- Light hydrocarbons (ethene, ethane, methane);
- Chloride;
- Total organic carbon (TOC);
- Ferrous iron;
- Sulfide;
- Sulfate and nitrate; and
- Field parameters (DO, oxidation-reduction potential, pH, specific conductance, and temperature).

- Where clear evidence of reductive dechlorination is not present in the MNA sampling results, additional parameters may be added in accordance with EPA MNA guidance. During the Remedial Design phase, the MNA well network would be thoroughly evaluated.

Institutional Controls. Institutional controls would be implemented to restrict future uses of the site to industrial uses, control access to the areas of concern, and prevent the use of untreated groundwater. Specific institutional controls include deed notifications, deed restrictions, and permits. These restrictions would be applied to the areas of remediation (including offsite, if possible), including enough area surrounding the impacted areas to ensure RAOs are satisfied.

Institutional controls would include: 1) filing an environmental covenant in accordance with the Missouri Environmental Covenants Act (MoECA), detailing the restrictions on site usage; 2) compliance with the provisions of CERCLA Section 120(h) (3) or other applicable statutory requirements in the event of property transfer; and 3) record the covenant at the local county recorder office. All land-use restrictions would be stated in full or by reference within zoning ordinances and/or deeds, easements, mortgages,

leases, or other instrument of property transfer. They would be maintained in perpetuity or until the requirements of remediation are achieved.

6.2.3 Alternative GW-3: MPE, Source Area and Off Site Chemical Oxidation, Hydraulic Control, Off Site Enhanced Reductive Dechlorination, Groundwater Extraction at SAW-2, Monitored Natural Attenuation, and Institutional Controls

Alternative GW-3 (Figure 6-5) includes a combination of the following technologies in the following locations:

- Continued operation of the MPE system in the Former Bulk Chemical Handling Area and the former Rail Spur Area.
- Hydraulic control through groundwater pumping at the downgradient property boundary.
- Chemical oxidation treatment in the Former Drum Rinse Area.
- Chemical Oxidation treatment of dissolved VOC hot spot (MW-17 area) in the offsite groundwater plume.
- ERD treatment of dissolved chlorinated VOC hot spot (MW-22 area) in the offsite groundwater plume.
- Continued groundwater extraction from the SAW-2 well.
- Monitored Natural Attenuation and Institutional controls.

The conceptual design assumptions for Alternative GW-3 are presented in Appendix B and discussed in more detail in the following sections.

Multiphase Extraction: Alternative GW-3 includes the continued operation of the HVE system in the Former Bulk Chemical Handling Area and Former Rail Spur Area where the system has significantly reduced dissolved groundwater concentrations during operation. Continued operation of the system would further reduce the dissolved groundwater concentrations and assist the additional site-wide groundwater remediation efforts. If warranted, based on additional data collected during future site activities, additional HVE wells would be included.

Hydraulic Control: Existing and new wells at the property boundary would be operated separately from the MPE system to maintain hydraulic control while ensuring reliability. One well used for the hydraulic testing (E47B) will be utilized in its current

configuration. Where possible, the remaining hydraulic control wells will be located adjacent to existing boundary wells E38, E39, and E43, and reinstalled into the upper bedrock to a depth of approximately 40 ft bgs to increase the potential for encountering zones of higher permeability and maximizing the width and depth of the capture zone. Two additional hydraulic control wells will be installed east of E43 to ensure capture of remnants of the rail spur plume. New discharge piping will be installed to each of these wells.

Each of the newly installed wells will be 4-inch diameter to allow flexibility in selection of groundwater extraction pumps. Screen intervals will vary based on location specific variables, but in general will be screened from approximately 5 ft above the top of bedrock to 40 ft bgs. Based on the results of the hydraulic testing, a pumping rate of approximately 1 gpm per well will be used for the design. Extracted water will be delivered to the existing treatment system which will be reconfigured so that it can operate independently from the MPE system. ERD Treatment. Groundwater with chlorinated VOC impacts near MW-22 in the offsite plume would be treated using ERD. These ERD treatment wells would extend into the top of bedrock in order to treat the full vertical extent of the shallow dissolved-phase plume. Routine injection of dilute organic carbon substrate solution would be used to stimulate naturally-occurring microorganisms, deplete oxygen and other available electron acceptors, and thereby establish and maintain anaerobic and reducing conditions.

Chemical Oxidation. Impacted groundwater in the source area and the portion of the offsite plume would be treated using chemical oxidation. The chemical oxidation technique in the source area would be conducted in coordination with the targeted excavation of soils. The oxidant will be injected into the permeable backfill. Additional chemical oxidation treatments would be conducted in the offsite portion of the plume near MW-17, where elevated concentrations of aromatic hydrocarbons are present. The oxidant would be injected directly into the groundwater using a series of injection wells completed across the unconsolidated soil/upper bedrock contact. Following the initial injection, monitoring would be conducted to determine if additional treatment was required.

Groundwater Extraction. Groundwater extraction from the SAW-2 well has resulted in a significant decline in dissolved VOC concentrations. To maximize the removal efforts of dissolved phase VOCs from SAW-2, a groundwater extraction pump would be installed to allow for continuous recovery in place of the current groundwater withdrawal program (periodic bailing or pumping) Groundwater recovered from the

SAW-2 well would be treated using the MPE groundwater treatment system and discharged to the POTW.

Monitored Natural Attenuation. MNA can be an acceptable groundwater remediation component where it can be documented to meet ARARs and where combined with source area removal. Alternative GW-2 includes monitoring of existing groundwater monitoring wells at the site (both on site and downgradient of the facility). Based on the review of available data, it appears that natural attenuation (via degradation of co-mingled degradable compounds such as petroleum hydrocarbons) is playing a significant role in contaminant mass reduction and plume control, especially for the CVOCs. Groundwater monitoring to support the MNA remedy would be performed annually to confirm the effectiveness of MNA following the completion of active remediation activities. Groundwater samples would be collected from a network of monitoring wells and analyzed for VOCs, including aromatic hydrocarbons (BTEX), ketones (acetone, MEK), CVOC parent compounds (PCE, TCE) and degradation products (DCE, vinyl chloride, and ethene), electron donors (carbon sources), biogeochemical indicators, and water quality parameters. These parameters include:

- VOCs;
- Light hydrocarbons (ethene, ethane, methane);
- Chloride;
- Total organic carbon (TOC);
- Ferrous iron;
- Sulfide;
- Sulfate and nitrate; and
- Field parameters (DO, oxidation-reduction potential, pH, specific conductance, and temperature).

Where clear evidence of reductive dechlorination is not present in the MNA sampling results, additional parameters may be added in accordance with EPA MNA guidance. During the Remedial Design phase, the MNA well network would be thoroughly evaluated.

Institutional Controls. Institutional controls would be implemented to restrict future uses of the site to industrial uses, control access to the areas of concern, and prevent

the use of untreated groundwater. Specific institutional controls include deed notifications, deed restrictions, and permits. These restrictions would be applied to the areas of remediation (including offsite, if possible), including enough area surrounding the impacted areas to ensure RAOs are satisfied.

Institutional controls would include: 1) filing an environmental covenant in accordance with the Missouri Environmental Covenants Act (MoECA), detailing the restrictions on site usage; 2) compliance with the provisions of CERCLA Section 120(h) (3) or other applicable statutory requirements in the event of property transfer; and 3) record the covenant at the local county recorder office. All land-use restrictions would be stated in full or by reference within zoning ordinances and/or deeds, easements, mortgages, leases, or other instrument of property transfer. They would be maintained in perpetuity or until the requirements of remediation are achieved.

6.2.4 Alternative GW-4: Source Area and Off Site Chemical Oxidation, Hydraulic Control, Groundwater Extraction at SAW-2 , Monitored Natural Attenuation, and Institutional Controls

Alternative GW-4 (Figure 6-6) includes a combination of the following technologies in the following locations:

- Installation of groundwater extraction and treatment at the downgradient property boundary.
- Chemical oxidation in the Former Drum Rinse Area.
- Chemical Oxidation treatment of dissolved VOC hot spot (MW-17 area) in the offsite groundwater plume.
- Continued groundwater extraction from the SAW-2 well,
- Monitored Natural Attenuation and Institutional controls.

The conceptual design assumptions for Alternative GW-4 are presented in Appendix B and discussed in more detail in the following sections.

Hydraulic Control: Existing and new wells at the property boundary would be operated separately from the MPE system to maintain hydraulic control while ensuring reliability. One well used for the hydraulic testing (E47B) will be utilized in its current configuration. Where possible, the remaining hydraulic control wells will be located

adjacent to existing boundary wells E38, E39, and E43, and reinstalled into the upper bedrock to a depth of approximately 40 ft bgs to increase the potential for encountering zones of higher permeability and maximizing the width and depth of the capture zone. Two additional hydraulic control wells will be installed east of E43 to ensure capture of remnants of the rail spur plume. New discharge piping will be installed to each of these wells.

Each of the newly installed wells will be 4-inch diameter to allow flexibility in selection of groundwater extraction pumps. Screen intervals will vary based on location specific variables, but in general will be screened from approximately 5 ft above the top of bedrock to 40 ft bgs. Based on the results of the hydraulic testing, a pumping rate of approximately 1 gpm per well will be used for the design. Extracted water will be delivered to the existing treatment system which will be reconfigured so that it can operate independently from the MPE system. Chemical Oxidation. Impacted groundwater in the source area and the portion of the offsite plume would be treated using chemical oxidation. The chemical oxidation technique in the source area would be conducted in coordination with the targeted excavation of soils. The oxidant will be injected into the permeable backfill. Additional chemical oxidation treatments would be conducted in the offsite portion of the plume near MW-17, where elevated concentrations of aromatic hydrocarbons are present. The oxidant would be injected directly into the groundwater using a series of injection wells completed across the unconsolidated soil/upper bedrock contact. Following the initial injection, monitoring would be conducted to determine if additional treatment was required.

Groundwater Extraction. Groundwater extraction from the SAW-2 well has resulted in a significant decline in dissolved VOC concentrations. To maximize the removal efforts of dissolved phase VOCs from SAW-2, a groundwater extraction pump would be installed to allow for continuous recovery in place of the current groundwater withdrawal program (periodic bailing or pumping) Groundwater recovered from the SAW-2 well would be treated using the MPE groundwater treatment system and discharged to the POTW.

Monitored Natural Attenuation. MNA can be an acceptable groundwater remediation component where it can be documented to meet ARARs and where combined with source area removal. Alternative GW-2 includes monitoring of existing groundwater monitoring wells at the site (both on site and downgradient of the facility). Based on the review of available data, it appears that natural attenuation (via degradation of co-mingled degradable compounds such as petroleum hydrocarbons) is playing a significant role in contaminant mass reduction and plume control, especially for the

CVOCs. Groundwater monitoring to support the MNA remedy would be performed annually to confirm the effectiveness of MNA following the completion of active remediation activities. Groundwater samples would be collected from a network of monitoring wells and analyzed for VOCs, including aromatic hydrocarbons (BTEX), ketones (acetone, MEK), CVOC parent compounds (PCE, TCE) and degradation products (DCE, vinyl chloride, and ethene), electron donors (carbon sources), biogeochemical indicators, and water quality parameters. These parameters include:

- VOCs;
- Light hydrocarbons (ethene, ethane, methane);
- Chloride;
- Total organic carbon (TOC);
- Ferrous iron;
- Sulfide;
- Sulfate and nitrate; and
- Field parameters (DO, oxidation-reduction potential, pH, specific conductance, and temperature).

- Where clear evidence of reductive dechlorination is not present in the MNA sampling results, additional parameters may be added in accordance with EPA MNA guidance. During the Remedial Design phase, the MNA well network would be thoroughly evaluated.

Institutional Controls. Institutional controls would be implemented to restrict future uses of the site to industrial uses, control access to the areas of concern, and prevent the use of untreated groundwater. Specific institutional controls include deed notifications, deed restrictions, and permits. These restrictions would be applied to the areas of remediation (including offsite, if possible), including enough area surrounding the impacted areas to ensure RAOs are satisfied.

Institutional controls would include: 1) filing an environmental covenant in accordance with the Missouri Environmental Covenants Act (MoECA), detailing the restrictions on site usage; 2) compliance with the provisions of CERCLA Section 120(h) (3) or other applicable statutory requirements in the event of property transfer; and 3) record the covenant at the local county recorder office. All land-use restrictions would be stated in

full or by reference within zoning ordinances and/or deeds, easements, mortgages, leases, or other instrument of property transfer. They would be maintained in perpetuity or until the requirements of remediation are achieved.

7. Detailed Analysis of Remedial Action Alternatives

This section presents a detailed analysis of each remedial action alternative developed in Section 6. These analyses are intended to aid in selection of an alternative that satisfies the RAOs, complies with the ARARs, provide a permanent solution (using alternative treatment technologies or resource-recovery technologies to the maximum extent practicable), and reduces toxicity, mobility, and/or volume of COCs for soil and groundwater.

In accordance with CERCLA Section 121, the NCP (USEPA, 1990), and USEPA RI/FS guidance (USEPA, 1988a), each alternative will undergo detailed analysis based on the following nine criteria:

- Overall Protection of Human Health and the Environment - Addresses how the alternative protects human health and the environment. This assessment focuses on how an alternative achieves protection over time and indicates how each source of contamination would be minimized, reduced, or controlled through treatment, engineering, or institutional controls. The evaluation of the degree of overall protection associated with each alternative is based largely on the exposure pathways and scenarios set forth in the risk assessment.

- Compliance with ARARs - Addresses whether the alternative complies with ARARs developed for the site as part of this FS. Chemical-specific and location-specific ARARs were presented in Section 3.2. Action-specific ARARs for the remedial action alternatives developed in Section 6 are presented in Tables 6-1 and 6-2 for soil and groundwater.

- Long-term Effectiveness and Permanence - Addresses the results of an alternative in terms of the residual risk remaining at the site after the RAOs have been met. The primary focus of this evaluation is the extent and effectiveness of the controls that will be applied to manage the risk posed by the residuals of the treatment process and/or untreated waste. The components of this criterion include the magnitude of the remaining risk measured by numerical standards such as cancer risk; adequacy and suitability of control used to manage treatment residual or untreated wastes; and the long-term reliability of management controls for providing continued protection from residuals (i.e. the assessment of potential failure of the technical components).

- Reduction of Mobility, Toxicity, or Volume - Addresses the statutory preference for selecting remedial actions that include treatment technologies that permanently and significantly reduce the mobility, toxicity, or volume of hazardous substances present at the site. Factors of this criterion to be evaluated include the treatment process employed; the amount of

hazardous material destroyed or treated; the degree of reduction in toxicity, mobility, or volume expected; the degree to which the treatment will be irreversible; and the type and quantity of treatment residuals. Each of the alternatives describes whether or not the statutory preference for treatment as a principal element is satisfied.

- Short-term Effectiveness - Addresses potential human health and environmental impacts of the alternative during the construction and implementation phase until remedial response objectives are met and the length of time until protection is achieved.

- Implementability - Addresses the technical and administrative feasibility of implementing an alternative and the availability of services and materials required during implementation. Implementability is further categorized into technical feasibility, administrative feasibility, and availability criteria.

- Cost - Addresses the capital and O&M costs, and includes a present worth analysis of all costs. The capital costs consist of direct costs (construction) and indirect costs (non-construction and overhead). Direct capital costs include construction costs, equipment costs, land and site development costs, relocation expenses, and disposal costs. Indirect capital costs include engineering expenses, legal fees and license or permit costs, start-up costs, and contingency allowances.

  O&M costs are post-construction costs necessary to ensure the continued effectiveness of a remedial action. These costs include operating labor costs, monitoring, maintenance materials and labor costs, auxiliary materials and energy, treatment residue disposal costs, purchased services, administrative cost, insurance, taxes, licensing costs, maintenance reserve and contingency funds, rehabilitation costs, and costs of periodic site reviews, if required.

  The cost estimates presented in this FS were developed utilizing USEPA guidance, professional engineering judgment, and quotations from appropriate vendors. In accordance with USEPA guidance, the cost estimates in this FS have been prepared to provide accuracy in the range of -30 to +50 percent USEPA, 2000). All capital and O&M cost estimates are expressed in 2010 dollars.

  After development of the capital and O&M costs, a present-worth analysis of the overall remedial action costs associated with each alternative was conducted. A present-worth analysis relates costs that occur over different time periods to present costs by discounting all future costs to the present value. This allows the cost of alternatives to be compared on the basis of a single figure that represents the capital required in 2006 dollars to construct, operate, and maintain the alternative throughout its planned life. The

present-worth calculations are based on a discount rate of 7 percent for the time period during which the costs are anticipated to occur (USEPA 2000).

- State Acceptance - Addresses the technical and administrative issues and concerns of the state (or support agency) regarding the alternative.

- Community Acceptance - Addresses public issues and concerns regarding the alternative.

Detailed descriptions of each remedial alternative and the associated criteria evaluations are presented in Tables 7-1 and 7-2 and in the following sections. A summary of the remedial costs is provided in Tables 7-3 and 7-4 for soil and groundwater. Detail for the timeframes and costs presented in the summary tables are presented in Appendix A (soil) and Appendix B (groundwater).

7.1 Detailed Analysis of Soil Remedial Action Alternatives

A detailed analysis of soil remedial action alternatives presented in Section 6.1 is provided in the following sections:

7.1.1 Alternative SR-1: No Action

The following sections present a detailed analysis of remedial action Alternative SR-1 for soil. Table 7-1 presents a summary of this analysis.

7.1.1.1 Overall Protection of Human Health and the Environment

Although the “No Action” alternative does not incorporate any onsite activities that would present exposure risks to the community, workers, or the environment, it would not reduce existing COC concentrations in soil, or provide measures to eliminate or control potential exposure pathways. Therefore, the “No Action” alternative would not achieve soil RAOs and is not protective of human health or the environment.

7.1.1.2 Compliance with ARARs

In the absence of chemical-specific ARARs, PRGs have been established for soil COCs at the site. The “No Action” alternative would not achieve PRGs for soil because no action would be taken to address existing COC concentrations in soil. Alternative SR-1 would comply with location-specific ARARs. There are no action-specific ARARs for Alternative SR-1.

7.1.1.3 Long-Term Effectiveness and Permanence

Long term effectiveness and permanence would not be achieved through the “No Action” alternative because land use restrictions would not be implemented to eliminate or provide long-term control of potential exposure pathways.

7.1.1.4 Reduction of Mobility, Toxicity, or Volume

While naturally occurring biological activity is likely to be reducing the concentration of COCs, the rate at which it is occurring is not known. The “No Action” alternative would reduce COCs toxicity and volume over time. The statutory preference for treatment as a principal element is not satisfied by the “No Action” alternative.

7.1.1.5 Short-Term Effectiveness

The “No Action” alternative does not incorporate any onsite activities that would present exposure risks to the community, workers, or the environment. Protectiveness would not be achieved through the “No Action” alternative.

7.1.1.6 Implementability

Due to the lack of technical components, the “No Action” alternative is technically feasible and would not limit or interfere with the ability to perform future remedial actions. However, the “No Action” alternative is unlikely to be administratively feasible due to the anticipated lack of monitoring and protection of human health and the environment.

7.1.1.7 Cost

There are no associated costs with the “No Action” alternative because no actions of any kind would be performed in connection with this alternative.

7.1.2 Alternative SR-2: Targeted Excavation, SVE, and Institutional Controls

The following sections present a detailed analysis of remedial action Alternative SR-2 for soil. Table 7-1 presents a summary of this analysis.

7.1.2.1 Overall Protection of Human Health and the Environment

Implementation of this alternative is expected to result in minimal exposure risks to the community, workers, or the environment which would be associated with excavation, transport and disposal of COC impacted soil, and emissions of vapors containing low concentrations of COC's from the MPE system. The remedial activities would protect indefinitely against both current and future human exposure to soil. Therefore, Alternative SR-2 would achieve the soil RAOs and be protective of human health and the environment.

7.1.2.2 Compliance with ARARs

In the absence of chemical-specific ARARs, PRGs have been established for soil COCs at the site. Remedial activities were designed to 1) eliminate currently identified COC impacts and 2) eliminate ongoing sources of groundwater impacts. This alternative would achieve soil RAOs by minimizing potential exposure via removal and in-situ remediation. Alternative SR-2 would comply with location- and action-specific ARARs.

7.1.2.3 Long-Term Effectiveness and Permanence

Alternative SR-2 would achieve long-term effectiveness and permanence by permanently removing COC impacted soil not affected by the HVE system and transferring it to an approved disposal facility, as well as removing COCs via SVE and the associated aerobic biodegradation. Any remaining COC impacted soils at locations inaccessible due to ongoing site activities will be capped to minimize exposure and reduce leaching to groundwater. A long-term management plan would be necessary to ensure permanence of institutional controls.

7.1.2.4 Reduction of Mobility, Toxicity, or Volume

The selected remediation activities would permanently reduce the mobility, toxicity and volume of COC impacted soil at the site. The statutory preference for treatment as a principal element is satisfied by the remedial activities used in Alternative SR-2.

7.1.2.5 Short-Term Effectiveness

Implementation of this alternative would result in minimal risks to the community, workers, and the environment. Excavation and disposal would be completed using approved methods and employing engineering controls to protect the community,

workers, and the environment. SVE emissions would meet existing permit requirements and be subject to periodic health and safety monitoring. Potential risks are limited to onsite populations for excavation activities and vapor emissions; potential risks apply to both onsite and offsite populations for the transportation and disposal of excavated soil. Institutional controls of COC impacted soils in inaccessible locations would be put in place immediately. Remedial response objectives and protectiveness would be anticipated to be achieved within 3 years.

7.1.2.6 Implementability

Implementation of this alternative is both technically and administratively feasible. The limited excavation and disposal and the continued operation of the MPE system would not interfere with ongoing operations at the site. The excavation would be completed using standard excavation techniques and locally available equipment and materials for backfill. Excavated soil would be disposed at an approved facility. Similarly, the expertise necessary to conduct these activities would be readily available. There would be no need to conduct future remedial actions if this alternative is implemented.

7.1.2.7 Cost

Table 7-3 and Appendix A present a summary of the present value calculations for Alternative SR-2 and the detailed cost backup, respectively. Capital costs include site preparation, earth work, transportation, and disposal costs. O&M costs include operation of the HVE system. The O&M costs for maintenance of institutional controls are captured under groundwater option GW-2.

Total capital costs for the implementation of SR-2 are estimated to be approximately $828,000.

7.1.3 Alternative SR-3: Target Excavation and Institutional Controls

The following sections present a detailed analysis of remedial action Alternative SR-3. Table 7-1 presents a summary of this analysis.

7.1.3.1 Overall Protection of Human Health and the Environment

Implementation of this alternative is expected to result in minimal exposure risks to the community, workers, or the environment which would be associated with excavation, transport and disposal of COC impacted soil. Any remaining COC impacted soils would be inaccessible to excavation, thereby allowing for the potential for future

exposure. The focused excavation, disposal, and institutional controls would indefinitely protect against both current and future human exposure to soil. Therefore, Alternative SR-3 would achieve the soil RAOs and be protective of human health and the environment.

7.1.3.2 Compliance with ARARs

In the absence of chemical-specific ARARs, PRGs have been established for soil COCs at the site. Remedial activities were designed to 1) eliminate currently identified COC impacts and 2) eliminate ongoing sources of groundwater impacts. This alternative would achieve soil RAOs by minimizing potential exposure via removal and in-situ remediation. Alternative SR-3 would comply with location- and action-specific ARARs.

7.1.3.3 Long-Term Effectiveness and Permanence

Alternative SR-3 would achieve long-term effectiveness and permanence for as long as the institutional controls are maintained. However, residual COC concentrations in soil could continue to leach to groundwater, which would prolong groundwater remediation activities. In addition, a long-term management plan would be necessary to ensure permanence of institutional controls.

7.1.3.4 Reduction of Mobility, Toxicity, or Volume

Alternative SR-3 would permanently reduce the mobility, toxicity, and volume of COC impacted soils removed from site. The statutory preference for treatment as a principal element is satisfied by excavation and institutional controls used in Alternative SR-3.

7.1.3.5 Short-Term Effectiveness

Implementation of this alternative would result in minimal risks to the community, workers, and the environment. Excavation and disposal would be completed using approved methods and employing engineering controls to protect the community, workers, and the environment. Potential risks are limited to onsite populations for excavation activities; potential risks apply to both onsite and offsite populations for the transportation and disposal of excavated soil. Remedial response objectives and protectiveness (active remediation completed and institutional controls in place to limit exposure) would be anticipated to be achieved within 1 year.

7.1.3.6 Implementability

Implementation of this alternative is both technically and administratively feasible. Limited excavation would not interfere with ongoing operations on the site. Similarly, the expertise necessary to complete the work would be readily available. Institutional controls would be readily implementable.

7.1.3.7 Cost

Table 7-3 and Appendix A present a summary of the present value calculations for Alternative SR-3 and the detailed cost backup, respectively. Capital costs include site preparation, excavation, transportation, disposal and institutional controls. There would be no annual O&M costs. Total capital costs are estimated to be approximately $467,000.

7.1.4 Alternative SR-4: In-Situ Thermal, Targeted Excavation and Institutional Controls

The following sections present a detailed analysis of remedial action Alternative SR-4. Table 7-1 presents a summary of this analysis.

7.1.4.1 Overall Protection of Human Health and the Environment

Implementation of this alternative is expected to result in minimal exposure risks to the community, workers, or the environment which would be associated with installation of thermal electrode and well installation, as well as excavation, transport and disposal of COC impacted soil. Any remaining COC impacted soils would be inaccessible to excavation, thereby allowing for the potential for future exposure. The focused excavation, disposal, and institutional controls would indefinitely protect against both current and future human exposure to soil. Therefore, Alternative SR-4 would achieve the soil RAOs and be protective of human health and the environment.

7.1.4.2 Compliance with ARARs

In the absence of chemical-specific ARARs, PRGs have been established for soil COCs at the site. Remedial activities were designed to 1) eliminate currently identified COC impacts and 2) eliminate ongoing sources of groundwater impacts. This alternative would achieve soil RAOs by minimizing potential exposure via removal and in-situ remediation. Alternative SR-4 would comply with location- and action-specific ARARs.

7.1.4.3 Long-Term Effectiveness and Permanence

Alternative SR-4 would achieve long-term effectiveness and permanence for as long as the institutional controls are maintained. However, residual COC concentrations in inaccessible soils in the Former Bulk Chemical Area could continue to leach to groundwater, which would prolong groundwater remediation activities. In addition, a long-term management plan would be necessary to ensure permanence of institutional controls.

7.1.4.4 Reduction of Mobility, Toxicity, or Volume

Alternative SR-4 would permanently reduce the mobility, toxicity, and volume of COC impacted soils removed from site and those treated via in-situ thermal. The statutory preference for treatment as a principal element is satisfied by the combination of in-situ thermal, excavation and institutional controls used in Alternative SR-4.

7.1.4.5 Short-Term Effectiveness

Implementation of this alternative would result in minimal risks to the community, workers, and the environment. In-situ thermal would be conducted on a controlled basis, with access limited to remediation workers during the period of treatment. Excavation and disposal would be completed using approved methods and employing engineering controls to protect the community, workers, and the environment. Potential risks are limited to onsite populations for excavation activities; potential risks apply to both onsite and offsite populations for the transportation and disposal of excavated soil. Remedial response objectives and protectiveness (active remediation completed and institutional controls in place to limit exposure) would be anticipated to be achieved within 1 year.

7.1.4.6 Implementability

Implementation of this alternative is both technically and administratively feasible. In-situ thermal and limited excavation would not interfere with ongoing operations on the site. Similarly, the expertise necessary to complete the work would be readily available. Institutional controls would be readily implementable.

7.1.4.7 Cost

Table 7-3 and Appendix A present a summary of the present value calculations for Alternative SR-4 and the detailed cost backup, respectively. Capital costs include site

preparation, in-situ thermal treatment, excavation, transportation, disposal and institutional controls. There would be no annual O&M costs following completion of the thermal treatment. Total capital costs are estimated to be approximately $1,383,000.

7.2 Detailed Analysis of Groundwater Remedial Action Alternatives

A detailed analysis of source area soil and groundwater remedial action alternatives presented in Section 6.2 is provided in the following sections.

7.2.1 Alternative GW-1: No Action

The following sections present a detailed analysis of remedial action Alternative GW-1 for groundwater. Table 7-2 presents a summary of this analysis.

7.2.1.1 Overall Protection of Human Health and the Environment

Although the “No Action” alternative does not incorporate any onsite activities that would present exposure risks to the community, workers, or the environment, it would not take measures to address existing COC concentrations in groundwater, or provide measures to eliminate or control potential exposure pathways. Natural attenuation processes may reduce VOC concentrations in groundwater to PRGs, but monitoring of these processes would not be performed under the “No Action” alternative. Therefore, the “No Action” alternative would not achieve groundwater RAOs and is not protective of human health or the environment.

7.2.1.2 Compliance with ARARs

Absent active remediation activities, Alternative GW-1 would not comply with chemical-specific ARARs for groundwater in a reasonable timeframe. While natural attenuation processes may reduce VOC concentrations in soil and groundwater to PRGs, monitoring of these processes would not be performed under the “No Action” alternative. Therefore, the “No Action” alternative would not comply with ARARs.

7.2.1.3 Long-Term Effectiveness and Permanence

Long term effectiveness and permanence would not be achieved through the “No Action” alternative because existing COC concentrations in groundwater would not be addressed and access or land use restrictions would not be implemented to eliminate or provide long-term control of potential exposure pathways. Natural attenuation processes may reduce VOC concentrations in groundwater to PRGs, but monitoring of

these processes would not be performed under the “No Action” alternative.

7.2.1.4 Reduction of Mobility, Toxicity, or Volume

Although natural attenuation processes may result in the reduction of VOC mobility, toxicity, or volume in groundwater, monitoring of these processes would not be performed under the “No Action” alternative. The statutory preference for treatment as a principal element is not satisfied by the “No Action” alternative.

7.2.1.5 Short-Term Effectiveness

The “No Action” alternative does not incorporate any activities that would present exposure risks to the community, workers, or the environment. Protectiveness would not be achieved through the “No Action” alternative.

7.2.1.6 Implementability

Due to the lack of technical components, the “No Action” alternative is technically feasible and would not limit or interfere with the ability to perform future remedial actions. However, the “No Action” alternative is unlikely to be administratively feasible due to the anticipated lack of monitoring and protection of human health and the environment.

7.2.1.7 Cost

There are no associated costs with the “No Action” alternative because no actions of any kind would be performed in connection with this alternative.

7.2.2 Alternative GW-2: Multiphase Extraction, SAW-2 Groundwater Extraction, Enhanced Reductive Dechlorination, Chemical Oxidation, Monitored Natural Attenuation, and Institutional Controls

The following sections present a detailed analysis of remedial action Alternative GW-2 for groundwater. Table 7-2 presents a summary of this analysis.

Operation of the HVE system will continue in Alternative GW-2, primarily to allow for continued operation of the SVE component to address residual soil impacts. However, operation of the HVE system will recover COC impacted groundwater and provide hydraulic control in the treatment areas of the Former Bulk Chemical Handling Area.

Enhanced reductive dechlorination is the primary groundwater treatment technology for CVOCs for Alternative GW-2. ERD will be implemented to treat the CVOC plume onsite via ERD treatment lines in the Former Drum Rinse Area. Detailed design of the injection trenches and injection procedures will be completed based on site hydrogeology, the results of the hydraulic testing, and the results of the previously conducted long-term ERD pilot test.

Chemical oxidation would be the primary treatment technology for dissolved VOCs in the offsite groundwater plume. Chemical oxidation would be implemented by direct injection of a peroxide compound, generating hydroxyl radicals for oxidation of VOCs. Injections will target the unconsolidated sediments and heavily weathered bedrock, in order to maximize contact with the groundwater within the bedrock. Free oxygen will be produced as a byproduct of chemical oxidation activities in the groundwater plume which will accelerate the aerobic bioremediation of any remaining aromatic hydrocarbons and ketones in the groundwater following the chemical oxidation process.

Groundwater extraction will be continued in SAW-2 and will provide recovery of dissolved VOCs that have previously migrated vertically down the open borehole due to inappropriate well construction prior to recompilation of the SAW-2 well. The groundwater extraction will exert hydraulic influence in the vicinity of the SAW-2 well that will reduce the potential for dissolved VOCs to migrate away from the SAW-2 borehole.

MNA and institutional controls will be initiated concurrent with starting active remediation activities.

7.2.2.1 Overall Protection of Human Health and the Environment

Implementation of groundwater alternative GW-2 is expected to result in minimal exposure risks to the community, workers, or the environment. Continued operation of the MPE system will generate vapors with low concentrations of VOCs and potentially expose workers to VOC impacted groundwater. Chemical oxidation requires the use of corrosive chemicals that can be safely handled by implementing appropriate health and safety rules. The remaining activities result in in-situ destruction of COCs preventing direct contact. The existing regulatory restriction on water wells within the Springfield Plateau Aquifer would protect against human exposure to groundwater impacts while VOC concentrations attenuate. Groundwater monitoring would be used to assess achievement of RAOs. Alternative GW-2 would thereby protect indefinitely

against both current and future human exposure to source area soil and groundwater and would be protective of human health and the environment.

7.2.2.2 Compliance with ARARs

The active remediation activities, MNA, and institutional controls would achieve ARARs for groundwater. Alternative GW-2 would comply with location- and action-specific ARARs.

7.2.2.3 Long-Term Effectiveness and Permanence

Alternative GW-2 would achieve long-term effectiveness and permanence for groundwater impacts at the site. Alternative GW-2 would result in the permanent reduction of VOC concentrations in groundwater. COC mass would be reduced by groundwater extraction, ERD, chemical oxidation, aerobic biodegradation, and natural attenuation. The use of institutional controls would also be implemented to limit exposure pathways.

7.2.2.4 Reduction of Mobility, Toxicity, or Volume

Alternative GW-2 would permanently reduce the mobility, toxicity, and volume of VOCs in groundwater, as treatment via groundwater extraction, ERD, aerobic biodegradation, chemical oxidation, and natural attenuation processes would result in permanent destruction of VOCs. The statutory preference for treatment as a principal element is satisfied by alternative GW-2 remedial activities.

7.2.2.5 Short-Term Effectiveness

Implementation of this alternative would result in minimal exposure risks to the community, workers, and the environment. Potential risks are limited to onsite populations. Active remedial response objectives and protectiveness would be achieved in approximately 10 years (5 active remediation and 5 years MNA).

7.2.2.6 Implementability

Implementation of this alternative is both technically and administratively feasible and would not interfere with ongoing operations at the site. Monitoring or injection wells and chemical oxidation injection borings would be installed using standard drilling methods and materials. These services are readily available, as are the services and materials necessary for the collection and analysis of groundwater samples.

Implementation of this alternative would not limit or interfere with the ability to perform future remedial actions. Offsite activities are dependent on third party access. Onsite institutional controls would be readily able to be implemented.

7.2.2.7 Cost

Table 7-4 and Appendix B present a summary of the present value calculations for Alternative GW-2 and the detailed cost backup, respectively. Capital costs include site preparation, installation of monitoring and substrate injection wells downgradient and within the vicinity of identified source areas, continuation of the bailing program at SAW-2, chemical oxidation, and institutional controls. O&M costs include the O&M of the HVE system, ERD treatment, MNA monitoring, and institutional controls. Periodic costs will include well abandonment and system demobilization. The total remediation duration for Alternative GW-2 is estimated to be 3 years.

Based on USEPA guidance (USEPA, 2000), the total present value life cycle cost of Alternative GW-2 using a discount rate of 7.0 percent is $1,739,000.

7.2.3 Alternative GW-3: Source Area and Off Site Chemical Oxidation, Hydraulic Control, Off Site Enhanced Reductive Dechlorination, Groundwater Extraction at SAW-2 , Monitored Natural Attenuation, and Institutional Controls

The following sections present a detailed analysis of remedial action Alternative GW-3 for groundwater. Table 7-2 presents a summary of this analysis.

Chemical oxidation would be the primary treatment technology for dissolved VOCs at the Former Drum Rinse Area and within the portion of the offsite groundwater plume where aromatic hydrocarbons are predominant. Enhanced reductive dechlorination would be used to accelerate already existing reductive dechlorination processes within portions of the offsite plume.

A series of existing and new wells at the property boundary would be used to provide hydraulic control and to prevent the dissolved plume from leaving the site. Groundwater extraction will be continued in SAW-2 and will provide recovery of dissolved VOCs that have previously migrated vertically down the open borehole due to inappropriate well construction prior to recompilation of the well. The groundwater extraction will exert hydraulic influence in the vicinity of the SAW-2 well that will reduce the potential for dissolved VOCs to migrate away from the SAW-2 borehole.

7.2.3.1 Overall Protection of Human Health and the Environment

Implementation of groundwater alternative GW-3 is expected to result in minimal exposure risks to the community, workers, or the environment. Chemical oxidation requires the use of corrosive chemicals that can be safely handled by implementing appropriate health and safety rules. The remaining activities result in in-situ destruction of COCs preventing direct contact. Additionally, institutional controls (i.e. groundwater use restrictions) would protect against human exposure to groundwater impacts while VOC concentrations attenuate. Groundwater monitoring would be used to assess achievement of RAOs. Alternative GW-3 would thereby protect indefinitely against both current and future human exposure to source area soil and groundwater and would be protective of human health and the environment.

7.2.3.2 Compliance with ARARs

The active remediation activities, MNA, and institutional controls would achieve ARARs for groundwater. Alternative GW-3 would comply with location- and action-specific ARARs.

7.2.3.3 Long-Term Effectiveness and Permanence

Alternative GW-4 would achieve long-term effectiveness and permanence for groundwater impacts at the site. Alternative GW-3 would result in the permanent reduction of VOC concentrations in groundwater. COC mass would be reduced by groundwater extraction, ERD, and chemical oxidation. MNA and the use of institutional controls would also be implemented.

7.2.3.4 Reduction of Mobility, Toxicity, or Volume

Alternative GW-3 would permanently reduce the mobility, toxicity, and volume of VOCs in groundwater, as treatment via groundwater extraction, ERD, aerobic biodegradation, chemical oxidation, and natural attenuation processes would result in permanent destruction of VOCs. The statutory preference for treatment as a principal element is satisfied by alternative GW-3 remedial activities.

7.2.3.5 Short-Term Effectiveness

Implementation of this alternative would result in minimal exposure risks to the community, workers, and the environment. Potential risks are limited to onsite populations. Remedial response objectives and protectiveness would be achieved in less than 10years (5 years of active remediation and 5 of MNA).

7.2.3.6 Implementability

Implementation of this alternative is both technically and administratively feasible and would not interfere with ongoing operations at the site. Monitoring or injection wells and chemical oxidation injection borings would be installed using standard drilling methods and materials. These services are readily available, as are the services and materials necessary for the collection and analysis of groundwater samples. Implementation of this alternative would not limit or interfere with the ability to perform future remedial actions. Institutional controls would be readily able to be implemented.

7.2.3.7 Cost

Table 7-4 and Appendix B present a summary of the present value calculations for Alternative GW-3 and the detailed cost backup, respectively. Capital costs include site preparation, installation of monitoring and substrate injection wells downgradient and within the vicinity of identified source areas, continuation of the recovery program at SAW-2, chemical oxidation, and institutional controls. O&M costs include the O&M of the hydraulic containment system, ERD treatment, MNA monitoring, and institutional controls. Periodic costs will include well abandonment and system demobilization. The total remediation duration for Alternative GW-3 is estimated to be 10 years.

Based on USEPA guidance (USEPA, 2000), the total present value life cycle cost of Alternative GW-3 using a discount rate of 7.0 percent is $1,081,000.

7.2.4 Alternative GW-4: Source Area Chemical Oxidation, Hydraulic Control, Groundwater Extraction at SAW-2, Monitored Natural Attenuation, and Institutional Controls

The following sections present a detailed analysis of remedial action Alternative GW-4 for groundwater. Table 7-2 presents a summary of this analysis.

Chemical oxidation would be the primary treatment technology for dissolved VOCs at the Former Drum Rinse Area and in the downgradient plume in the area of MW-17.

A series of existing and new wells at the property boundary would be used to provide hydraulic control and to prevent the dissolved plume from leaving the site. Groundwater extraction will be continued in SAW-2 and will provide recovery of dissolved VOCs that have previously migrated vertically down the open borehole due to inappropriate well construction prior to recompilation of the SAW-2 well. The groundwater extraction will exert hydraulic influence in the vicinity of the SAW-2 well that will reduce the potential for dissolved VOCs to migrate away from the SAW-2 borehole.

7.2.4.1 Overall Protection of Human Health and the Environment

Implementation of groundwater alternative GW-4 is expected to result in minimal exposure risks to the community, workers, or the environment. Chemical oxidation requires the use of corrosive chemicals that can be safely handled by implementing appropriate health and safety rules. The remaining activities result in in-situ destruction of COCs preventing direct contact. Additionally, institutional controls (i.e. groundwater use restrictions) would protect against human exposure to groundwater impacts while VOC concentrations attenuate. Groundwater monitoring would be used to assess achievement of RAOs. Alternative GW-4 would thereby protect indefinitely against both current and future human exposure to source area soil and groundwater and would be protective of human health and the environment.

7.2.4.2 Compliance with ARARs

The active remediation activities, MNA, and institutional controls would achieve ARARs for groundwater. Alternative GW-4 would comply with location- and action-specific ARARs.

7.2.4.3 Long-Term Effectiveness and Permanence

Alternative GW-4 would achieve long-term effectiveness and permanence for groundwater impacts at the site. Alternative GW-4 would result in the permanent reduction of VOC concentrations in groundwater. COC mass would be reduced by groundwater extraction, and chemical oxidation, and natural attenuation. Institutional controls would also be implemented.

7.2.4.4 Reduction of Mobility, Toxicity, or Volume

Alternative GW-4 would permanently reduce the mobility, toxicity, and volume of VOCs in groundwater, as treatment via groundwater extraction, chemical oxidation, and

natural attenuation processes would result in permanent destruction of VOCs. The statutory preference for treatment as a principal element is satisfied by alternative GW-4 remedial activities.

7.2.4.5 Short-Term Effectiveness

Implementation of this alternative would result in minimal exposure risks to the community, workers, and the environment. Potential risks are limited to onsite populations. Remedial response objectives and protectiveness would be achieved in 20 years.

7.2.4.6 Implementability

Implementation of this alternative is both technically and administratively feasible and would not interfere with ongoing operations at the site. Monitoring or chemical oxidation injection wells would be installed using standard drilling methods and materials. These services are readily available, as are the services and materials necessary for the collection and analysis of groundwater samples. Implementation of this alternative would not limit or interfere with the ability to perform future remedial actions. Institutional controls would be readily able to be implemented.

7.2.4.7 Cost

Table 7-4 and Appendix B present a summary of the present value calculations for Alternative GW-4 and the detailed cost backup, respectively. Capital costs include site preparation, installation of monitoring and substrate injection wells, continuation of the groundwater recovery program at SAW-2, chemical oxidation, and institutional controls. O&M costs include the O&M of the HVE system, MNA monitoring, and institutional controls. Periodic costs will include well abandonment and system demobilization. The total remediation duration for Alternative GW-4 is estimated to be 20 years.

Based on USEPA guidance (USEPA, 2000), the total present value life cycle cost of Alternative GW-4 using a discount rate of 7.0 percent is $1,030,000.

8. Development of Site Wide Alternatives

The comparative analyses of remedy duration and cost for soil and groundwater alternatives are outlined in Tables 7-3 and 7-4, with supporting cost detail provided in Appendix A (soil) and Appendix B (groundwater).

The development of remedial action alternatives to this point has followed the process below:

- Identification of RAOs and requirements for remediation (Section 3);
- Identification and screening of applicable technologies and formulation of remedial action alternatives for soil and groundwater (Sections 4 through 6); and
- Individual analysis of soil and groundwater remedial action alternatives (Section 7).

The formulation of the site-wide alternatives for this FS is developed in the following manner:

- A comparative analysis of the soil and groundwater remedial action alternatives is presented using the threshold and balancing evaluation criteria (Sections 8.1 and 8.2); and
- The preferred remedial option for soil and groundwater are presented in Section 8.3.

8.1 Comparative Analysis of Soil Remedial Action Alternatives

Alternative SR-1 (No Action) does not satisfy the seven evaluation criteria, the RAOs, and would not be acceptable to the community or state. Alternatives SR-2 and SR-3 would satisfy RAOs. Additional comparison of alternatives SR-2 and SR-3 using the evaluation criteria are provided in the following sections.

8.1.1 Overall Protection of Human Health and the Environment

Soil alternatives SR-2, SR-3, and SR-4 achieve RAOs and are protective of human health and the environment. Due to the continued operation of the HVE system, alternative SR-2 provides a greater level of protectiveness because of its more aggressive treatment of soils inaccessible to excavation.

8.1.2 Compliance with ARARs

Alternatives SR-2, SR-3, and SR-4 remove the bulk of the unsaturated soil with concentrations of COCs exceeding the remediation goals. However, existing structures will prevent complete removal. All three alternatives remove the exposure pathway through use of institutional controls.

8.1.3 Long-Term Effectiveness and Permanence

Alternative SR-2, SR-3, and SR-4 would provide long-term effectiveness and permanence.

8.1.4 Reduction of Mobility, Toxicity, and Volume

Alternatives SR-2, SR-3, and SR-4 reduce toxicity, mobility, and volume of COC impacted soil. Alterative SR-2 would provide greater reduction than SR-3 because of its ability to reduce mobility, toxicity, and volume in soils inaccessible to excavation. SR-4 would provide the greatest reduction in mobility, toxicity, and volume in soils due to destruction of COCs extending into the saturated zone.

8.1.5 Short-Term Effectiveness

Implementation of Alternatives SR-2, SR-3, and SR-4 would result in minimal exposure risks to the community, workers, and the environment. All alternatives would result in potential risks to onsite and offsite populations due to the transportation of excavated material to a disposal facility.

8.1.6 Implementability

Alternatives SR-2, SR-3, and SR-4 are technically and administratively feasible and would not interfere with ongoing operations at the facility.

8.1.7 Cost

There are no costs associated with Alternative SR-1. Of the remaining alternatives, Alternative SR-4 is the highest present value life-cycle cost of $1,383,000 and Alternative SR-3 is the lowest present value life-cycle cost of $467,000. Table 7-3 and Appendix A provide further information regarding cost.

8.2 Comparative Analysis of Groundwater Remedial Action Alternatives

Alternative GW-1 (No Action) does not satisfy the seven evaluation criteria, the RAOs, and would not be acceptable to the community or state. Alternatives GW-2, GW-3, and GW-4 would satisfy RAOs. Additional comparison of alternatives GW-2, GW-3, and GW-4 using the evaluation criteria are provided in the following sections.

8.2.1 Overall Protection of Human Health and the Environment

Alternatives GW-2, GW-3, and GW-4 achieve RAOs and provide overall protection of human health and the environment and provide protection to site-wide groundwater through institutional controls and the combination of removal and in-situ destruction of COC impacted groundwater.

8.2.2 Compliance with ARARs

Alternatives GW-2, GW-3, and GW-4 comply with ARARs, although due to the continued operation of the MPE system and hot spot treatment, alternatives GW-2 and GW-3 are more aggressive remedial technology and would meet ARARs over a shorter remedial timeframe.

8.2.3 Long-Term Effectiveness and Permanence

Alternatives GW-2, GW-3, and GW-4 would provide long-term effectiveness and permanence. However, due to the continued operation of the HVE system and offsite plume treatment, alternative GW-2 and GW-3 a complete removal of COC impacted groundwater over a shorter period of time.

8.2.4 Reduction of Mobility, Toxicity, and Volume

Alternatives GW-2, GW-3 and GW-4 would reduce the mobility, toxicity, and volume of both onsite and offsite COCs. The dependence of natural attenuation for the offsite CVOC plume reduces the overall rate of COC reduction for Alternative GW-4

8.2.5 Short-Term Effectiveness

Implementation of Alternatives GW-2, GW-3, and GW-4 would result in minimal exposure risks to the community, workers, and the environment. Alternatives GW-2 and GW-3 would result in the slightly greatest exposure risks to the community,

workers, and the environment due to continued operation of the HVE system which will generate small amounts of VOCs in the extracted vapors and potentially expose site workers to COC impacted groundwater.

8.2.6 Implementability

Alternatives GW-2, GW-3, and GW-4 are technically and administratively feasible, comparable, and would not interfere or only minimally interfere with ongoing operations at the site.

8.2.7 Cost

There are no costs associated with Alternative GW-1. Of the remaining alternatives, Alternative GW-4 has the lowest net present value life-cycle cost of $1,030,000 and Alternative GW-2 has the highest net present value life-cycle cost of $1,818,000. Table 7-4 and Appendix B provide further information regarding cost.

8.3 Preferred Remedial Action Alternatives

8.3.1 Soil Remediation

The recommended soil remedial action for the Brenntag site is alternative SR-2. As discussed in Section 7, the recommended alternative consists of excavation of impacted soils accompanied by implementation of an optimized MPE system, and institutional controls. For the purposes of this FS the conceptual design includes three areas of targeted excavation as illustrated on Figure 6-1, optimization of the existing HVE system and demarcation of an excavation management zone. The Plant area that has been designated for excavation controls and concrete pad maintenance (to prevent worker exposure and infiltration) is shown on Figure 6-1. The total cost of this alternative is estimated to be approximately $829,000. A detail of the estimated cost is provided in Appendix A.

8.3.2 Groundwater Remediation

The recommended groundwater remedial action for the Brenntag site is alternative GW-4. As discussed in Section 7, the recommended alternative utilizes a combination of the chemical oxidation for the source area in the Former Drum Rinse Area and off site near MW-17, groundwater extraction for the SAW-2 well, hydraulic control at the downgradient site boundary and MNA.

For the purposes of this FS the groundwater remediation conceptual design includes installation of injection points within the permeable backfill (from SR-2 excavation activities), as illustrated on Figure 6-6 -, optimization of the existing HVE system at the downgradient property boundary and groundwater extraction at the SAW-2 well. A MNA plan will also be implemented to document continued natural attenuation of both the remaining onsite and offsite portions of the dissolved VOC plume. The total cost of this alternative is estimated to be $1,030,000. A detail of the estimated cost is provided in Appendix B.

9. References

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Tables

Table 3-1. Chemical-Specific ARARs

Media	Source	Law/Regulation	Requirement of Law/Regulation	ARAR/TBC Status
Groundwater - Federal	40 CFR Part 141	Safe Drinking Water Act, National Primary Drinking Water Regulations, Maximum Contaminant Levels (MCLs)	Specify the maximum permissible concentrations of contaminants in public drinking water supplies. Federally enforceable standards based, in part, on health effects and on the availability and cost of treatment techniques.	ARAR – Relevant and appropriate for groundwater that is or may be used for drinking water.
	40 CFR Part 141	Safe Drinking Water Act, National Primary Drinking Water Regulations, Maximum Contaminant Level Goals (MCLGs)	Specify the maximum concentration of contaminants in public drinking water supplies at which no known or anticipated adverse human health effects will occur. Non-enforceable health-based goals set equal to or lower than MCLs.	ARAR – Relevant and appropriate for groundwater that is or may be used for drinking.
	40 CFR Part 143	Safe Drinking Water Act, National Secondary Drinking Water Regulations, Secondary Maximum Contaminant Levels (SMCLs)	Provide non-enforceable standards for constituents in public drinking water supplies that affect the aesthetic qualities related to public acceptance.	TBC –Promulgated aesthetic, but non-enforceable guidance levels for constituents in drinking water.
	USEPA Region 9 PRG Table 2004	Preliminary Remediation Goals (PRGs)	Provide non-enforceable, generic, risk-based contaminant concentrations to be used for site “screening”.	TBC – Non-promulgated risk-based guidance levels for constituents.
Groundwater - State	10 CSR 20-7.031	MDNR Water Quality Criteria (MWQC)	Provides chemical, physical, and biological properties of water that are necessary to protect beneficial water uses.	ARAR – Applicable to all state groundwater in aquifers or caves.
	10 CSR 60-4	MDNR Maximum Contaminant Levels (MMCLs)	Provide maximum contaminant levels or action levels for constituents in Missouri public water systems.	ARAR - Relevant and appropriate for groundwater that is or may be used for drinking.
	10 CSR 25-18.010	MDNR – Missouri Risk-Based Corrective Action (MRBCA) Process	Replacing Corrective Action Levels for Missouri, MRBCA provides non-enforceable, conservatively-derived, risk-based target concentrations for the remediation of sites addressed under Missouri’s Voluntary Cleanup Program.	TBC – EPA has not accepted the use of MRBCA guidance on Superfund or Superfund-caliber sites.

ARAR applicable or relevant and appropriate requirements
CFR code of federal regulations
CSR code of state regulations
MDNR Missouri Department of Natural Resources
OU Operable Unit
TBC to be considered
SC United States Code
USEPA United States Environmental Protection Agency

Table 3-2. Location-Specific ARARs

Location	Law/Regulation	Requirement of Law/Regulation	ARAR status
Floodplains	40 CFR 6.302(b) Executive Order No. 11988	Avoid, to the extent possible, or minimize long and short term adverse impacts associated with the occupancy and modification of floodplains and to avoid direct or indirect support of floodplain development if a practicable alternative exists. Evaluate potential effects of actions that may be taken in floodplains and ensure that planning and budgeting reflect consideration of flood hazards and floodplain management.	ARAR: Not applicable to activities conducted at the Brenntag site since it is not located within a 100-year floodplain.
	40 CFR 6 Appendix A	Provide leadership and take action to reduce the risk of flood loss, to minimize the impact of floods on human safety, health, and welfare, and to restore and preserve the natural and beneficial values served by floodplains.	
	40 CFR 264.18(b)	Design, construct, operate, and maintain facility in manner that prevents washout of any hazardous waste by a 100-year flood.	
Wetlands	40 CFR 6.302(a) 40 CFR 6 Appendix A Executive Order No. 11990 40 CFR 230.3(t)	Avoid, to the extent possible, or minimize long and short term adverse impacts associated with the destruction, loss, or modification of wetlands and to avoid direct or indirect support of new construction in wetlands if a practicable alternative exists. Provide leadership and take action to minimize destruction, loss, or degradation of wetlands, and to preserve and enhance the natural and beneficial values of wetlands.	ARAR: Not relevant and appropriate since there are no wetland areas within or near the Brenntag site.
Green and Christian Counties	10 CSR 23-3.100(3)	Prohibits the construction of new drinking water wells in the Springfield Plateau Aquifer. Well s completed in the underlying Ozark Aquifer are required to have well casing that extends through the Northview Shale.	ARAR: Relevant and appropriate for deep bedrock wells completed at or near the site.
Fish and Wildlife Resources	40 CFR 6.302(g) Fish and Wildlife Coordination Act (16 USC 661 et. seq.)	Take action to protect fish and wildlife resources, which may be affected by actions that will result in the control or structural modification of any natural stream or body of water for any purpose. Mitigate, prevent, and compensate for project-related losses of wildlife resources and enhance these resources.	ARAR: Not relevant and appropriate to activities conducted within the Brenntag site.

ARAR applicable or relevant and appropriate requirements
TBC to be considered
USC United States Code
CFR code of federal regulations
CSR code of state regulations

Table 3-3. Risk-Based Remediation Goal Summary

Groundwater - Hypothetical Future Resident Exposure Scenario

	$PRG_{cancer\ risk}$ Target Risk = 1 x 10^{-6}	$PRG_{cancer\ risk}$ Target Risk = 1 x 10^{-5}	$PRG_{non\text{-}cancer\ risk}$ Target Hazard Quotient = 1	Federal MCL	Tap Water Regional Screening Level	Remediation Goal	
	(ug/L)	(ug/L)	(ug/L)	(ug/L)	(ug/L)	(ug/L)	Rationale
Benzene	0.37	3.7	14.5	5	0.41	5	MCL
Bromodichloromethane	0.11	1.1	177	80	0.12	80	MCL
Carbon Tetrachloride	0.36	3.6	16.3	5	0.44	5	MCL
Chloroform	0.06	0.6	33.8	80	0.19	80	MCL
1,1-Dichloroethane	0.1	1	1512	--	2.4	1	cancer risk PRG (1x10^{-5})
1,2-Dichloroethane	0.14	1.4	180	5	0.15	5	MCL
1,1-Dichloroethene	NA	NA	2	0.007	340	2.02	non-cancer risk PRG
cis-1,2-Dichloroethene	NA	NA	14.1	70	73	70	MCL
1,2-Dichloropropane	0.36	3.6	8.2	5	0.39	5	MCL
Ethylbenzene	0.0	0.22	21	700	1.5	700	MCL
Methylene Chloride	0.8	8	138	5	4.8	8	cancer risk PRG (1x10^{-5})
Naphthalene	0.13	1.3	4.9	--	0.14	1.3	cancer risk PRG (1x10^{-5})
1,1,1,2-Tetrachloroethane	0.49	4.9	179	--	0.52	4.9	cancer risk PRG (1x10^{-5})
1,1,2,2-Tetrachloroethane	0.063	0.63	146	--	0.067	0.63	cancer risk PRG (1x10^{-5})
Tetrachloroethene (PCE)	0.064	0.64	25.1	5	0.11	5	MCL
Toluene	NA	NA	49	1000	2300	1000	MCL
1,1,2-Trichloroethane	0.23	2.3	30.7	5	0.24	5	MCL
Trichloroethene (TCE)	1.8	18	NA	5	2	18	cancer risk PRG (1x10^{-5})
1,2,4-Trimethylbenzene	NA	NA	0.6	--	15	0.6	non-cancer risk PRG
1,3,5-Trimethylbenzene	NA	NA	2.8	--	370	2.8	non-cancer risk PRG
Vinyl Chloride	0.024	0.24	12.6	2	0.016	2	MCL
Xylenes (total)	NA	NA	134	10000	200	10000	MCL

PRG = Preliminary Remediation Goal; MCL = Maximum Contaminant Level

Soil - Hypothetical Future Resident Exposure Scenario

	$PRG_{cancer\ risk}$ Target Risk = 1 x 10^{-6}	$PRG_{cancer\ risk}$ Target Risk = 1 x 10^{-5}	$PRG_{non\text{-}cancer\ risk}$ Target Hazard Quotient = 1	Protection of Groundwater Soil Screening Level	Remediation Goal	
	(mg/kg)	(mg/kg)	(mg/kg)	(mg/kg)	(mg/kg)	Rationale
1,2,4-Trimethylbenzene	NA	NA	50	0.021	50	non-cancer risk PRG
1,3,5-Trimethylbenzene	NA	NA	104	0.52	104	non-cancer risk PRG

PRG = Preliminary Remediation Goal

Table 4-1. Soil - Preliminary Screening of Corrective Actions

General Response Action	Technology Type	Process Option	Description	Retained? (Yes/No)	Comment/Rationale
No Action	None	None	Not Applicable	Yes	Used as a baseline for comparison to other process options.
Institutional Controls	Access Restrictions	Deed Notification	Using legal actions to prevent excavation, control land use, and prohibit or restrict trenching in contaminated soil.	Yes	Access restrictions are usually used in conjunction with other technology types for remedial actions.
		Deed Restrictions			
Monitored Natural Attenuation	Monitored Natural Attenuation	Groundwater Monitoring to Evaluate Soil Leaching to Groundwater Effects	Perform routine groundwater monitoring to assess reductions in contaminant concentrations due to natural processes.	Yes	Monitoring is usually used in conjunction with other technology types for remedial actions.
Removal	Excavation	Excavation	Physical removal of impacted soil with treatment or off site disposal	Yes	Effective with shallow accessible soils.
Capping	Capping	Impermeable Cap or Vegetative Cover	Place impermeable barrier at ground surface to minimize physical contact with COCs and to minimize leaching by reducing infiltration from the surface.	No	Does not eliminate leaching from COCs in saturated soils or soil within range of groundwater fluctuation.
In-Situ Treatment	Physical Treatment	Soil Vapor Extraction	Extract VOCs from subsurface in vapor form.	Yes	Most effective with volatile compounds in permeable and unsaturated soils.
		In-Situ Thermal	Use electrical resistance heating to volatilize target compounds and remove via SVE	Yes	Effective with low permeability and saturated soils
	Chemical Treatment	Fenton's Reagent/Hydrogen Peroxide	Use of Fenton's Reagent/ hydrogen peroxide to oxidize contaminants in situ or increase the dissolved oxygen.	Yes	Fenton's reagent has been used successfully in similar settings to oxidize COCs known to be present at the site.
		Ozone	Gaseous ozone is injected into vadose zone soil to oxidize VOCs or increase the dissolved oxygen.	No	Successful deliver of ozone unlikely to be effective in low permeability soils present at the site.
	Biological Treatment	Anaerobic Bioremediation	The injection of a substrate to stimulate native microorganisms and degrade contaminants.	Yes	In-situ bioremediation has been applied successfully at a variety of sites. An in-situ bioremediation pilot test was completed in the immediate vicinity of MW-1 with encouraging results in degrading CVOCs.
		Aerobic Bioremediation	The injection of an oxygen source to stimulate aerobic degradation of contaminants.	Yes	In-situ aerobic bioremediation can be effective for non aromatic hydrocarbons and ketones present at the site.

Table 4-1. Soil - Preliminary Screening of Corrective Actions

General Response Action	Technology Type	Process Option	Description	Retained? (Yes/No)	Comment/Rationale
Ex-Situ Treatment	Physical Treatment	Soil Washing	Contaminants preferentially sorb to fine grained particles which are removed from from bulk soil by screening process. Coarse grained soils can typically be returned to excavation. Fine grained material is treated and/or disposed of off site.	No	Results in wash water that requires secondary treatment prior to disposition (see groundwater process options). Least effective in soils with high percentage of silt and clay.
	Physical Treatment	Stabilization/soil mixing	Contaminants are immobilized by mixing with cement or fly ash and the mixture can be returned to an open excavation or used in concrete or asphalt construction.	No	Does not destroy contaminants which may be re-released to the environment in the future.
	Chemical Treatment	UV/Chemical Oxidation	Involves destroying contaminants by changing the oxidation state using UV radiation and chemical oxidants.	No	Similar to landfarming, this technology uses UV available in sunlight and added oxidizing chemicals. Typically unnecessary since atmospheric air can be added by tilling.
	Biological Treatment	Aeration/Landfarming	A landfarm is constructed to maximize air and sunlight exposure that enhances volatilization of VOCs.	Yes	Very successful in addressing VOCs with limited success in destroying more recalcitrant CVOCs.
		Composting	Like landfarming, composting uses addition of nutrients to enhance natural biological degradation of COCs.	No	Composting is landfarming with the addition of nutrients to promote and maintain aerobic biological activity.

Shading indicates that the process option was eliminated during the initial screening stage.

COCs	Constituents of Concern
CVOCs	Chlorinated Volatile Organic Compounds
VOCs	Volatile Organic Compounds
NPDES	National Pollutant Discharge Elimination System
POTW	Publicly Owned Treatment Works
UV	Ultra-violet

4.2. Groundwater – Preliminary Screening of Corrective Actions

General Response Action	Technology Type	Process Option	Description	Retained? (Yes/No)	Comment/Rationale
No Action	None	None	Not applicable.	Yes	Used as a baseline for comparison to other process options.
Institutional Controls	Access Restrictions	Deed Notifications	Using legal actions to prevent groundwater use, control land use, and prohibit potable use of groundwater.	Yes	Access restrictions are usually used in conjunction with other technology types for remedial actions.
		Deed Restrictions			
Monitored Natural Attenuation	Monitored Natural Attenuation	Groundwater Monitoring	Perform routine groundwater monitoring to assess reductions in contaminant concentrations due to natural processes.	Yes	Monitoring is usually used in conjunction with other technology types for remedial actions.
Containment	Barriers	Slurry Wall	Using a bentonite slurry to form an impermeable wall that prevents the migration of contaminated groundwater.	No	An impermeable barrier wall may create unpredictable effects on vertical groundwater flow, and create undesirable vertical flow paths.
		Sheet Piling	Using steel sheet piles to form an impermeable wall that prevents the migration of contaminated groundwater.		
		Grout Curtain	Injecting cement grout to create an impermeable wall that prevents the migration of contaminated groundwater.		
		Groundwater Extraction	Hydraulic containment through the extraction of groundwater.	Yes	Collection of groundwater from extraction wells for above-ground treatment.
In-Situ Treatment	Physical Treatment	Multi-phase Extraction	Utilizes vacuum pressure to physically rmove separate phase contaminants and physically strip volatile organic compounds from the subsurface.	Yes	Currently employed with limited effectiveness in AOC 1 and has been retained as a potential action in combination with other process options.
	Chemical Treatment	Fenton's Reagent/Hydrogen Peroxide	Use of Fenton's Reagent/ hydrogen peroxide to oxidize contaminants in situ or increase the dissolved oxygen.	Yes	Fenton's reagent has been used successfully in similar settings to oxidize COCs known to be present at the site.
		Reactive Iron	Use of zero valence iron to chemically reduce contaminants in situ.	Yes	Zero valence iron has been shown to be effective in similar settings to reduce COCs known to be present at the site.
	Biological Treatment	Anaerobic Bioremediation	The injection of a substrate to stimulate native microorganisms and degrade contaminants.	Yes	In-situ bioremediation has been applied successfully at a variety of sites with similar characteristics. An in-situ bioremediation pilot test was completed in the immediate viciinty of MW-1 with encouraging results.
		Aerobic Bioremediation	The injection of an oxygen source (e.g., hydrogen peroxide, ozone, or air sparging) to aerobically degrade contaminants.	Yes	In-situ aerobic bioremediation has proven effective for aromatic hydrocarbons and ketones present at the site.

4.2. Groundwater – Preliminary Screening of Corrective Actions

General Response Action	Technology Type	Process Option	Description	Retained? (Yes/No)	Comment/Rationale
Ex-Situ Treatment	Physical Treatment	Air Stripper	Contaminants are removed from the aqueous phase in a counter-current packed media column air stripper or tray aerator configuration.	Yes	Ex-situ treatment of groundwater using carbon adsorption has been successfully applied at Brenntag (in conjunction with groundwater extraction and discharge).
	Physical Treatment	Carbon Adsorption	Contaminants are removed from the aqueous phase onto activated carbon.	Yes	Ex-situ treatment of groundwater using air stripping has been successfully applied at Brenntag (in conjunction with groundwater extraction and discharge).
	Chemical Treatment	UV/Chemical Oxidation	Involves destroying contaminants by changing the oxidation state using UV radiation and chemical oxidants (e.g., ozone).	No	Ex-situ treatment of groundwater using UV/chemical oxidation has been determined to not be cost effective compared to carbon adsorption.
	Biological Treatment	Constructed Wetland Treatment System	Involves construction of a wetlands treatment system to create an anaerobic and reducing environment.	No	Can be used as a polishing step in conjunction with other remediation technologies. The site does not afford a suitable location for wetlands construction.
		Bioreactor	Involves treatment of groundwater using activated sludge.	No	Construction and operation of a bioreactor to address CVOCs, aromatic hydrocarbons and ketones would be costly compared to other process options.
Discharge	On-Site	Reinjection	Reinject treated groundwater meeting discharge limits.	No	Unlikely to be applied at the site as currently operating system has permit to discharge to POTW. Low permeabilities of soils limits potential effectiveness of reinjection.
		Surface Water Discharge	Discharge treated groundwater meeting NPDES permit limits to a surface water body.		
	Off-Site	POTW	Transport treated groundwater to the POTW.	Yes	Interrim remediation currently discharges treated groundwater to the NPDES.

Shading indicates that the process option was eliminated during the initial screening stage.

COCs	Constituents of Concern
CVOCs	Chlorinated Volatile Organic Compounds
VOCs	Volatile Organic Compounds
NPDES	National Pollutant Discharge Elimination System
POTW	Publicly Owned Treatment Works
UV	Ultra-violet

Table 5-1. Process Options Screening Summary - Soil

Remedial Technology	Remedial Technology Process Option	Effectiveness Evaluation	Implementability Evaluation	Relative Cost Evaluation	Retained?
No Action	No Action	---	---	---	Yes: Required by NCP and USEPA guidance as a baseline for comparison to other process options.
Institutional Controls	Deed Notification	Moderate to high: Effective for protection of potential on-site receptors by reducing potential for exposure, but does not reduce environmental impacts or prevent leaching of contaminants from source areas to regional groundwater and thus, potential off-site receptors.	High: Brenntag owns the facility and can specify deed requirements in any future property transaction.	Low: Negligible cost.	Yes: Conventional technology. Considered in conjunction with other technologies.
	Deed Restriction	Moderate: Effective for protection of potential on-site receptors by reducing potential for exposure, but does not reduce environmental impacts or prevent leaching of contaminants from source areas to regional groundwater and thus, potential off-site receptors.	High: Brenntag owns the facility and can specify deed requirements in any future property transaction.	Low: Negligible cost.	Yes: Conventional technology. Considered in conjunction with other technologies.
Removal	Excavation	High: Permanently removes source mass and contaminated soil, although does not address source area groundwater concerns.	Low to moderate: Significant portions of impacted soil may be inaccessible to excavation. Where accessible, excavation of shallow soil impacts is readily achievable.	High: High capital costs.	Yes: Conventional technology. Considered in conjunction with other technologies.
Disposal	Offsite Landfill	High: Permanently eliminates VOCs as a source of site environmental impacts.	Moderate: Readily implementable if classified as non-hazardous waste.	High: High capital cost.	Yes: Conventional technology. Considered in conjunction with other technologies.
	Onsite Consolidation	Low to Moderate: Consolidation of source area material would not be effective disposal, nor permanently eliminating VOCs as source of environmental impacts.	Low: Small size of site limits area available for consolidation. Regulatory approval of onsite consolidation unlikely.	Low to Moderate: Low to moderate capital costs.	No: Considered in conjunction with other technologies for disposal of drill cuttings and other IDW.
In-Situ Physical Treatment	Capping	Low: Shallow groundwater and large range of fluctuation leaves even shallow soil in potential contact with groundwater.	Low: Significant portions of impacted soil may be inaccessible to capping due to site operation activities.	Moderate: Moderate capital costs.	No: Low effectiveness and implementability keep this from being an effective technology.
	Soil Vapor Extraction	Moderate: When used as component of MPE, has proven effective as interim measure at the site. Overall low permeability of site has limited effectiveness.	High: Soil vapor extraction is currently being conducted at the site as part of an interim remediation system.	Moderate: High capital costs have already been incurred, low cost to optimize system; high O&M costs.	Yes: Conventional technology currently in use at the site. Considered in conjunction with other technologies.

Table 5-1. Process Options Screening Summary - Soil

Remedial Technology	Remedial Technology Process Option	Effectiveness Evaluation	Implementability Evaluation	Relative Cost Evaluation	Retained?
In-Situ Chemical Treatment	Chemical Oxidation	Moderate: Effective on VOC compounds present at the site. Low permeability soils limit the potential for direct contacts of oxidant with VOCs. Free oxygen delivered as a byproduct of BIOX method will promote aerobic biodegradation	Moderate: Implementable as an aggressive source area treatment approach. Will require injection permit.	High: High capitals costs; low O&M costs.	Yes: Conventional technology. Considered in conjunction with other technologies.
	Ozone	Low: Short half life and low permeability of native sediments, limit the potential for contact with VOCs in soil.	Low to Moderate: Implementable as an aggressive source area treatment approach.	High: High capital costs; high O&M costs.	No: Not effective and cost prohibitive when compared to other source treatment technologies.
In-Situ Biological Treatment	Enhanced Reductive Dechlorination	Moderate: Difficult to implement in unsaturated soil, but effective in saturated soils. Effective for remediation of chlorinated VOCs in groundwater. Ineffective for remediation of non chlorinated compounds.	High: Proven technology currently in pilot test phase at site.	Moderate: Moderate capital costs; moderate O&M costs.	Yes: Conventional technology. Considered in conjunction with other technologies.
	Aerobic Bioremediation	Moderate: Effective for remediation of non chlorinated VOCs in unsaturated soils. More difficult to achieve in low permeability saturated media.	High: Proven technology currently being conducted on unsaturated soils at the site as part of the interim remediation system.	Low to Moderate: Moderate capital costs already incurred; low O&M costs.	Yes: Considered in conjunction with other technologies.
Ex-Situ Physical Treatment	Soil Washing	Low: Not effective in predominantly fine grained soils.	Low to moderate: Significant portions of impacted soil may be inaccessible for removal. Where accessible, excavation of shallow soil impacts is readily achievable.	High: High capital costs.	No: Not technically feasible nor cost effective over other technologies
	Soil Stabilization/Soil Mixing	Low: Stabilization of VOC in impacted soils not feasible.	Low to moderate: Significant portions of impacted soil may be inaccessible for removal. Where accessible, excavation of shallow soil impacts is readily achievable.	High: High capital costs.	No: Not technically feasible nor cost effective over other technologies
Ex-Situ Biological Treatment	Aeration/ Landfarming	Moderate to High: Highly effective on aerobically degradable VOCs. Removal of chlorinated VOCs depends on effective aeration of low permeability soils.	Moderate: Insufficient room on site. Would be difficult to obtain regulatory approval for offsite treatment location.	Moderate capital cost: Offsite implementation would require construction of landfarm treatment cell to control run off.	No: Technically feasible, but not cost effective when compared to other technologies.
	Composting	Low: Combination of treatment requirements for VOCs present in soil make composting technically difficult.	Moderate: Insufficient room on site. Would be difficult to obtain regulatory approval for offsite treatment location.	Moderate capital cost: Offsite implementation would require construction of landfarm treatment cell to control run off.	No: Not technically feasible nor cost effective over other technologies

Notes:

	Shading indicates that process option will not be retained for further evaluation.
---	Evaluation not required.
NCP	National Contingency Plan
O&M	Operation and Maintenance
USEPA	United States Environmental Protection Agency
VOC	Volatile Organic Compound

Table 5-2. Process Options Screening Summary - Groundwater

Remedial Technology	Remedial Technology Process Option	Effectiveness Evaluation	Implementability Evaluation	Relative Cost Evaluation	Retained: yes or no
No Action	No Action	---	---	---	Yes: Required by NCP and USEPA guidance as a baseline for comparison to other process options.
Institutional Controls	Deed Notification	Moderate: Effective for protection of potential on-site receptors by reducing potential for exposure, but does not reduce environmental impacts or prevent off site migration of contaminants from source areas to potential off-site receptors.	High: Brenntag owns the facility and can specify deed requirements in any future property transaction.	Low: Negligible cost.	Yes: Conventional technology. Considered in conjunction with other technologies.
	Deed Restriction	Moderate: Effective for protection of potential on-site receptors by reducing potential for exposure, but does not reduce environmental impacts or prevent off site migration of contaminants from source areas to potential off-site receptors.	High: Brenntag owns the facility and can specify deed requirements in any future property transaction.	Low: Negligible cost.	Yes: Conventional technology. Considered in conjunction with other technologies.
Monitored Natural Attenuation	Groundwater Monitoring	Moderate: Not effective for reducing VOC concentrations in site-wide groundwater to cleanup goals within a reasonable timeframe.	High: Requires only enhancement of existing groundwater monitoring program.	Low to Moderate: Low capital costs due to existing monitoring well network, although enhancement may be required; moderate long-term O&M costs.	Yes: Effective in long-term reduction of COCs and monitoring the effects of other remediation technologies.
Containment	Slurry Wall	Moderate: Effective for containment of impacted groundwater when used in conjunction with other technologies such as groundwater extraction. Requires long-term operation for remediation of groundwater to cleanup goals. Long-term effectiveness depends on continued future operation.	Moderate: Implementable, although impractical to extend below unconsolidated sediments into shallow bedrock.	Moderate: Moderate capital costs, low O&M costs but would be used in conjunction with other technologies with significant O&M costs.	No: Would be used in conjunction with existing groundwater extraction system without offering significant additional performance.
	Sheet Piling	Moderate: Effective for containment of impacted groundwater when used in conjunction with other technologies such as groundwater extraction. Requires long-term operation for remediation of groundwater to cleanup goals. Long-term effectiveness depends on continued future operation.	Moderate: Implementable, although limited to unconsolidated sediments. Not feasible to extend into shallow bedrock.	Moderate: Moderate capital costs, low O&M costs but would be used in conjunction with other technologies with significant O&M costs.	No: Would be used in conjunction with existing groundwater extraction system without offering significant additional performance.
	Grout Curtain	Moderate: Effective for containment of impacted groundwater when used in conjunction with other technologies such as groundwater extraction. Requires long-term operation for remediation of groundwater to cleanup goals. Long-term effectiveness depends on continued future operation.	Moderate: Implementable	Moderate: Moderate capital costs, low O&M costs but would be used in conjunction with other technologies with significant O&M costs.	No: Would be used in conjunction with existing groundwater extraction system without offering significant additional performance.
	Groundwater Extraction	Moderate to High: Effective for containment of impacted groundwater. Requires long-term operation for remediation of groundwater to cleanup goals. Long-term effectiveness depends on continued future operation.	High: Groundwater extraction and ex situ treatment currently implemented at site as component of MPE system.	Moderate: Low capital costs due to existing groundwater extraction and treatment system, although enhancement may be required; moderate long-term O&M costs.	Yes: Effective and proven when used in conjunction with other technologies.
In-Situ Physical Treatment	Multi-Phase Extraction	Moderate to High: Effective for containment of impacted groundwater. Requires long-term operation for remediation of groundwater to cleanup goals. Long-term effectiveness depends on continued future operation.	High: MPE and ex situ treatment currently implemented at site.	Moderate: Low capital costs as system is currently in operation at the site, although enhancement may be required; moderate long-term O&M costs.	Yes: Effective and proven when used in conjunction with other technologies.

Table 5-2. Process Options Screening Summary - Groundwater

Remedial Technology	Remedial Technology Process Option	Effectiveness Evaluation	Implementability Evaluation	Relative Cost Evaluation	Retained: yes or no
In-Situ Chemical Treatment	Chemical Oxidation	Moderate: Moderately effective for VOCs in groundwater.	Moderate: May require permit for injection of permanganate.	Moderate: Moderate capital costs; no O&M costs.	Yes: Considered in conjunction with other technologies
	Reactive (Zero Valent) Iron	Low to Moderate: Moderately effective for containment of chlorinated VOCs in groundwater. Not effective on aromatic hydrocarbons and ketones.	Moderate: Implementable as a reactive wall barrier.	High: High capital costs; low O&M costs.	No: Does not offer containment advantages over the existing groundwater extraction system.
In-Situ Biological Treatment	Enhanced Reductive Dechlorination	Moderate to High: Effective for remediation of chlorinated VOCs in groundwater. Not effective on aromatic hydrocarbons and ketones.	Moderate to High: Proven technology currently being pilot tested at the site. May require permit for injection of substrates.	Low to Moderate: Moderate capital costs; moderate O&M costs.	Yes: Effective and proven when used in conjunction with other technologies.
	Aerobic Biodegradation	Moderate to High: Effective for remediation of non chlorinated VOCs in groundwater.	Moderate to High: Vertical well air sparging adds oxygen to groundwater.	Moderate: Moderate capital costs; moderate O&M costs.	Yes: Effective and proven when used in conjunction with other technologies.
Ex-Situ Physical Treatment	Air Stripping	High: Effective for ex-situ remediation of VOCs in groundwater.	High: Groundwater extraction and ex situ treatment via air stripping currently implemented at site.	Moderate: Low capital costs due to existing groundwater extraction and treatment system, although enhancement may be required; low to moderate long-term O&M costs.	Yes: Considered in conjunction with groundwater extraction, and already implemented at site.
	Carbon Adsorption	Moderate: Effective for ex-situ remediation of most VOCs in groundwater. Not effective for vinyl chloride	Moderate: Component of existing MPE extraction and ex situ treatment currently implemented at site.	Moderate: Low capital costs due to existing groundwater extraction and treatment system, although enhancement may be required; low to moderate long-term O&M costs.	Yes: Considered in conjunction with groundwater extraction, and already implemented at site.
Ex-Situ Chemical Treatment	Ultraviolet/ Chemical Oxidation	Moderate to High: Moderately effective for ex situ treatment of VOCs in groundwater.	Moderate: Proven and often implemented technology.	High: Moderate capital costs; high O&M costs.	No: Does not offer significant benefit over air stripping.
	Catalytic Oxidation	High: Highly effective for ex-situ treatment of VOCs.	High: Technology already applied to site.	Moderate: Technology already applied at site.	No: Does not offer significant benefit over air stripping.
Ex-Situ Biological Treatment	Constructed Wetland Treatment System	Moderate: May be effective for small quantities of IDW waste.	Moderate: Implementable for small quantities of IDW waste.	High: High capital cost.	No: Does not offer significant benefit over air stripping.
	Bioreactor	High: Effective for destruction of VOCs.	Low: Requires permits for manifesting, transportation, and disposal.	High: High capital cost; low O&M cost.	No: Does not offer significant benefit over air stripping.
Discharge	Publicly Owned Treatment Works	High: Requires the lowest level of treatment prior to discharge.	High: Already implemented at site.	Moderate: Moderate O&M costs.	Yes: Considered in conjunction with groundwater extraction, and already implemented at site.
	Groundwater Reinjection	High: Requires high level of treatment to meet discharge standards.	Low to Moderate: Requires permit for discharge to groundwater.	Moderate to High: Moderate to high costs for treatment prior to reinjection.	No: Does not offer significant benefit over POTW discharge.
	Surface Water Discharge	Moderate: Requires high level of treatment to meet discharge standards.	Moderate: Require discharge permit.	Moderate to High Moderate to high costs for treatment prior to discharge.	No: Does not offer significant benefits over POTW discharge.
	Air Discharge	High: Proven technology, currently used at site in conjunction with air stripper.	High: Currently used at site.	Low: Low capital costs; low O&M costs.	Yes: Proven technology already implemented at site.

Notes:

	Shading indicates that process option will not be retained for further evaluation.
---	Evaluation not required.
COC	Chemicals of Concern
NCP	National Contingency Plan
O&M	Operation and Maintenance
POTW	Publicly Owned Treatment Works
USEPA	United States Environmental Protection Agency
VOC	Volatile Organic Compound

Table 6-1. Action-Specific ARARs for Soil Remedial Action Alternatives

Action	Law/Regulation	Requirement of Law/Regulation	ARAR/TBC status
Moving, mixing or disturbing soil (i.e. grading, transporting materials, excavating, mechanical soil mixing)	10 CSR 10-6.170	Restricts emission of particulate matter to ambient air beyond the premises of origin.	ARAR: Applicable for activities that may potentially emit particulate matter to ambient air.
	40 CFR 52.1-30 40 CFR 52.870-884	National Ambient Air Quality Standards. Establishes national standards for criteria pollutants in ambient air.	ARAR: Applicable for activities that may potentially emit particulate matter to ambient air.
	40 CFR 264.1032 (Subpart AA)	Requires that the total organic emission from all process vents be reduced to below 3.1 tons per year or be reduced by 95% by weight.	ARAR: Relevant and appropriate to emissions from air stripper.
Grading or excavation	10 CSR 20-6.010 10 CSR 20-6.200	Establishes permit requirements and storm water regulations for all persons who operate, use, maintain existing storm water point sources or who disturb land that would result in a storm water point source. Provides regulations for management of storm water runoff, erosion control, and sediment transport.	ARAR: Applicable for grading/excavation.
	33 USC 1251.Section 304(a)	Clean Water Act, National Recommended Water Quality Criteria. Provides recommended chemical, physical and biological criteria for the protection of aquatic life and human health in surface water.	TBC: Non-promulgated recommendation for surface water quality standards. May be considered for storm or surface water runoff during remedial activities.
	10 CSR 10-7.031	State of Missouri Water Quality Criteria. Provides chemical, physical and biological criteria necessary to protect beneficial uses of surface water.	ARAR: Applicable to storm or surface water runoff during remedial activities.
Hazardous waste handling	40 CFR 264, Subpart G 10 CSR 25-7.264(2)(G)	The State of Missouri, in 10 CSR 25-7.264(2)(G), incorporates by reference and sets forth standards which modify or add to the federal closure and post-closure requirements set forth in 40 CFR 264, Subpart G.	ARAR: Applicable for areas or sites where hazardous wastes have been disposed, deposited, released, or discharged.
	40 CFR 261 40 CFR 136 (App. A) 10 CSR 25.4-261	Establishes requirements for identifying RCRA hazardous wastes and analytical requirements for testing and evaluating solid, hazardous, and water wastes.	ARAR: Applicable for identifying RCRA hazardous wastes.
	40 CFR 262, Subparts A through D 49 CFR 171-173 and 177-180 10 CSR 25-5.262	Establishes requirements and standards for hazardous waste classification packaging, labeling, manifesting, record keeping, and shipping.	ARAR: Applicable for off-site disposal of media contaminated with hazardous substances.

Table 6-1. Action-Specific ARARs for Soil Remedial Action Alternatives

Action	Law/Regulation	Requirement of Law/Regulation	ARAR/TBC status
Hazardous waste handling (cont.)	40 CFR 263 10 CSR 25-6.263	The State of Missouri, in 10 CSR 25-6.263, incorporates by reference and sets forth standards which modify or add to the federal regulations for transportation of hazardous wastes set forth in 40 CFR Part 263.	ARAR: Applicable for transportation of media contaminated with hazardous substances.
	40 CFR Parts 107, 171-177 40 CFR 262.20(f) 10 CSR 25-5.262	Establishes regulations for transportation of hazardous materials.	ARAR: Applicable for off-site transportation of RCRA-listed characteristic waste.
	40 CFR 268 10 CSR 25-7.268 10 CSR 80-3.010	Establishes requirements and restrictions for hazardous waste disposal at landfill facilities.	ARAR: Applicable for off-site disposal of media contaminated with hazardous substances.
	40 CFR 264, Subpart N 10 CSR 25-7.264(2)(N)	The State of Missouri, in 10 CSR 25-7.264(2)(N), incorporates by references and sets forth standards which modify or add to the federal treatment standards and specified technologies for solid wastes subject to land disposal restrictions set forth in 40 CFR Part 264, Subpart N.	ARAR: Applicable for off-site disposal of media contaminated with hazardous substances.
	CERCLA 121(d)(3)	Facilities used for off-site disposal of hazardous wastes are required to be in compliance with all pertinent RCRA requirements.	ARAR: Applicable for off-site disposal of media contaminated with hazardous substances.
	Missouri Revised Statute Chapter 260, Section 260.380	Establishes fee requirements and documentation, shipping and handling, transportation, and disposal requirements for hazardous waste generators.	ARAR: Applicable for off-site disposal of excavated soil.
Well Installation	10 CSR 23-4	Establishes construction standards and regulations for extraction wells and monitoring wells.	ARAR: Applicable for monitoring and extraction wells installed.
Surface Impoundment occurrence	40 CFR 264, Subpart K 10 CSR 25-7.264.(2)(K)	The State of Missouri, in 10 CSR 25-7.264(2)(K), incorporates by reference and sets forth standards which modify or add to the federal closure and post-closure requirements for surface impoundments set forth in 40 CFR Part 264, Subpart K.	ARAR: Potentially applicable if contaminated source areas are classified as surface impoundments.

Table 6-1. Action-Specific ARARs for Soil Remedial Action Alternatives

Action	Law/Regulation	Requirement of Law/Regulation	ARAR/TBC status
Groundwater treatment system operation	40 CFR 52.1-30 40 CFR 52.870-884 40 CFR 60.1-19 10 CSR 10-6.101 10 CSR 10-6.080 National Emission Standards for Hazardous Air Pollutants	Establishes national and State of Missouri standards for criteria pollutants in ambient air.	ARAR: Applicable for air/vapor discharges from groundwater treatment systems.
	Missouri Title V Operating Permit Program 10 CSR 10-6	Establishes a federal operating permit program for numerous sources of air pollution. Establishes the State of Missouri regulations and requirements for construction and operation of facilities that may create a source of air pollution. Includes NAAQS, which have been adopted by the State of Missouri and are enforced through permits.	ARAR: Applicable for air/vapor discharges from groundwater treatment systems.
	40 CFR 264, Subpart X 10 CSR 25-7.264(2)(X)	The State of Missouri, in 10 CSR 25-7.264(2)(X), incorporates by reference and sets forth standards which modify or add to the federal regulations for miscellaneous treatment units set forth in 40 CFR Part 264, Subpart X.	ARAR: Applicable if the groundwater treatment system is classified as a miscellaneous treatment unit.
	10 CSR 10-4.070	Chapter 4 - Air Quality Standards and Air Pollution Control Regulations for the Springfield-Greene County Area	ARAR: Relevant and appropriate for air discharge from treatment systems
	Missouri Revised Statute Chapter 644	Missouri Clean Water Law. Establishes permit requirements, standards, and limitations for discharges to waters of the state.	ARAR: Relevant and appropriate for the site.

Table 6-1. Action-Specific ARARs for Soil Remedial Action Alternatives

Action	Law/Regulation	Requirement of Law/Regulation	ARAR/TBC status
Groundwater Monitoring	40 CFR 264.92-95	The groundwater protection standard is established in 40 CFR 264.92. Subsequent sections define hazardous constituents, constituent concentration limits and the compliance point.	ARAR: Relevant and appropriate to impacted groundwater.
	40 CFR 264.100	Establishes requirements for corrective action by owner or operator of a regulated hazardous waste treatment, storage or disposal facility in the case of releases of hazardous material. The owner/operator must establish and implement a groundwater monitoring program in conjunction with the corrective action.	ARAR: Relevant and appropriate to impacted groundwater.
Institutional controls implemented	CERCLA 121(c)	Any remedial action resulting in contaminants remaining onsite with concentrations greater than allowed for unrestricted use must be reviewed at least every five years.	ARAR: Applicable for areas with contamination remaining onsite.

ARAR applicable or relevant and appropriate requirements
CERCLA Comprehensive Environmental Response, Compensation, and Liability act
CFR code of federal regulations
CSR code of state regulations
NAAQS National Ambient air Quality Standards
POTW publicly-owned treatment works
ppm parts per million
RCRA Resource Conservation and Recovery Act
ROD Record of Decision
TBC to be considered
USC United States Code

Table 6-2. Action-Specific ARARs for Groundwater Remedial Action Alternatives

Action	Law/Regulation	Requirement of Law/Regulation	ARAR/TBC Status
Moving, mixing or disturbing soil (i.e. grading, transporting materials, excavating, mechanical soil mixing)	10 CSR 10-6.170	Restricts emission of particulate matter to ambient air beyond the premises of origin.	ARAR: Applicable for activities that may potentially emit particulate matter to ambient air.
	40 CFR 52.1-30 40 CFR 52.870-884	National Ambient Air Quality Standards. Establishes national standards for criteria pollutants in ambient air.	ARAR: Applicable for activities that may potentially emit particulate matter to ambient air.
	40 CFR 264.1032 (Subpart AA)	Requires that the total organic emission from all process vents be reduced to below 3.1 tons per year or be reduced by 95% by weight.	ARAR: Relevant and appropriate to emissions from air stripper.
Grading or excavation	10 CSR 20-6.010 10 CSR 20-6.200	Establishes permit requirements and storm water regulations for all persons who operate, use, maintain existing storm water point sources or who disturb land that would result in a storm water point source. Provides regulations for management of storm water	ARAR: Applicable for grading/excavation.
	33 USC 1251.Section 304(a)	Clean Water Act, National Recommended Water Quality Criteria. Provides recommended chemical, physical and biological criteria for the protection of aquatic life and human health in surface water.	TBC: Non-promulgated recommendation for surface water quality standards. May be considered for storm or surface water runoff during remedial activities.
	10 CSR 10-7.031	State of Missouri Water Quality Criteria. Provides chemical, physical and biological criteria necessary to protect beneficial uses of surface water.	ARAR: Applicable to storm or surface water runoff during remedial activities.

Table 6-2. Action-Specific ARARs for Groundwater Remedial Action Alternatives

Action	Law/Regulation	Requirement of Law/Regulation	ARAR/TBC Status
Hazardous waste handling	40 CFR 264, Subpart G 10 CSR 25-7.264(2)(G)	The State of Missouri, in 10 CSR 25-7.264(2)(G), incorporates by reference and sets forth standards which modify or add to the federal closure and post-closure requirements set forth in 40 CFR 264, Subpart G.	ARAR: Applicable for areas or sites where hazardous wastes have been disposed, deposited, released, or discharged.
	40 CFR 261 40 CFR 136 (App. A) 10 CSR 25.4-261	Establishes requirements for identifying RCRA hazardous wastes and analytical requirements for testing and evaluating solid, hazardous, and water wastes.	ARAR: Applicable for identifying RCRA hazardous wastes.
	40 CFR 262, Subparts A through D 49 CFR 171-173 and 177-180 10 CSR 25-5.262	Establishes requirements and standards for hazardous waste classification packaging, labeling, manifesting, record keeping, and shipping.	ARAR: Applicable for off-site disposal of media contaminated with hazardous substances.
	40 CFR 263 10 CSR 25-6.263	The State of Missouri, in 10 CSR 25-6.263, incorporates by reference and sets forth standards which modify or add to the federal regulations for transportation of hazardous wastes set forth in 40 CFR Part 263.	ARAR: Applicable for transportation of media contaminated with hazardous substances.
	40 CFR Parts 107, 171-177 40 CFR 262.20(f) 10 CSR 25-5.262	Establishes regulations for transportation of hazardous materials.	ARAR: Applicable for off-site transportation of RCRA-listed characteristic waste.
	40 CFR 268 10 CSR 25-7.268 10 CSR 80-3.010	Establishes requirements and restrictions for hazardous waste disposal at landfill facilities.	ARAR: Applicable for off-site disposal of media contaminated with hazardous substances.
	40 CFR 264, Subpart N 10 CSR 25-7.264(2)(N)	The State of Missouri, in 10 CSR 25-7.264(2)(N), incorporates by references and sets forth standards which modify or add to the federal treatment standards and specified technologies for solid wastes subject to land disposal restrictions set forth in 40 CFR Part 264, Subpart N	ARAR: Applicable for off-site disposal of media contaminated with hazardous substances.
	CERCLA 121(d)(3)	Facilities used for off-site disposal of hazardous wastes are required to be in compliance with all pertinent RCRA requirements.	ARAR: Applicable for off-site disposal of media contaminated with hazardous substances.
	Missouri Revised Statute Chapter 260, Section 260.380	Establishes fee requirements and documentation, shipping and handling, transportation, and disposal requirements for hazardous waste generators.	ARAR: Applicable for off-site disposal of excavated soil.
Well Installation	10 CSR 23-4	Establishes construction standards and regulations for extraction wells and monitoring wells.	ARAR: Applicable for monitoring and extraction wells installed.

Table 6-2. Action-Specific ARARs for Groundwater Remedial Action Alternatives

Action	Law/Regulation	Requirement of Law/Regulation	ARAR/TBC Status
Surface Impoundment occurrence	40 CFR 264, Subpart K 10 CSR 25-7.264.(2)(K)	The State of Missouri, in 10 CSR 25-7.264(2)(K), incorporates by reference and sets forth standards which modify or add to the federal closure and post-closure requirements for surface impoundments set forth in 40 CFR Part 264, Subpart K.	ARAR: Potentially applicable if contaminated source areas are classified as surface impoundments.
Groundwater treatment system operation	40 CFR 52.1-30 40 CFR 52.870-884 40 CFR 60.1-19 10 CSR 10-6.101 10 CSR 10-6.080 National Emission Standards for Hazardous Air Pollutants	Establishes national and State of Missouri standards for criteria pollutants in ambient air.	ARAR: Applicable for air/vapor discharges from groundwater treatment systems.
	40 CFR 264.1032 (Subpart AA)	Requires that the total organic emission from all process vents be reduced to below 3.1 tons per year or be reduced by 95% by weight.	ARAR: Relevant and appropriate to emissions from air stripper.
	Missouri Title V Operating Permit Program 10 CSR 10-6	Establishes a federal operating permit program for numerous sources of air pollution. Establishes the State of Missouri regulations and requirements for construction and operation of facilities that may create a source of air pollution. Includes NAAQS, which have been adopted by the State of Missouri and are enforced through permits.	ARAR: Applicable for air/vapor discharges from groundwater treatment systems.
	40 CFR 264, Subpart X 10 CSR 25-7.264(2)(X)	The State of Missouri, in 10 CSR 25-7.264(2)(X), incorporates by reference and sets forth standards which modify or add to the federal regulations for miscellaneous treatment units set forth in 40 CFR Part 264, Subpart X.	ARAR: Applicable if the groundwater treatment system is classified as a miscellaneous treatment unit.
	10 CSR 10-4.070	Chapter 4 - Air Quality Standards and Air Pollution Control Regulations for the Springfield-Greene County Area	ARAR: Relevant and appropriate for air discharge from treatment systems
	Missouri Revised Statute Chapter 644	Missouri Clean Water Law. Establishes permit requirements, standards, and limitations for discharges to waters of the state.	ARAR: Relevant and appropriate for the site.

Table 6-2. Action-Specific ARARs for Groundwater Remedial Action Alternatives

Action	Law/Regulation	Requirement of Law/Regulation	ARAR/TBC Status
Discharging water to POTW	40 CFR 403 10 CSR 20-6.100	Establishes pre-treatment program and regulations for waters discharged to a POTW.	ARAR: Applicable for water discharged (i.e. from a treatment system) to POTW.
Groundwater Monitoring	40 CFR 264.92-95	The groundwater protection standard is established in 40 CFR 264.92. Subsequent sections define hazardous constituents, constituent concentration limits and the compliance point.	ARAR: Relevant and appropriate to impacted groundwater.
	40 CFR 264.100	Establishes requirements for corrective action by owner or operator of a regulated hazardous waste treatment, storage or disposal facility in the case of releases of hazardous material. The owner/operator must establish and implement a groundwater monitoring program in conjunction with the corrective action.	ARAR: Relevant and appropriate to impacted groundwater.
Institutional controls implemented	CERCLA 121(c)	Any remedial action resulting in contaminants remaining onsite with concentrations greater than allowed for unrestricted use must be reviewed at least every five years.	ARAR: Applicable for areas with contamination remaining onsite.

ARAR applicable or relevant and appropriate requirements
CERCLA Comprehensive Environmental Response, Compensation, and Liability act
CFR code of federal regulations
CSR code of state regulations
NAAQS National Ambient air Quality Standards
POTW publicly-owned treatment works

ppm parts per million
RCRA Resource Conservation and Recovery Act
ROD Record of Decision

TBC to be considered
USC Code United States

Table 7-1. Summary of Detailed and Comparative Analysis of Soil Remedial Action Alternatives

	Evaluation Criteria	Alternative SR-1 No Action	Alternative SR-2 Targeted Excavation, SVE, and Institutional Controls	Alternative SR-3 Targeted Excavation and Institutional Controls	Alternative SR-4 In-Situ Thermal, Targeted Excavation, and Institutional Controls
Threshold Criteria					
1)	Overall protection of human health and the environment	Does not provide overall protection of human health or the environment. Does not minimize, reduce, or control COC impacts in soil or potential exposure risks. Source area RAOs would not be met.	Protective of human health and the environment by mitigating potential leaching of COCs from soil to groundwater. Source area RAOs would be met.	Protective of human health and the environment by mitigating potential leaching of COCs from soil to groundwater. Source area RAOs would be met. Would not address VOCs in inaccessible locations.	Protective of human health and the environment by mitigating potential leaching of COCs from soil to groundwater. Source area RAOs would be met. Would not address VOCs in inaccessible locations.
2)	Compliance with ARARs	There are no location specific ARARs, but chemical specific ARARS (risked based PRGs) have been developed. Does not comply with action specific ARARs.	In the absence of chemical-specific ARARs, PRGs have been established for soil COCs at the site. This alternative would achieve soil RAOs by minimizing potential exposure via removal and in-situ remediation. This alternative would comply with location- and action-specific ARARs.	In the absence of chemical-specific ARARs, PRGs have been established for soil COCs at the site. This alternative would achieve soil RAOs by minimizing potential exposure via removal and institutional controls. This alternative would comply with location- and action-specific ARARs.	In the absence of chemical-specific ARARs, PRGs have been established for soil COCs at the site. This alternative would achieve soil RAOs by minimizing potential exposure via removal and in-situ remediation. This alternative would comply with location- and action-specific ARARs.
Balancing Criteria					
3)	Long-term effectiveness and permanence	Not effective or permanent. Potential exposure and leaching to groundwater pathway associated with COCs in soil would remain with no controls or long-term management plan.	Effective in protecting human health and the environment as long as institutional controls are maintained. Long-term management plan necessary for ensuring permancence of institutional controls. SVE would operate until chemical-specific ARAs are met or until recovery of soil vapors demonstrates diminishing returns.	Effective in protecting human health and the environment as long as institutional controls are maintained. Long-term management plan necessary for ensuring permancence of institutional controls.	Effective in protecting human health and the environment as long as institutional controls are maintained. Long-term management plan necessary for ensuring permancence of institutional controls.
4)	Reduction of mobility, toxicity, or volume	Natural attenuation processes may reduce mobility, toxicity, or volume of source area impacts, although monitoring of these processes would not be performed.	Reduces mobility, toxicity, and volume of VOCs in source area soil.	Reduces mobility, toxicity, and volume of VOCs in source area groundwater and soil, but not VOCs in inaccessible soils.	Reduces mobility, toxicity, and volume of VOCs in source area groundwater and soil, but not VOCs in inaccessible soils.
5)	Short-term effectiveness	No activities would be implemented that would mitigate potential short-term exposure risks to human health or leaching COCs from soil to graoundwater.	Excavation and SVE system installation may expose workers, adjacent populations, or the environment to potential exposure risks, but risks would be minimized through engineering controls. Potential risks would be limited to onsite populations. Remedial action objectives estimated to be met in < 3 years.	Excavation may expose workers, adjacent populations, or the environment to potential exposure risks, but risks would be minimized through engineering controls. Potential risks would be limited to onsite populations. Remedial action objectives may not be achieved due to inaccessible VOCs.	Excavation may expose workers, adjacent populations, or the environment to potential exposure risks, but risks would be minimized through engineering controls. Potential risks would be limited to onsite populations. Remedial action objectives may not be achieved due to inaccessible VOCs.

Table 7-1. Summary of Detailed and Comparative Analysis of Soil Remedial Action Alternatives

	Evaluation Criteria	Alternative SR-1 No Action	Alternative SR-2 Targeted Excavation, SVE, and Institutional Controls	Alternative SR-3 Targeted Excavation and Institutional Controls	Alternative SR-4 In-Situ Thermal, Targeted Excavation, and Institutional Controls
6)	Implementability	Technically feasible due to lack of technical components. However, not administratively feasible due to lack of monitoring or protection of human health or the environment.	Technically and administratively feasible. Excavation in targeted areas and installation of supplemental SVE system would temporarily disrupt ongoing on site operations.	Technically and administratively feasible. Excavation in targeted areas would temporarily disrupt ongoing on site operations.	Technically and administratively feasible. Excavation in targeted areas would temporarily disrupt ongoing on site operations.
7)	Cost	Periodic Costs: $37,400	Capital Costs: $412,600 Annual O&M Costs: $51,400 Annual MNA O&M/Reporting Costs: $0 (captured by GW MPE Option) Periodic Costs: $37,400 Total Present Value Cost: $ 594,200	Capital Costs: $ 338,500 Annual O&M Costs: $0 Annual MNA O&M/Reporting Costs: NA - see GW Periodic Costs: $ 37,400 Total Present Value Cost: $ 375,900	Capital Costs: $ 873,500 Annual O&M Costs: $ 63,000 Annual MNA O&M/Reporting Costs: NA - see GW Periodic Costs: $ 106,400 Total Present Value Cost: $ 1,079,000
Modifying Criteria					
8)	State Acceptance	Likely not acceptable	Aggressive soure reduction and control of exposure pathways make alternative acceptable	Aggressive soure reduction and control of exposure pathways make alternative acceptable	Aggressive soure reduction and control of exposure pathways make alternative acceptable
9)	Community Acceptance	Likely not acceptable	Aggressive soure reduction and control of exposure pathways make alternative acceptable	Aggressive soure reduction and control of exposure pathways make alternative acceptable	Aggressive soure reduction and control of exposure pathways make alternative acceptable

Notes:
All costs are estimated to an accuracy of +50 percent to -30 percent (USEPA, 2000)

Abbreviations:

ARAR	applicable or relevant and appropriate requirement
COC	constituent of concern
GW	Groundwater
SVE	soil vapor extraction
RAOs	Remedial Action Objectives
RI/FS	Remedial Investigation/Feasibility Study
ROD	Record of Decision

Table 7-2. Summary of Detailed and Comparative Analysis of Groundwater Remedial Action Alternatives

	Evaluation Criteria	Alternative GW-1 No Action	Alternative GW-2 MPE, ERD Line Treatment, Groundwater Extraction at SAW-2, Chemical Oxidation, MNA, Institutional Controls	Alternative GW-3 Chemox Source and Hot Spot Treatment, Hydraulic Control, ERD Hot Spot Plume Treatment, MNA, Institutional Controls	Alternative GW-4 Chemox Source nd Hot Spot Treatment, Hydraulic Control, MNA, Institutional Controls
Threshold Criteria					
1)	Overall protection of human health and the environment	Does not provide overall protection of human health or the environment. Does not minimize, reduce, or control COC impacts in groundwater or associated exposure risks. Existing MPE/groundwater extraction and treatment system would be eliminated. Groundwater RAOs would not be met.	Protective of human health and the environment by eliminating potential exposure to VOCs in groundwater. Prevents COCs from migrating past facility boundaries, removes and destroys VOCs in groundwater, and prevents exposure to contaminated groundwater. Groundwater RAOs would be met.	Protective of human health and the environment by eliminating potential exposure to VOCs in groundwater. Prevents COCs from migrating past facility boundaries, removes and destroys VOCs in groundwater, and prevents exposure to contaminated groundwater. Groundwater RAOs would be met, however, VOCs in inaccessible soils within the smear zone would not be addressed.	Protective of human health and the environment by eliminating potential exposure to VOCs in groundwater. Prevents COCs from migrating past facility boundaries, removes and destroys VOCs in groundwater, and prevents exposure to contaminated groundwater. Groundwater RAOs would be met, however, VOCs in inaccessible soils within the smear zone would not be addressed.
2)	Compliance with ARARs	Does not comply with chemical-specific ARARs. Complies with location-specific ARAR. No action-specific ARARs.	Complies with ARARs.	Complies with ARARs.	Complies with ARARs.
Balancing Criteria					
3)	Long-term effectiveness and permanence	Not effective or permanent. Potential exposure risks associated with COCs in groundwater would remain with no controls or long-term management plan.	Effective and permanent for removal of COCs from groundwater and source area soils below the water table.	Effective and permanent for removal of COCs from groundwater.	Effective and permanent for removal of COCs from groundwater.
4)	Reduction of mobility, toxicity, or volume	Natural attenuation processes may reduce mobility, toxicity, or volume of COCs in groundwater, although monitoring of these processes would not be performed.	Reduces mobility, toxicity, and volume of COCs in groundwater.	Reduces mobility, toxicity, and volume of COCs in groundwater.	Reduces mobility, toxicity, and volume of COCs in groundwater.
5)	Short-term effectiveness	No activities would be implemented that would present potential short-term exposure risks to human health or the environment.	Minimal short-term exposure risks and impacts to workers, adjacent populations, or the environment that would be managed through engineering controls. Potential risks would be limited to onsite populations. Remedial response objectives anticipated to be met in approximately 10 years (5 active and 5 MNA).	Minimal short-term exposure risks and impacts to workers, adjacent populations, or the environment that would be managed through engineering controls. Potential risks would be limited to onsite populations. Remedial response objectives anticipated to be met in approximately 10 years (5 active and 5 MNA).	Minimal short-term exposure risks and impacts to workers, adjacent populations, or the environment that would be managed through engineering controls. Potential risks would be limited to onsite populations. Remedial response objectives anticipated to be met in approximately 20 years (5 active and 15 MNA).
6)	Implementability	Technically feasible due to lack of technical components. However, not administratively feasible due to lack of monitoring or protection of human health or the environment.	Technically and administratively feasible. Requires some modification to existing system and installation of additional injection infrastructure for ERD. Would temporarily disrupt ongoing operations at the site.	Technically and administratively feasible. Requires some modification to existing system and installation of additional injection infrastructure for ERD. Would temporarily disrupt ongoing operations at the site.	Technically and administratively feasible. Requires some modification to existing system and installation of additional injection infrastructure for ERD. Would temporarily disrupt ongoing operations at the site.
7)	Cost	Decommissioning existing systems and infrastructure: $ 174,600	Capital Costs: $ 878,000	Capital Costs: $ 490,000	Capital Costs: $ 463,000
			Annual O&M Costs: $140,800	Annual O&M Costs: $ 66,400	Annual O&M Costs: $36,000
			Annual MNA & Reporting Costs: $33,900	Annual MNA & Reporting Costs: $33,900	Annual MNA & Reporting Costs: $33,900
			Periodic Decomissioning Costs: $ 214,700	Periodic Decomissioning Costs: $232,900	Periodic Decomissioning Costs: $204,000
			Total Present Value Cost: $1,818,000	Total Present Value Cost: $1,081,000	Total Present Value Cost: $1,030,000
Modifying Criteria					
8)	State Acceptance	Likely not acceptable.	Aggressive soure reduction and control of exposure pathways make alternative acceptable	Aggressive soure reduction and control of exposure pathways make alternative acceptable	Aggressive soure reduction and control of exposure pathways make alternative acceptable
9)	Community Acceptance	Likely not acceptable.	Aggressive soure reduction and control of exposure pathways make alternative acceptable	Aggressive soure reduction and control of exposure pathways make alternative acceptable	Aggressive soure reduction and control of exposure pathways make alternative acceptable

Notes:
All costs are estimated to an accuracy of +50 percent to -30 percent (USEPA, 2000)

ARAR	applicable or relevant and appropriate requirement
COC	constituent of concern
MNA	monitored natural attenuation
GW	Groundwater
RAOs	Remedial Action Objectives
RI/FS	Remedial Investigation/Feasibility Study
ROD	Record of Decision
VOCs	volatile organic compounds

Table 7-3. Summary of Comparative Analysis of Soil Remedial Alternative Costs

Remedial Alternative	Description	Total SVE Capital Cost ($)	Total SVE O&M Cost ($)	Drum Rinse Excavation Cost ($)	Former Bulk Chemical Excvation Cost ($)	Total In-situ Thermal Cost ($)	Total In-situ Thermal O &M Cost ($)	Institutional Control Cost ($)	Total Capital Cost ($)	Total O & M Cost ($)	Total Periodic Cost ($)	Time Frame for Remediation (Yrs)	Present Value ($)
Remedial Alternative SR-1	No Action	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
Remedial Alternative SR-2	SVE, Excavation, and Institutional Controls	$74,100	$315,800	$322,000	$96,000	NA	NA	$11,500	$503,600	$315,800	$37,400	3	$827,800
Remedial Alternative SR-3	Excavation and Institutional Controls (includes decommissioning of existing SVE system)	NA	NA	$322,000	$96,000	NA	NA	$11,500	$429,500	NA	$37,400	1	$466,900
Remedial Alternative SR-4	In-situ Thermal, Former Bulk Chemical excavation and Institutional Controls (includes decommissioning of existing SVE system)	NA	NA	NA	$96,000	$1,070,000	$198,100	$11,500	$1,177,500	$198,100	$106,400	1	$1,383,000

Notes:

Assumes a 7% discount rate per year after the first year of project life was applied per *A Guide to Developing and Documenting Cost Estimates During the Feasibility Study,* EPA 540-R-00-002 OSWER 9355.0-75; July 2000.

Costs are rounded to the nearest $100.

Costs are based on an accuracy of +50/-30% (USEPA, 2000).

Acronyms:
SR- Soil Remedy
NA - not applicable
SVE - Soil vapor extraction
U.S. EPA - United States Environmental Protection Agency
OSWER - Office of Solid Waste and Emergency Response

Table 7-4. Comparative Analysis of Groundwater Remedial Alternative Costs

		Remediation Costs																		MNA and Periodic Costs			
Remedial Alternative	Description	MPE Capital Cost ($)	MPE O&M Cost ($)	ERD Treatment Line Capital Cost ($)	ERD Treatment LIne O&M ($)	ERD Hot Spot Plume Treatment (assumes 50% of ERD Treatment Lines) ($)	ERD Hot Spot Plume Treatment, O&M (assumes half the O&M of ERD Treatment Lines) ($)	Property Boundary Hydraulic Control ($)	Property Boundary Hydraulic Control O&M ($)	SAW-2 Hydraulic Control ($)	SAW-2 Hydraulic Control ($)	Source Area Chemical Oxidation Implementation Cost ($)	Offsite Chemical Oxidation Implementation Cost ($)	Institutional Controls ($)	Institutional Controls O&M ($)	Total Capital Cost ($)	Recurring Annual O&M Cost ($)	Time Frame for Non-MNA Remediaton (Yrs)	Present Value for Active Remediation ($)	Annual MNA & Reporting Cost ($)	End of Project (decomissioning) Cost ($)	Time Frame for MNA (Yrs)	Present Value Life Cycle Cost
GW-1	No Action	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	$174,600	NA	$174,600
GW-2	• Continuation of MPE System • SAW-2 Hydraulic Control • ERD Treatment Lines • Chemical Oxidation - Offsite Plume • MNA • Institutional Controls	$59,300	$80,000	$242,800	$60,800	NA	NA	NA	NA	$59,400	$9,500	$94,280	$505,000	$11,500	$600	$878,000	$150,300	3 - ERD 5 - hydraulic control	$1,548,000	$33,900	$214,700	10 (5 years following active remediation)	$1,818,000
GW-3	• Chemox Source and Hot Spot Treatment • Property Boundary & SAW-2 Hydraulic Control • ERD Hot Spot Plume Treatment • MNA • Institutional Controls	NA	NA	NA	NA	$121,400	$30,400	$182,900	$26,500	$59,400	$9,500	$94,280	$115,000	$11,500	$100	$490,000	$66,400	3 - ERD 5 - hydraulic control	$848,000	$33,900	$232,900	10 (5 years following active remediation)	$1,081,000
GW-4	• Chemox Source and Hot Spot Treatment • Property Boundary & SAW-2 • Hydraulic Control • MNA • Institutional Controls	NA	NA	NA	NA	NA	NA	$182,900	$26,500	$59,400	$9,500	$94,280	$115,000	$11,500	$600	$348,080	$36,000	5 - hydraulic control	$958,000	$33,900	$204,000	20 (15 years following active remediation)	$1,030,000

Notes: HVE O&M costs include incremental costs for soil SVE O&M

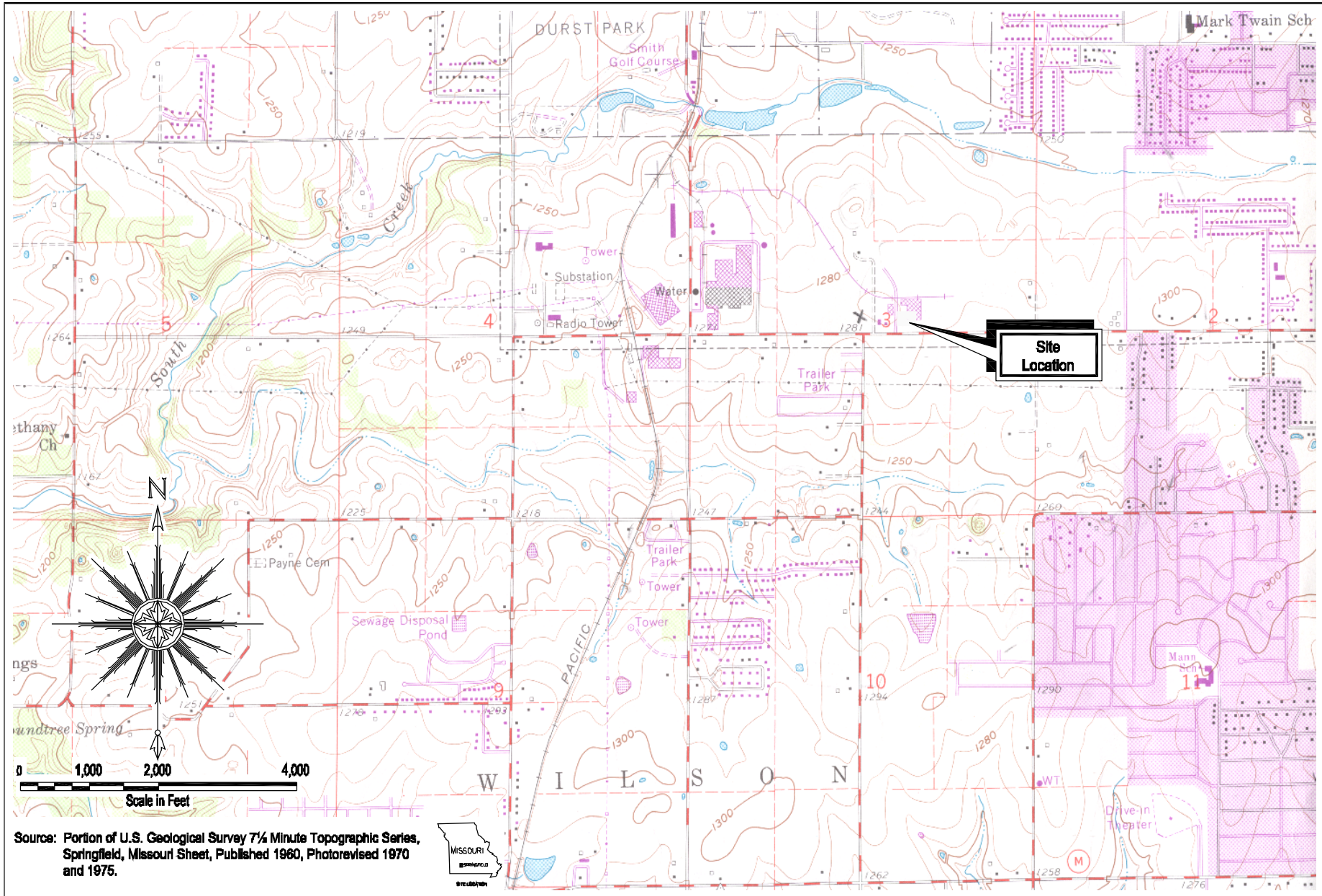
Assumes a project life of 3 years for HVE, ERD, and GW Extraction and 10 years for MNA. A 7% discount rate was applied per *A Guide to Developing and Documenting Cost Estimates During the Feasibility Study,* EPA 540-R-00-002

All costs are rounded to the nearest $100

All costs are based on an accuracy of +50/-30% (USEPA, 2000)

GW - groundwate
ERD - in-situ reactive zone
MNA - monitored natural attenuation
HVE - high vacuum extraction
NA - not applicable
O&M - operation and maintenance

Figures



Source: Portion of U.S. Geological Survey 7½ Minute Topographic Series, Springfield, Missouri Sheet, Published 1960, Photorevised 1970 and 1975.

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Brenntag/HCI Chemtech
2235 W. Battlefield Rd.

SITE LOCATION - TOPOGRAPHIC MAP

Springfield, Missouri

Project Number	OK001255.0036
Drawing Date	21 June 2007
Figure	1-1

BRENNTAG/HCI Chemtech
2235 W. Battlefield Rd.
Springfield, Missouri

VICINITY MAP - AERIAL PHOTO

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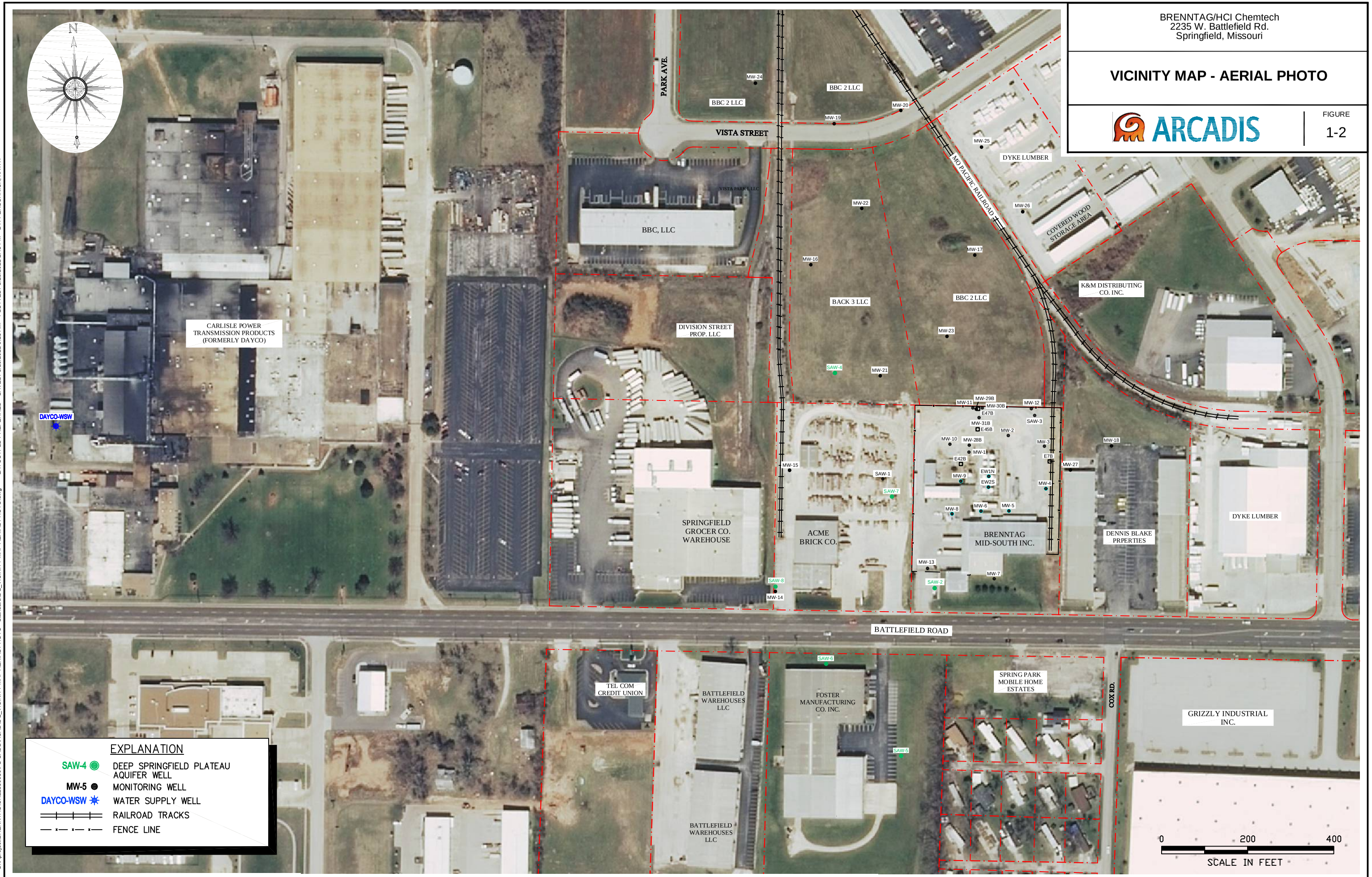
FIGURE
1-2



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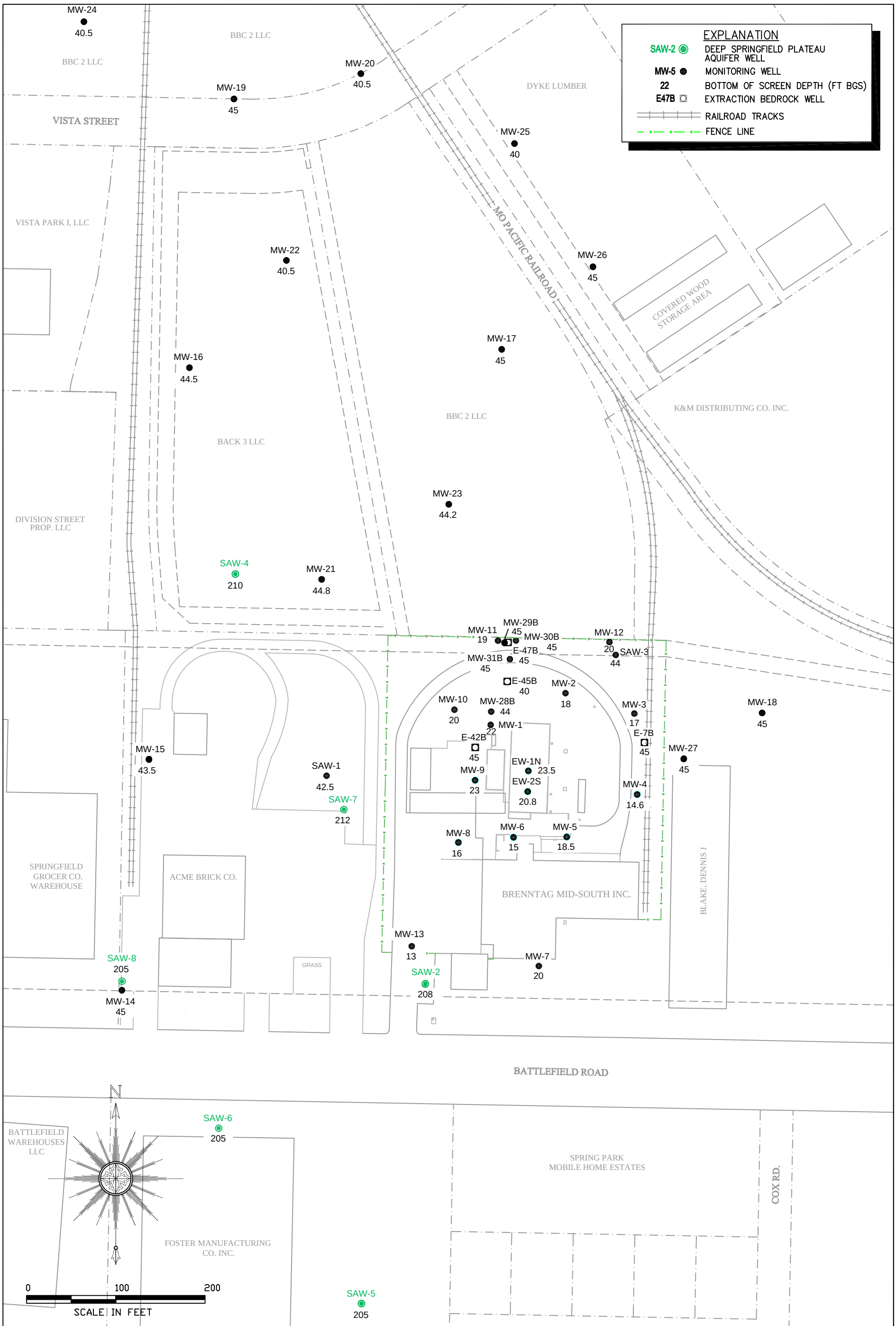

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Task Manager	W._FRENCH
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2235 W. Battlefield Rd.

SITE MAP - MONITORING WELL NETWORK

Springfield, Missouri

Project Number	OK001255.0036
Drawing Date	8-03-10
Figure	1-3

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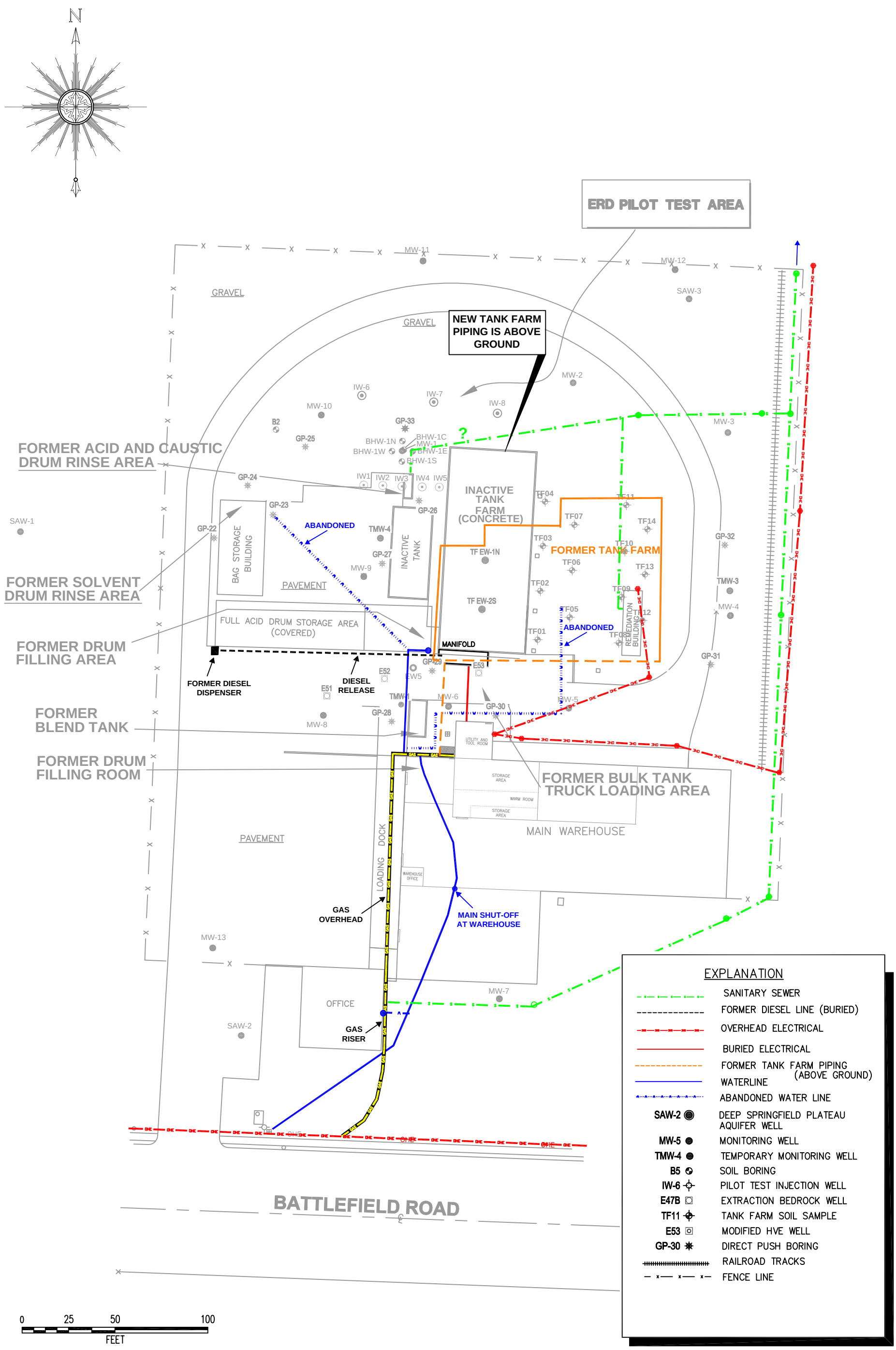

Area Manager: B. Guillette	ARCADIS	Brenntag/HCl Chemtech 2235 W. Battlefield Rd.	Project Number: OK001255.0036	
Project Manager: W. French	5100 E. Skelly Drive Suite 1000 Tulsa, Oklahoma 74135 Tel: 918-664-9900 Fax: 918-664-9925 www.arcadis-us.com	SITE MAP - UTILITIES	Drawing Date: 17 November 2009	
Task Manager: W. French		Springfield, Missouri	Figure: 1-4	
Technical Review: W. French				

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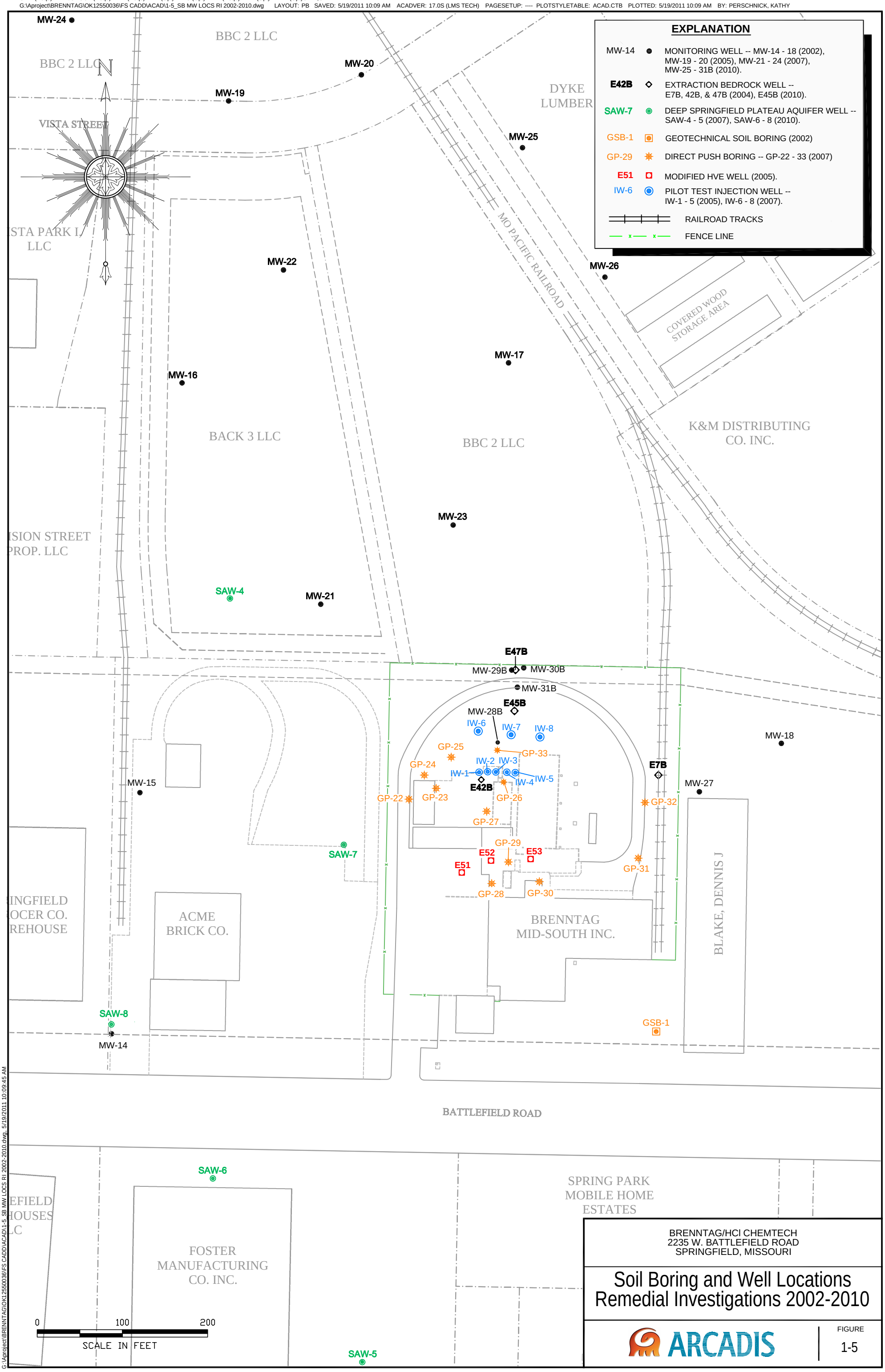

BRENNTAG/HCl CHEMTECH
2235 W. BATTLEFIELD ROAD
SPRINGFIELD, MISSOURI

Soil Boring and Well Locations Remedial Investigations 2002-2010

ARCADIS

FIGURE
1-5

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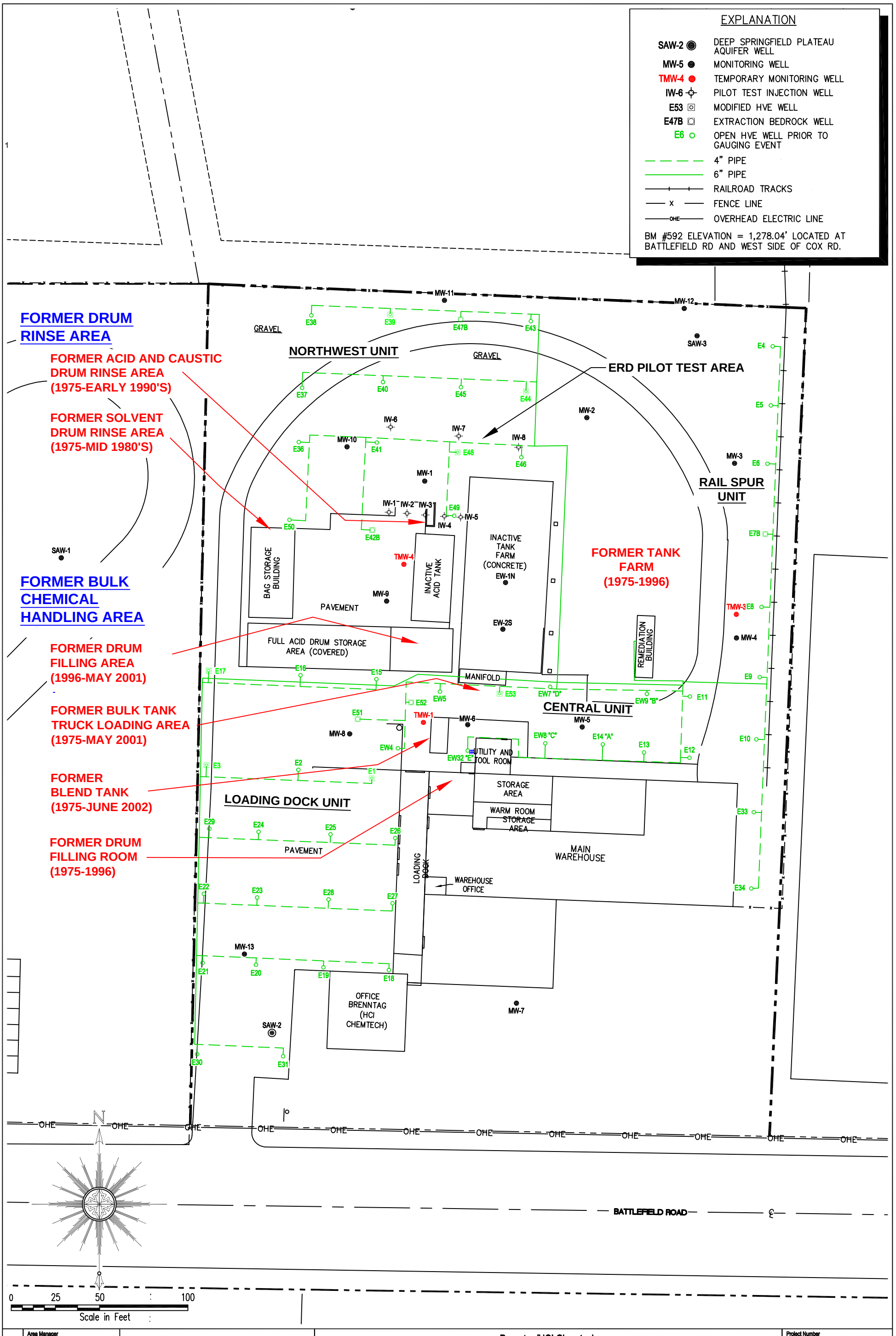

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Brenntag/HCI Chemtech
2235 W. Battlefield Rd.

Previous Site Operations

Springfield, Missouri

Project Number	OK001255.0036
Drawing Date	26 June 2007
Figure	2-1

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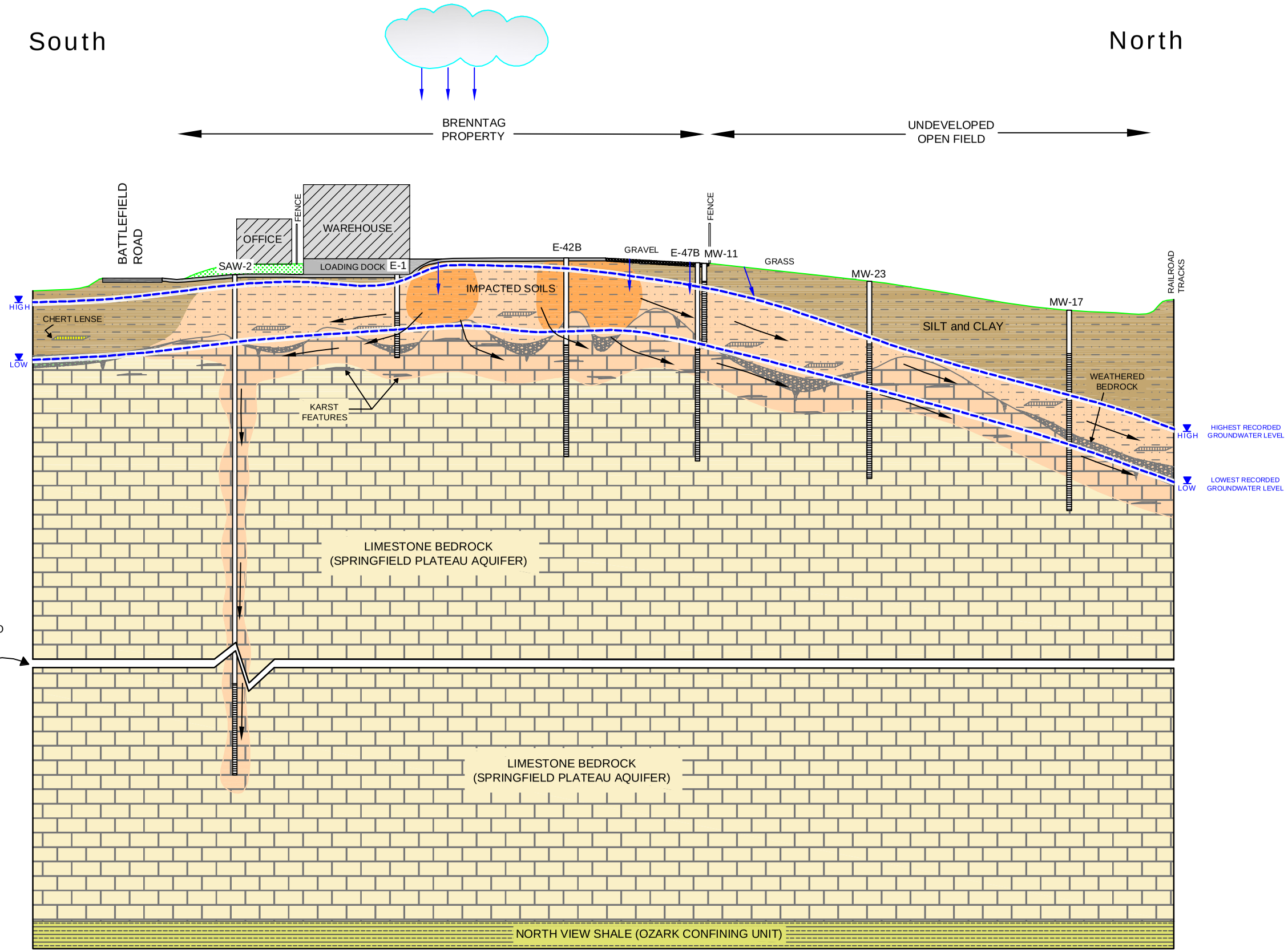

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Task Manager	W. French
Technical Review	W. French

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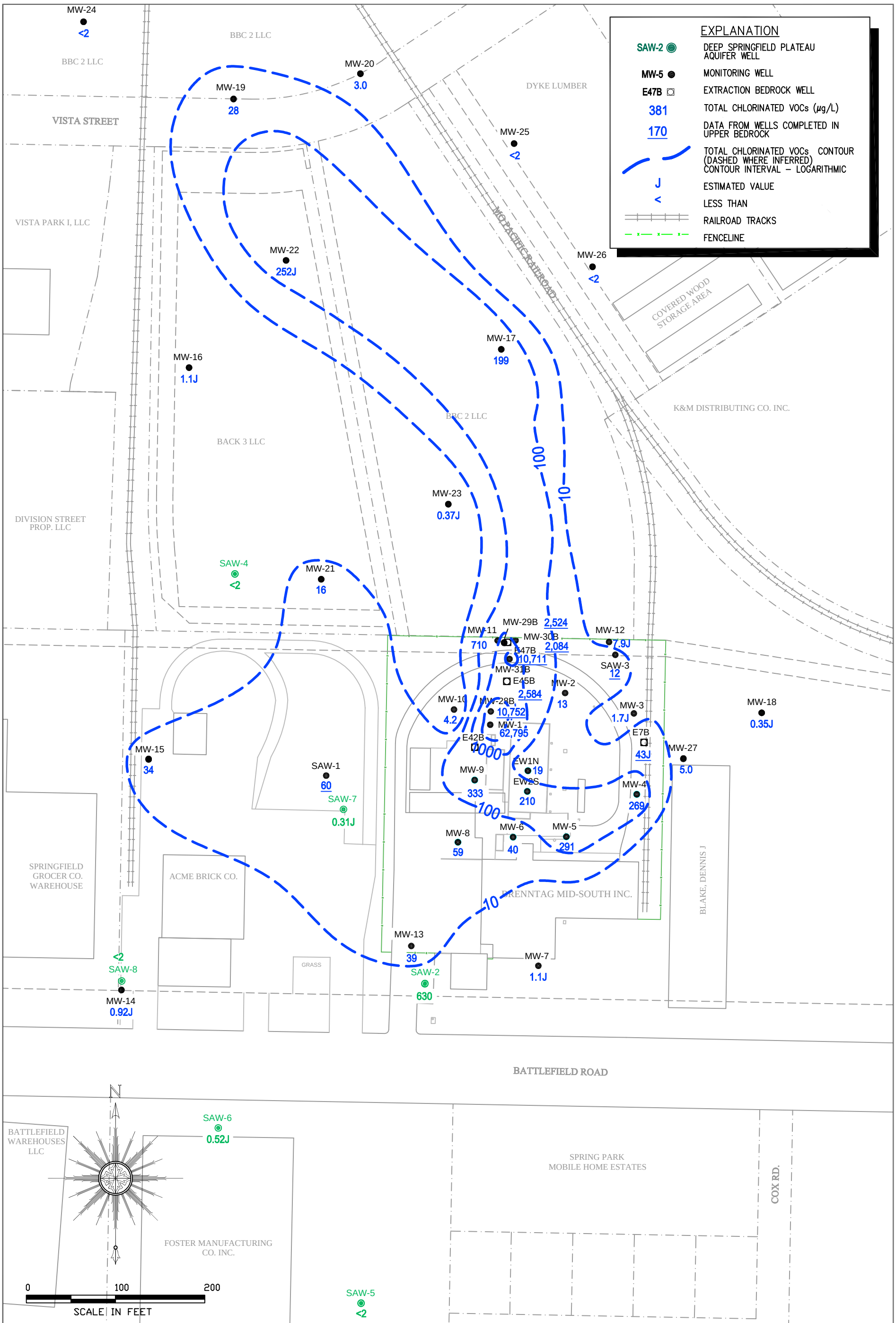
Conceptual Site Model

Springfield, Missouri

Project Number	OK001255.0016
Drawing Date	9 July 2007
Figure	2-2



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Total Chlorinated VOC Concentrations in Groundwater August 3-5, 2010

Springfield, Missouri

Project Number	OK001255.2010
Drawing Date	9-7-10
Figure	2-3

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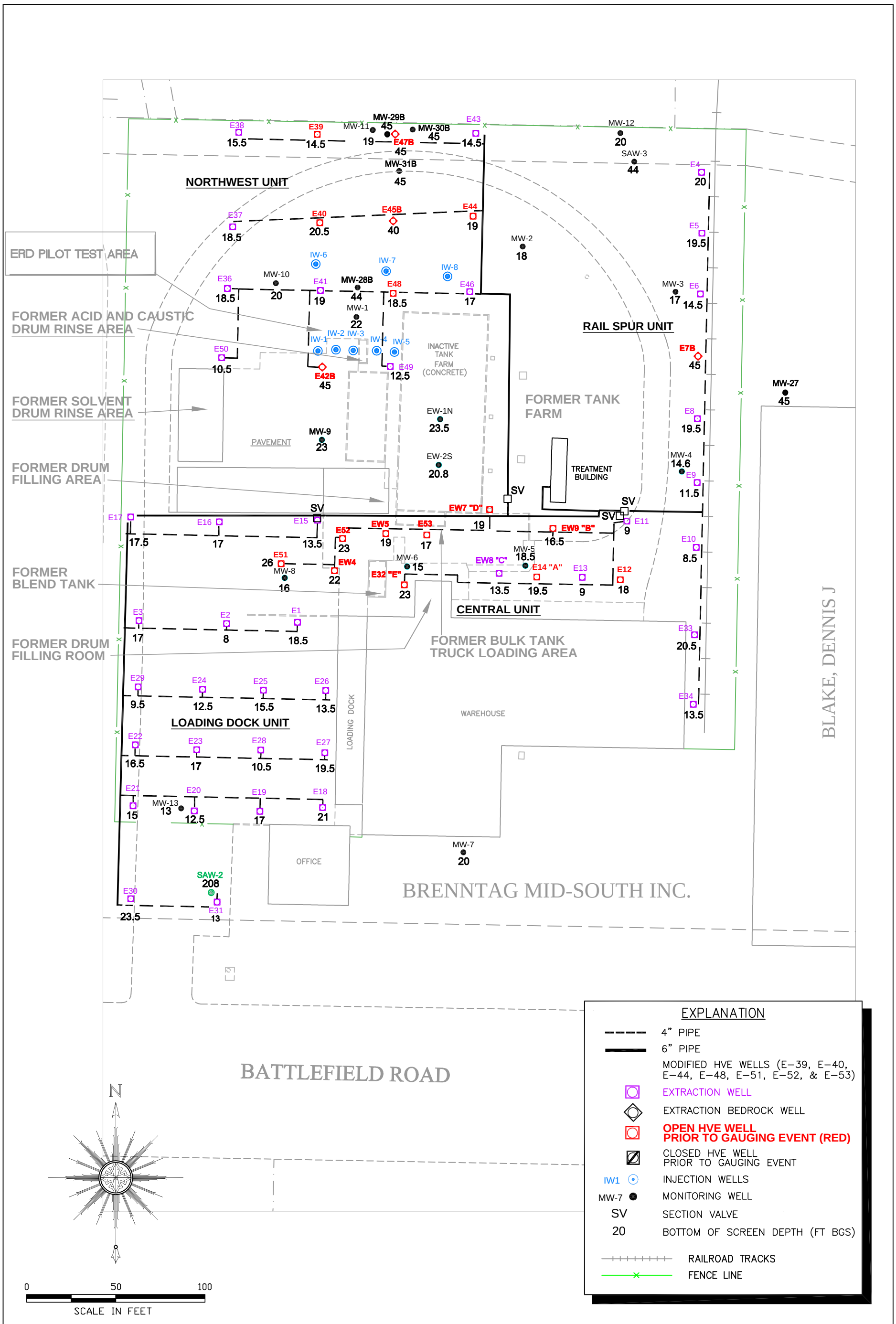

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HIGH VACUUM EXTRACTION WELL LOCATIONS

Springfield, Missouri

Project Number	OK001255.2010
Drawing Date	6-16-10
Figure	2-4

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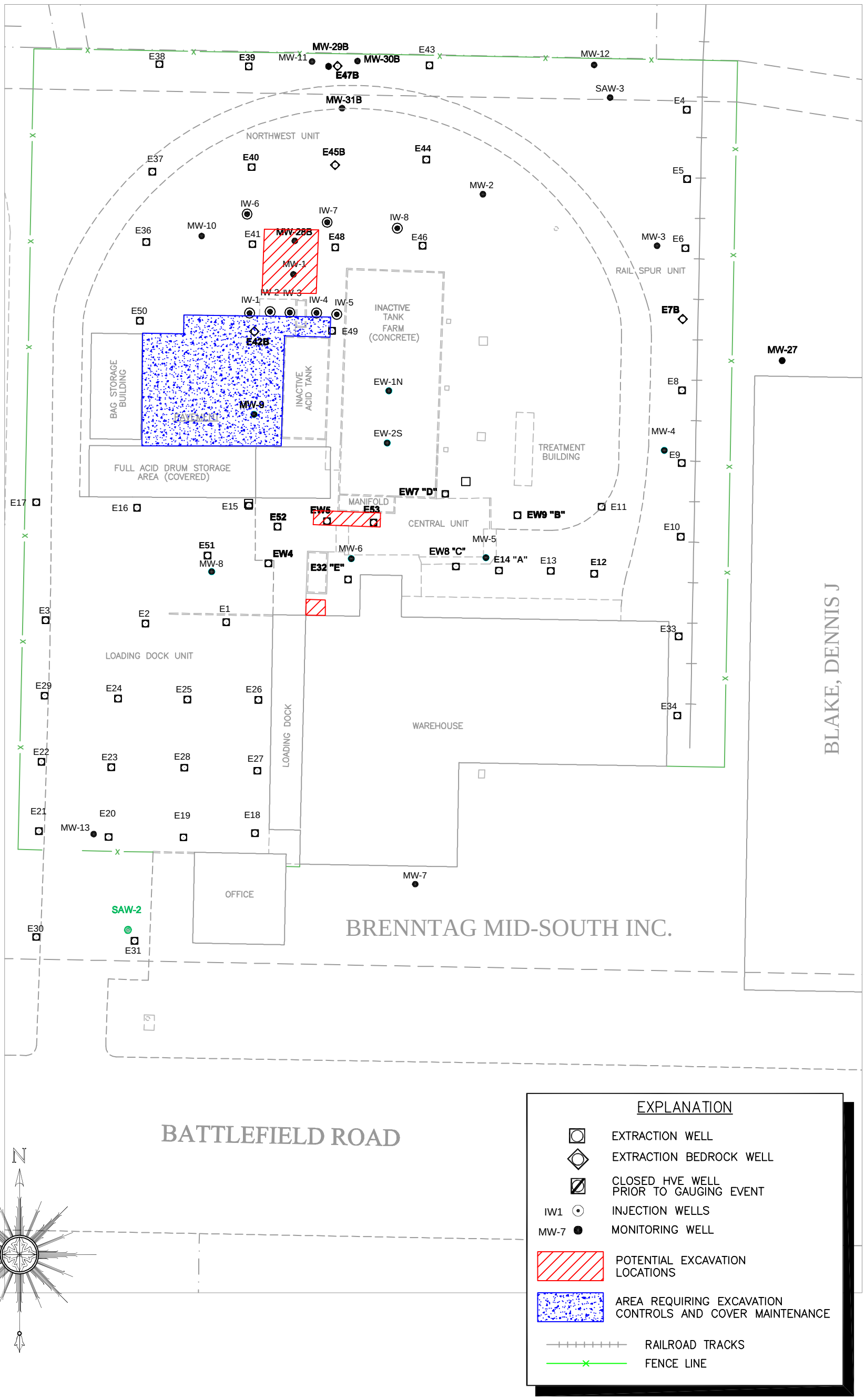

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CONCEPTUAL LAYOUT FOR ALTERNATIVE SR-2 SVE, TARGET EXCAVATION AND INSTITUTIONAL CONTROLS

Springfield, Missouri

Project Number	OK001255.0036
Drawing Date	12-3-10
Figure	6-1

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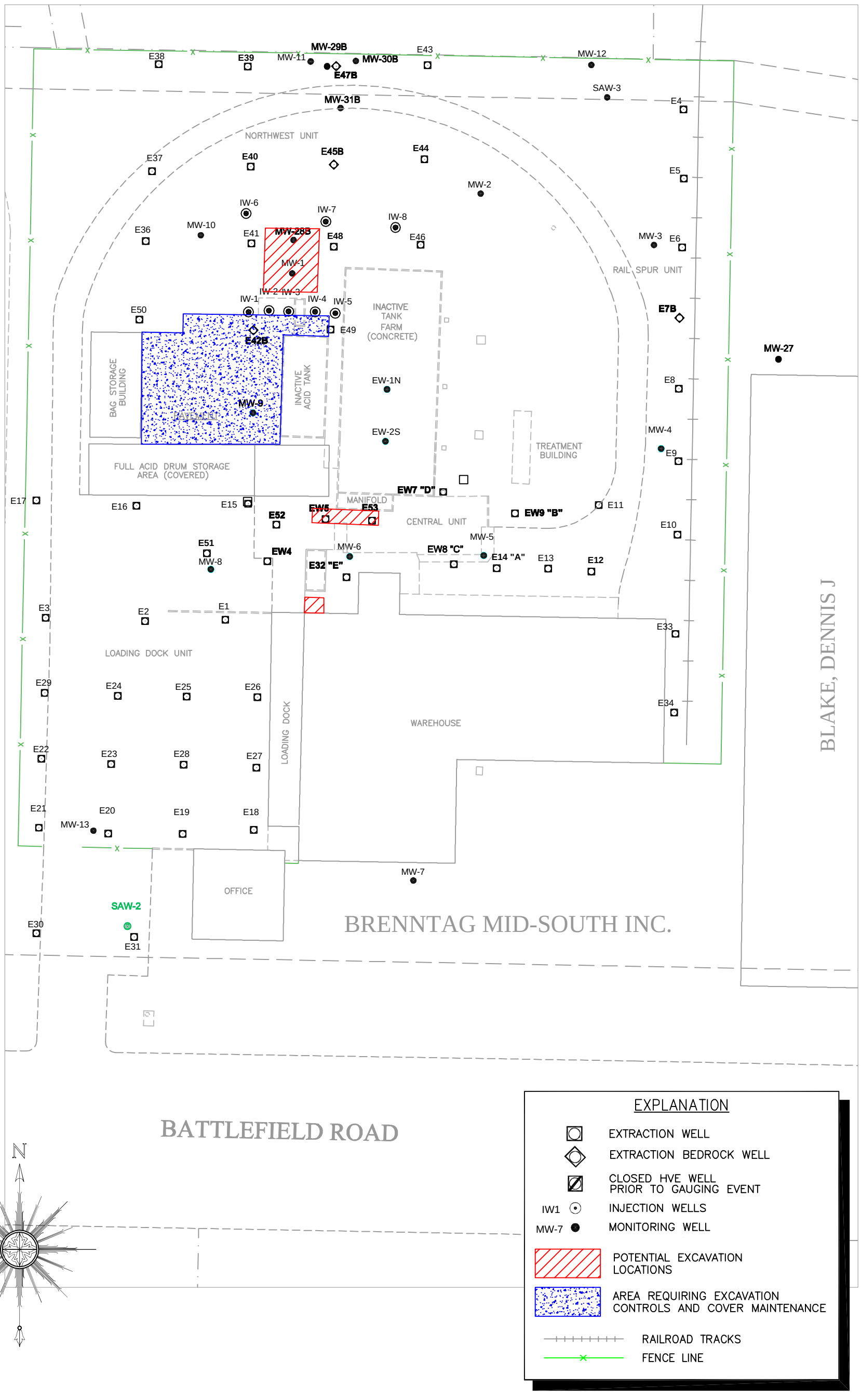

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CONCEPTUAL LAYOUT FOR ALTERNATIVE SR-3 TARGET EXCAVATION AND INSTITUTIONAL CONTROLS

Springfield, Missouri

Project Number	OK001255.0036
Drawing Date	12-3-10
Figure	6-2

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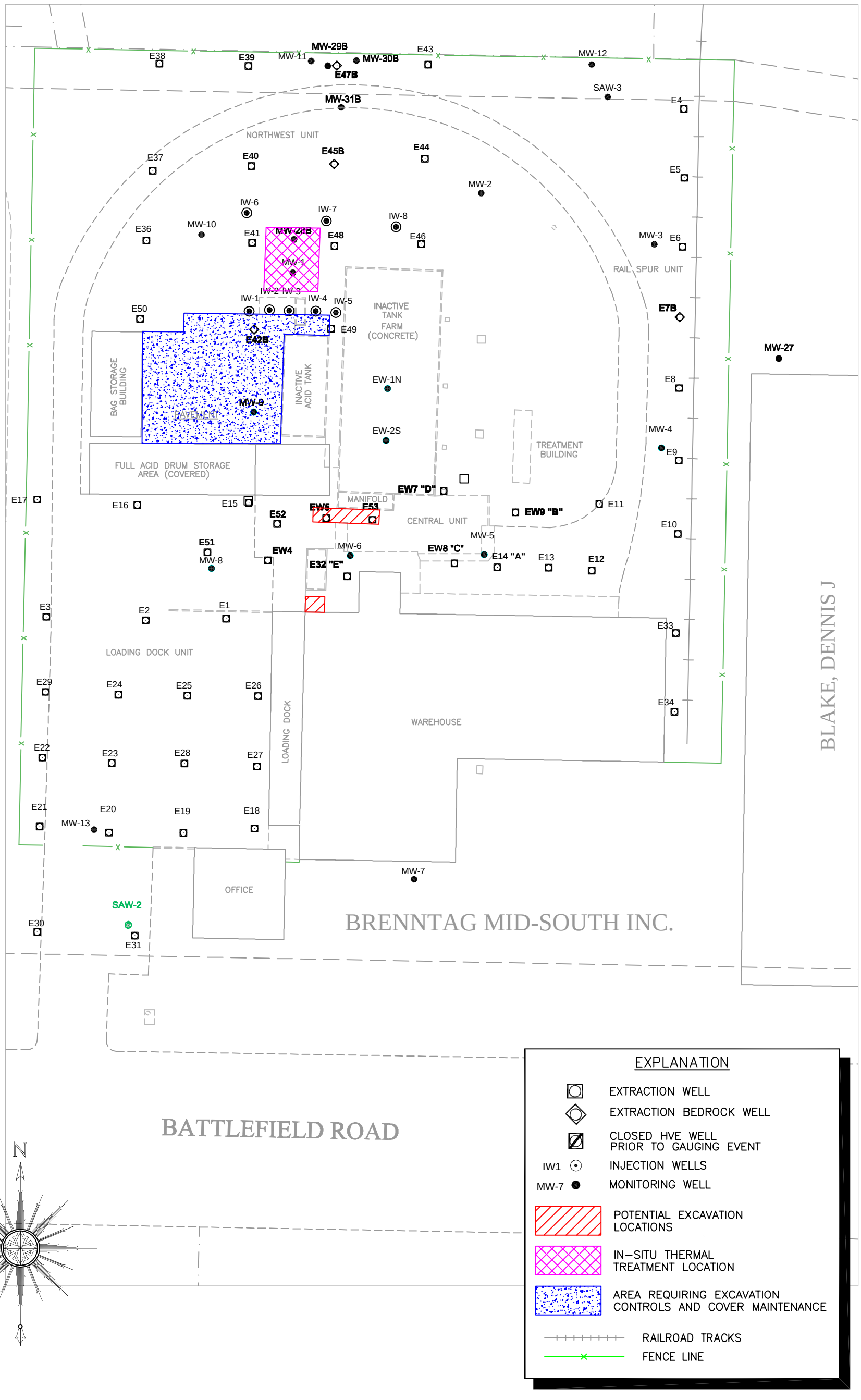

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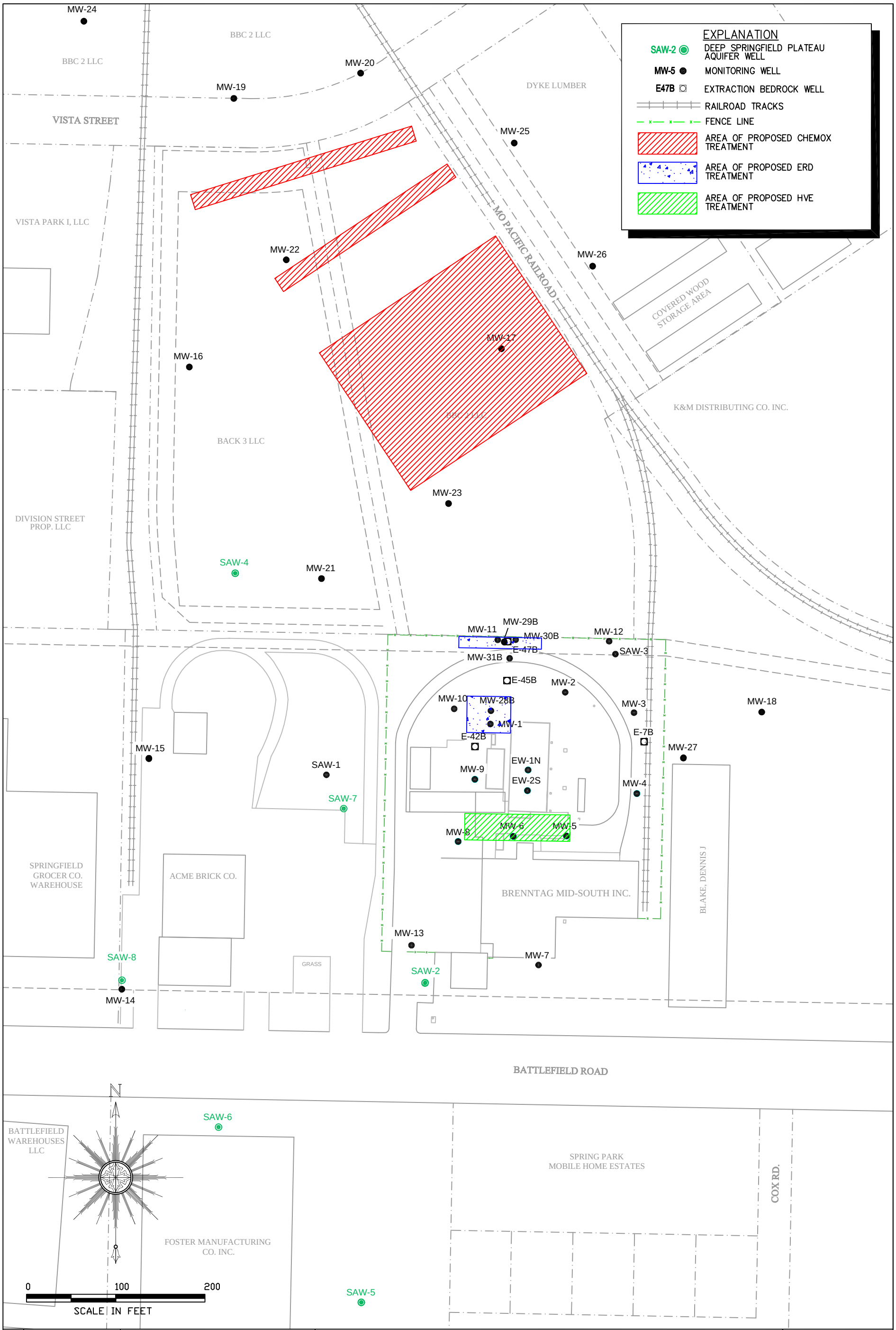
CONCEPTUAL LAYOUT FOR ALTERNATIVE SR-4
IN-SITU THERMAL, TARGET EXCAVATION AND INSTITUTIONAL CONTROLS

Springfield, Missouri

Project Number	OK001255.0036
Drawing Date	12-3-10
Figure	6-3



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CONCEPTUAL LAYOUT FOR ALTERNATIVE GW-2 HVE, ERD LINE TREATMENT, GROUNDWATER EXTRACTION AT SAW-2, CHEMICAL OXIDATION, MNA, INSTITUTIONAL CONTROLS

Springfield, Missouri

Project Number	OK001255.0036
Drawing Date	12-13-10
Figure	6-4

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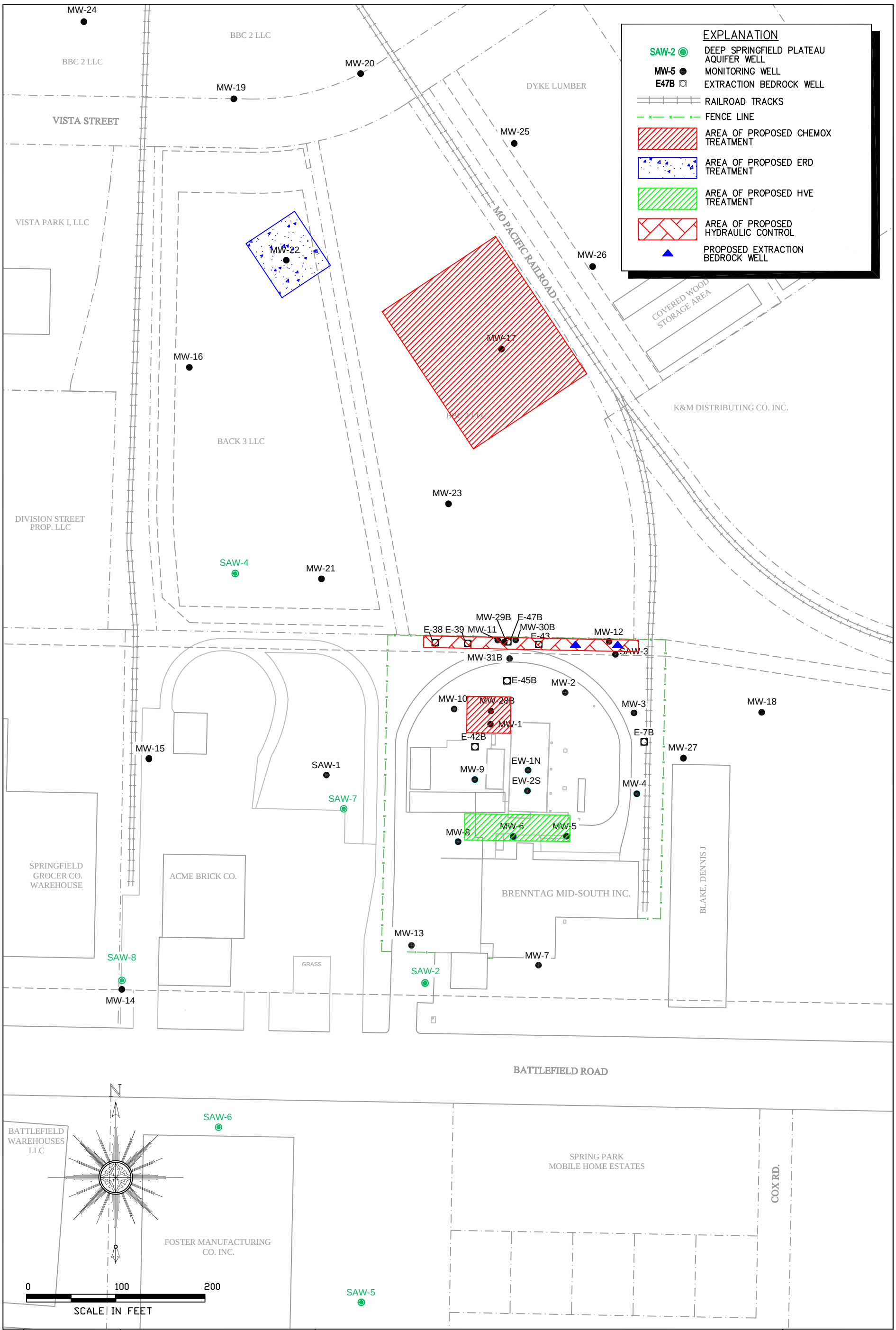

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CONCEPTUAL LAYOUT FOR ALTERNATIVE GW-3
HVE, SOURCE AREA AND HOT SPOT CHEMICAL OXIDATION,
HYDRAULIC CONTROL, ENHANCED REDUCTIVE DECHLORINATION,
GROUNDWATER EXTRACTION AT SAW-2, MONITORED NATURAL ATTENUATION AND
INSTITUTIONAL CONTROL
Springfield, Missouri

Project Number	OK001255.0036
Drawing Date	12-13-10
Figure	6-5

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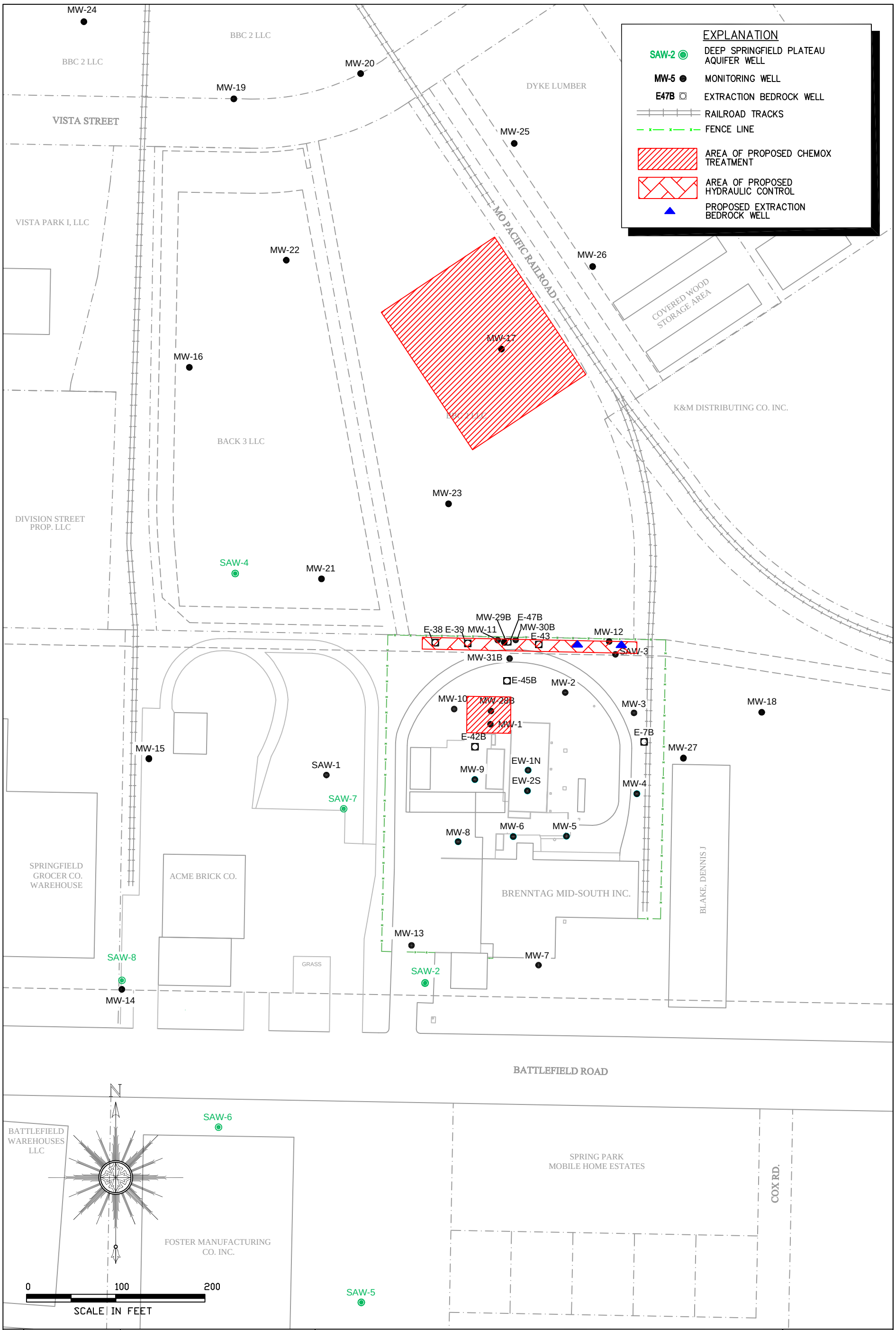

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CONCEPTUAL LAYOUT FOR ALTERNATIVE GW-4 SOURCE AREA AND HOT SPOT CHEMICAL OXIDATION, HYDRAULIC CONTROL, GROUNDWATER EXTRACTION AT GW-2, MONITORED NATURAL ATTENUATION AND INSTITUTIONAL CONTROL

Springfield, Missouri

Project Number	OK001255.0036
Drawing Date	12-13-10
Figure	6-6

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Appendix A

Detailed Soil Remediation Costs

Appendix A Summary of Comparative Analysis of Soil Remedial Alternative Costs
Brenntag Springfield Facility

		Remediation Costs											
Remedial Alternative	Description	Total SVE Capital Cost ($)	Total SVE O&M Cost (3 yrs) ($)	Drum Rinse Excavation Cost ($)	Former Bulk Chemical Excavation Cost ($)	Total In-situ Thermal Cost ($)	Total In-situ Thermal O & M Cost ($)	Institutional Control Cost ($)	Total Capital Cost ($)	Total O & M Cost ($)	Periodic Cost ($)	Time Frame for Remediation (Yrs)	Present Value Three year Life-Cycle ($)
Remedial Alternative SR-1	No Action	NA	NA	NA	NA	NA	NA	NA	NA	NA	$37,400	NA	NA
Remedial Alternative SR-2	SVE, Excavation, and Institutional Controls	$74,100	$322,000	$322,000	$96,000	NA	NA	$11,500	$503,600	$322,000	$37,400	3	$834,000
Remedial Alternative SR-3	Excavation and Institutional Controls (includes decommissioning of existing SVE system)	NA	NA	$322,000	$96,000	NA	NA	$11,500	$429,500	NA	$37,400	1	$466,900
Remedial Alternative SR-4	In-situ Thermal, Former Bulk Chemical excavation and Institutional Controls (includes decommissioning of existing SVE system)	NA	NA	NA	$96,000	$1,070,000	$198,100	$11,500	$1,177,500	$198,100	$106,400	1	$1,383,000

Notes:

Assumes a project life of 3 years of project life. A 7% discount rate was applied per *A Guide to Developing and Documenting Cost Estimates During the Feasibility Study,* EPA 540-R-00-002 OSWER 9355.0-75; July 2000.

Costs are rounded to the nearest $100.
Costs are based on an accuracy of +50/-30% (USEPA, 2000).
Acronyms
SR - Soil Remedy
NA - not applicable
MPE- Multi-phase extraction
O&M - Operations and Maintenance
SVE - Soil vapor extraction
U.S. EPA - United States Environmental Protection Agency
Yrs - Years

SOIL REMEDIAL ALTERNATIVE COST ESTIMATE

EXCAVATION AND OFFSITE DISPOSAL

Former Drum Rinsing Area

Impacted Soil Surface Area	625	sf
Excavation Surface Area (to account for sloping walls)	2,209	sf
Excavation Depth	22	ft
Total excavation (Impacted Soil)	509	cy
SideWall Excavation (2:1 Slope)	896	cy
Total excavation	1,406	cy
Volume of Impacted Soils	13,750	cubic feet
Soil - Percent hazardous	0	%
Soil - Percent Non Hazardouns	100	%
Soil - assume 3,400 lbs/yd	2,389	tons

	Quantity	Unit	Labor - D	Equipment	Materials	Total	rounded to 100	rounded to 1000	Reference
Site Preparation									
Mobilization / Demobilization, construction equipment (including)	1	LUMP SUM	---	---	---	$5,000	$5,000	$5,000	ARCADIS Estimate
	Quantity	Unit	Labor - D	Equipment	Materials	Total			Reference
Treatment Activities									
Crawler-mounted hydraulic excavator	1,406	CY	$1.25	$3.00	$0	$5,974	$6,000	$6,000	ARCADIS Estimate
Shoring	0	SQ FT	0.00	5.45	$0	$0	$0	$0	ARCADIS Estimate
Analytical - Confirmation Samples (4 per wall)	32	each			$125	$4,000	$4,000	$4,000	ARCADIS Estimate
Soil disposal, hazardous, TCLP	0	TON	$0	$0	$500	$0	$0	$0	ARCADIS Estimate
Soil transportation, hazardous, TCLP	0	LOADS	$0	$0	$2,000	$0	$0	$0	ARCADIS Estimate
Soil disposal, non-hazardous	2,389	TON	$0	$0	$60	$143,367	$143,400	$143,000	ARCADIS Estimate
Soil transportation, non-hazardous	109	LOADS	$0	$0	$350	$38,014	$38,000	$38,000	ARCADIS Estimate
Common fill	1,406	CY	$0.00	$0.00	$20.00	$28,111	$28,100	$28,000	ARCADIS Estimate
Backfill in 8-inch lifts - Compacted to 95% Proctor	1,406	CY	$1.20	$1.50	---	$2,108	$2,100	$2,000	ARCADIS Estimate
Topsoil, 6"	0	CY	$4.06	$2.89	$25.00	$0	$0	$0	ARCADIS Estimate
Pavement Replacement - Concrete	625	Square Feet	$2.00	$1.00	$5.00	$5,000	$5,000	$5,000	ARCADIS Estimate
Seeding, vegetative cover	0.0	ACRE	$67.71	$52	$0	$0	$0	$0	ARCADIS Estimate
						Capital Cost Total:	$231,600	$232,000	
Site Preparation and Remediation Activities Subtotal						$231,574	$231,600	$232,000	
	Quantity	Unit	Labor - D	Equipment	Materials	Total			Reference
Indirect Costs									
Engineering and construction oversight	1	LUMP SUM	$25,000	$0	$0	$25,000	$25,000	$25,000	
Engineering Design	1	LUMP SUM	$12,000	$0	$0	$12,000	$12,000	$12,000	
Project Management	1	LUMP SUM	$6,000	$0	$0	$6,000	$6,000	$6,000	
Implementation of H&S measures (includes Air Monitoring around site)	1	LUMP SUM	$5,000	$0	$0	$5,000	$5,000	$5,000	
						Indirect Cost Subtotal:	$48,000	$48,000	
						Capital and Indirect Cost Subtotal:	$279,600	$280,000	
						Contingency (15%):	$41,900	$42,000	
						Capital Cost Total:	$321,500	$322,000	

NOTE:
RSM = Costs estimated using RSMeans Environmental Remediation Cost Data - Unit Price, Building Construction Cost Data - Unit Price, and Heavy Construction - Unit Price, 2004.
Cost Quotes = Cost quotes obtained from local vendors

SOIL REMEDIAL ALTERNATIVE COST ESTIMATE

EXCAVATION AND OFFSITE DISPOSAL

Impacted Soil Surface Area	600	sf	
Excavation Surface Area (to account for sloping walls)	600	sf	
Excavation Depth	5	ft	
Total excavation (Impacted Soil)	111	cy	Former Bulk Chemical Handling Area:
SideWall Excavation (vertical Slope)	45	cy	Near EW-5 and GP-29 - 40 ft x 10 ft = 400 sf
Total excavation	156	cy	
Volume of Impacted Soils	3,000	cubic feet	
Soil - Percent hazardous	0	%	
Soil - Percent Non Hazardouns	100	%	
Soil - assume 3,400 lbs/yd	266	tons	

	Quantity	Unit	Labor - D	Equipment	Materials	Total	rounded to 1000	Reference
Site Preparation								
Mobilization / Demobilization, construction equipment (including)	1	LUMP SUM	---	---	---	$5,000	$5,000	ARCADIS Estimate
	Quantity	Unit	Labor - D	Equipment	Materials	Total		Reference
Treatment Activities								
Crawler-mounted hydraulic excavator	156	CY	$1.25	$3.00	$0	$665	$1,000	ARCADIS Estimate
Shoring	0	SQ FT	0.00	5.45	$0	$0	$0	ARCADIS Estimate
Analytical - Confirmation Samples (4 per wall)	32	each			$125	$4,000	$4,000	ARCADIS Estimate
Soil disposal, hazardous, TCLP	0	TON	$0	$0	$500	$0	$0	ARCADIS Estimate
Soil transportation, hazardous, TCLP	0	LOADS	$0	$0	$2,000	$0	$0	ARCADIS Estimate
Soil disposal, non-hazardous	266	TON	$0	$0	$60	$15,960	$16,000	ARCADIS Estimate
Soil transportation, non-hazardous	12	LOADS	$0	$0	$350	$4,232	$4,000	ARCADIS Estimate
Common fill	156	CY	$0.00	$0.00	$20.00	$3,129	$3,000	ARCADIS Estimate
Backfill in 8-inch lifts - Compacted to 95% Proctor	156	CY	$1.20	$1.50	---	$235	$0	ARCADIS Estimate
Topsoil, 6"	0	CY	$4.06	$2.89	$25.00	$0	$0	ARCADIS Estimate
Pavement Replacement - Concrete	600	Square Feet	$2.00	$1.00	$5.00	$4,800	$5,000	ARCADIS Estimate
Seeding, vegetative cover	0.0	ACRE	$67.71	$52	$0	$0	$0	ARCADIS Estimate
						Capital Cost Total:	$38,000	
	Quantity	Unit	Labor - D	Equipment	Materials	Total		Reference
Indirect Costs								
Site Preparation and Remediation Activities Subtotal						$38,021	$38,000	
Engineering and construction oversight	1	LUMP SUM	$15,000	$0	$0	$15,000	$15,000	
Engineering Design	1	LUMP SUM	$15,000	$0	$0	$15,000	$15,000	
Project Management	1	LUMP SUM	$10,000	$0	$0	$10,000	$10,000	
Implementation of H&S measures (includes Air Monitoring around site)	1	LUMP SUM	$5,000	$0	$0	$5,000	$5,000	
						Indirect Cost Subtotal:	$45,000	
						Capital and Indirect Cost Subtotal:	$83,000	
						Contingency (15%):	$12,000	
						Capital Cost Total:	$96,000	

NOTE:

RSM = Costs estimated using RSMeans Environmental Remediation Cost Data - Unit Price, Building Construction Cost Data - Unit Price, and Heavy Construction - Unit Price, 2004.

Cost Quotes = Cost quotes obtained from local vendors

SOIL REMEDIAL ALTERNATIVE COST ESTIMATE

SOIL VAPOR EXTRACTION W/ SYSTEM OPTIMIZATION

Design Assumptions:

Continue to operate existing MPE system as soil vapor extraction and install additional wells to specifically address soil.

8	wells	Additional wells added to optimize system
22	ft	Total well depth
15	ft	well screen

	Quantity	Unit	Labor - D	Equipment	Materials	Total	Reference
Site Preparation							
Mobilization / Demobilization	1	LUMP SUM	---	---	---	$2,500	ARCADIS Project Experience
	Quantity	Unit	Labor - D	Equipment	Materials	Total	Reference
Remediation Activities							
Recovery Well Drilling							
Well Drilling	176	FEET	$52	$31	$31	$20,200	Estimate
IDW Management							
15 CY Roll-off	1	EACH	$800	$620	$0	$1,400	Estimate
Drill cuttings disposal, hazardous	0	TONS			$110	$0	Estimate
Drill cuttings transportation, hazardous, TCLP	0	TONS			$120	$0	Estimate
Drill cuttings disposal, non-hazardous	8	TONS			$91	$700	Estimate
Trenching and Piping							
Water piping, 2-inch diameter Polyethylene SDR 21 pipe, installed;	150	FEET	$52	$30	$12	$18,700	RSM 33 26 0504
					Capital Cost Total:	$43,500	
	Quantity	Unit	Labor - D	Equipment	Materials	Total	Reference
Indirect Costs							
Site Preparation and Remediation Activities Subtotal						$43,500	
Engineering and construction oversight (20%)	1	LUMP SUM	$8,700	$0	$0	$8,700	ESTIMATE
Engineering Design (15%)	1	LUMP SUM	$6,525	$0	$0	$6,525	ESTIMATE
Project Management (10%)	1	LUMP SUM	$4,350	$0	$0	$4,350	ESTIMATE
Implementation of H&S measures (3%)	1	LUMP SUM	$1,305	$0	$0	$1,305	ESTIMATE
					Total Indirect Costs:	$20,880	
					Capital and Indirect Cost Subtotal:	$64,380	
					Contingency (15%):	$9,700	
					Capital and Indirect Cost Total:	$74,100	
Operations and Maintenance - Annual							
Electrical Use	1	LUMP SUM	$0	$0	$20,000	$20,000	ARCADIS project experience
O&M, equipment service, labor, 12 hrs per week for one year	624	HOURS	$85	$0	$0	$53,000	ARCADIS project experience
O&M, equipment service, parts	1	LUMP SUM	$0	$0	$7,500	$7,500	ARCADIS project experience
Liquid phase carbon changeouts, 1 changeout per year	1	LS	$0	$0	$1,500.00	$1,500	ARCADIS project experience
Discharge water to POTW, 2 gpm, continuous	526	1000 GALLONS	$0	$0	$2.00	$1,100	ARCADIS project experience
					Annual O&M:	$83,100	
					Contingency (15%):	$12,465	
					Annual O & M Total Costs:	$95,565	
PERIODIC COSTS							
Well Abandonment	1,628	LF	1.81	4.13	$1.72	$12,462	ESTIMATE
Demobilize/Decommision	1	LS	--	--	$20,000	$20,000	ESTIMATE
					Subtotal:	$32,500	
					Contingency (15%):	$4,900	
					Periodic Total Costs:	$37,400	

SOIL REMEDIAL ALTERNATIVE COST ESTIMATE

INSTITUTIONAL CONTROL

Design Assumptions

Institutional Control will be implemented as part of groundwater remedy.

	Quantity	Unit	Labor - D	Equipment	Materials	Cost Per Unit	Total	Reference
Institutional Control Implementation								
Institutional Control Implementation	1	LUMP SUM				$10,000	$10,000	
						Capital Cost Subtotal:	$10,000	
						Total Indirect Cost:	$0	
						Capital and Indirect Cost Subtotal:	$10,000	
						Contingency (15%):	$1,500	
						Capital and Indirect Cost Total:	$11,500	
	Quantity	**Unit**	**Labor - D**	**Equipment**	**Materials**	**Cost Per Unit**	**Total**	**Reference**
Operations and Maintenance - Annual								
Institutional Control Maintenance	1	LUMP SUM					$0	Estimate
						O&M Cost Subtotal:	$0	
						Contingency (15%):	$0	
						O&M Cost Total:	$0	

SOIL REMEDIAL ALTERNATIVE COST ESTIMATE

IN-SITU THERMAL TREATMENT OF SOIL SURROUNDING MW-1

Impacted Soil Surface Area	625	sf	Area near MW-1 is an unpaved gravel surface and will not require repaving
Volume of soil removed during electrode and trenching install	3	cubic yards	
Depth to Bedrock	22	ft	
Total volume of in-situ treated soil	13,750	cy	
Soil - Percent hazardous	0	%	
Soil - Percent Non Hazardouns	100	%	
Soil - assume 1.7 tons/yd	4	tons	

	Quantity	Unit	Labor - D	Equipment	Materials		Total	rounded to 100	rounded to 1000	Reference
Site Preparation										
Mobilization / Demobilization, construction equipment (including)	1	LUMP SUM	---	---	---		$5,000	$5,000	$5,000	ARCADIS Estimate
	Quantity	Unit	Labor - D	Equipment	Materials		Total			Reference
Treatment Activities										
Thermal treatment subcontractor	1	Lump Sum	NA	NA	$650,000		$650,000	$650,000	$650,000	ARCADIS Estimate
Dedicated Electrical service installation	1	Lump Sum	NA	NA	$25,000		$25,000	$25,000	$25,000	ARCADIS Estimate
Soil disposal, hazardous, TCLP	0	TON	$0	$0	$500	$0	$0	$0	$0	ARCADIS Estimate
Soil transportation, hazardous, TCLP	0	LOADS	$0	$0	$2,000	$0	$0	$0	$0	ARCADIS Estimate
Soil disposal, non-hazardous	4	TON	$0	$0	$40	$200	$174	$200	$0	ARCADIS Estimate
Soil transportation, non-hazardous	0	LOADS	$0	$0	$300	$100	$59	$100	$0	ARCADIS Estimate
Common fill	0	CY	$0.00	$0.00	$12.00		$0	$0	$0	ARCADIS Estimate
Backfill in 8-inch lifts - Compacted to 95% Proctor	0	CY	$0.20	$0.50	---		$0	$0	$0	ARCADIS Estimate
Topsoil, 6"	0	CY	$4.06	$2.89	$10.00		$0	$0	$0	ARCADIS Estimate
Pavement Replacement - Concrete	0	Square Feet	$2.00	$1.00	$3.00		$0	$0	$0	ARCADIS Estimate
Seeding, vegetative cover	0.0	ACRE	$67.71	$52	$3,491		$0	$0	$0	ARCADIS Estimate
							Capital Cost Total:	$680,300	$680,000	
O & M Costs	Quantity	Unit	Labor - D	Equipment	Materials		Total			
annual O&M	12	Months	500.00	500.00	250.00	$1.72	$15,000.00	$15,000	$15,000	Costs Captured in GW-2
Annual electrical utility	1	yr	--	--	--	$40,000	$40,000.00	$40,000	$40,000	Costs Captured in GW-3
							Subtotal:	$55,000	$55,000	
							Contingency (15%):	$8,250	$8,300	
							Annual O & M Total Costs:	$63,250	$63,000	
PERIODIC COSTS	Quantity	Unit	Labor - D	Equipment	Materials		Total			
Demobilize/Decommision	1	LS	--	--	--	$20,000	$20,000.00	$20,000	$20,000	Costs Captured in GW-3
							Subtotal:	$20,000	$20,000	
							Contingency (15%):	$3,000	$3,000	
							Periodic Total Costs:	$23,000	$23,000	
	Quantity	Unit	Labor - D	Equipment	Materials		Total			Reference
Indirect Costs										
Site Preparation and Remediation Activities Subtotal										
Engineering and construction oversight	1	LUMP SUM	$120,000	$0	$0		$120,000	$120,000	$120,000	
Engineering Design	1	LUMP SUM	$15,000	$0	$0		$15,000	$15,000	$15,000	
Project Management	1	LUMP SUM	$90,000	$0	$0		$90,000	$90,000	$90,000	
Implementation of H&S measures (includes Air Monitoring around site)	1	LUMP SUM	$25,000	$0	$0		$25,000	$25,000	$25,000	
							Indirect Cost Subtotal:	$250,000	$250,000	
							Capital and Indirect Cost Subtotal:	$930,300	$930,000	
							Contingency (15%):	$139,500	$140,000	
							Capital Cost Total:	$1,069,800	$1,070,000	

NOTE:
RSM = Costs estimated using RSMeans Environmental Remediation Cost Data - Unit Price, Building Construction Cost Data - Unit Price, and Heavy Construction - Unit Price, 2004.
Cost Quotes = Cost quotes obtained from local vendors

Appendix B

Detailed Groundwater Remediation Costs

Appendix B Comparative Analysis of Groundwater Remedial Alternative Costs
Brenntag Springfield Facility

		Remediation Costs																		MNA and Periodic Costs			
Remedial Alternative	Description	MPE Capital Cost ($)	MPE O&M Cost (annual) ($)	ERD Treatment Line Capital Cost ($)	ERD Treatment LIne O&M (annual) ($)	ERD Hot Spot Plume Treatment (assumes 50% of ERD Treatment Lines) ($)	ERD Hot Spot Plume Treatment, O&M (assumes half the O&M of ERD Treatment Lines) ($)	Property Boundary Hydraulic Control ($)	Property Boundary Hydraulic Control O&M (annual) ($)	SAW-2 Hydraulic Control ($)	SAW-2 Hydraulic Control O&M (annual) ($)	Source Area Chemical Oxidation Implementation Cost ($)	Offsite Chemical Oxidation Implementation Cost ($)	Institutional Controls ($)	Institutional Controls O&M ($)	Total Capital Cost ($)	Recurring Annual O&M Cost ($)	Time Frame for Non-MNA Remediaton (Yrs)	Present Value for Active Remediation ($)	Annual MNA & Reporting Cost ($)	End of Project (decomissioning) Cost ($)	Time Frame for MNA (Yrs)	Present Value Life Cycle Cost
GW-1	No Action	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	$174,600	NA	$174,600
GW-2	• Continuation of MPE System • SAW-2 Hydraulic Control • ERD Treatment Lines • Chemical Oxidation - Offsite Plume • MNA • Institutional Controls	$59,300	$81,600	$242,800	$60,800	NA	NA	NA	NA	$59,400	$9,500	$94,280	$505,000	$11,500	$600	$878,000	$142,400	3 - ERD 5 - hydraulic control	$1,555,000	$33,900	$214,700	10 (5 years following active remediation)	$1,823,000
GW-3	• Chemox Source and Hot Spot Treatment • Property Boundary & SAW-2 Hydraulic Control • ERD Hot Spot Plume Treatment • MNA • Institutional Controls	NA	NA	NA	NA	$121,400	$30,400	$182,900	$26,500	$59,400	$9,500	$94,280	$115,000	$11,500	$100	$490,000	$66,400	3 - ERD 5 - hydraulic control	$848,000	$33,900	$232,900	10 (5 years following active remediation)	$1,081,000
GW-4	• Chemox Source and Hot Spot Treatment • Property Boundary & SAW-2 • Hydraulic Control • MNA • Institutional Controls	NA	NA	NA	NA	NA	NA	$182,900	$26,500	$59,400	$9,500	$94,280	$115,000	$11,500	$600	$463,000	$36,000	5 - hydraulic control	$958,000	$33,900	$204,000	20 (15 years following active remediation)	$1,030,000

Notes: MPE O&M costs include incremental costs for soil SVE O&M

Assumes a project life of 3 years for MPE, IRZ, andGW Extraction and 10 years for MNA. A 7% discount rate was applied per *A Guide to Developing and Documenting Cost Estimates During the Feasibility Study,* EPA 540-R-00-002 OSWER 9355.0-75; July 2000

All costs are rounded to the nearest $100

All costs are based on an accuracy of +50/-30% (USEPA, 2000)

Acronyms:

GW - groundwater
IRZ - in-situ reactive zone
MNA - monitored natural attenuation
MPE - multi-phase extraction
NA - not applicable
O&M - operation and maintenance

GROUNDWATER REMEDIAL ALTERNATIVE COST ESTIMATE

GW-2: MULTI-PHASE EXTRACTION W/ SYSTEM OPTIMIZATION

Design Assumptions:

Continue to operate existing MPE system

4	wells	Additional wells added to optimize system
40	ft	Total well depth
20	ft	well screen
3	years	Remediation Time Frame

	Quantity	Unit	Labor - D	Equipment	Materials	Total	Reference
Site Preparation							
Mobilization / Demobilization	1	LUMP SUM	---	---	---	$2,500	ARCADIS Project Experience
	Quantity	**Unit**	**Labor - D**	**Equipment**	**Materials**	**Total**	**Reference**
Remediation Activities							
Recovery Well Drilling							
Well Drilling	160	FEET	$52	$31	$31	$18,300	Estimate
IDW Management							
15 CY Roll-off	1	EACH	$800	$620	$0	$1,400	Estimate
Drill cuttings disposal, hazardous	0	TONS			$110	$0	Estimate
Drill cuttings transportation, hazardous, TCLP	0	TONS			$120	$0	Estimate
Drill cuttings disposal, non-hazardous	7	TONS			$91	$600	Estimate
Trenching and Piping							
Water piping, 2-inch diameter Polyethylene SDR 21 pipe, installed;	150	FEET	$45	$30	$12	$17,300	RSM 33 26 0504
					Capital Cost Total:	$40,100	
	Quantity	**Unit**	**Labor - D**	**Equipment**	**Materials**	**Total**	**Reference**
Indirect Costs							
Site Preparation and Remediation Activities Subtotal						$40,100	
Engineering and construction oversight (20%)	1	LUMP SUM	$8,020	$0	$0	$8,020	ESTIMATE
Engineering Design (15%)	1	LUMP SUM	$6,015	$0	$0	$6,015	ESTIMATE
Project Management (10%)	1	LUMP SUM	$4,010	$0	$0	$4,010	ESTIMATE
Implementation of H&S measures (3%)	1	LUMP SUM	$1,203	$0	$0	$1,203	ESTIMATE
					Total Indirect Costs:	$19,248	
					Capital and Indirect Cost Subtotal:	$59,348	
					Contingency (0%):	$0	
					Capital and Indirect Cost Total:	$59,300	
	Quantity	**Unit**	**Labor - D**	**Equipment**	**Materials**	**Total**	**Reference**
Operations and Maintenance - Annual							
Electrical Use	1	LUMP SUM	$0	$0	$20,000	$20,000	ARCADIS project experience
O&M, equipment service, labor, 12 hrs per week for one year	442	HOURS	$120	$0	$0	$53,000	ARCADIS project experience
O&M, equipment service, parts	1	LUMP SUM	$0	$0	$5,000	$5,000	ARCADIS project experience
Liquid phase carbon changeouts, 1 changeout per year	1	LS	$0	$0	$0.00	$1,500	ARCADIS project experience
Discharge water to POTW, 2 gpm, continuous	1,051	1000 GALLONS	$0	$0	$2.00	$2,100	ARCADIS project experience
					Annual O&M:	$81,600	
					Contingency (0% based on historical performance):	$0	
					O&M Cost Total:	$81,600	
PERIODIC COSTS							
Well Abandonment	1,612	LF	18.08	41.25	$1.72	$130,500	Estimate
Demobilize/Decommision	1	LS	--	--	$20,000	$20,000	Estimate
					Subtotal:	$150,500	
					Contingency (15%):	$22,600	
					Periodic Total Costs:	$173,100	
					Total Estimated MPE Costs:	$477,200	2007 Dollars

GROUNDWATER REMEDIAL ALTERNATIVE COST ESTIMATE

ERD TREATMENT TRENCHES

Design Assumptions

Monitoring Wells			Trenches		
Number of Shallow Monitoring wells	2		Total length of treatment trenches	150	feet
Depth of MW	32	feet			
MW screen length	10	feet			
			Depth of Injection trench	20	feet
			Width of injection trench	3	feet
			Construction Schedule	50	feet of trench/day
Drilling Schedule	1	well/day	Number of Injections per year	4.0	
			Injection Volume, solution	10,098	gal/event
			dilution factor, weight	2%	
			Molasses per inj. event	148	gallons
Former Drum Rinsing Area Excavation					
Surface Area of Backfill	625	feet			
			Sampling Labor - low flo	4	wells/person/day
			# Quarterly Samples	2	samples
Unsaturated Volume of Backfill	8	feet	# Monthly Samples	2	samples
Number of Injections per year	4.0		# Annual Samples	5	samples
Injection Volume, solution	11,220	gal/event			
dilution factor, weight	2%		Level D Safety Level =	0.8	Labor productivity
Molasses per inj. event	164	gallons	Localization Factor	1.02	
			Profit Factor	30%	
			Injection Labor/event	50	hours (2 weeks per event)
			Trench Spoils		
			Total Volume	335	cubic yards
			Total Weight	503	Tons (at 1.5 tons/cubic yard)
			Hazardous, TCLP	0%	
			Hazardous, Fail TCLP	0%	
			Non-Hazardous	100%	

	Quantity	Unit	Cost Per Unit	Total	Reference
Monitoring Well Installation					
Mobilization and Demobilization	1	Per Rig	$2,100	$2,100	Estimate
Orientation/Safety Training	2	Crew HR	$155	$310	Estimate
Per Diem, (2 men)	2	Day	$130	$260	Estimate
Drilling - Hollow Stem Augers w/spoons	64	LF	$12	$768	Estimate
3' x 3' x 4 in thick concrete pad	2	Each	$140	$280	Estimate
Locking Cap on Steel Riser Pipe	2	Each	$50	$100	Estimate
Protective Outer Casing (stickup)	2	Each	$155	$310	Estimate
2" x 5' x 0.010 PVC Screen	4	Each	$23	$92	Estimate
Well Registration	2	Each	$105	$210	Estimate
Decontamination and Disposal	1	LS	--	$500	Estimate
Injection Trench Installation					
Trenching & Backfill	150	LF	$250	$37,500	Estimate
Injection System					
Injection Trailer	1	LS	--	$18,000	est. from previous
Miscellaneous valves and fittings	1	LS	--	$1,500	est. from previous
IDW Management					
15 CY Roll-off	22	EACH	$1,420	$31,700	Estimate
Excavation spoils Transportation and Disposal, non-hazardous	503	TONS	$150	$75,400	Estimate
			Capital Cost Subtotal:	$164,100	
Indirect Costs					
Site Preparation and Remediation Activities Subtotal					
Engineering Design	1	LUMP SUM	15%	$24,600	Estimate
Engineering and construction oversight	1	LUMP SUM	20%	$32,800	Estimate
Project Management	1	LUMP SUM	10%	$16,400	Estimate
Implementation of H&S measures	1	LUMP SUM	3%	$4,900	Estimate
			Total Indirect Cost:	$78,700	
			Capital and Indirect Cost Subtotal:	$242,800	
			Contingency (0%):	$0	
			Capital and Indirect Cost Total:	$242,800	
	Quantity	**Unit**	**Cost Per Unit**	**Total**	**Reference**
Operations and Maintenance - Annual					
Reagent Costs (molasses)	3,647	Pounds	$0.75	$2,735	Estimate
Injection labor	160	hours	$75	$12,000	Estimate
Monitoring Labor	9	Person-Day	$1,000	$9,300	Estimate
Monitoring Analytical	37	Each	$250	$9,300	Estimate
Quarterly System Reporting	4	events	$1,000	$4,000	Estimate
Water Costs	21	per 1000-gal	$3	$100	Estimate
O&M Labor	29	wells	$500	$14,500	Estimate
Annual Well Reinstall	0	wells	$500	$0	Estimate
Annual Well Development	1	Lump Sum	$1,000	$1,000	Estimate
			Annual O&M Cost Subtotal:	$52,900	
			Contingency (15%):	$7,900	
			O&M Cost Total:	$60,800	
PERIODIC COSTS					
Well Abandonment	64	LF	$61.82	$5,100	Estimate
Demobilize/Decommission	1	LS	$20,000	$20,000	Estimate
			Periodic Costs Subtotal:	$25,100	
			Contingency (15%):	$3,800	
			PERIODIC TOTAL COSTS	$28,900	
			Total ERD Treatment Line Costs:	$454,100	2007 Dollars

GROUNDWATER REMEDIAL ALTERNATIVE COST ESTIMATE

GW-2: SAW-2 GROUNDWATER EXTRACTION

Design Assumptions

Source area average DTW	25	ft bgs
Pumping Elevation	200	ft bgs
Pumping Rate	50	gal per day
Total Trenching Length	50	ft
Total Extraction Wells	1	Existing SAW2 Well
Depth of Extraction Wells	220	ft
Well Drill Cutting	0	CY
Electrical Connection Run Length	100	ft
Overhead and Profit Factor	30%	

Assumptions: Produced groundwater will be pumped to treatment system via existing extraction piping.
Electrical submersible pump will be used to evacuate well.
SAW2 will be modified as extractionwell.
Costs assume MPE system will also be operating, thus no additional permitting or discharge sampling will be required, and O&M costs will be incremental level required to operate single

	Quantity	Unit	Labor - D	Equipment	Materials	Cost per unit	Total	Reference
Site Preparation								
Mobilization / Demobilization	1	LUMP SUM	--	--	--	$5,000	$5,000	Estimate
	Quantity	**Unit**	**Labor - D**	**Equipment**	**Materials**	**Cost per unit**	**Total**	**Reference**
Remediation Activities								
Modify SAW 2 wellhead, install well vault with flow meter and piping.	1	EACH	$1,200	$500	$1,500	$3,200	$3,200	Estimate
Connect SAW2 piping to piping from adjacent existing (but inactive MPE well)	200	FEET	$63	$30	$12	$105	$20,900	Estimate
Electrical submersible pump, piping, electrical controls	1	EACH	$0	$7,000	$0	$7,000	$7,000	Estimate
Trenching and backfill for wellhead electrical connections	20	CY	$30.00	$15	$2.00	$47	$1,200	Estimate
Wellhead shelter for control panel and product recovery drum	1	EACH	--	--	$300	$300	$300	Estimate
						Capital Cost Subtotal:	$37,600	
Indirect Costs								
Engineering Design (25%)	1	LUMP SUM	--	--	--	25%	$9,400	Estimate
Engineering and construction oversight (20%)	1	LUMP SUM	--	--	--	20%	$7,500	Estimate
Project Management (10%)	1	LUMP SUM	--	--	--	10%	$3,800	Estimate
Implementation of H&S measures (3%)	1	LUMP SUM	--	--	--	3%	$1,100	Estimate
						Indirect Cost Subtotal:	$21,800	
						Capital and Indirect Cost Subtotal:	$59,400	
						Contingency (0%):	$0	
						Capital Cost Total:	$59,400	
Operations and Maintenance								
Electrical Power	1	LS			$5,000	$5,000	$5,000	ARCADIS Project Experience
Well Development	1	LS			$1,000	$1,000	$1,000	ARCADIS Project Experience
O&M Site Visits	12	LUMP SUM	250.00			$250.00	$3,000	ARCADIS Project Experience
Repairs	1	LS	--	--		$500	$500	Estimate
						O&M Annual Cost Subtotal:	$9,500	
						Contingency (0%):	$0	
						O&M Annual Cost Total:	$9,500	
PERIODIC COSTS								
Demob/Decommision	1	LUMP SUM	--	--	--	$1,000	$1,000	Estimate
Well Abandonment	208	LF	$25.00	$20	$3.00	$48.00	$10,000	Estimate
						Periodic Costs Subtotal:	$11,000	
						Contingency (15%):	$1,700	
						Periodic Costs:	$12,700	
						Total Estimated Groundwater Extraction Costs:	$100,600	2010 Dollars

NOTE:
RSM = Costs estimated using RSMeans Environmental
Cost Quotes = Cost quotes obtained from local vendors

GROUNDWATER REMEDIAL ALTERNATIVE COST ESTIMATE

GW-3: PROPERTY BOUNDARY HYDRAULIC CONTROL

Design Assumptions

Source area average DTW	25	ft bgs
Pumping Elevation	200	ft bgs
Pumping Rate	50	gal per day
Total Trenching Length	700	ft
Total Extraction Wells	10	
Depth of Extraction Wells	30	ft
Well Drill Cutting	8	CY
Electrical Connection Run Length	700	ft
Overhead and Profit Factor	30%	

Assumptions: Three (3) recovery wells to a depth of 40 feet bgs with 20 feet of screen.
Pneumatic pumps deliver recovered groundwater to carbon treatment prior to discharge to POTW.
System will operate independently of MPE system to maximize reliability.

Costs assume MPE system will also be operating, thus no additional permitting or discharge sampling will be required, and O&M costs will be incremental level required to operate single pump

	Quantity	Unit	Labor - D	Equipment	Materials	Cost per unit	Total	Reference
Site Preparation								
Mobilization / Demobilization	1	LUMP SUM	--	--	--	$8,000	$8,000	Estimate
	Quantity	**Unit**	**Labor - D**	**Equipment**	**Materials**	**Cost per unit**	**Total**	**Reference**
Remediation Activities								
Install wells - drilling cost, materials, and labor	120	LF	$12	$45	$35	$92	$11,000	Estimate
Develop/test	60	HR	$100	$150	$0	$250	$15,000	Estimate
Connect pump and piping	10	Days	$1,050	$0	$0	$1,050	$10,500	Estimate
Pneumatic submersible pump and tubing	1	LS	$0	$15,000	$0	$15,000	$15,000	Estimate
Equipment skid including air compressor, bag filters and carbon vessels	1	LS	$0	$35,000	$0	$35,000	$35,000	Estimate
Trenching and backfill for wellhead connections	700	LF	$15.00	$15	$2.00	$32	$29,100	Estimate
Capital Cost Subtotal:							$123,600	
Indirect Costs								
Engineering Design (25%)	1	LUMP SUM	--	--	--	15%	$18,500	Estimate
Engineering and construction oversight (20%)	1	LUMP SUM	--	--	--	20%	$24,700	Estimate
Project Management (10%)	1	LUMP SUM	--	--	--	10%	$12,400	Estimate
Implementation of H&S measures (3%)	1	LUMP SUM	--	--	--	3%	$3,700	Estimate
Indirect Cost Subtotal:							$59,300	
Capital and Indirect Cost Subtotal:							$182,900	
Contingency (0%):							$0	
Capital Cost Total:							$182,900	
Operations and Maintenance								
Electrical Power	1	LS			$ 5,000.00	$5,000.00	$5,000	ARCADIS Project Experience
Well Development	1	LS				1,000	$1,000	ARCADIS Project Experience
Liquid phase carbon changeouts	2	LS	$0		$0	$0.00	$2,500	ARCADIS project experience
O&M Site Visits	12	LUMP SUM	1,000.00			$1,000.00	$12,000	ARCADIS Project Experience
Repairs	1	LS	--	--		$6,000	$6,000	Estimate
O&M Annual Cost Subtotal:							$26,500	
Contingency (0%):							$0	
O&M Annual Cost Total:							$26,500	
PERIODIC COSTS								
Demob/Decommision	1	LUMP SUM	--	--	--	$5,000	$5,000	Estimate
Well Abandonment	300	LF	$25.00	$45	$3.00	$73.00	$21,900	Estimate
Periodic Costs Subtotal:							$26,900	
Contingency (15%):							$4,000	
Periodic Costs:							$30,900	
Total Estimated Groundwater Extraction Costs:							$293,300	2007 Dollars

NOTE:
RSM = Costs estimated using RSMeans Environmental
Cost Quotes = Cost quotes obtained from local vendors

GROUNDWATER REMEDIAL ALTERNATIVE COST ESTIMATE

GW-2: CHEMICAL OXIDATION

Treatment Surface Area	55,200	sf
Treatment Depth	35	ft
Injection Well ROI	15	ft
* of Injection Lines	8	
# of Injection wells	61	

	Quantity	Unit	Labor - D	Equipment	Materials	Total	rounded to 100	rounded to 1000	Reference
Site Preparation									
Mobilization / Demobilization, construction equipment (including)	1	LUMP SUM	---	---	---	$20,000	$20,000	$20,000	RSM 33 14 0201
						Site Preparation Cost Total	$20,000	$20,000	RSM 700 0050
	Quantity	Unit	Labor - D	Equipment	Materials	Total			Reference
Well Installation									
Install wells - drilling cost, materials, and labor	2,147	LF	$12	$30	$35	$77	$165,293	$165,000	Estimate
Develop/test	186	HR	$100	$150	$0	$250	$46,500	$47,000	Estimate
						Well Installation Cost Total	$211,793	$212,000	RSM 700 0050
Chemical Oxidant									
Mixing Trailer	12	weeks			$250.00	$3,000	$3,000	$3,000	
Klozur	75,000	LBS			$1.35	$101,250	$101,300	$101,000	
						Oxidant Cost Total:	$104,300	$104,000	
						Captial Cost Total	$336,093	$336,000	
	Quantity	Unit	Labor - D	Equipment	Materials	Total			Reference
Indirect Costs									
Engineering and construction oversight (6%)	1	LUMP SUM	$40,000	$0	$0	$40,000	$40,000	$40,000	
Operational Oversight	60	DAYS	$800	$0	$0	$48,000	$48,000	$48,000	
Implementation of H&S measures (2%)	1	LUMP SUM	$15,000	$0	$0	$15,000	$15,000	$15,000	
						2	$103,000	$103,000	
						Capital and Indirect Cost Subtotal:	$439,093	$439,000	
						Contingency (15%):	$65,900	$66,000	
						Capital Cost Total:	$504,993	$505,000	

GROUNDWATER REMEDIAL ALTERNATIVE COST ESTIMATE

GW-3: CHEMICAL OXIDATION

Treatment Surface Area	22,500	sf
Treatment Depth	35	ft
Injection Well ROI	15	ft
* of Injection Lines	3	
# of Injection wells	15	

	Quantity	Unit	Labor - D	Equipment	Materials	Total	rounded to 100	rounded to 1000	Reference
Site Preparation									
Mobilization / Demobilization, construction equipment (including)	1	LUMP SUM	---	---	---	$5,000	$5,000	$5,000	RSM 33 14 0201
						Site Preparation Cost Total	$5,000	$5,000	RSM 700 0050
	Quantity	Unit	Labor - D	Equipment	Materials	Total			Reference
Well Installation									
Install wells - drilling cost, materials, and labor	525	LF	$12	$30	$35	$77	$40,425	$40,000	Estimate
Develop/test	20	HR	$100	$150	$0	$250	$5,000	$5,000	Estimate
						Well Installation Cost Total	$45,425	$45,000	RSM 700 0050
Chemical Oxidant									
Klozur	15,000	LBS			$1.35	$20,250	$20,300	$20,000	
						Oxidant Cost Total:	$20,300	$20,000	
						Captial Cost Total	$70,725	$71,000	
	Quantity	Unit	Labor - D	Equipment	Materials	Total			Reference
Indirect Costs									
Engineering and construction oversight (6%)	1	LUMP SUM	$4,244	$0	$0	$4,244	$4,200	$4,000	
Operational Oversight	30	DAYS	$800	$0	$0	$24,000	$24,000	$24,000	
Implementation of H&S measures (2%)	1	LUMP SUM	$1,415	$0	$0	$1,415	$1,400	$1,000	
						2	$29,600	$30,000	
						Capital and Indirect Cost Subtotal:	$100,325	$100,000	
						Contingency (15%):	$15,000	$15,000	
						Capital Cost Total:	$115,325	$115,000	

GROUNDWATER REMEDIAL ALTERNATIVE COST ESTIMATE

GW-3 & 4: CHEMICAL OXIDATION

Former Drum Rinse Area - Source Area

Excavation Volume (unsaturated pore space)	5,000	ft3	Assumes Treatment in Former Drum Rinsing Area. The backfill of the soil excavation in this area will be used for delivery of oxidant.
Pore Volume	11220	gallons	Injection events will be conducted by delivering approximately 3 pore volumes into the soil excavation backfill to force oxidant into formation
Oxidant concentration	5%		Assume three injection events over first year of treatment
Mass of oxidant required	4,656	lbs	

	Quantity	Unit	Labor - D	Equipment	Materials	Total	rounded to 1000	Reference
Site Preparation								
Mobilization / Demobilization	1	LUMP SUM	---	---	---	$2,500	$3,000	ESTIMATE
						Site Preparation Cost Total	$3,000	ESTIMATE
	Quantity	**Unit**	**Labor - D**	**Equipment**	**Materials**	**Total**		ESTIMATE
Injection Activities								
Injection labor	160	hours	--	--	--	$75	$12,000	Estimate
Monitoring Labor	45	hours	--	--	--	$85	$4,000	Estimate
Monitoring Analytical	40	Each	--	--	--	$125	$5,000	Estimate
Quarterly System Reporting	4	events	--	--	--	$1,500	$6,000	Estimate
Water Costs	11	per 1000-gal	--	--	3.00	$34	$0	Estimate
Mixing Trailer	21	DAYS		$150		$3,150	$3,000	
						Injection Cost Total	$30,000	ESTIMATE
Chemical Oxidant								ESTIMATE
Klosur	13,969	lbs			$2.50	$34,922	$35,000	ESTIMATE
						Oxidant Cost Total:	$35,000	
						Chemical Oxidation Injection Total	$68,000	
	Quantity	**Unit**	**Labor - D**	**Equipment**	**Materials**	**Total**		
Indirect Costs								2007 Dollars
Engineering and construction oversight (5%)	1	LUMP SUM	--	--	--	15%	$10,200	
Operational Oversight	0	DAYS	--	--	--	15%	$0	
Implementation of H&S measures (2%)	1	LUMP SUM	--	--	--	6%	$4,080	
						Indirect Cost Subtotal:	$14,280	
						Injection and Indirect Cost Subtotal:	$82,280	
						Contingency (15%):	$12,000	
						Chemical Injection Cost Total:	$94,280	

GROUNDWATER REMEDIAL ALTERNATIVE COST ESTIMATE

INSTITUTIONAL CONTROLS

Design Assumptions

	Quantity	Unit	Labor - D	Equipment	Materials	Cost Per Unit	Total	Reference
Institutional Control Implementation								
Institutional Control Implementation	1	LUMP SUM					$10,000	
						Capital Cost Subtotal:	$10,000	
						Total Indirect Cost:	$0	
						Capital and Indirect Cost Subtotal:	$10,000	
						Contingency (15%):	$1,500	
						Capital and Indirect Cost Total:	$11,500	
	Quantity	**Unit**	**Labor - D**	**Equipment**	**Materials**	**Cost Per Unit**	**Total**	**Reference**
Operations and Maintenance - Annual								
Institutional Control Maintenance	1	LUMP SUM				500	$500	Estimate
						O&M Cost Subtotal:	$500	
						Contingency (15%):	$100	
						O&M Cost Total:	$600	

GROUNDWATER REMEDIAL ALTERNATIVE COST ESTIMATE
ANNUAL MNA and REPORTING

Design/Execution Assumptions		
Annual Event		
Total MNA wells	14	annual groundwater sampling
Sampling Frequency	1	per year
QA/QC samples	20%	of total samples
sampling time	3	man-hours per well per event
Prep Time	0.7	man-hours per well per event
Travel Time	0.85	man-hours per well per event
Wells per day	7	
Sampling Days	4	2 people times two days x twice per year
Clerical / Secretarial Time	1.5	man-hours per well per event
Project Manager Time	0.35	man-hours per well per event
Data Analysis and Reporting Time for Project Engineer	2	man-hours per well per event
Data Analysis and Reporting Time for Junior Engineer	4	man-hours per well per event

Labor					
Description	**Unit**	**Unit Rate**	**Quantity**	**Revenue**	**Notes**
Senior Expert	hour	$153	1	$153	1 hour per event
Principal Sci/Eng/Arch/Designer	hour	$130	1	$130	1 hour per event
Senior Sci/Eng/Arch/Designer	hour	$130	5	$651	P.M. time
Project Sci/Eng/Arch/Designer	hour	$92	28	$2,573	Reporting
Staff Sci/Eng/Arch/Designer	hour	$92	56	$5,146	Reporting
Sci/Eng/Arch/Designer 2	hour	$68	64	$4,362	prep and reporting
Sci/Eng/Arch/Designer 2	hour	$68	36	$2,454	field work
Sci/Eng/Arch/Designer 1	hour	$55	18	$990	field work
Clerical / Secretarial	hour	$39	21	$818	
			Subtotal:	**$17,300**	

Subcontractors					
Description	**Unit**	**Unit Rate**	**Quantity**	**Revenue**	**Notes**
Laboratory					
Laboratory					
VOC's	each	$64	17	$1,088	
Metals	each	$88	17	$1,496	
Light hydrocarbons (methane, ethane, ethene)	each	$75	17	$1,275	
Total Organic Carbon (TOC)-single analysis	each	$25	17	$425	
Anions (Br, Cl, F, PO4, SO4, NO3, NO2)	each	$75	17	$1,275	
Sulfide	each	$20	17	$340	
Chloride	each	$20	17	$340	
Ferrous Iron	each	$25	17	$425	
Alkalinity Total (Bicarbonate/Carbonate/Hydroxide)	each	$8	17	$136	
			Subtotal:	**$6,800**	

Expenses					
Description	**Unit**	**Unit Rate**	**Quantity**	**Revenue**	**Notes**
PID	day	$75	4	$300	
Submersible pump w/ control box	day	$205	4	$820	
Horiba U-22 with flow-through cell	day	$140	4	$560	
Generator	day	$75	4	$300	
Water level indicator	day	$30	4	$120	
Interface probe	day	$60	4	$240	
Daily Low-flow Setup	day	$150	4	$600	
Tubing	100 ft	$22	4	$88	
Decon area setup/supplies	day	$25	4	$100	
Level D PPE	day/person	$25	8	$200	
Miscellaneous (photographs, gas, tolls, supplies, etc.)	day	$20	4	$80	
Shipping (Coolers)	each	$100	4	$400	
Truck/car rental	day/person	$75	4	$300	
Lodging	day/person	$100	8	$800	
Meals (overnight stay)	day/person	$40	8	$320	
Meals (day work)	day/person	$20	8	$160	
			Subtotal:	**$5,400**	
			Contingency, 15%	**$4,400**	
			Total Annual MNA Cost:	**$33,900**	
			MNA Total for 10 Years:	**$339,000**	2007 Dollars

Present Worth Analysis

Alternative GW-1 NO ACTION - includes decommissioning all existing remediation infrastructure, systems, and wells in year 1

interest rate: 7%

ACTIVE REMEDIATION

Year	Amount	PW at Year 1	p/f factor
1	$ 174,600	$ 174,600	1.00
2		$ -	0.935
3		$ -	0.873
4		$ -	0.816
5		$ -	0.763
6		$ -	0.713
7		$ -	0.666
8		$ -	0.623
9		$ -	0.582
10		$ -	0.544
11		$ -	0.508
12		$ -	0.475
13		$ -	0.444
14		$ -	0.415
15		$ -	0.388
16		$ -	0.362
17		$ -	0.339
18		$ -	0.317
19		$ -	0.296
20		$ -	0.277
21		$ -	0.258
22		$ -	0.242
23		$ -	0.226
24		$ -	0.211
25		$ -	0.197
26		$ -	0.184
27		$ -	0.172
28		$ -	0.161
29		$ -	0.150
30		$ -	0.141
31		$ -	0.131
PRESENT WORTH:		**$174,600**	

Notes: Capital Cost is HVE+ERD+ChemOx + SAW-2+Inst Control
O&M is HVE/ERD/SAW-2 for 3 years

LIFE CYCLE COST

Year	Amount	PW at Year 1	p/f factor
1	$ 174,600	$ 174,600	1.00
2	$ -	$ -	0.935
3	$ -	$ -	0.873
4		$ -	0.816
5		$ -	0.763
6		$ -	0.713
7		$ -	0.666
8		$ -	0.623
9		$ -	0.582
10		$ -	0.544
11		$ -	0.508
12		$ -	0.475
13		$ -	0.444
14		$ -	0.415
15		$ -	0.388
16		$ -	0.362
17		$ -	0.339
18		$ -	0.317
19		$ -	0.296
20		$ -	0.277
21		$ -	0.258
22		$ -	0.242
23		$ -	0.226
24		$ -	0.211
25		$ -	0.197
26		$ -	0.184
27		$ -	0.172
28		$ -	0.161
29		$ -	0.150
30		$ -	0.141
31		$ -	0.131
PRESENT WORTH:		**$174,600**	

Notes: Years 4 through 10 include MNA costs
Year 10 includes Decomissioning cost

Present Worth Analysis

Alternative GW-2

interest rate: 7%

ACTIVE REMEDIATION

Year	Amount	PW at Year 1	p/f factor
1	$ 1,020,400	$ 1,020,400	1.00
2	$ 186,400	$ 174,206	0.935
3	$ 186,400	$ 162,809	0.873
4	$ 125,100	$ 102,119	0.816
5	$ 125,600	$ 95,820	0.763
6		$ -	0.713
7		$ -	0.666
8		$ -	0.623
9		$ -	0.582
10		$ -	0.544
11		$ -	0.508
12		$ -	0.475
13		$ -	0.444
14		$ -	0.415
15		$ -	0.388
16		$ -	0.362
17		$ -	0.339
18		$ -	0.317
19		$ -	0.296
20		$ -	0.277
21		$ -	0.258
22		$ -	0.242
23		$ -	0.226
24		$ -	0.211
25		$ -	0.197
26		$ -	0.184
27		$ -	0.172
28		$ -	0.161
29		$ -	0.150
30		$ -	0.141
31		$ -	0.131
PRESENT WORTH:		**$1,555,353**	

Notes: Capital Cost is HVE+ERD+ChemOx + SAW-2+Inst Control
O&M is HVE/ERD/SAW-2 for 3 years

LIFE CYCLE COST

Year	Amount	PW at Year 1	p/f factor
1	$ 1,020,400	$ 1,020,400	1.00
2	$ 186,400	$ 174,206	0.935
3	$ 186,400	$ 162,809	0.873
4	$ 153,500	$ 125,302	0.816
5	$ 153,500	$ 117,104	0.763
6	$ 33,900	$ 24,170	0.713
7	$ 33,900	$ 22,589	0.666
8	$ 33,900	$ 21,111	0.623
9	$ 33,900	$ 19,730	0.582
10	$ 248,600	$ 135,222	0.544
11		$ -	0.508
12		$ -	0.475
13		$ -	0.444
14		$ -	0.415
15		$ -	0.388
16		$ -	0.362
17		$ -	0.339
18		$ -	0.317
19		$ -	0.296
20		$ -	0.277
21		$ -	0.258
22		$ -	0.242
23		$ -	0.226
24		$ -	0.211
25		$ -	0.197
26		$ -	0.184
27		$ -	0.172
28		$ -	0.161
29		$ -	0.150
30		$ -	0.141
31		$ -	0.131
PRESENT WORTH:		**$1,822,643**	

Notes: Years 4 through 10 include MNA costs
Year 10 includes Decomissioning cost

Present Worth Analysis

Alternative GW-3

interest rate: 7%

ACTIVE REMEDIATION

Year	Amount	PW at Year 1	p/f factor
1	$ 556,400	$ 556,400	1.00
2	$ 100,400	$ 93,832	0.935
3	$ 100,400	$ 87,693	0.873
4	$ 70,000	$ 57,141	0.816
5	$ 70,000	$ 53,403	0.763
6		$ -	0.713
7		$ -	0.666
8		$ -	0.623
9		$ -	0.582
10		$ -	0.544
11		$ -	0.508
12		$ -	0.475
13		$ -	0.444
14		$ -	0.415
15		$ -	0.388
16		$ -	0.362
17		$ -	0.339
18		$ -	0.317
19		$ -	0.296
20		$ -	0.277
21		$ -	0.258
22		$ -	0.242
23		$ -	0.226
24		$ -	0.211
25		$ -	0.197
26		$ -	0.184
27		$ -	0.172
28		$ -	0.161
29		$ -	0.150
30		$ -	0.141
31		$ -	0.131
PRESENT WORTH:		**$848,469**	

Notes: Capital Cost is ERD+GW Ext+Inst Control
O&M is ERD for 3 years and GW Ext for 20 years

LIFE CYCLE COST

Year	Amount	PW at Year 1	p/f factor
1	$ 556,400	$ 556,400	1.00
2	$ 100,400	$ 93,832	0.935
3	$ 100,400	$ 87,693	0.873
4	$ 70,000	$ 57,141	0.816
5	$ 70,000	$ 53,403	0.763
6	$ 33,900	$ 24,170	0.713
7	$ 33,900	$ 22,589	0.666
8	$ 33,900	$ 21,111	0.623
9	$ 33,900	$ 19,730	0.582
10	$ 266,800	$ 145,122	0.544
11		$ -	0.508
12		$ -	0.475
13		$ -	0.444
14		$ -	0.415
15		$ -	0.388
16		$ -	0.362
17		$ -	0.339
18		$ -	0.317
19		$ -	0.296
20		$ -	0.277
21		$ -	0.258
22		$ -	0.242
23		$ -	0.226
24		$ -	0.211
25		$ -	0.197
26		$ -	0.184
27		$ -	0.172
28		$ -	0.161
29		$ -	0.150
30		$ -	0.141
31		$ -	0.131
PRESENT WORTH:		**$1,081,191**	

Notes: Years 21 through 27 include MNA costs
Year 27 includes Decomissioning cost

Present Worth Analysis

Alternative GW-4

interest rate: 7%

ACTIVE REMEDIATION

Year	Amount	PW at Year 1	p/f factor
1	$ 499,000	$ 499,000	1.00
2	$ 70,500	$ 65,888	0.935
3	$ 70,500	$ 61,577	0.873
4	$ 70,500	$ 57,549	0.816
5	$ 70,500	$ 53,784	0.763
6	$ 70,500	$ 50,266	0.713
7	$ 70,500	$ 46,977	0.666
8	$ 70,500	$ 43,904	0.623
9	$ 70,500	$ 41,032	0.582
10	$ 70,500	$ 38,347	0.544
11		$ -	0.508
12		$ -	0.475
13		$ -	0.444
14		$ -	0.415
15		$ -	0.388
16		$ -	0.362
17		$ -	0.339
18		$ -	0.317
19		$ -	0.296
20		$ -	0.277
21		$ -	0.258
22		$ -	0.242
23		$ -	0.226
24		$ -	0.211
25		$ -	0.197
26		$ -	0.184
27		$ -	0.172
28		$ -	0.161
29		$ -	0.150
30		$ -	0.141
31		$ -	0.131
PRESENT WORTH:		**$958,324**	

Notes: Capital Cost is ERD+GW Ext+Inst Control
O&M is ERD for 3 years and GW Ext for 20 years

LIFE CYCLE COST

Year	Amount	PW at Year 1	p/f factor
1	$ 499,000	$ 499,000	1.00
2	$ 70,500	$ 65,888	0.935
3	$ 70,500	$ 61,577	0.873
4	$ 70,500	$ 57,549	0.816
5	$ 70,500	$ 53,784	0.763
6	$ 33,900	$ 24,170	0.713
7	$ 33,900	$ 22,589	0.666
8	$ 33,900	$ 21,111	0.623
9	$ 33,900	$ 19,730	0.582
10	$ 33,900	$ 18,439	0.544
11	$ 33,900	$ 17,233	0.508
12	$ 33,900	$ 16,106	0.475
13	$ 33,900	$ 15,052	0.444
14	$ 33,900	$ 14,067	0.415
15	$ 33,900	$ 13,147	0.388
16	$ 33,900	$ 12,287	0.362
17	$ 33,900	$ 11,483	0.339
18	$ 33,900	$ 10,732	0.317
19	$ 33,900	$ 10,030	0.296
20	$ 237,900	$ 65,781	0.277
21		$ -	0.258
22		$ -	0.242
23		$ -	0.226
24		$ -	0.211
25		$ -	0.197
26		$ -	0.184
27		$ -	0.172
28		$ -	0.161
29		$ -	0.150
30		$ -	0.141
31		$ -	0.131
PRESENT WORTH:		**$1,029,756**	

Notes: Years 21 through 27 include MNA costs
Year 27 includes Decomissioning cost