FINAL

FEASIBILITY STUDY
FOR THE
ALABAMA ARMY NATIONAL GUARD (ALARNG)
ORGANIZATIONAL MAINTENANCE SHOP 28 (OMS-28)
1622 SOUTH BROAD STREET
MOBILE, MOBILE COUNTY, ALABAMA
GROUNDWATER INCIDENT NUMBER GW 07-01-02

Prepared for

US Army Corps of Engineers®

Mobile District

Contract Number W91278-10-D-0089
Delivery Order Number 0004

February 2014

leidos

11-078(E)/020414

LEIDOS
Contributed to the preparation of this document and should not be considered an eligible contractor for its review.

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1622 SOUTH BROAD STREET
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Prepared by

Leidos Consulting Engineers, Inc.
301 Laboratory Road
Oak Ridge, TN 37830

for
USACE, Mobile District
under
Contract Number W91278-10-D-0089
Delivery Order Number 0004

February 2014

I, the undersigned, certify that I am a qualified professional engineer with competence in the subject matter dealt with in this document. I further certify that this document has been prepared under my responsible charge, in compliance with standard professional practices, the laws and rules governing the engineering profession under Chapter 11 of the Alabama Licensure Law and the Administrative Code.

2/5/14

Patricia A. Stoll, P.E.
Leidos Consulting Engineers, Inc.

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TABLES

FIGURES

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ACRONYMS

ADEM	Alabama Department of Environmental Management
ALARNG	Alabama Army National Guard
AMSL	above mean sea level
ARAR	applicable or relevant and appropriate requirement
ARBCA	Alabama risk-based corrective action
BGS	below ground surface
CERCLA	Comprehensive Environmental Response, Compensation, and Liability Act
CFR	*Code of Federal Regulations*
COC	chemical of concern
DCE	dichloroethene
DD	Decision Document
DHC	*Dehalococcoides* sp.
DO	dissolved oxygen
DOT	U. S. Department of Transportation
EPA	U. S. Environmental Protection Agency
FS	feasibility study
FUDS	Formerly Used Defense Sites
gpm	gallons per minute
GRA	general response action
HI	hazard index
ISCO	in-situ chemical oxidation
LUC	land use control
LUCIP	Land Use Control Implementation Plan
MAA	Mobile Airport Authority
MCL	maximum contaminant level
MNA	monitored natural attenuation
NCP	National Oil and Hazardous Substances Pollution Contingency Plan
NOD	natural oxidant demand
O&M	operations and maintenance
OMS	Organizational Maintenance Shop
ORP	oxidation-reduction potential
PAH	polycyclic aromatic hydrocarbon
PCE	tetrachloroethene
PSV	preliminary screening value (Alabama)
RAO	remedial action objective
RBTL	risk-based target level
RI	remedial investigation
RL	remediation level
RM	risk management
RSL	regional screening level (EPA)
SRS™	Slow Release Substrate™
SSL	soil screening level (for the protection of groundwater)
TBC	to be considered
TCE	trichloroethene
TOC	total organic carbon
USACE	U. S. Army Corps of Engineers
UST	underground storage tank
VC	vinyl chloride

VOC	volatile organic compound
ZVI	zero valent iron

EXECUTIVE SUMMARY

U. S. Army Corps of Engineers (USACE), Mobile District contracted Leidos, formerly a part of Science Applications International Corporation, to prepare this Feasibility Study (FS) Report subsequent to the *Revision 2 Remedial Investigation Report for the Alabama Army National Guard (ALARNG) Organizational Maintenance Shop 28 (OMS-28), 1622 South Broad Street, Mobile, Alabama, Groundwater Incident No. GW 07-01-02* (SAIC 2013) for Organizational Maintenance Shop (OMS) 28 located at the Brookley Aeroplex. This FS utilizes the nature and extent of risks posed by areas of contaminated media identified in the Remedial Investigation (RI) Report for OMS-28 and evaluates potential remedial options. The RI Report recommended an FS to evaluate alternatives for addressing contamination in groundwater that resulted from residual constituents in soil at OMS-28.

ES.1 OMS-28 SITE DESCRIPTION

OMS-28 is located in the logistics/manufacturing district of the Brookley Aeroplex. The Alabama Army National Guard (ALARNG) operates the Field Maintenance Shop (formerly known as the OMS) in the northwest corner of the Brookley Aeroplex on property owned by the Alabama Armory Commission. Mobile Airport Authority (MAA) owns the property directly west of the OMS-28 site, and residential property is located to the north.

In 1992, four underground storage tanks (USTs) were removed from three separate locations (Pit 1, Pit 2, and Pit 3) at the OMS. According to USACE, Pits 1 and 3 were clean-closed following the tank removal, and no subsequent investigations were required after the closure. A single 2,000-gal gas/diesel UST at Pit 2 was removed in October 1992. The preliminary investigation of Pit 2 did not fully determine the extent of petroleum contamination in soil or groundwater. A secondary investigation of Pit 2 was completed in December 1994, which established the extent of petroleum contamination in soil and groundwater at the site. The 1994 secondary investigation was followed by quarterly groundwater monitoring for petroleum contamination beginning in 1995. In 2004 and 2005, additional site characterization was performed because groundwater monitoring indicated that petroleum-related contamination had extended beyond the network of monitoring wells installed during the original 1994 secondary investigation. The presence of a chlorinated solvents plume was discovered downgradient of Pit 2 during this 2004/2005 investigation. The chlorinated solvents, specifically trichloroethene (TCE), were not related to the gasoline/diesel fuel UST being investigated and were believed to be the result of a localized solvent spill located on OMS-28 property approximately 200 ft west-northwest of Pit 2 (Aerostar 2007). No additional information regarding the details of a spill (i.e., when, amount of the spill, what was spilled, or who was responsible) has been provided in any of the historical documents.

Initially, investigation of the OMS-28 chlorinated solvents plume followed a Resource Conservation and Recovery Act path following the discovery of TCE under the UST regulatory requirements. In September 2010, the ALARNG submitted a request to the Alabama Department of Environmental Management (ADEM) to continue the activities at the site under the Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA). ADEM concurred with this approach in e-mail correspondence dated September 9, 2010 (ADEM 2010a).

ES.2 SUMMARY OF NATURE AND EXTENT OF CONTAMINATION

Soil. Fifteen volatile organic compounds (VOCs) were detected in soil at OMS-28; however, constituents in the soil did not exceed residential or industrial regional screening levels (RSLs) (May 2012). While the constituents in the soil do not exceed the RSLs and are, therefore, not a risk to human health, there are three where the constituents in the soil may be acting as a residual source for the TCE and tetrachloroethene (PCE) groundwater plumes. The largest area of soil exceeding the protection of groundwater soil screening levels (SSLs) is located in the vicinity of MW-8, and the area exceeding the SSL for TCE and PCE is approximately 70 by 80 ft. Two, smaller, isolated areas of soil exceeding the protection of groundwater SSLs are located approximately 200 ft northwest of MW-8 at soil sample location B-17 and approximately 250 ft west of MW-8 at soil sample location B-13. The concentrations of TCE and PCE in soil in the vicinity of MW-8 and B-17 may be providing a residual source of constituents in the soil for the two groundwater plumes.

Groundwater. Eighteen VOCs were detected in groundwater during the investigations from 2006 through 2008. As of the last sampling event in September 2010, *cis*-1,2-dichloroethene; PCE; and TCE were the only compounds where the concentrations exceeded their respective U. S. Environmental Protection Agency tap water RSLs. Concentrations of TCE and PCE exceeded their respective maximum contaminant levels (MCLs). In September 2010, TCE was detected in shallow wells MW-8, OMS-28-3, and OMS-28-5 but was not detected in the remaining shallow wells (MW-5, MW-6, MW-9, MW-12, OMS-28-2, and OMS-28-7), which delineated the horizontal extent of the plume boundary. PCE was detected in shallow well OMS-28-5 but was not detected in the other shallow wells. TCE and PCE were not detected in the three deep wells. Based on the results of the September 2010 sampling event and the 2006 Phase I and II temporary wells, there appears to be a TCE plume and a PCE plume. The PCE may have already degraded in the vicinity of MW-8 as it is no longer being observed in that part of the TCE plume.

ES.3 SUMMARY OF THE RISK ASSESSMENT

The maximum concentrations of PCE and TCE in groundwater exceeded the 2008 residential Alabama preliminary screening values (PSVs); therefore, PCE and TCE were identified as chemicals of concern (COCs) in the Alabama Risk-Based Corrective Action Report, which was presented in Appendix M of the RI Report for OMS-28 (SAIC 2013). Current and future use of the site includes commercial and occasional construction workers. A trespasser is a potential receptor. For the purpose of evaluating a future residential use of the site, the resident adult and resident child were considered due to residential properties adjacent to the site boundary. As a result, the receptors evaluated in the Alabama Risk-Based Correction Action Report were the commercial worker-adult, construction worker-adult, trespasser (adolescent), resident child, and resident adult.

Current use of the site is acceptable for the commercial worker, construction worker, and trespasser. Future residents may be at risk if ingestion of groundwater was to occur at a hypothetical well for potential exposure.

ES.4 REMEDIAL ACTION OBJECTIVES AND REMEDIAL LEVELS

The remedial action objectives (RAOs) for OMS-28 are (1) to prevent human ingestion of groundwater containing TCE, PCE, or their degradation products in concentrations above their respective federal MCLs (where available), and (2) to restore the properties that are not owned by the ALARNG to unlimited use and unrestricted exposure condition. No action is warranted for soil as contaminant concentrations do not pose a risk to human health receptors.

The most likely foreseeable land use for the site is industrial; however, there is residential land use immediately adjacent to the ALARNG and MAA property to the north. TCE and PCE were identified as COCs for remediation in groundwater. The MCLs for these constituents are the remedial levels, which will provide the requisite level of protectiveness for unlimited use and unrestricted exposure conditions.

ES.5 DEVELOPMENT AND EVALUATION OF REMEDIAL ALTERNATIVES

Five remedial alternatives for groundwater were developed and evaluated in this FS. No action is warranted for soil because concentrations of TCE and PCE in soil are less than the residential and industrial RSLs. However, there are concentrations of TCE and/or PCE in the vadose zone soil, located within the aerial extent of the groundwater plume, that exceed the protection of groundwater SSLs. This residual soil mass is acting as a continuing source for groundwater contamination. Excavation to remove this residual soil mass exceeding the SSLs for the protection of groundwater from the vadose zone is being included with some of the groundwater remedial alternatives as a cost effective measure to reduce overall costs and remediation timeframes.

- **Alternative 1: No Action** proposes no active treatment to address contaminants. This alternative is presented for comparison with other alternatives in accordance with CERCLA and National Oil and Hazardous Substances Pollution Contingency Plan (NCP) requirements. There is no cost associated with this alternative because no action would occur.

- **Alternative 2: Monitored Natural Attenuation of Groundwater** would include implementation of groundwater monitoring to show that natural attenuation is reducing contamination as predicted. Land use controls (LUCs) would be implemented to ensure continued industrial land use and groundwater use restrictions.

- **Alternative 3: Monitored Natural Attenuation of Groundwater with Excavation of Soil** would include implementation of groundwater monitoring to show that natural attenuation is reducing contamination as predicted. In addition, the residual soil contaminant mass in the vadose zone acting as a secondary source to groundwater would be excavated to reduce the monitored natural attenuation (MNA) timeframe. There are two areas within the TCE and PCE groundwater plumes where the residual contaminant mass in the vadose zone soil is acting as a secondary source to groundwater. Excavation of the area surrounding wells OMS-28-6 and MW-8 would be approximately 70 by 80 ft to a depth of 4 to 7 ft below ground surface (BGS), and excavation of the area surrounding boring B-17 would be approximately 20 by 20 ft to a depth of 8 to 12 ft BGS. LUCs would be implemented to ensure continued industrial land use and groundwater use restrictions.

- **Alternative 4: Biological/Chemical Reduction of Groundwater with Excavation of Soil** would include proposed injection of an engineered vegetable oil substrate package or other carbon source for treatment of groundwater until the MCLs for TCE and PCE are achieved. To expedite the remedial timeframe following injection, this alternative also would include the excavation of the residual soil mass that is acting as a continuing source for groundwater contamination and transportation of the resulting waste to a permitted municipal solid waste landfill for disposal. The excavation areas would be the same as those presented in Alternative 2.

- **Alternative 5: In-Situ Chemical Oxidation of Groundwater with Excavation of Soil** would include proposed injection of a chemical oxidant for treatment of groundwater until the MCLs for TCE and PCE are achieved. To expedite the remedial timeframe following injection(s), this alternative also would include the excavation of the residual soil mass that is acting as a continuing source for groundwater contamination and transportation of the resulting waste to a permitted municipal solid waste landfill for disposal. The excavation areas would be the same as those presented in Alternative 2.

The proposed alternatives were evaluated individually and also compared against each other to identify principal tradeoffs that differentiate the alternatives. The evaluation considered the following nine statutory criteria, as required by the NCP.

Overall Protection of Human Health and the Environment. The no action alternative would not change the current site conditions and, therefore, would not achieve the RAOs. The remaining alternatives provide varying degrees of overall protection of human health and the environment based primarily on the length of time anticipated to achieve remediation levels (RLs). The MNA of groundwater alternatives (Alternatives 2 and 3), without and with soil excavation, would each attain the RAOs within approximately 30 and 25 years, respectively, at the end of the MNA period. The alternatives containing biological/chemical reduction of groundwater or in-situ chemical oxidation (ISCO) of groundwater (Alternatives 4 and 5) along with excavation of soil would each attain the RAOs within approximately 5 to 6 years at the restoration of groundwater to below the RLs. Based upon the anticipated time to achieve RLs in groundwater, among these four alternatives, Alternatives 2 through 5 would achieve full protectiveness at the end of the remedy, but Alternative 2 would take the longest to achieve the RL and would be considered the least protective of human health and the environment.

Compliance with Applicable or Relevant and Appropriate Requirements (ARARs). The no action alternative is not required to comply with ARARs. The four remaining alternatives would comply with the chemical-specific ARARs (i.e., MCLs) for groundwater at the end of the remedial timeframe. The excavation portion of Alternatives 3, 4, and 5 would comply with the location- and action-specific ARARs, including the characterization and shipment of excavated soil for proper disposal as well as the control of particulate emissions and sedimentation due to stormwater run-off.

Short-Term Effectiveness. There would be no short-term impacts associated with the no action alternative. The four remaining alternatives share potential for negative impacts due to construction and operational hazards related to well installation, abandonment, excavation, and/or soil disposal. The MNA of groundwater alternative (Alternative 2) presents the lowest potential for negative impacts as no injection or excavation activities would be performed. The biological/chemical reduction of groundwater with soil excavation alternative (Alternative 4) has a lower potential for negative impacts than the ISCO of groundwater alternative (Alternative 5) due to the benign nature of the engineered vegetable oil-based substrate package amendments proposed for injection. The ISCO of groundwater with soil excavation alternative (Alternative 5) has the highest potential for negative impacts to workers and the environment during implementation, primarily due to the hazardous nature of oxidants proposed for injection.

Long-Term Effectiveness. The no action alternative would have no long-term effectiveness or permanence because risks to human health and the environment would not be achieved. The MNA alternatives (Alternatives 2 and 3) would take the longest to achieve long-term effectiveness and permanence, after an MNA period of approximately 30 and 25 years, respectively. Alternatives 3 through 5 would each employ a removal technology to remove the residual contaminant mass in the vadose zone soil above the SSLs for the protection of groundwater. The alternatives containing biological/chemical reduction of groundwater and ISCO of groundwater (Alternatives 4 and 5) also would use active treatment to reduce risk in groundwater over similar time periods, approximately 5 and 6 years, respectively.

Reduction in Toxicity, Mobility, or Volume. The no action alternative would not result in the reduction of toxicity, mobility, or volume through treatment. The MNA alternatives (Alternatives 2 and 3) would result in the reduction of toxicity and volume of PCE and TCE in groundwater through MNA, not active treatment. The alternatives containing biological/chemical reduction of groundwater and ISCO of groundwater (Alternatives 4 and 5) would employ an active treatment technology to reduce toxicity and volume of PCE and TCE in groundwater. None of the alternatives would reduce mobility of the contaminants in groundwater; however, mobility is not very high at OMS-28. Alternatives 3 through 5 would each result in a nearly 100% reduction in volume of on-site soil exceeding SSLs for the protection of groundwater but through removal, not treatment.

Implementability. The no action alternative would not involve construction and is, therefore, readily implementable. The remaining alternatives are each readily implementable with slight variations. All of these alternatives would involve well installation and groundwater sampling. Alternatives 3, 4, and 5 also would involve soil excavation and well abandonment. Alternatives 4 and 5 would require additional injection well installation and injection activities.

Cost. The approximate present value costs for each of the five alternatives are provided in Table ES-1.

Table ES-1. Summary of Present Value Costs for OMS-28 Alternatives

Alternative	Duration (years)	Discounted or Present Value		
		Capital Cost	O&M/Periodic Cost	Total Cost
1: No Action	30	$0	$0	$0
2: Monitored Natural Attenuation of Groundwater	30	$141,775	$1,685,777	$1,827,553
3: Monitored Natural Attenuation of Groundwater with Excavation of Soil	25	$761,013	$1,317,577	$2,078,591
4: Biological/Chemical Reduction of Groundwater with Excavation of Soil	5	$2,104,540	$866,013	$2,970,553
5: In-situ Chemical Oxidation of Groundwater with Excavation of Soil	6	$3,396,464	$726,655	$4,123,119

O&M = Operation and maintenance.
OMS = Organizational Maintenance Shop.

State and Community Acceptance. These are the last two of the nine statutory evaluation criteria. Responses to comments from state regulators and the community regarding the alternatives will be addressed in the Decision Document. Community acceptance will be evaluated as part of the selection process. Input from the community will be solicited during the public comment period.

ES.6 SELECTION OF THE PREFERRED ALTERNATIVE

The recommended alternative is Alternative 4 – Biological/Chemical Reduction of Groundwater with Excavation of Soil. This alternative is recommended because it will achieve substantial risk reduction by active groundwater treatment followed by performance monitoring. This combination reduces risk sooner and costs less than the other active treatment alternative. The other MNA-related alternatives were less costly; however, the timeframe to achieve risk reduction and site closure was 25 to 30 years or longer.

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1.0 INTRODUCTION

U. S. Army Corps of Engineers (USACE), Mobile District contracted Leidos, formerly a part of Science Applications International Corporation, to prepare this Feasibility Study (FS) Report subsequent to the *Revision 2 Remedial Investigation Report for the Alabama Army National Guard (ALARNG) Organizational Maintenance Shop 28 (OMS-28), 1622 South Broad Street, Mobile, Alabama, Groundwater Incident No. GW 07-01-02* (SAIC 2013) for Organizational Maintenance Shop (OMS) 28 located at the Brookley Aeroplex. This FS utilizes the nature and extent of risks posed by areas of contaminated media identified in the Remedial Investigation (RI) Report for OMS-28 and evaluates potential remedial options as contracted within the scope of work under contract number W91278-10-D-0089, delivery order number 0004. The RI Report recommended an FS to evaluate alternatives for addressing contamination in groundwater that resulted from residual constituents in the soil at OMS-28. The conclusions and recommendations of the RI Report were accepted by the Alabama Department of Environmental Management (ADEM) in correspondence dated August 8, 2013 (ADEM 2013).

The study was performed in accordance with the U. S. Environmental Protection Agency's (EPA's) *Guidance for Conducting Remedial Investigations and Feasibility Studies Under the Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA)* (EPA 1988b). The evaluations were based upon information generated from past site activities, as documented in the RI Report for OMS-28 (SAIC 2013).

In preparing this report, Leidos relied on written information provided by secondary sources, including information provided by the customer. Because the assessment consisted of evaluating a limited supply of information, Leidos may not have identified all potential items of concern and/or discrepancies and, therefore, warrants only that the project activities under this contract have been performed within the parameters and scope communicated by USACE, Mobile District and reflected in the contract. Leidos made no independent investigations concerning the accuracy or completeness of the information relied upon.

1.1 PURPOSE OF THE REPORT

The purpose of an FS is to develop the most appropriate and effective range of contaminated media management options that ensure the protection of human health and the environment at a contaminated site (EPA 1988b). Options are evaluated based upon site characteristics, remediation goals, and the performance of remedial technologies. Assessment of the remedial alternatives involves the consideration of any or a combination of the following options (EPA 1988b):

- Complete elimination or destruction of hazardous substances at the site,
- Reduction of concentrations of hazardous substances to acceptable health-based levels, and/or
- Prevention of exposure to hazardous substances via engineering or institutional controls.

This FS summarizes the results of the RI Report for OMS-28 at the Brookley Aeroplex. The objectives of the RI Report for OMS-28 were to: (1) summarize all the historical information about the site in a concise document, (2) present the results of the soil and groundwater investigations at the site, and (3) summarize the Alabama risk-based corrective action (ARBCA) evaluation presented in Appendix M of the RI Report for OMS-28 (SAIC 2013).

This FS was prepared utilizing data summarized in the RI Report for OMS-28 and presented in other historical reports. The data influenced the development of remedial alternatives for groundwater in this FS, which, in turn, will support an informed risk management decision.

1.2 ORGANIZATION OF THE REPORT

This FS is organized in accordance with EPA's Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA) RI/FS guidance (1988b), as well as applicable USACE guidance. Below is a summary of the components of the report and appendices.

- Chapter 1.0 provides summary background information, including site description, history, site conditions, nature and extent of contamination, fate and transport, and risk assessment, for OMS-28.

- Chapter 2.0 outlines the development of remedial action objectives (RAOs), describes general response actions (GRAs), and describes the identification and screening of technology types and process options considered for possible use in remediation.

- Chapter 3.0 summarizes potential federal and state chemical-, location-, and action-specific applicable or relevant and appropriate requirements (ARARs) for the possible remedial actions.

- Chapter 4.0 develops remedial alternatives from technologies and process options that passed initial screening.

- Chapter 5.0 presents the detailed and comparative analyses of viable remedial action alternatives developed to address chemicals and media of concern using the seven criteria specified by EPA CERCLA guidance.

- Chapter 6.0 provides a list of references used to develop this report.

- Appendices:
  - Appendix A contains detailed cost estimates.
  - Appendix B contains preliminary fate and transport modeling.

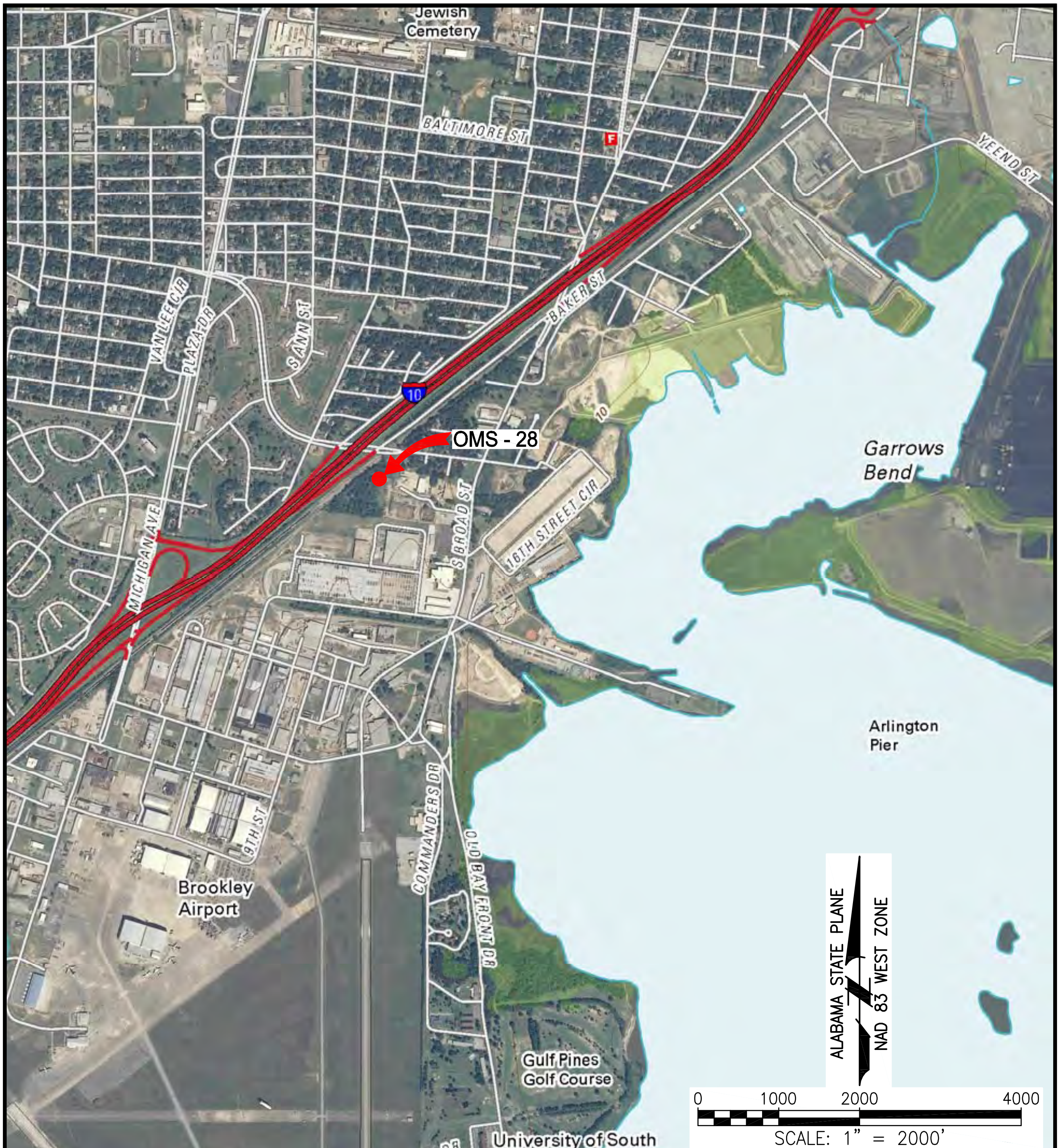
1.3 SITE DESCRIPTION, BACKGROUND, AND HISTORY

1.3.1 Site Description

OMS-28 is located in Mobile County, near downtown Mobile at 1622 South Broad Street, between Interstate 10 and Mobile Bay. The subject property is located in Section 1, Township 4 South, Range 1 West, and at approximate location Longitude 88°03'42" West and Latitude 30°39'11" North within the Brookley Aeroplex (Figure 1-1). The OMS-28 site is surrounded by Interstate 10 to the west and north, the Fort Floyd A. McCorkle Alabama Army National Guard (ALARNG) facility building to the east, and Hood Distribution and SpillTech, Inc. to the south on O'Donoghue Street.

The Brookley Aeroplex, formerly the Brookley Field Industrial Complex, includes runways and maintenance areas for aircraft, underground and aboveground fuel storage facilities, associated buildings, roads, housing, and landfills. No human consumption or agricultural wells are located within the boundaries of the Brookley Aeroplex.

The Brookley Aeroplex is designated by the Federal Aviation Administration as operating with a Part 139 certification. The property is now owned by the Mobile Airport Authority (MAA), an entity of the city of Mobile. The Brookley Aeroplex is currently the region's largest industrial park and is used as an airport by the MAA.



SOURCE:

UNITED STATES GEOLOGICAL SURVEY, MOBILE, AL, 2011.

KEY MAP:
NOT TO SCALE

leidos

FIGURE 1-1
SITE LOCATION MAP

OMS - 28
ALABAMA ARMY NATIONAL GUARD
MOBILE, ALABAMA

DRAWN BY:	REV. NO./DATE:	CAD FILE:
R. BEELER	0/10-04-13	/11013/DWGS/L83_LOCA-01

1.3.2 Site Background and History

Four underground storage tanks (USTs) were removed from three separate locations (Pit 1, Pit 2, and Pit 3) at the OMS in 1992. According to the ALARNG, Pit 1 and Pit 3 were clean-closed following the tank removal, and no subsequent investigations were required after the closure. The chlorinated solvents plume was discovered at OMS-28 during one of the investigations associated with Pit 2.

A single 2,000-gal gas/diesel UST at Pit 2 was removed in October 1992. Following the removal of the UST, a preliminary investigation was performed by USACE for Pit 2 in October 1993, and the report was submitted to the ADEM. The preliminary investigation did not fully determine the extent of petroleum contamination in soil or groundwater. A secondary investigation of Pit 2 was completed in December 1994, which established the extent of petroleum contamination in soil and groundwater at the site. The 1994 secondary investigation was followed by quarterly groundwater monitoring for petroleum contamination beginning in 1995.

In 2004 and 2005, Bechtel-S performed additional site characterization because groundwater monitoring indicated that petroleum-related contamination had extended beyond the network of monitoring wells installed during the original 1994 secondary investigation. The results were reported in the *Secondary Investigation Addendum Report, OMS #28 – Pit #2, Alabama National Guard OMS, 1622 South Broad Street, Mobile, Alabama, Facility ID#: 14587-097-012257, UST Incident #93-02-15* (Bechtel-S 2005a). During sampling for the Secondary Investigation Addendum Report in November 2004, the benzene, toluene, ethylbenzene, and xylenes reporting limits for MW-8 were higher than the other groundwater samples due to the dilution (by the laboratory) of this sample by a factor of 20. It was later determined that the dilution was required due to the interference by trichloroethene (TCE) in the sample. The TCE was not related to the gasoline/diesel fuel tank being investigated and was believed to be the result of a localized solvent spill located approximately 200 ft west-northwest of Pit 2. No other groundwater samples collected during that event required dilution by the laboratory.

In March 2005, all of the monitoring wells (MW-1, MW-2, MW-3, MW-5, MW-6, MW-7, and MW-8) that had been installed to delineate the extent of contamination around Pit 2 were sampled and analyzed for full-suite volatile organic compounds (VOCs). With the exception of monitoring well MW-8, TCE was not detected in the groundwater samples collected from the monitoring wells. TCE was detected in the groundwater samples collected from monitoring well MW-8 and its duplicate at concentrations of 460 and 430 µg/L, respectively, which were above the maximum contaminant level (MCL) of 5 µg/L. *cis*-1,2-Dichloroethene (DCE) was the only other VOC detected in the groundwater sample collected from monitoring well MW-8 and its duplicate at concentrations of 11 and 10 µg/L, respectively, which were below the MCL of 70 µg/L. No other contaminants exceeded ADEM initial screening limits in the groundwater samples submitted for analysis.

1.3.3 Previous Investigations

The original petroleum-focused investigations centered on the contamination associated with the UST located at Pit 2. The UST-related investigations performed are documented in the following reports:

- *UST Closure Site Assessment Report, The Amory Commission of Alabama OMS #28 and 29 – Pit #1, Pit #2 and Pit #3* (CWA 1992).

- *Preliminary Investigation Report, OMS #28 Pit #2* (PELA 1993).

- *Underground Storage Tank Secondary Investigation Report, Alabama National Guard Armory OMS #28 and 29 - Pit #2* (PELA 1994).

- Secondary Investigation Addendum Report (Bechtel-S 2005a).

The chlorinated solvents investigations performed following the discovery of TCE in MW-08 in 2005 are documented in the following reports:

- *TCE Comprehensive Investigation at the Organizational Maintenance Shop 28 (OMS-28), Alabama Army National Guard, 1622 South Broad Street, Mobile, Alabama, Groundwater Incident No. GW 07-01-02* (Aerostar 2007).

- *Supplemental Comprehensive Investigation Report for the Alabama Army National Guard (ALARNG) Organizational Maintenance Shop 28 (OMS-28), 1622 South Broad Street, Mobile, Alabama, Groundwater Incident No. GW 07-01-02* (Aerostar 2008).

- *Supplemental Comprehensive Investigation Groundwater Monitoring Report for the Alabama Army National Guard (ALARNG) Organizational Maintenance Shop 28 (OMS-28), 1622 South Broad Street, Mobile, Alabama, Groundwater Incident No. GW 07-01-02* (Aerostar 2009a, 2009b, 2009c, 2010, 2011).

- *Revision 2 Remedial Investigation Report for the Alabama Army National Guard (ALARNG) Organizational Maintenance Shop 28 (OMS-28), 1622 South Broad Street, Mobile, Alabama, Groundwater Incident No. GW 07-01-0* (SAIC 2013).

1.4 SITE CONDITIONS

1.4.1 Physiography and Topography

The Brookley Aeroplex is located within Mobile County. Much of the land in Mobile County is used for industrial and agricultural purposes. Large areas along the Mobile and Tensaw Rivers and along the coast are characterized by low-lying, swampy terrain and brackish water. The Brookley Aeroplex is included in this area. The Brookley Aeroplex lies entirely within the East Gulf Coastal Plain physiographic section, Alluvial-Deltaic Plain District and Coastal Lowlands District.

The Brookley Aeroplex is relatively flat with an elevation of 20 to 30 ft above mean sea level (AMSL) (SAIC 2013). OMS-28 is located in the northeast corner of the Brookley Aeroplex where the elevations are closer to 30 ft AMSL.

1.4.2 Climate

The climate for the Mobile area is wet and subtropical. Temperatures typically range from the low 40's on winter nights to the low 90's on summer days. Precipitation ranges from 2.9 to 7.0 in. per month. The wettest months are March, July, and August. The average annual precipitation is 64 in. Wind speeds range from 6.9 to 10.5 miles per hour.

1.4.3 Surface Water Hydrology

According to the *Remedial Investigation Report, The Former Brookley Air Force Base, Mobile, Alabama* (Kevric 2004), the Brookley Aeroplex is part of the Mobile Bay Watershed. The fluvial drainage area of this watershed encompasses nearly two-thirds of the state of Alabama and crosses into Georgia, Mississippi, and Tennessee. This coastal lowlands aquifer system, according to the EPA State Health Evaluation (EPA 1999), has an Index Watershed Indicator of "Less Serious Water Quality Problems (Low Vulnerability to Stressors such as Pollutant Loading)." Furthermore, ADEM's 2010 Alabama

Unified Watershed Assessment classified parts of Mobile Bay as Category 1 – "waters that are attaining all applicable water quality standards" or Category 5 – "waters in which a pollutant has caused or is suspected of causing impairment" (ADEM 2010b). The Category 1 classification was associated with Mobile County. The Baldwin County portion of Mobile Bay received the Category 5 classification. These findings sited beach monitoring data where pathogen exceedances occurred in more than 10% of the samples in 2008 and 2009 due to a collection system failure.

At OMS-28, there are no current surface water body features within a 1,000-ft radius of the site (SAIC 2013). Surface flow from stormwater run-off across the site varies due to surface grade, vegetation, and porous surface medium.

1.4.4 Site Geology and Site Hydrogeology

According to the RI Report for OMS-28 (SAIC 2013), the general site geology with some exceptions is as follows:

- Ground surface to approximately 5 ft below ground surface (BGS) is a silty clay loam.
- Beginning at approximately 5 ft BGS, medium-grained sands, silty sands, and clayey sands were encountered in various borings.
- Beginning at depths ranging between 16 and 35 ft BGS, a gray stiff clay was encountered, which continued to a depth of 70 to 84 ft BGS.
- At depths ranging between 70 and 84 ft BGS, a coarse-grained sand was encountered. In the exploratory boring, the coarse-grained sand ended at 90 ft BGS where clayey sand extended to a depth of 104 ft BGS. Sandy clay and silty clay were encountered from 104 ft BGS to boring termination depth at 120 ft BGS.

According to the Supplemental Comprehensive Investigation Groundwater Monitoring Report of January (Aerostar 2011), the groundwater flow direction at the OMS-28 site in September 2010 was estimated to be to the northwest. This flow direction is consistent with the flow direction determined during the previous sampling events conducted in March 2010, November 2009, and May 2009. The hydraulic gradient for the shallow surficial aquifer was 0.0120 ft/ft in May 2009, 0.0126 ft/ft in November 2009, and 0.0127 ft/ft in March 2010 (SAIC 2013). Based on historical data, groundwater was encountered at approximately 3 to 10 ft BGS depending on annual fluctuations (SAIC 2013). The average horizontal flow velocity was estimated to range between 2.8 and 4.5 ft/year (SAIC 2013). The average hydraulic conductivity (7.05 × 10-5 cm/sec) for the shallow surficial aquifer was based on slug test values provided in the UST ARBCA (Bechtel-S 2005b). Values of effective porosity range from 0.20 for silt to 0.32 for medium-grained sand; the value will vary depending on the silt and clay content.

1.4.5 Groundwater Use

According to the RI Report for OMS-28 (SAIC 2013), there are no water supply wells within a 1,000-ft radius of OMS-28. The use of groundwater in this area as a potable water source is unlikely due to its shallow nature, its proximity to Mobile Bay, and the fact that all residential water for drinking and other uses is provided by the public water supply system. Potable water is supplied to the OMS-28 facility through the city of Mobile municipal water supply. Private water supply wells in the Mobile area typically tap the deeper Miocene-Pliocene aquifer at approximately 100 ft BGS rather than the surficial groundwater encountered at the site (Bechtel-S 2005b). No future development of shallow groundwater on-site or on nearby off-site locations is likely because of the availability of public water supplies and the poor production potential of the surficial aquifer. Based on historical data, the water table appears to fluctuate between 3 and 10 ft BGS depending on seasonal/annual fluctuations. In 2010, the water table was closer to 5 ft BGS.

1.4.6 Demography and Land Use

The Brookley Aeroplex covers 1,700 acres and is home to more than 100 businesses employing approximately 3,700 people in 4.6 million ft^2 of industrial space. The Brookley Aeroplex is divided into two distinct land areas: the airfield and the industrial park. The airfield consists of runways, taxiways, aprons, and vacant land. It is bounded by a variety of uses, including residential areas, cemeteries, the National Guard, and the University of South Alabama. The industrial park, set between Interstate 10 and the airfield, stretches nearly 2 miles along the highway and contains lands occupied by aging industrial buildings and infrastructure. Industrial facilities at the Brookley Aeroplex are housed in two districts, which are the Aerospace District and the Industrial Park.

The Brookley Aeroplex Master Plan was introduced in 2003 and includes five development districts of identifiable, industrial neighborhoods, which are shown in Figure 1-2. The property north of the Brookley Aeroplex and located south of Duval Street is zoned residential.

- Aerospace – aerospace and aviation-related development.
- Light Industrial – light industrial/flex development, including owner-user and speculative products.
- Industrial/Infill/Incubator – small-scale industrial development with business incubator.
- Office/Research – office park/retail space development.
- Logistics/Manufacturing – development to compliment Mobile Container Terminal and Intermodal Container Transfer Facility growth.

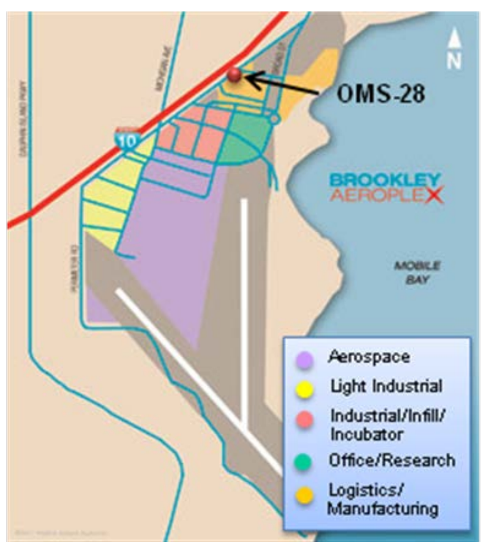


Figure 1-2. Brookley Aeroplex Land Use Map

1.4.7 Ecology

The U. S. Fish and Wildlife has listed several species of concern (candidate, recovery, endangered, or threatened) that are known or are believed to occur in Mobile County, which include the bald eagle (*haliaeetus ieucocephalus*), wood stork (*mycteria americana*), piping plover (*charadrius melodus*), gulf sturgeon (*acipenser oxyrinchus desotoi*), West Indian manatee (*trichechus manatus*), hawksbill sea turtle (*Eretmochelys imbricata*), leatherback sea turtle (*dermochelys coriacea*), kemp's ridley sea turtle (*lepidochelys kempii*), green sea turtle (*chelonia mydas*), loggerhead sea turtle (*caretta caretta*), Alabama red-belly turtle (*Pseudemys alabamensis*), eastern indigo snake (*drymarchon corais couperi*), black pine snake (*pituophis melanoleucus lodingi*), and gopher tortoise (*gopherus polyphemus*) (SAIC 2013).

Critical habitats for the piping plover, gulf sturgeon, West Indian manatee, hawksbill sea turtle, leatherback sea turtle, and green sea turtle are located at the mouth of Mobile Bay and not located within 2 miles of Brookley Aeroplex. No known ecological survey has been conducted at the Brookley Aeroplex since the ecological reconnaissance conducted as part of the Former Brookley AFB RI activities in the early 2000s. According to the U. S. Fish and Wildlife, no threatened or endangered species have been reported or confirmed on the property. The gopher tortoise, which is an upland species, is scattered in small numbers across Mobile County and may be present on or near the site (Everson 2012).

At OMS-28, the surface features consist of vegetative cover comprised of oak trees, scrub trees, grasses, and brush (SAIC 2013). No structures are present on the OMS-28 site (i.e., on the source soil or over the groundwater plume). The ALARNG facility building is located approximately 250 ft east of the site. The nearest residential structure is approximately 250 ft northeast of the site.

1.5 NATURE AND EXTENT OF CONTAMINATION

1.5.1 Soil

Fifteen VOCs (2-butanone; acetone; bromomethane; carbon disulfide; chloroform; *cis*-1,2-DCE; isopropylbenzene; methyl acetate; methylcyclohexane; methylene chloride; naphthalene; tetrachloroethene [PCE]; toluene; TCE; and trichlorofluoromethane) were detected sporadically in the 61 soil samples across the 27 locations with no discernible trends between 2006 and 2008. The concentrations of constituents were below their respective residential and industrial EPA regional screening levels (RSLs) (May 2012). The concentrations of four VOCs (*cis*-1,2-DCE; methylene chloride; PCE; and TCE) exceeded their respective protection of groundwater soil screening levels (SSLs). Of these, TCE and PCE were considered the primary chemicals of concern (COCs) exceeding the protection of groundwater SSLs.

Sixteen semivolatile organic compounds (acenaphthene, acenaphthylene, anthracene, benzo[a]anthracene, benzo[a]pyrene, benzo[b]fluoranthene, benzo[g,h,i]perylene, benzo[k]fluoranthene, bis[2-ethylhexyl]phthalate, carbazole, chrysene, fluoranthene, fluorene, indeno[1,2,3-cd]pyrene, phenanthrene, and pyrene) were detected in the soil samples. The concentrations of four polycyclic aromatic hydrocarbons (PAHs) exceeded their respective residential and industrial RSLs. In addition, all PAH detections were in surface soil and were outside the boundary of the ALARNG property and are not thought to be attributable to ALARNG activities.

There are three areas of PCE and/or TCE in soil that may be acting as a residual source for the TCE and PCE groundwater plumes. The largest area of soil concentrations exceeding the protection of groundwater SSLs is located in the vicinity of MW-8, and the area exceeding the protection of groundwater SSL for TCE and PCE is approximately 60 by 60 ft. The vertical extent of PCE and/or TCE in soil is located throughout the unsaturated zone from ground surface to the water table observed during drilling at approximately 15 ft BGS. However, concentrations in the area of MW-8 are below the residential RSLs for TCE and PCE. The TCE concentrations in soil samples from HA-01, HA-02, HA-03, HA-06, HA-07, HA-08, HA-12, HA-14, HA-15, OMS-28-3, OMS-28-4, OMS-28-5, and OMS-28-6 exceeded the protection of groundwater SSL of 0.0018 mg/kg but were less than the residential RSL of 0.91 mg/kg. The PCE concentrations in soil samples from HA-05, HA-07, and HA-13 exceeded the protection of groundwater SSL of 0.0023 mg/kg but were less than the residential RSL of 22 mg/kg. OMS-28-3 is located 60 ft north of MW-8, and the TCE concentration was 0.211J mg/kg at 10 to 15 ft BGS. OMS-28-4 is located 130 ft northwest of MW-8, and the TCE concentration was 0.027 mg/kg at 10 to 15 ft BGS. The concentrations in OMS-28-3 and OMS-28-4 at 10 to 15 ft BGS exceeded the protection of groundwater SSL for TCE. The precise location of these samples collection is unknown for these two samples but is probably from just above the water table. It is probable that contaminated groundwater trapped in the capillary fringe above the water table may have contributed to the exceedances.

Two smaller isolated areas of PCE and/or TCE in soil exceeding the protection of groundwater SSLs are located approximately 200 ft northwest of MW-8 at soil sample location B-17 on MAA property and approximately 250 ft west of MW-8 at soil sample location B-13 on MAA property. The PCE concentrations in surface and subsurface soil samples from B-17 exceeded the protection of groundwater SSL of 0.0023 mg/kg but were below the residential RSL of 22 mg/kg. The area exceeding the protection of groundwater SSL around B-17 is estimated to be 15 by 20 ft. The vertical extent of PCE concentrations in the vicinity of B-17 extends to at least 10 ft BGS; however, it probably extends deeper as the vertical extent was not delineated in B-17. The TCE concentration in the surface soil sample from B-18 exceeded the protection of groundwater SSL of 0.0018 mg/kg but was below the residential RSL of 0.91 mg/kg. The area exceeding the protection of groundwater SSL around B-13 is estimated to be 15 by 15 ft. The vertical extent of TCE concentrations in soil at B-13 does not extend any deeper than 6 ft BGS.

The concentrations of TCE and PCE in the vicinity of MW-8 and at the two smaller isolated locations in the vicinity of B-17 and B-13 were below the residential and industrial RSLs for TCE and PCE.

1.5.2 Groundwater

Eighteen VOCs (1,2-dichloroethane; acetone; benzene; *cis*-1,2-DCE; chloroform; chloromethane; cyclohexane; ethylbenzene; isopropylbenzene; methylcyclohexane; methylene chloride; naphthalene; PCE; toluene; TCE; total xylenes; *trans*-1,2-DCE; and vinyl chloride [VC]) were detected in groundwater during the investigations from 2006 through 2008. The concentrations of 1,2-dichloroethane; benzene; *cis*-1,2-DCE; chloroform; ethylbenzene; naphthalene; PCE; TCE; VC; and total xylenes exceeded their respective EPA tap water RSLs. However, by September 2010, only the concentrations of *cis*-1,2-DCE; PCE; and TCE exceeded their respective EPA tap water RSLs. The concentrations of TCE and PCE exceeded their respective MCLs. In September 2010, TCE was detected in three shallow wells (MW-8, OMS-28-3, and OMS-28-5). TCE was not detected in the remaining shallow wells (MW-5, MW-6, MW-9, MW-12, OMS-28-2, and OMS-28-7), which delineate the horizontal extent of the plume boundary. TCE was not detected in the three deep wells (OMS-28-1, OMS-28-4, and OMS-28-6). PCE was detected in one shallow well (OMS-28-5) and was not detected in the other shallow wells or in the deep wells. Based on the results of the September 2010 sampling event and the 2006 Phase I and II temporary wells, there appears to be a TCE plume and a PCE plume. The PCE may have already degraded in the vicinity of MW-8 and is no longer being observed in that part of the TCE plume.

Vertical migration of the contaminants is limited by a stiff, dense clay that is located at 30 ft BGS. Above the stiff clay is a sandy clay or clayey sand, which also limits vertical migration. The vertical extent of groundwater contamination is determined by vertical groundwater sample delineation from deep wells OMS-28-4 and OMS-28-6, which are located within the boundary of the TCE plume. These deep wells did not indicate the presence of contamination during the six consecutive groundwater sampling events between 2008 and 2010.

The estimated dimension of the groundwater TCE plume is 320 by 120 ft and of the PCE plume is 100 by 65 ft. The estimated length of the TCE plume does not account for biodegradation of the TCE that has been occurring in the subsurface; however, MW-11 was abandoned at the private property owner's request and, therefore, the well has not been resampled to verify that the TCE concentrations have decreased. Based on the depth of the screens in the shallow wells, the vertical depth of the plumes extends to approximately 20 ft BGS. However, the possibility exists that the plume may extend to the top of the stiff clay, which is 30 to 35 ft BGS. The TCE plume is an elliptical feature oriented to the northwest from the larger area of soil concentrations centered around MW-8 on OMS-28 property onto MAA property to the west. The PCE plume is an elliptical feature oriented to the northwest located near the smaller area of soil concentrations in the vicinity of B-17 on the MAA property. A review of the groundwater data from the shallow wells over six consecutive groundwater sampling events has demonstrated that the horizontal extent of the groundwater plumes remains relatively stable (i.e., they are no longer expanding).

1.6 FATE AND TRANSPORT

VOCs were the primary constituents detected in soil samples exceeding protection of groundwater SSLs. VOCs were the only constituents in groundwater observed in significant quantities above MCLs. The presence of PCE; TCE; and *cis*-1,2-DCE in the unsaturated soil at concentrations above SSLs protective of groundwater serves as a continuing source of groundwater contamination. Once these contaminants enter the subsurface, there are several mechanisms that affect the overall fate and transport in the environment.

- Leaching is a concern because of the potential for a chemical to move through the soil and contaminate the groundwater.
- Diffusion is the process by which a contaminant in water will move from an area of greater concentration toward an area where it is less concentrated.
- Advection is the movement of dissolved solute with flowing groundwater.
- Mechanical dispersion or mixing occurs because, as contaminated groundwater travels through the stratum, the fluid does not travel all at the same velocity.
- Adsorption of a solute onto an aquifer material (e.g., clay) results in a reduction of concentration in the aqueous phase and a retardation of the velocity of contaminant migration.
- Degradation of contaminants is an important factor in evaluating the fate and transport.

The most important process for the natural biodegradation of the more highly chlorinated solvents, PCE and TCE, is reductive dechlorination. In general, reductive dechlorination occurs by sequential dechlorination from PCE to TCE to DCE to VC to ethene. Of these compounds, PCE is the most susceptible to reductive dechlorination because it is the most oxidized. Conversely, VC is the least susceptible to reductive dechlorination because it is the least oxidized of these compounds.

1.7 RISK ASSESSMENT

The maximum concentrations of PCE and TCE exceeded the 2008 residential Alabama preliminary screening values (PSVs); therefore, PCE and TCE were identified as COCs in the ARBCA in Appendix M of the RI Report (SAIC 2013). Current and future use of the site includes commercial and occasional construction workers. A trespasser could be a potential receptor. There are residential homes within 500 ft of the site boundary. For the purpose of evaluating a future residential use of the site as unrestricted, the resident adult and resident child were considered in the evaluation. As a result, the receptors evaluated in the ARBCA in Appendix M of the RI Report (SAIC 2013) were the commercial worker-adult, construction worker-adult, trespasser (adolescent), resident child (within 500 ft), and resident adult (within 500 ft).

The results of the ARBCA Risk Management (RM)-1 evaluation using default parameters did not identify a cumulative risk that exceeded appropriate risk levels for a commercial worker, construction worker, or trespasser. However, under the future use scenario of unrestricted use (i.e., residential scenario), there is a cumulative risk that exceeds risk levels for a resident child or resident adult for exposure to groundwater.

The results of the ARBCA RM-2 evaluation using default and site-specific fate and transport parameters did not identify a cumulative risk that exceeded appropriate risk levels for a commercial worker, construction worker, or trespasser. However, under the future use scenario of unrestricted use (i.e., residential scenario), there is a cumulative risk that exceeds risk levels for a resident child or resident adult who may ingest groundwater. The ARBCA in Appendix M of the RI Report (SAIC 2013) recognizes risk when the cumulative risk value is greater than 1E-05 and a hazard index (HI) is greater than 1.0. RM-2 risk-based target levels (RBTLs) were calculated for those receptors where a cumulative risk or HI exists. For the resident child, the cumulative risk is 7.04E-04 and the HI is 3.22. For the resident adult, the cumulative risk is 1.51E-03 and the HI is 1.38.

Currently, there is no risk to receptors (i.e., commercial worker, construction worker, or trespasser) under the current land use scenario. However, RBTLs for corrective action were developed to achieve a future use scenario of unrestricted use (i.e., residential scenario). To eliminate the exposure risk to groundwater under the residential scenario, the calculated RBTLs were 2.3 µg/L (TCE) and 3.32 µg/L (PCE) for the residential child and 1.07 µg/L (TCE) and 1.55 µg/L (PCE) for the residential adult. These RBTLs are lower than the EPA MCLs of 5 µg/L for TCE and 5 µg/L for PCE.

For protection of groundwater use without biodegradation, the RM-2 model identified allowable concentrations of TCE at the soil source, groundwater source (i.e., MW-8), sentry well (i.e., MW-8), and hypothetical well for potential exposure (i.e., located approximately 155 ft from the downgradient edge of the soil source). To be protective at the hypothetical well for potential exposure, allowable concentrations for TCE were identified as 1.12 mg/kg at the soil source, 25.8 µg/L at the groundwater source/sentry well, and 5.0 µg/L at the hypothetical well for potential exposure. Allowable concentrations for PCE were identified as 1.16 mg/kg at the soil source, 25.8 µg/L at the groundwater source/sentry well, and 5.0 µg/L at the hypothetical well for potential exposure. If the future potential point of exposure is the source, then the MCL of 5.0 µg/L will be the allowable concentration of TCE or PCE at MW-8.

Current use of the site is acceptable for the commercial worker, construction worker, and trespasser. Future residents may be at risk if ingestion of groundwater was to occur at a hypothetical well for potential exposure.

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2.0 IDENTIFICATION AND SCREENING OF REMEDIAL APPROACHES

2.1 REMEDIAL ACTION OBJECTIVES

RAOs are based on an assessment of the threat to human health as evaluated in the RI Report for OMS-28 (SAIC 2013). The contaminated medium at OMS-28 is groundwater. PCE and TCE were identified as COCs in groundwater. Surface water and sediment are not present at the site.

The results of the ARBCA RM-2 evaluation using default and site-specific fate and transport parameters did not identify a cumulative risk that exceeded appropriate risk levels for a commercial worker, construction worker, or trespasser. However, a cumulative risk exceeding risk levels is present for an unrestricted future use scenario for a resident child or resident adult who may ingest groundwater. The ARBCA presented in Appendix M of the RI Report (SAIC 2013) recognizes risk when the cumulative risk value is greater than 1E-05 and an HI is greater than 1. The cumulative risk for a resident child is 7.04E-04 and the HI is 3.22. The cumulative risk and HI for a resident adult are 1.51E-03 and 1.38, respectively. Therefore, based on the findings of the RI Report for OMS-28, the RAOs are as follows:

- Prevent human ingestion of groundwater containing TCE, PCE, or their degradation products in concentrations above their respective federal MCLs (where available).

- Restore the properties that are not owned by the ALARNG to unlimited use and unrestricted exposure condition.

No action is warranted for soil as concentrations do not pose a risk to human health receptors.

2.2 REMEDIATION LEVELS

Remediation levels (RLs) to achieve the human health RAOs were developed for groundwater to guide remediation efforts. Table 2-1 contains the possible groundwater remedial goal options and the selected RLs for groundwater at OMS-28. The RBTLs listed for the resident child and resident adult were calculated in the ARBCA RM-2 evaluation presented in Appendix M of the RI Report (SAIC 2013), which was summarized in Section 1.7. Future residents may be at risk if ingestion of groundwater was to occur at a hypothetical well for potential exposure. The maximum allowable concentration for PCE and TCE was identified as 5.0 µg/L at the hypothetical well for potential exposure in the ARBCA RM-2 evaluation. In accordance with 40 *Code of Federal Regulations* (*CFR*) Section 300.430(e)(2)(i)(B), the MCL of 5.0 µg/L has been selected as the RL for TCE and PCE in groundwater.

2.3 EXTENT OF REMEDIAL ACTION

The sizes of the TCE and PCE groundwater plumes with concentrations exceeding RLs (i.e., 5 µg/L for each COC) have been estimated based on the groundwater sampling results shown on Figure 2-1. The PCE contaminant plume (exceeding 5 µg/L) based on 2010 groundwater results covers approximately 5,000 ft^2. The TCE contaminant plume (exceeding 5 µg/L) based on 2010 groundwater results covers approximately 17,000 ft^2. The maximum area of the 2006 TCE contaminant plume covers approximately 83,500 ft^2 assuming the full extent extends to the wells where concentrations were non-detect. Between 2006 and 2010, an overall decreasing trend in the PCE and TCE concentrations is evident in the wells within the

Table 2-1. Groundwater Remedial Goal Options and Selected RLs

Analyte	Unit	Maximum Detect Historical Sampling[a] (2005 to 2010)	Maximum Detect September 2010 Monitoring Event[b]	MCL	Resident Child RBTL[c]	Resident Adult RBTL[c]
Groundwater						
PCE	µg/L	234 (OMS-28-05, 05/09)	33 (OMS-28-05)	**5**	3.32	1.55
TCE	µg/L	460 (MW-8, 03/05)	149 (OMS-28-03)	**5**	2.3	1.7

[a] Historical sampling was conducted during the TCE comprehensive investigation and supplemental comprehensive investigation groundwater monitoring that were documented in the Remedial Investigation Report for Organizational Maintenance Shop-28 (SAIC 2013).
[b] Most recent sampling event in which groundwater analytical data are available.
[c] Risk Management-2 cleanup levels (Appendix M of the RI Report, SAIC 2013).
Bold indicates the selected RL.
MCL = Maximum contaminant level. RL = Remediation level.
PCE = Tetrachloroethene. TCE = Trichloroethene.
RBTL = Risk-based target level.

plume boundary, with periodic spikes in concentrations followed by decreasing concentrations; Table 2-1 illustrates the difference in PCE and TCE maximum concentrations detected prior to 2010 and in September 2010. Active remediation will be focused within the boundaries of the 2010 TCE and PCE plumes, and natural attenuation will be relied upon to continue contaminant degradation outside these boundaries. Additional wells will be required closer to the 2010 plume boundaries to document that natural attenuation is taking place and may be required within the plume to evaluate the effectiveness of treatment.

2.4 GENERAL RESPONSE ACTIONS

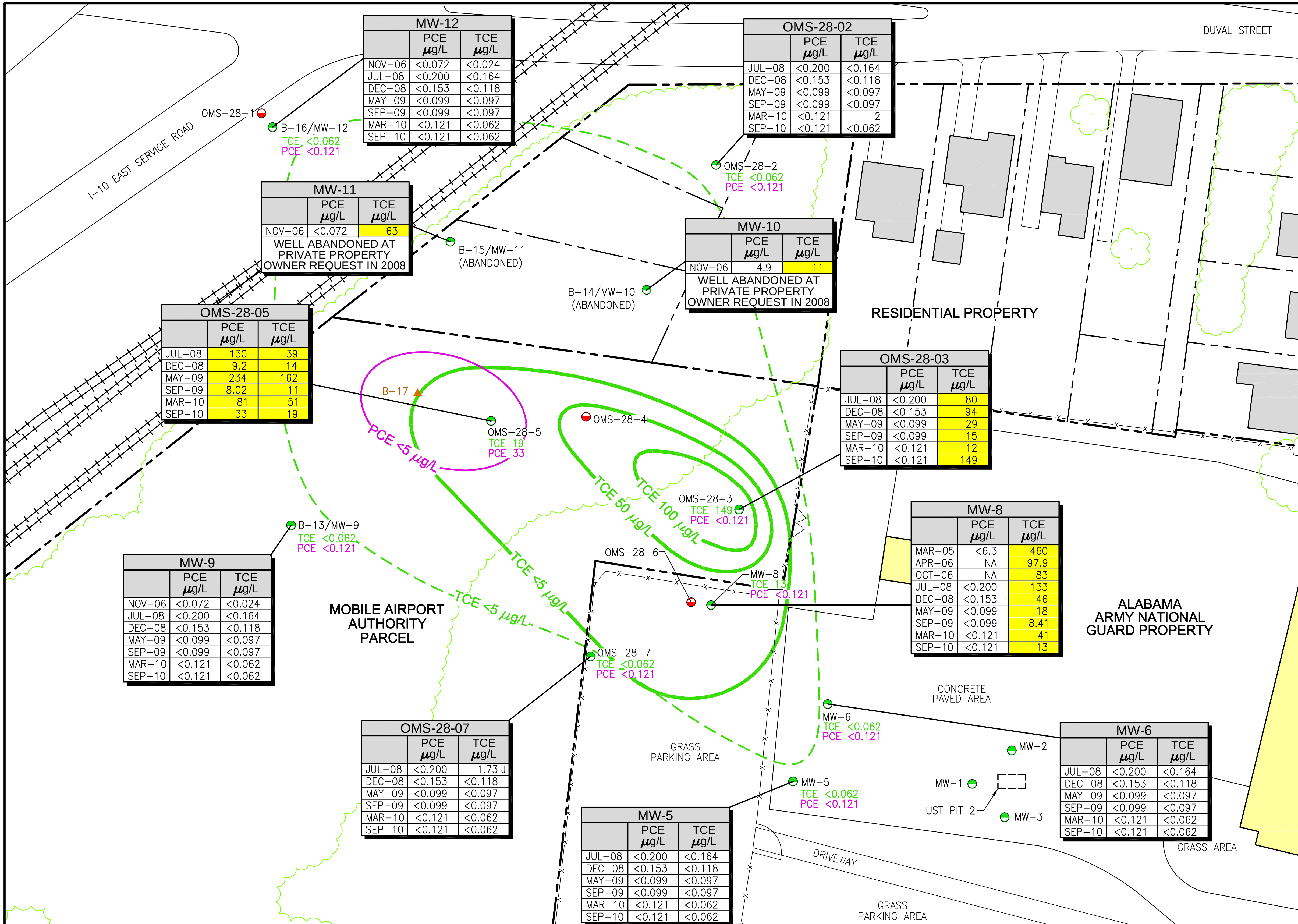
GRAs describe those actions that will satisfy the RAO(s) (EPA 1988b). GRAs may include treatment, removal, containment, and institutional controls. In addition, a no action response is required by the National Oil and Hazardous Substances Pollution Contingency Plan (NCP; EPA 1990) to provide a baseline against which the other alternatives can be compared. The following GRAs were considered in response to contaminated groundwater at OMS-28:

- no action,
- institutional controls,
- containment,
- treatment,
- removal,
- disposal, and
- monitored natural attenuation (MNA).

These GRAs are described below.

2.4.1 No Action

No action is required for evaluation under the NCP and is the baseline to which other remedial alternatives are compared. No action may provide an appropriate alternative if no unacceptable risks are present at the site. This GRA provides a baseline against which to compare other, more proactive alternatives. No action is taken at the site to reduce any hazard to human health or the environment. Any existing actions, such as restrictions or monitoring, are discontinued.



MW-12

	PCE µg/L	TCE µg/L
NOV-06	<0.072	<0.024
JUL-08	<0.200	<0.164
DEC-08	<0.153	<0.118
MAY-09	<0.099	<0.097
SEP-09	<0.099	<0.097
MAR-10	<0.121	<0.062
SEP-10	<0.121	<0.062

OMS-28-02

	PCE µg/L	TCE µg/L
JUL-08	<0.200	<0.164
DEC-08	<0.153	<0.118
MAY-09	<0.099	<0.097
SEP-09	<0.099	<0.097
MAR-10	<0.121	2
SEP-10	<0.121	<0.062

MW-11

	PCE µg/L	TCE µg/L
NOV-06	<0.072	63

WELL ABANDONED AT PRIVATE PROPERTY OWNER REQUEST IN 2008

MW-10

	PCE µg/L	TCE µg/L
NOV-06	4.9	11

WELL ABANDONED AT PRIVATE PROPERTY OWNER REQUEST IN 2008

OMS-28-05

	PCE µg/L	TCE µg/L
JUL-08	130	39
DEC-08	9.2	14
MAY-09	234	162
SEP-09	8.02	11
MAR-10	81	51
SEP-10	33	19

OMS-28-03

	PCE µg/L	TCE µg/L
JUL-08	<0.200	80
DEC-08	<0.153	94
MAY-09	<0.099	29
SEP-09	<0.099	15
MAR-10	<0.121	12
SEP-10	<0.121	149

MW-8

	PCE µg/L	TCE µg/L
MAR-05	<6.3	460
APR-06	NA	97.9
OCT-06	NA	83
JUL-08	<0.200	133
DEC-08	<0.153	46
MAY-09	<0.099	18
SEP-09	<0.099	8.41
MAR-10	<0.121	41
SEP-10	<0.121	13

MW-9

	PCE µg/L	TCE µg/L
NOV-06	<0.072	<0.024
JUL-08	<0.200	<0.164
DEC-08	<0.153	<0.118
MAY-09	<0.099	<0.097
SEP-09	<0.099	<0.097
MAR-10	<0.121	<0.062
SEP-10	<0.121	<0.062

OMS-28-07

	PCE µg/L	TCE µg/L
JUL-08	<0.200	1.73 J
DEC-08	<0.153	<0.118
MAY-09	<0.099	<0.097
SEP-09	<0.099	<0.097
MAR-10	<0.121	<0.062
SEP-10	<0.121	<0.062

MW-5

	PCE µg/L	TCE µg/L
JUL-08	<0.200	<0.164
DEC-08	<0.153	<0.118
MAY-09	<0.099	<0.097
SEP-09	<0.099	<0.097
MAR-10	<0.121	<0.062
SEP-10	<0.121	<0.062

MW-6

	PCE µg/L	TCE µg/L
JUL-08	<0.200	<0.164
DEC-08	<0.153	<0.118
MAY-09	<0.099	<0.097
SEP-09	<0.099	<0.097
MAR-10	<0.121	<0.062
SEP-10	<0.121	<0.062

LEGEND:

- RESIDENTIAL BUILDING
- COMMERCIAL BUILDING
- ASPHALT ROAD
- RAILROAD TRACKS
- CHAIN LINK FENCE
- PROPERTY BOUNDARY
- TREE LINE
- SHALLOW MONITORING WELL
- DEEP MONITORING WELL
- TCE CONTOUR (2006)
- TCE CONTOUR (SEPT 2010)
- PCE CONTOUR (SEPT 2010)
- CONTAMINATION EXCEEDING MCL

NOTES:

1. HISTORICAL LOCATIONS DIGITIZED FROM BASE MAP PROVIDED BY AEROSTAR ENVIRONMENTAL SERVICES INC. (AEROSTAR 2007).
2. MONITORING WELL LOCATIONS PROVIDED BY AEROSTAR ENVIRONMENTAL SERVICES INC. (AEROSTAR 2008).
3. MW-1, MW-2, MW-3 HAVE NOT BEEN ANALYZED FOR FULL SUITE VOCs, ONLY BTEX UNDER THE UST PROGRAM.

MAXIMUM CONTAMINANT LEVELS (MCLs) µg/L	
TCE	5
PCE	5

ALABAMA STATE PLANE NAD 83 WEST ZONE

0 30 60 120

SCALE: 1" = 60'

leidos

FIGURE 2-1.
HISTORICAL TCE AND PCE
GROUNDWATER QUALITY MAP

OMS - 28
ALABAMA ARMY NATIONAL GUARD
MOBILE, ALABAMA

DRAWN BY:	REV. NO./DATE:	CAD FILE:
R. BEELER	0/11-18-13	/11013/DWGS/L83_CHRT_GW-01

2.4.2 Institutional Controls

Institutional controls are measures taken to minimize the exposure of humans or ecological receptors to contaminated media. Such measures include access and use restrictions (e.g., restrictions on land use, groundwater use, or well drilling) and groundwater monitoring. The volume, mobility, and toxicity of contaminants are not reduced through the application of institutional controls; therefore, institutional controls alone will not achieve RAOs. Institutional controls will be evaluated to support or compliment other process options.

2.4.3 Containment

Containment technologies are applicable to a wide range of contaminants and reduce worker and short-term public risk to contaminated media. Construction of caps or covers is a containment technology that places surface barriers over contaminated soil and buried waste to prevent direct contact, to reduce erosion, and to reduce the amount of water that infiltrates through the waste. Isolation of contaminated groundwater may be accomplished by approaches such as installation of barriers that inhibit groundwater flow or by extraction of groundwater to prevent downgradient contaminant migration. Uncontaminated groundwater downgradient from a plume will be protected from intrusion of contaminants, thereby minimizing additional impact to the aquifer.

2.4.4 Treatment

Treatment is conducted either in-situ or ex-situ to reduce contaminant concentrations to acceptable levels. Common types of treatment include biological, chemical, physical, and thermal. Biological treatment involves using microbes to degrade contaminants. Chemical treatment processes add chemicals to react with contaminants to reduce their toxicity or mobility. Physical processes involve either physically binding the contaminants to reduce mobility or the potential for exposure or extracting the contaminant(s) from a medium to reduce volumes. Thermal treatment, such as incineration, uses high temperatures to volatilize, decompose, or melt contaminants. For media treated by ex-situ methods, the treatment may allow soil or groundwater to be placed back into the ground.

2.4.5 Removal

One of the simplest groundwater remediation techniques involves the installation of groundwater recovery wells placed within or at the downgradient end of a contaminant plume. The groundwater in a well is pumped to the surface using a submersible groundwater pump, generating a continuous drawdown for hydraulic control of the plume. Intercepted groundwater is usually transported to a waste water or groundwater treatment system for treatment prior to discharge or re-injection. The relative partitioning of the contaminants between soil and groundwater phases and the mobility of the groundwater through the soil will determine the length of time the pumping system must be operated and, thus, the system operation and maintenance (O&M) costs. Groundwater recovery is effective for plume containment and control. However, it is generally inefficient and very time consuming as a pump and treat system. Groundwater recovery is an expensive approach to plume and source area remediation because of the slow dissolution of sorbed contaminant mass.

Removal technologies would excavate the contaminated soil and move the resulting waste to an alternate location for treatment and/or disposal. Mechanical excavation generally uses a variety of conventional excavation equipment, such as excavators, track loaders, and front-end loaders of differing sizes. Due to the expected depth of excavation and limited overall volume of contaminated soil, the excavated soil would likely be placed directly into lined and/or covered dump trucks or roll-off containers for transport to the ultimate treatment, storage, and disposal facility.

2.4.6 Disposal

Disposal involves the final and permanent placement of waste material in a manner protective of human health and the environment. The impacted media are disposed on-site in an engineered facility or off-site in a permitted or licensed facility, such as a regulated landfill. Similarly, concentrated waste resulting from treatment processes is disposed on-site in a permanent disposal cell or off-site in an approved disposal facility. Transportation is accomplished utilizing various methods, including truck, railcar, and/or barge.

2.4.7 Monitored Natural Attenuation

Natural attenuation is the reduction in the concentration and mass of a contaminant due to naturally occurring physical, chemical, and biological processes unaided by human intervention. These processes take place whether or not other active cleanup measures are in place; however, the right conditions must exist underground for natural attenuation to be a viable alternative for remediation. MNA includes regular monitoring of site conditions and contaminant concentrations to ensure that people and the environment are protected during the natural attenuation process.

2.5 IDENTIFICATION AND SCREENING OF TECHNOLOGIES

2.5.1 Initial Screening of Technologies

Table 2-2 presents the initial screening of technologies for possible remedial action in response to contaminated groundwater at OMS-28. This table summarizes remedial technologies and process options within each GRA, presented in Section 2.4, and provides an initial screening based upon whether each technology is capable of remediating the chlorinated solvents present in groundwater at OMS-28 and achieving the RAOs. Technologies retained from this initial screening undergo a more detailed evaluation in the following section.

2.5.2 Detailed Screening of Technologies

In this section, technologies retained from the initial screening are further evaluated against criteria of effectiveness, implementability, and cost (three of the NCP balancing criteria). The rationale for either retaining or eliminating treatment options for groundwater at the site is summarized in Table 2-3. Remedial options retained from this detailed screening process will be used to develop the remedial alternatives presented in Chapter 4.0.

2.5.3 Effectiveness

The effectiveness criterion assesses the ability of a remedial technology to protect human health and the environment by reducing the toxicity, mobility, or volume of contaminants. Each technology is evaluated for the ability to achieve RAOs, potential impacts to human health and the environment during construction and implementation, and overall reliability.

2.5.4 Implementability

Each process option technology is evaluated for implementability in terms of technical feasibility; administrative feasibility; and availability of the necessary material, equipment, and work force. The assessment considers each technology's short- and long-term implementability. Short-term implementability considerations include constructability of the remedial technology, near-term reliability,

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Table 2-2. Initial Screening of Technologies for Groundwater Remediation

GRA	Technology Type	Process Option	Description	Retained for Further Evaluation?
No Action	None	None	No action is taken at the site. Current LUCs, access restrictions, and monitoring programs will be discontinued. No remedial technologies will be implemented to reduce hazards to potential human or ecological receptors or to return land to unrestricted use	**Retained.** Required to be carried through for CERCLA analysis
Institutional Controls	Access Restrictions	LUCs	Implement LUCs at the site to restrict access to and use of groundwater	**Retained.** May be used in conjunction with one or more technologies
	Monitoring	Groundwater Monitoring Wells	Monitoring of contaminants and groundwater plume migration over a period of time. May be used in conjunction with another technology to measure the effectiveness of that technology or the fate and transport of contaminants	**Retained.** May be used in conjunction with one or more technologies
Containment	Physical Barriers	Slurry Walls	Excavated trench backfilled with a low-permeability slurry to contain/divert contaminated groundwater flow	Not retained. Does not reduce VOC concentrations in impacted groundwater
		Deep Well Injection	Liquid waste disposal method in which contaminated liquid waste is injected into geologic formations that have no potential to allow migration of contaminants into potential potable aquifers	Not retained. The remedial alternative selected for groundwater at OMS-28 will restore groundwater concentrations to below federal MCLs. Consequently, disposal of contaminated groundwater will not be necessary
Treatment	In-Situ Biological Treatment	Enhanced Bioremediation (biological reduction)	Indigenous or inoculated microorganisms (e.g., fungi, bacteria, and other microbes) degrade organic contaminants found in groundwater, converting them to innocuous end products. Electron donor compounds are injected to stimulate anaerobic reductive dechlorination of chlorinated VOCs	**Retained**
		Phytoremediation	The use of plants to remove, transfer, stabilize, and destroy contaminants in subsurface through plants' natural tendency to adsorb organic and inorganic substances from the ground	**Retained**
	In-Situ Physical/ Chemical Treatment	Air Sparging	Air injected into the contaminated aquifer creates an underground stripper that removes contaminants by volatilization. Contaminants are flushed into the unsaturated zone where they may be removed by a vapor extraction system	Not retained. Technology is not reliable at sites where groundwater is less than 10 ft BGS
		Bioslurping	Combines elements of bioventing and vacuum-enhanced pumping of free product that is lighter than water to recover free product from groundwater	Not retained. Technology focuses on remediation of media contaminated with hydrocarbons. The primary contaminants at OMS-28 are PCE and TCE
		Chemical Oxidation	Oxidation chemically converts hazardous contaminants to non-hazardous or less toxic compounds that are more stable, less mobile, and/or inert. Various strong oxidizing agents (e.g., permanganate, ozone, hydrogen peroxide, or Fenton's reagent) degrade organic contaminants in groundwater	**Retained**
		Chemical Reduction	Chemical reduction involves the addition of a reducing agent (i.e., ZVI) for the purpose of degrading toxic contaminants to non-toxic or less toxic compounds	**Retained**
		Directional Wells (enhancement)	Wells are installed horizontally or at an angle to reach contaminants not accessible by vertical wells	Not retained. Groundwater at OMS-28 is accessible through traditional vertical wells
		Dual-Phase Extraction	A high-vacuum system is used to remove various combinations of contaminated groundwater, free product, and vapor from the subsurface. Extracted liquids and vapor are treated and collected for disposal	Not retained. No free-phase product is present at OMS-28. In addition, concentrations do not indicate that NAPL is present at the site
		Thermal Treatment	Various methods may be used to heat the subsurface (e.g., electrical resistive heating or steam injection) to vaporize volatile and semivolatile contaminants. Vaporized components rise to the unsaturated zone where they are removed by vacuum extraction and subsequently treated	Not retained. Technology is not reliable at sites where groundwater is less than 10 ft BGS
		Hydrofracturing Enhancements	Pressurized water is injected into the subsurface to increase the permeability of consolidated or relatively impermeable material. Typical applications are linked with SVE, in-situ bioremediation, and pump-and-treat systems	Not retained. Geologic conditions at OMS-28 do not require an increase in permeability for any retained in-situ treatment technology
		In-Well Air Stripping	Pressurized air is injected into a vertical well that has been screened at two depths. VOCs vaporize within the well at the top of the water table as air bubbles out of the water. Vapors are drawn off by an SVE system	Not retained. Technology is not reliable at sites where groundwater is less than 10 ft BGS
		Passive/Reactive Treatment Walls	A permeable reaction wall is installed across the flow path of a contaminant plume, thus allowing the passage of water while prohibiting the movement of contaminants through the wall by employing such agents as zero-valent metals, sorbents, and microbes. Contaminants are either degraded or retained within the barrier material	Not retained. Slow groundwater velocity at the site would require excessive treatment time via this technology

Table 2-2. Initial Screening of Technologies for Groundwater Remediation (continued)

GRA	Technology Type	Process Option	Description	Retained for Further Evaluation?
Treatment	Ex-Situ Biological Treatment (assuming pumping)	Bioreactors	Extracted groundwater is placed within a biological reactor with microorganisms capable of degrading contaminants	Not retained. Ex-situ technology must be combined with groundwater recovery, such as pumping, which is not retained
		Constructed Wetlands	Artificial wetland system constructed to accumulate and remove metals, explosives, and organic contaminants from influent waters using natural geochemical and biological processes	Not retained. Ex-situ technology must be combined with groundwater recovery, such as pumping, which is not retained
	Ex-Situ Physical/Chemical Treatment (assuming pumping)	Adsorption/Absorption	Solutes concentrate at the surface of a sorbent, thereby reducing their concentration in the bulk liquid phase. Adsorbents may include GAC, forage sponge, sorption clays, and synthetic resins	Not retained. Ex-situ technology must be combined with groundwater recovery, such as pumping, which is not retained
		Advanced Oxidation Processes	Destruction of organic contaminants in water by oxidation with ozone	Not retained. Ex-situ technology must be combined with groundwater recovery, such as pumping, which is not retained
		Air Stripping	Transfer of volatile contaminants from groundwater to air in a packed air stripping column	Not retained. Ex-situ technology must be combined with groundwater recovery, such as pumping. Although this technology results in a reduction in volume of contaminated groundwater, contaminants are simply shifted to another media, which will then require treatment and/or disposal
		GAC/Liquid-Phase Carbon Adsorption	Adsorption of VOCs by activated carbon from a water or air stream by contact in a carbon-packed vessel	Not retained. Ex-situ technology must be combined with groundwater recovery, such as pumping. In addition, treated groundwater and contaminated media (GAC) must be properly disposed
		Ion Exchange	Dissolved metals and other inorganics are removed from liquids through an exchange of ions as contaminated media are passed over a bed of resin, inorganic, or natural polymeric material	Not retained. Treatment focuses on remediation of media contaminated with dissolved metals and other inorganics. The primary contaminants at OMS-28 are PCE and TCE
		Precipitation/Coagulation/ Flocculation	Use of pH adjustment, addition of a chemical precipitant, and flocculation to transform dissolved contaminants into an insoluble solid. Solids may then be removed from the liquid phase by sedimentation or filtration	Not retained. Treatment focuses on remediation of media contaminated with dissolved metals and radionuclides. The primary contaminants at OMS-28 are PCE and TCE
		Separation	Processes, such as distillation, filtration, and reverse osmosis, that detach contaminants from groundwater	Not retained. Technology must be combined with groundwater recovery, such as pumping. Although this technology results in a reduction in volume of contaminated groundwater, contaminants are simply shifted to another media, which will then require treatment and/or disposal
		Sprinkler Irrigation	Pressurized distribution of VOC-contaminated water through a standard sprinkler irrigation system. VOCs are transferred from the dissolved aqueous phase to the vapor phase and released into the atmosphere	Not retained. Technology must be combined with groundwater recovery, such as pumping, and requires regulatory approval to discharge VOCs into the atmosphere
Removal	Groundwater Recovery	Groundwater Pumping	Recovery of contaminated groundwater by pumping to the surface for ex-situ treatment and disposal	Not retained. Historically, pump-and-treat systems are not efficient and have long remediation timeframes
MNA	None	None	Natural attenuation processes that can degrade contaminants (e.g., dilution, dispersion, volatilization, adsorption, and biodegradation) are monitored to verify reductions	**Retained**

BGS = Below ground surface.
CERCLA = Comprehensive Environmental Response, Compensation, and Liability Act.
GAC = Granulated activated carbon.
GRA = General response action.
LUC = Land use control.
MCL = Maximum contaminant level.
MNA = Monitored natural attenuation.
NAPL = Nonaqueous-phase liquid.
OMS-28 = Organizational Maintenance Shop-28.
PCE = Tetrachloroethene.
SVE = Soil vapor extraction.
TCE = Trichloroethene.
VOC = Volatile organic compound.
ZVI = Zero valent iron.

Table 2-3. Detailed Screening of Technologies for Groundwater Remediation

Media	GRA	Technology Type	Process Option	Effectiveness	Implementability	Cost	Screening Comment
Groundwater	No Action	None	None	This alternative does not meet the RAO for the site. This alternative does not provide protection of human health or the environment	Implementability is not involved with this alternative because no action is taken	No costs are associated with the no action alternative	**Retained.** Required by CERCLA
	Institutional Controls	Access Restrictions	LUCs	Technology is effective in restricting access as long as restrictions are maintained or upheld	Easily implemented with minimal level of effort	Low cost	**Retained**
		Monitoring	Groundwater Monitoring Wells	Technology is very effective for monitoring contaminants undergoing natural attenuation or while other remedial technologies are implemented	Easily implemented. Requires the installation of new wells and/or use of existing wells	Low cost	**Retained**
	Treatment	In-Situ Biological Treatment	Enhanced Bioremediation (biological reduction)	Technology is effective for the treatment of chlorinated solvent plumes. May require injections of both microbes and electron donor materials to obtain optimum conditions	Readily implemented. New and existing wells would be utilized for injection of electron donor solution. An ADEM UIC Class V Well Permit would be required	Moderate cost	**Retained**
			Phytoremediation	Technology effectiveness depends upon selection of the proper plants, which can clean up chemicals as deep as their roots can grow	Moderately difficult to implement. Depth of groundwater at OMS-28 would require the use of trees for this technology	High cost	Not retained
		In-Situ Physical/ Chemical Treatment	Chemical Oxidation	Technology is effective for the treatment of chlorinated solvents. May require multiple injections of oxidants to address contaminant rebound	Readily implemented. New and existing wells would be utilized for injection of oxidant solutions. An ADEM UIC Class V Well Permit would be required	Moderate cost	**Retained**
			Chemical Reduction	Innovative technology that has been shown to accelerate reducing conditions for the effective treatment of chlorinated solvents. May require multiple injections of amendments to address contaminant rebound	Readily implemented. New and existing wells would be utilized for injection of oxidant solutions. An ADEM UIC Class V Well Permit would be required	Moderate cost	**Retained**
	MNA	None	None	Effectiveness varies with site conditions. At OMS-28, natural attenuation of PCE and TCE is evident	Readily implementable. New and existing wells would be monitored for an extended period of time	Moderate cost	**Retained**

ADEM = Alabama Department of Environmental Management.
CERCLA = Comprehensive Environmental Response, Compensation, and Liability Act.
GRA = General response action.
LUC = Land use control.
MNA = Monitored natural attenuation.
OMS-28 = Organizational Maintenance Shop-28.
PCE = Tetrachloroethene.
RAO = Remedial action objective.
TCE = Trichloroethene.
UIC = Underground injection control.

the ability to obtain necessary approvals from other agencies, and the likelihood of obtaining a favorable community response. Long-term implementability evaluates the ease of undertaking additional remedial actions if necessary, monitoring the effectiveness of the remedy, and O&M.

2.5.5 Cost

The cost criterion evaluates each remedial process in terms of relative capital and O&M costs. Costs for each technology are rated qualitatively on the basis of engineering judgment.

3.0 APPLICABLE OR RELEVANT AND APPROPRIATE REQUIREMENTS

CERCLA Section 121 specifies that remedial actions must comply with requirements or standards under federal or more stringent state environmental laws that are “applicable or relevant and appropriate to the hazardous substances or particular circumstances” at the site. Inherent in the interpretation of ARARs is the assumption that protection of human health and the environment is ensured. This section summarizes potential federal and state chemical-, location-, and action-specific ARARs for the potential remedial actions at the site.

ARARs include those federal and state regulations that are designed to protect the environment. Applicable requirements are “those cleanup standards, standards of control, and other substantive environmental protection requirements, criteria, or limitations promulgated under federal environmental or state environmental or facility siting law that specifically address a hazardous substance, pollutant, contaminant, remedial action, location, or other circumstance at a CERCLA site” (40 *CFR* 300.5). EPA has stated in the NCP that applicable requirements are those requirements that would apply if the response action were not taken under CERCLA.

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

In the absence of federal- or state-promulgated regulations, there are many criteria, advisories, guidance values, and proposed standards that are not legally binding but may serve as useful guidance for setting protective cleanup levels. These are not potential ARARs but are to-be-considered (TBC) guidance (40 *CFR* 300.400[g][13]).

CERCLA remedial response actions at a site must comply only with the substantive requirements of a regulation (CERCLA Section 121[e]). Substantive requirements are those that pertain directly to the actions or conditions at an area of concern, while administrative requirements facilitate their implementation. EPA recognizes that certain administrative requirements (e.g., consultation with state agencies and reporting) are accomplished through state involvement and public participation. These administrative requirements also should be observed if they are useful in determining cleanup standards at the site (55 *CFR* 8757).

3.1 POTENTIAL APPLICABLE OR RELEVANT AND APPROPRIATE REQUIREMENTS

EPA classifies ARARs as chemical-, action-, and location-specific to provide guidance for identifying and complying with ARARs (EPA 1988a).

- Chemical-specific ARARs are health- or risk-based numerical values or methodologies that, when applied to site-specific conditions, allow numerical values to be established. These values establish the acceptable amount or concentration of a chemical that may be found in, or discharged to, the ambient environment (EPA 1988a).

- Action-specific ARARs are rules, such as performance or design or other activity-based rules, that place requirements or limitations on actions.

- Location-specific ARARs are rules that place restrictions on the concentration of hazardous substances or the conduct of activities solely because they occur in special locations (EPA 1988a).

As explained in the following paragraph, rules from each of these categories are ARARs only to the extent that they relate to the degree of cleanup.

CERCLA Section 121 governs cleanup standards at CERCLA sites. ARARs originate in the subsection of CERCLA that specifies the degree of cleanup at each site, CERCLA Section 121(d). In Section 121(d)(2), CERCLA expressly directs that ARARs are to address specific COCs at each site, specifying the level of protection to be attained by any chemicals remaining at the site. CERCLA Section 121(d)(2) provides that, with respect to hazardous substances, pollutants, or contaminants remaining on-site at the completion of a remedial action, an ARAR is

> "Any standard, requirement, criteria, or limitation under any Federal environmental law … or any promulgated standard, requirement, criteria, or limitation under a State environmental or facility siting law that is more stringent than any Federal standard, requirement, criteria, or limitation."

In addition to the standards promulgated within the federal and state regulations, published guidance documentation may be evaluated as part of the ARARs identification process. While published guidance, unless incorporated by rule, is not an ARAR, such documents may be identified as TBC criteria and utilized within the FS process.

In summary, chemical-, action-, or location-specific requirements will be ARARs to the extent that they establish standards protective of human health and the environment for chemicals that will remain on-site after the remedial action and ensure protection of site workers and the environment during remedy implementation. Requirements identified as chemical-specific ARARs must ensure a degree of cleanup that is protective of human health and the environment under the circumstances presented by the release.

Table 3-1 presents the potential ARARs for remedial action at OMS-28.

Table 3-1. Potential ARARs for OMS-28

Activity or Condition Triggering Requirement	Citation	ARAR	Requirement
Chemical-Specific ARARs			
Contamination in groundwater in excess of established MCLs from a constituent listed in 40 *CFR* Part 141	40 *CFR* 161.60	Applicable	Provides MCLs for organic contaminants that apply to community and non-transient, non-community water systems, including groundwater that may be utilized for such purposes. Contaminants found within groundwater that exceed the identified MCLs include TCE and PCE. The MCL for both is identified as 0.005 mg/L
Action-Specific ARARs			
Operation and/or abandonment of a Class V injection well	ADEM Administrative Code r.335-6-8	Applicable	Establishes prohibited activities, required actions, rules for permit applications and technical submittals, and permit requirements related to the operation and abandonment of Class V injection wells
Selection of a remedial alternative that will not return the site to unrestricted use	UECA, Code of Alabama 1975, Sections 35-19-1 to 35-19-14; ADEM Administrative Code r.335-5	Applicable	UECA establishes requirements for environmental covenants; ADEM Administrative Code requires an environmental covenant for any site undergoing a response action that does not return the property to unrestricted use
Disturbance of ground cover that results in potential transport of sediment due to stormwater run-off	40 *CFR* 122.26; ADEM Administrative Code r.335-6-12	Applicable (excavation sites greater than 1 acre)	Establishes stormwater discharge requirements at construction sites 1 acre or more in size. Requirements may be considered relevant and appropriate for areas of soil disturbance less than 1 acre in size. Under ADEM Administrative Code r335-6-12, an NPDES construction site is required to obtain NPDES coverage irrespective of size
Open burning of vegetation and untreated wood during clearing and grubbing activities	ADEM Administrative Code r. 335-3-3	Applicable	Establishes the provisions under which open burning may be conducted
Construction activities (including soil removal) that could result in fugitive particulate emissions	ADEM Administrative Code r. 335-3-4-.02	Applicable	Establishes limits and provisions for the control of fugitive particulate emissions during construction and operation of certain units and activities
Characterization of generated environmental media to determine whether it contained a hazardous waste. Generation and management of a hazardous waste or environmental media that contains a hazardous waste	40 *CFR* Part 262; ADEM Admin. Code r. 335-14-3	Applicable	Establishes provisions for the characterization, reporting, manifesting, packaging for transport, and accumulation of hazardous wastes

Table 3-1. Potential ARARs for OMS-28 (continued)

Activity or Condition Triggering Requirement	Citation	ARAR	Requirement
Generation, management, and disposal of industrial wastes within the state of Alabama that are not hazardous wastes	ADEM Administrative Code r. 335-13	Applicable	Establishes the requirements for documentation/certifications that must be submitted prior to disposal of industrial or special wastes at solid waste disposal facilities within Alabama
Location-Specific ARARs			
Actions that jeopardize the existence of a listed species, or result in the destruction or adverse modification of critical habitat, must be avoided or reasonable and prudent mitigation measures taken. No such species have been identified within the remediation area	16 U.S.C. 1531 et seq., Section 7(a)(2)	Applicable	Requires that any activity taken that results in an impact to endangered species or critical habitat must be avoided or mitigated
TBC Criteria			
Contamination at sites located within the state of Alabama in excess of PSVs	Alabama Risk-Based Corrective Action Guidance Report (Table 2-2)	TBC	Establishes a consistent procedure for evaluating the cumulative risk at a site and developing RBTLs. Provides PSVs for initial evaluation of site contamination in various media, including soil and groundwater

ADEM = Alabama Department of Environmental Management.
ARAR = Applicable or relevant and appropriate requirement.
CFR = Code of Federal Regulations.
MCL = Maximum contaminant level.
NPDES = National Pollutant Discharge Elimination System.
OMS-28 = Organizational Maintenance Shop-28.
PCE = Tetrachloroethene.
PSV = Preliminary screening value.
RBTL = Risk-based target level.
TBC = To be considered.
TCE = Trichloroethene.
U.S.C. = United States Code.
UECA = (Alabama) Uniform Environmental Covenants Act.

4.0 DEVELOPMENT OF REMEDIAL ALTERNATIVES

This chapter presents the development and description of remedial alternatives assembled from combinations of process options carried forward from the technology screening. The approach to alternative development, a description of each alternative, and the evaluation results are provided below.

4.1 DEVELOPMENT OF ALTERNATIVES

The CERCLA remedial alternative selection process is used to identify and plan the implementation of CERCLA remedial actions that eliminate, reduce, or control risks to human health and the environment (40 *CFR* 300). The purpose of the FS, as defined in the NCP, is to develop a range of possible remedies that protect human health and the environment, maintain protection over time, and minimize untreated waste. Criteria for identifying possible applicable technologies to achieve these goals are provided in EPA guidance (EPA 1988b) and the NCP (EPA 1990).

The NCP defines the following preferences in developing remedial alternatives:

- Use of treatment to address the principal threats posed by a site, wherever practical.

- Use of engineering controls (e.g., containment) for waste that poses a relatively low, long-term threat and for which treatment is not practical.

- Implementation of a combination of actions, as appropriate, to achieve protection of human health and the environment.

- Use of institutional controls (e.g., drinking water supply controls and deed restrictions) to supplement engineering controls for short- and long-term management to prevent or limit exposures to hazardous substances.

- Selection of an innovative technology when the technology offers the potential for comparable or better treatment performance or implementability, fewer adverse impacts than other technologies, or lower costs than demonstrated technologies for similar levels of performance.

- Restoration of environmental media, such as groundwater, to their beneficial uses whenever practical and within a reasonable timeframe. When restoration of groundwater to beneficial uses is not practical, EPA expects to prevent further migration of the contaminant plume, prevent human and environmental exposures to contaminated groundwater, and evaluate further risk reduction.

EPA guidance (EPA 1988b) establishes an approach to developing appropriate remedial alternatives. In implementing this approach, the scope, characteristics, and complexity of the specific conditions at the site were considered to develop a range of alternatives (no action, limited action, or comprehensive action) that would protect human health and the environment. Protection may be achieved by eliminating, reducing, or controlling risks posed by each pathway at the site.

The purpose of the range of remedial alternatives is to present decision-makers with several technical and economic options to achieve the RAOs. Process options carried forward from the screening of technologies in Chapter 2.0 were combined to form remedial alternatives.

The remedial alternatives developed in this FS are based on the limited data available from past site activities. Uncertainties in the assumptions regarding the nature and extent of contaminated media used to develop these remedial alternatives could significantly impact effectiveness, implementability, and cost. The remedial alternatives developed for contaminated groundwater at OMS-28 are presented below.

4.2 DESCRIPTION OF REMEDIAL ALTERNATIVES

This section presents alternatives for remedial action at OMS-28 using the results of the technology screening conducted in Chapter 2.0. Technologies retained from Chapter 2.0 include access restrictions, monitoring, in-situ biological treatment, in-situ physical/chemical treatment, and MNA; whereas, physical barriers, ex-situ biological treatment, ex-situ physical/chemical treatment, and groundwater recovery were eliminated from further consideration. Alternatives presented within this chapter include one or more of these technologies with the exception of the no action alternative, which is required by CERCLA as a basis for comparison with other alternatives. The alternatives are

- Alternative 1: No Action,
- Alternative 2: Monitored Natural Attenuation of Groundwater,
- Alternative 3: Monitored Natural Attenuation of Groundwater with Excavation of Soil,
- Alternative 4: Biological/Chemical Reduction of Groundwater with Excavation of Soil, and
- Alternative 5: In-Situ Chemical Oxidation of Groundwater with Excavation of Soil.

No action is warranted for soil because concentrations of TCE and PCE are less than the residential and industrial RSLs and, therefore, do not pose a risk to human health receptors. However, there are concentrations of TCE and/or PCE in the vadose zone soil, located within the aerial extent of the groundwater plume, that exceed the protection of groundwater SSLs. This residual soil mass is acting as a continuing source for groundwater contamination that will prolong the timeframe of any groundwater remedial alternative. Excavation to remove this residual soil mass exceeding the SSLs for the protection of groundwater from the vadose zone is being included with groundwater remedial alternatives as a cost-effective measure to reduce overall costs and remediation timeframes.

4.2.1 Alternative 1 – No Action

The no action alternative is presented as a baseline for comparison with other alternatives in accordance with the NCP. Under this alternative, no remediation of contaminated groundwater would be conducted at OMS-28. No institutional controls (e.g., restrictions on groundwater use) would be implemented. Access to contaminated media would be unrestricted. No monitoring of groundwater concentrations would be performed.

4.2.2 Alternative 2 – Monitored Natural Attenuation of Groundwater

Actions for groundwater at OMS-28 under this alternative are as follows:

- MNA of contaminated groundwater, and
- Land use controls (LUCs).

This alternative consists of MNA of groundwater until the MCLs for TCE and PCE are achieved.

4.2.2.1 Remedial design

A remedial design work plan would be developed prior to the initiation of remedial actions. This plan would outline the groundwater monitoring requirements and the sampling and analysis plan. A site-specific health and safety plan would be developed to cover the health and safety of remediation workers.

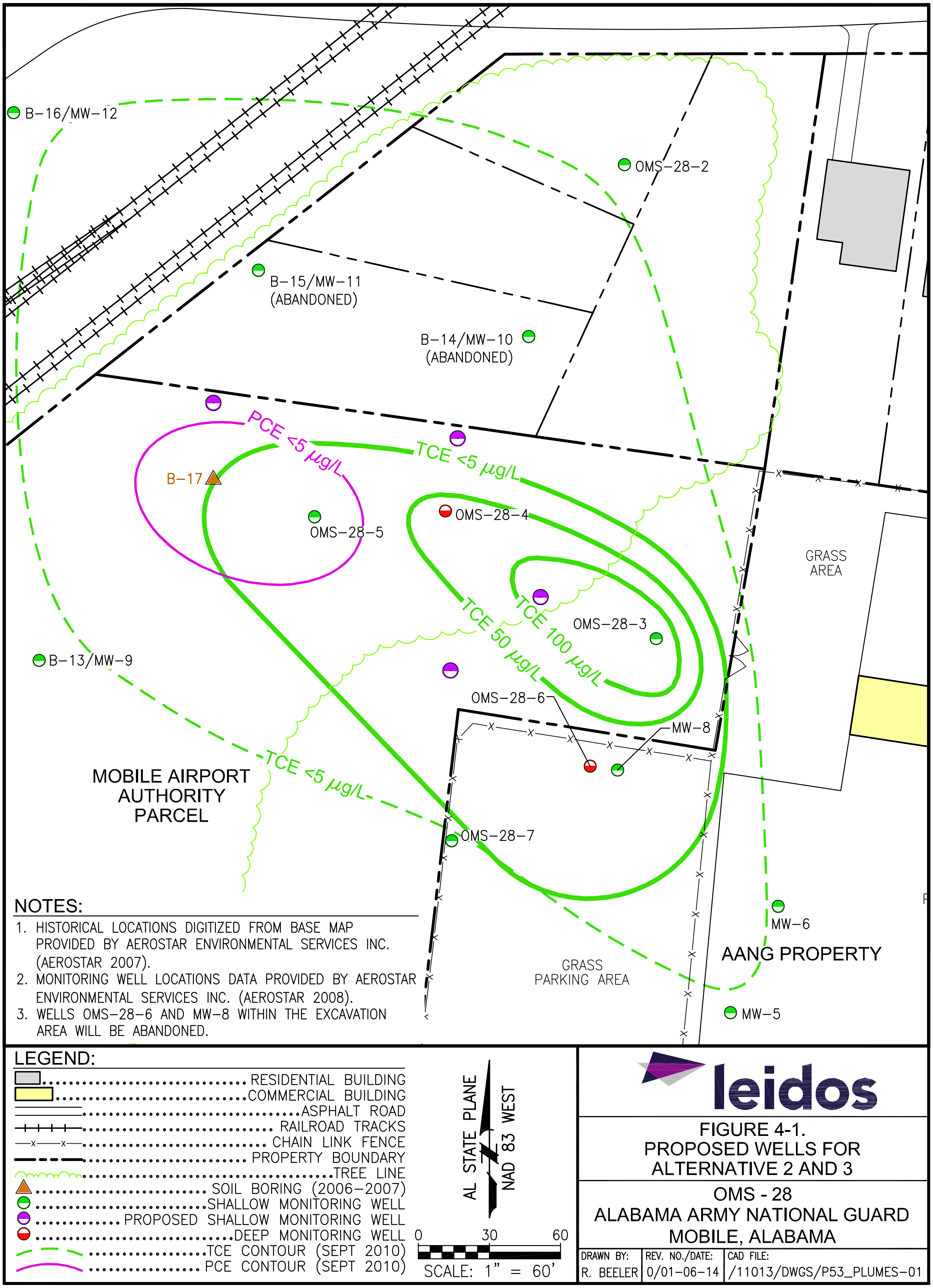
4.2.2.2 Monitored natural attenuation

Groundwater monitoring would be used to show that natural attenuation is reducing contamination as predicted. The monitoring well network would include nine existing shallow monitoring wells (OMS-28-2, OMS-28-3, OMS-28-5, OMS-28-7, MW-5, MW-6, MW-8, MW-9, and MW-12) and four new shallow monitoring wells. Deep wells would not be included in the monitoring program because historical sampling has shown that these wells are not contaminated. Following review of the groundwater results of the baseline groundwater sampling event, approximately four new wells would be installed at the site (Figure 4-1). It is anticipated that two of these groundwater monitoring wells would be installed downgradient of the groundwater plume adjacent to the MAA property boundary north of existing well OMS-28-4 and soil boring B-17, and two of these wells would be installed downgradient of the soil source area in the vicinity of MW-8 for better coverage of the existing groundwater plume. Based upon the results of preliminary modeling (Appendix B), it is estimated that PCE and TCE in groundwater would naturally attenuate to below MCLs within approximately 15 to 20 years for PCE and approximately 35 to 40 years for TCE, assuming that the residual source mass in soil is not removed. Field parameters and laboratory chemical analyses would be used to establish baseline conditions. Field parameters would include pH, specific conductivity, temperature, dissolved oxygen (DO), oxidation-reduction potential (ORP), and static water level. Laboratory analyses would include analysis for VOCs, total organic carbon (TOC), alkalinity, sulfate, methane, ethane, ethene, and nitrate/nitrite. Groundwater monitoring would be conducted semiannually for the first 10 years, on an annual basis for the second 10 years, and then on a biannual basis until concentrations are below MCLs.

4.2.2.3 Land use controls

To ensure effective implementation of institutional controls, a Land Use Control Implementation Plan (LUCIP) may be developed prior to the implementation of institutional controls. The LUCIP would present the exposure assumptions for OMS-28 and state the institutional control objectives and land restrictions for the site. The LUCIP also would discuss potential future modifications and/or termination of institutional controls, reporting requirements, CERCLA 5-year reviews, institutional control enforcement, and property transfers. The ALARNG can only recommend to landowners that LUCs or deed restrictions be implemented on private and commercial property. The ALARNG does not have the authority to implement, enforce, or maintain LUCs on the current private and commercial landowners of the off-site parcels or properties.

Environmental covenants are required to be executed for sites in Alabama that are not remediated to the standard of unrestricted use. OMS-28 is owned by the federal government and is, therefore, legally unable to execute an environmental covenant during the period of federal ownership. In lieu of an environmental covenant, a Notice of Environmental Use Restriction for the portion of OMS-28 owned by the federal government would be prepared and submitted to ADEM for approval that gives notice of the current and future use of the federal property. Under this alternative, the ALARNG would attempt to gain permission from the current private and commercial landowners of the off-site parcels or properties for an environmental covenant. A copy of the recorded, executed document, if obtained, would be submitted to ADEM for inclusion in the Alabama Registry of Environmental Covenants.


B-16/MW-12
OMS-28-2
B-15/MW-11
(ABANDONED)
B-14/MW-10
(ABANDONED)
PCE <5 µg/L
TCE <5 µg/L
B-17
OMS-28-4
OMS-28-5
GRASS
AREA
TCE 50 µg/L
TCE 100 µg/L
OMS-28-3
B-13/MW-9
OMS-28-6
MW-8
TCE <5 µg/L
MOBILE AIRPORT
AUTHORITY
PARCEL
OMS-28-7
MW-6
AANG PROPERTY
GRASS
PARKING AREA
MW-5
NOTES:
1. HISTORICAL LOCATIONS DIGITIZED FROM BASE MAP PROVIDED BY AEROSTAR ENVIRONMENTAL SERVICES INC. (AEROSTAR 2007).
2. MONITORING WELL LOCATIONS DATA PROVIDED BY AEROSTAR ENVIRONMENTAL SERVICES INC. (AEROSTAR 2008).
3. WELLS OMS-28-6 AND MW-8 WITHIN THE EXCAVATION AREA WILL BE ABANDONED.
LEGEND:
RESIDENTIAL BUILDING
COMMERCIAL BUILDING
ASPHALT ROAD
RAILROAD TRACKS
CHAIN LINK FENCE
PROPERTY BOUNDARY
TREE LINE
SOIL BORING (2006-2007)
SHALLOW MONITORING WELL
PROPOSED SHALLOW MONITORING WELL
DEEP MONITORING WELL
TCE CONTOUR (SEPT 2010)
PCE CONTOUR (SEPT 2010)
AL STATE PLANE
NAD 83 WEST
0 30 60
SCALE: 1" = 60'
leidos
FIGURE 4-1.
PROPOSED WELLS FOR
ALTERNATIVE 2 AND 3
OMS - 28
ALABAMA ARMY NATIONAL GUARD
MOBILE, ALABAMA
DRAWN BY: R. BEELER
REV. NO./DATE: 0/01-06-14
CAD FILE: /11013/DWGS/P53_PLUMES-01

Under this remedial alternative, the use restrictions instituted by the ALARNG through the use of the environmental covenant would include, at minimum

- Restricting groundwater use (i.e., water well drilling or groundwater pumping).

4.2.2.4 Five-year reviews

As part of the CERCLA Section 121(c) 5-year remedy review process, the ALARNG would prepare a report evaluating the continued effectiveness of the remedy and an assessment of whether there is a need to modify institutional controls. Five-year reviews would be conducted because this alternative does not allow for unlimited use and unrestricted exposure. The ALARNG would verify that the institutional controls are properly documented and enforced to ensure that the institutional controls are protective of human health, safety, and the environment. Each 5-year review would evaluate whether conditions have changed due to such factors as contaminant attenuation, contaminant migration, or a change in land use. If risk levels change following the initial implementation of institutional controls, modification of the institutional controls would be considered. Based on the preliminary fate and transport modeling results, MNA of TCE to the MCL will take approximately 40 years. For the purpose of this FS, it is assumed that 5-year reviews would be conducted for approximately 30 years.

4.2.3 Alternative 3 – Monitored Natural Attenuation of Groundwater with Excavation of Soil

Actions for groundwater at OMS-28 under this alternative are as follows:

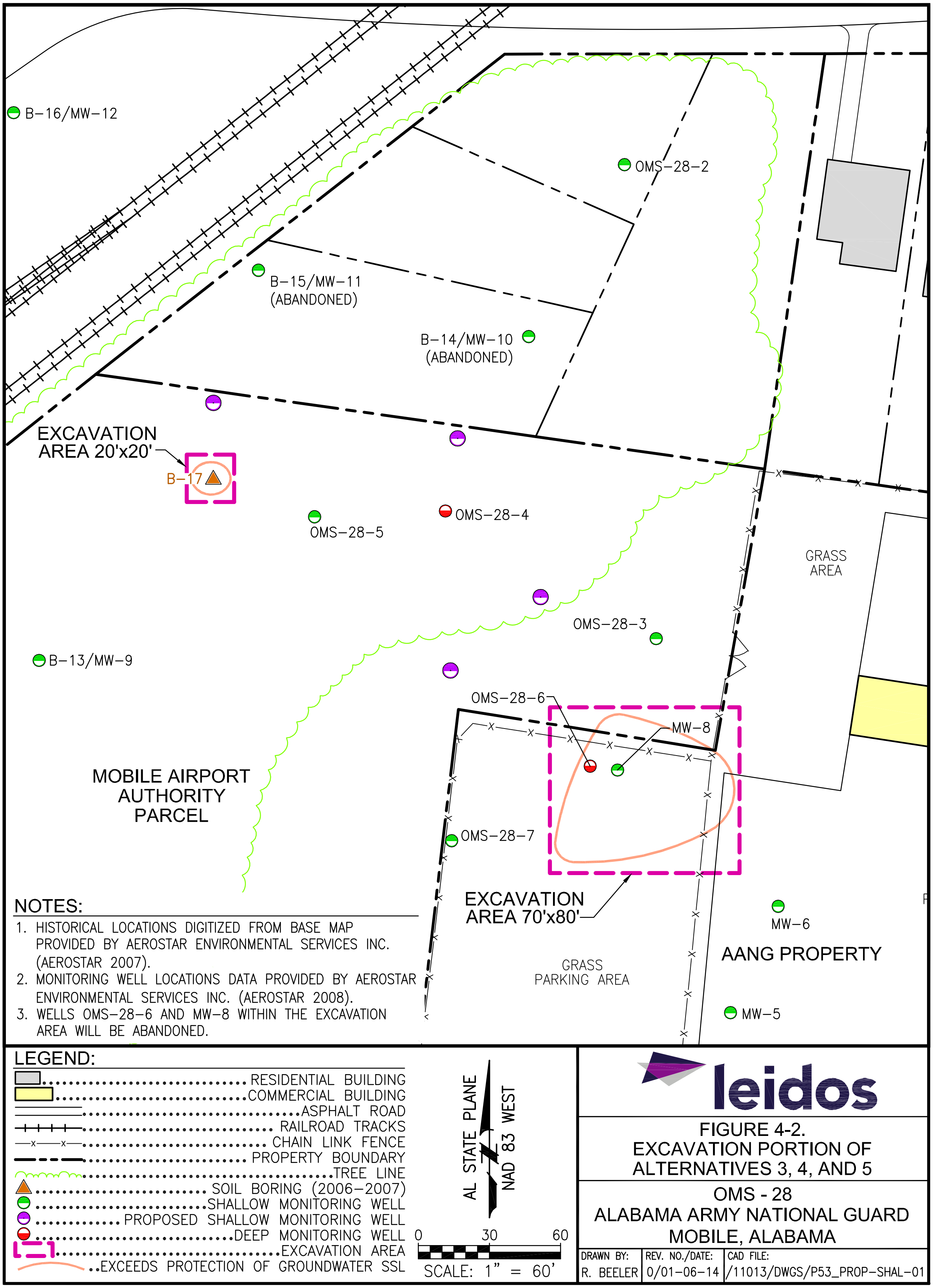
- MNA of contaminated groundwater, and
- excavation of soil exceeding the SSLs for protection of groundwater.

This alternative consists of MNA of groundwater until the MCLs for TCE and PCE are achieved. To expedite the MNA timeframe, this alternative also includes excavation of the residual soil mass acting as a continuing source for groundwater contamination and transportation of the resulting waste to a permitted municipal solid waste landfill for disposal. There are two areas within the TCE and PCE groundwater plumes where the residual contaminant mass in the vadose zone soil is acting as a secondary source to groundwater.

Excavation would remove soil exceeding the SSLs for the protection of groundwater from the vadose zone in the two areas within the groundwater plume where concentrations of TCE and/or PCE exceed the protection of groundwater SSLs (Figure 4-2). Excavation of the area surrounding wells OMS-28-6 and MW-8 (approximately 70 by 80 ft) and boring B-17 (approximately 20 by 20 ft) would result in approximately 1,850 yd^3 of soil (ex situ) for disposal. The depth of the excavation would extend to the groundwater table, which ranged from 4 to 7 ft BGS in MW-8 and 8 to 12 ft BGS in OMS-28-5 between 2005 and 2010. This ex-situ volume estimate assumes a 15% swell factor and 15% constructability factor for the excavated soil. The surface vegetation would be cleared to the MAA property boundary to the west and north to allow for: (1) access for conventional excavation equipment and dump trucks, (2) the excavation to expand if confirmatory sampling indicated that the excavation boundaries were larger than 20 by 20 ft, and (3) the installation of monitoring wells along the northern MAA property boundary (Figure 4-2).

4.2.3.1 Remedial design

A remedial design work plan would be developed prior to the initiation of remedial actions. This plan would outline the construction permitting requirements, the site preparation activities (e.g., staging and equipment storage areas, truck routes, and stormwater controls), the extent of the excavation, the


B-16/MW-12
OMS-28-2
B-15/MW-11
(ABANDONED)
B-14/MW-10
(ABANDONED)
EXCAVATION
AREA 20'x20'
B-17
OMS-28-4
OMS-28-5
GRASS
AREA
OMS-28-3
B-13/MW-9
OMS-28-6
MW-8
MOBILE AIRPORT
AUTHORITY
PARCEL
OMS-28-7
EXCAVATION
AREA 70'x80'
MW-6
AANG PROPERTY
GRASS
PARKING AREA
MW-5
NOTES:
1. HISTORICAL LOCATIONS DIGITIZED FROM BASE MAP PROVIDED BY AEROSTAR ENVIRONMENTAL SERVICES INC. (AEROSTAR 2007).
2. MONITORING WELL LOCATIONS DATA PROVIDED BY AEROSTAR ENVIRONMENTAL SERVICES INC. (AEROSTAR 2008).
3. WELLS OMS-28-6 AND MW-8 WITHIN THE EXCAVATION AREA WILL BE ABANDONED.
LEGEND:
RESIDENTIAL BUILDING
COMMERCIAL BUILDING
ASPHALT ROAD
RAILROAD TRACKS
CHAIN LINK FENCE
PROPERTY BOUNDARY
TREE LINE
SOIL BORING (2006-2007)
SHALLOW MONITORING WELL
PROPOSED SHALLOW MONITORING WELL
DEEP MONITORING WELL
EXCAVATION AREA
EXCEEDS PROTECTION OF GROUNDWATER SSL
AL STATE PLANE
NAD 83 WEST
0
30
60
SCALE: 1" = 60'
leidos
FIGURE 4-2.
EXCAVATION PORTION OF
ALTERNATIVES 3, 4, AND 5
OMS - 28
ALABAMA ARMY NATIONAL GUARD
MOBILE, ALABAMA
DRAWN BY:
R. BEELER
REV. NO./DATE:
0/01-06-14
CAD FILE:
/11013/DWGS/P53_PROP-SHAL-01

sequence of construction activities, the decontamination of construction/drilling equipment, and the transportation and disposal of soil. There are no RLs for soil; therefore, this plan would specify the vertical and lateral extents of the excavation limits or the cleanup criteria. Engineering and administrative controls (e.g., erosion controls and health and safety controls) would be determined prior to the active construction period to ensure remediation workers and the environment are protected. A site-specific health and safety plan would be developed to cover the health and safety of remediation workers, on-site ALARNG personnel, Brookley Aeroplex personnel, and the general public.

4.2.3.2 Soil excavation, confirmatory sampling, and disposal

Prior to any ground disturbance, erosion control material, such as silt fences and straw bales, would be installed to minimize sediment run-off. Dust generation would be minimized during excavation activities by keeping equipment movement areas and excavation areas misted with water.

Monitoring wells OMS-28-5, OMS-28-6, and MW-8 would be abandoned prior to excavation activities. To allow access for conventional excavation equipment and dump trucks, approximately 300 linear ft of fence would be removed from the north and east sides of the proposed excavation area around MW-8, and surface vegetation (trees and shrubs) would be removed over an area of approximately 160 by 160 ft in the vicinity of B-17. The surface vegetation would be cleared to the MAA property boundary to the west and north to allow the excavation to expand if confirmatory sampling indicated that excavation was required beyond the initial 20- by 20-ft area. Clearing and grubbing would be conducted using conventional construction equipment, such as backhoes, bulldozers, and front-end loaders. The equipment, and primarily the dump trucks, would be routed through the ALARNG facility on a daily basis.

Residual contaminated soil would be excavated using conventional excavation equipment, such as excavators, front-end loaders, etc. Confirmatory soil samples would be collected from the edges of the excavated areas and analyzed for VOCs to confirm the removal of contaminants exceeding the requirements defined in the remedial design work plan. Excavated soil would be characterized and properly disposed at an off-site facility. Excavated areas would be backfilled with clean soil and restored to match the existing grade.

Excavated soil would be analyzed for Resource Conservation and Recovery Act VOCs using the Toxicity Characteristic Leaching Procedure for purposes of waste characterization for disposal. One grab sample would be collected for every 20 yd^3 of excavated soil intended for disposal. Once 10 grab samples have been collected, the samples will be combined to create one composite sample. A composite sample would be analyzed for every 200 yd^3 of excavated material for the purpose of waste characterization. It is estimated that approximately 10 composite samples in total would be collected and analyzed. All excavated soil would be assumed characteristically non-hazardous due to the concentrations of contamination reported in the RI Report for OMS-28 (SAIC 2013) that did not exceed the RSLs and not considered a listed waste.

The excavated soil would either be stockpiled on-site or placed directly into lined and/or covered dump trucks or roll-off containers for transport to the ultimate disposal site. Non-hazardous waste soil would be transported to a permitted landfill, such as the Chastang Landfill in Mt. Vernon, Mobile County, Alabama, which is located approximately 30 miles from the site. All shipments would be accompanied by appropriate waste documentation.

4.2.3.3 Site restoration

The site would be restored by backfilling the excavation to the ground surface, adding topsoil or soil amendments as required to promote vegetation growth, and seeding and mulching to establish surface vegetation.

4.2.3.4 Monitored natural attenuation

Following excavation, groundwater monitoring would be used to show that natural attenuation was reducing contamination as predicted. The monitoring well network would include seven existing shallow monitoring wells (OMS-28-2, OMS-28-3, OMS-28-7, MW-5, MW-6, MW-9, and MW-12), two shallow replacement monitoring wells, and four new shallow monitoring wells (Figure 4-1). Deep wells would not be included in the monitoring program because historical sampling has shown that these wells are not contaminated. Shallow replacement monitoring wells would be installed in the vicinity of former wells MW-8 and OMS-28-5, which would have been abandoned prior to excavation. Following review of the groundwater results of the baseline groundwater sampling event, approximately four new wells would be installed at the site. It is anticipated that two of these groundwater monitoring wells would be installed downgradient of the groundwater plume adjacent to the MAA property boundary north of existing well OMS-28-4 and soil boring B-17, and two of these wells would be installed downgradient of the soil source area in the vicinity of MW-8 for better coverage of the existing groundwater plume. Based upon the results of preliminary modeling (Appendix B), it is estimated that PCE and TCE in groundwater would naturally attenuate to below MCLs within approximately 10 to 15 years for PCE and approximately 25 to 30 years for TCE, assuming that the residual source mass in soil is removed. Field parameters and laboratory chemical analyses would be used to establish baseline conditions. Field parameters would include pH, specific conductivity, temperature, DO, ORP, and static water level. Laboratory analyses would include analysis for VOCs, TOC, alkalinity, sulfate, methane, ethane, ethene, and nitrate/nitrite. Groundwater monitoring would be conducted semiannually for the first 10 years and then on an annual basis until concentrations are below MCLs.

4.2.3.5 Land use controls

LUCs reviews would be conducted as described in Alternative 2 (Section 4.2.2.3).

4.2.3.6 Five-year reviews

Five-year reviews would be conducted as described in Alternative 2 (Section 4.2.2.4). For the purpose of this FS, it is assumed that 5-year reviews would be conducted for approximately 25 years under this alternative.

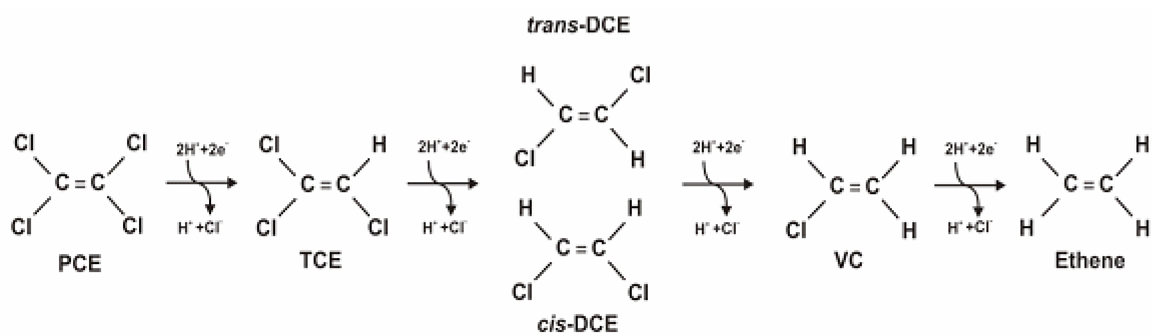
4.2.4 Alternative 4 – Biological/Chemical Reduction of Groundwater with Excavation of Soil

Actions for groundwater at OMS-28 under this alternative are as follows:

- biological/chemical reduction of contaminated groundwater, and
- excavation of soil exceeding the SSLs for protection of groundwater.

This alternative consists of anaerobic bioremediation (i.e., biological reduction) that may be coupled with abiotic chemical reduction using zero valent iron (ZVI) (i.e., chemical reduction), if deemed necessary, of groundwater until the MCLs for TCE and PCE are achieved. To expedite the remediation timeframe, this alternative also includes the excavation of the residual soil mass acting as a continuing source for groundwater contamination and transportation of the resulting waste to a permitted municipal solid waste landfill for disposal. There are two areas within the TCE and PCE groundwater plumes where the residual contaminant mass in the vadose zone soil is acting as a secondary source to groundwater.

Excavation of residual contaminated soil would be conducted as described in Alternative 3. Following excavation, an electron donor, such as an engineered vegetable oil substrate package or other carbon source, would be injected into the subsurface via temporary injection points. In most subsurface environments, the main biodegradation mechanism for chlorinated ethenes is anaerobic reductive dechlorination, which occurs by sequential removal of chloride ions from PCE to TCE to *cis*-1,2-DCE; *trans*-1,2-DCE; or 1,1-DCE to VC to ethene and ethane, and eventual mineralization to carbon dioxide and water. An electron donor, typically hydrogen, is consumed, and hydrochloric acid is generated at each stage of the anaerobic dechlorination reaction (see Figure 4-3).



Source: ITRC 2008.

Figure 4-3. Primary Anaerobic Reductive Dechlorination Pathway for PCE to TCE to Ethene

An oxygen-depleted environment with low redox potential (i.e., negative ORP) is required for this series of degradation reactions to proceed at reasonable rates in the subsurface groundwater environment. The competing electron acceptors oxygen, nitrate, and ferric iron must be depleted in the groundwater environment before the anaerobic reductive dechlorination process will occur at significant rates. The reductive dechlorination reactions occur at similar ORP levels as the sulfate reduction and methanogenesis reactions, approximately 100 mV or lower (EPA 2000). High concentrations of sulfate (on the order of 100 mg/L), which is also an electron acceptor, may retard the anaerobic reductive dechlorination process. Besides anaerobic, low ORP conditions, the reductive dechlorination reactions also require a near-neutral groundwater pH; therefore, pH adjustment may be necessary for certain systems. Sodium hydroxide, sodium bicarbonate, and potassium bicarbonate are the common chemicals used for pH adjustment. Other reactions, such as cometabolic degradation and abiotic degradation, may be responsible for a significant portion of chlorinated ethene disappearance; both of these mechanisms can occur along with anaerobic reductive dechlorination under anaerobic conditions. Abiotic dechlorination alone is usually slower than microbial dechlorination, but abiotic dechlorination is usually complete. Abiotic agents that enhance the anaerobic reductive dechlorination of chlorinated ethanes and ethenes are zero-valent metals (e.g., ZVI), sulphide minerals, or green rusts.

Review of the information summarized in the RI Report for OMS-28 (SAIC 2013) provided limited information regarding the current aquifer geochemistry conditions at OMS-28. Other than VOC concentration data, only pH, temperature, conductivity, and DO data were available. DO readings in September 2010 were generally less than 1 mg/L, which is indicative of anaerobic conditions. No ORP measurements have been reported to confirm the anaerobic nature of the site. Other sites (e.g., Formerly

Used Defense Sites [FUDS] Site 27 and AOC-009) within the confines of Brookley Aeroplex indicate anaerobic aquifer conditions.

A biostimulation remedial action was implemented at Site 27 in 2007 using Slow Release Substrate™ (SRS™). SRS™ is a vegetable oil-based substrate package that can be used by naturally occurring microorganisms as an energy and carbon source to reductively dechlorinate solvents. Site 27 is located within the confines of the Brookley Aeroplex, approximately 1 mile south-southwest of OMS-28, and has a similar lithology and aquifer properties as OMS-28. The results from the 2007 SRS™ treatment showed a reduction of TCE along with the persistence of potentially hazardous byproducts *cis*-1,2-DCE and VC. A groundwater sample collected from monitoring well B27-MW08 in 2010 contained a population of *Dehalococcoides* sp. (DHC) of 5.75 × 103 cell/mL, and the VC (bvcA) reductase genes were found in 5.47 × 102 cells/mL (Bechtel-S 2011). DHC is the primary bacterium responsible for the complete biological degradation of PCE, TCE, and the daughter products. The presence of bvcA indicates the potential for biodegradation of VC.

An in-situ chemical reduction pilot study was implemented at AOC-009 in 2012 and 2013 when EHC® was initially injected. EHC® is a controlled-release, integrated carbon and ZVI source that yields redox potentials as low as -500 mV. Redox potentials in this range facilitate the timely and effective removal of recalcitrant chlorinated organics (e.g., PCE) and other persistent compounds with less formation of potentially problematic intermediates, such as DCE and VC from the anaerobic degradation of PCE and TCE. AOC-009 is located within the confines of the Brookley Aeroplex, approximately 2 miles south-southwest of OMS-28, and has a similar lithology and aquifer properties as OMS-28. The results from the first monitoring event following the EHC® treatment showed a 80 to 85% reduction in TCE and other compounds in wells AOC-009155 and AOC009-5, and over 95% reduction in well AOC009-15I.

4.2.4.1 Remedial design

A remedial design work plan would be developed prior to the initiation of remedial actions, as described in Alternative 3 (Section 4.2.3.1). This plan would also include details regarding the groundwater injection activities.

Review of the historical documents provided limited information regarding the current aquifer geochemistry conditions. Other than VOC concentration data, only pH, temperature, conductivity, and DO data were available. If biological/chemical reduction is selected as the preferred remedy for groundwater, a baseline groundwater sampling event would be conducted to collect groundwater samples for VOCs, metals, TOC, alkalinity, hardness, biochemical oxygen demand, chemical oxygen demand, sulfate, nitrate/nitrite, methane, ethane, ethene, hydrogen, volatile fatty acids, phospholipid fatty acids, and DHC with gene analysis. In addition, field parameters, including pH, temperature, conductivity, DO, and ORP, would be collected. If necessary, a bench-scale treatability study might be conducted. This information would be used during the remedial design phase to make appropriate adjustments to the amendments and quantities presented in this proposed alternative. In addition, the design phase would determine whether the chemical reduction portion of the alternative remains a cost-effective phase of the alternative.

4.2.4.2 Soil excavation, confirmatory sampling, disposal, and site restoration

Soil excavation, confirmatory sampling, and disposal activities would be conducted as described in Alternative 3 (Section 4.2.3.2). Restoration activities would be conducted as described in Alternative 3 (Section 4.2.3.3).

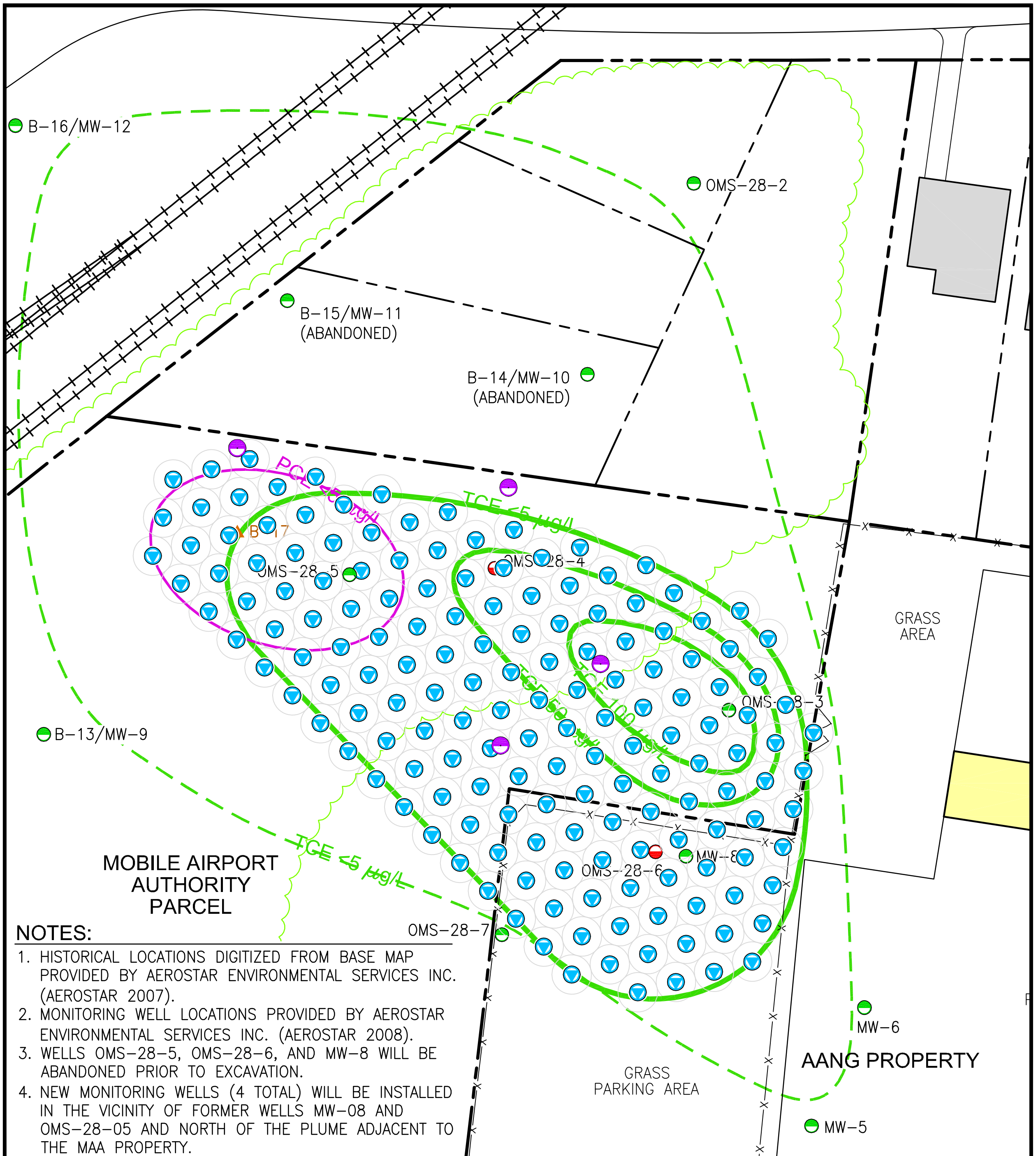
4.2.4.3 Biological/Chemical reduction

There are several commercial products of engineered vegetable oil-based substrate packages (e.g., SRS™, EOS®, EHC®, and EHC®-L) that provide a carbon source for the enhanced reductive dechlorination of chlorinated solvents (i.e., biological reduction). SRS™ and EOS® each consist of a combination of controlled-release carbon and nutrients used for stimulating in-situ biological reducing conditions for dechlorination of organic solvents. EHC® is a dry powder that is composed of controlled-release carbon, ZVI particles, and nutrients used for stimulating in-situ biological and chemical reducing conditions for dechlorination of organic solvents. EHC®-L is a liquid variant of EHC®. Manufacturer's experience indicates that the radius of influence for EHC® via direct-push installation is estimated at 5 to 8 ft, requiring an injection spacing of 10 to 15 ft, and that the injection spacing for EHC®-L would be approximately 15 ft. The injection spacing for SRS™ and EOS® would also be approximately 15 ft. Although the injection grids are similar for the various engineered products, the cost for the alternative varies significantly depending on the substrate material selected. SRS™ or EOS® cost less than EHC® and EHC®-L because ZVI is not included. The weight of EHC® required per well is higher than EHC®-L, and the cost is also higher per pound. Therefore, the description of this alternative and the costs presented in Appendix A assume the use of EHC®-L because it would be the lowest cost biological/chemical reduction treatment. The remedial design work plan would select the most appropriate of the engineered vegetable oil-based substrate package, specify injection quantities, and determine if the chemical reduction component (e.g., ZVI) is warranted based on pre-remediation baseline groundwater concentrations and other aquifer conditions.

The required volume of electron donor for biological/chemical reduction treatment is the greater of either the stoichiometric, geochemical, and competitive demands to degrade the chlorinated solvent or the residual oil saturation that must be overcome to achieve distribution in the subsurface. For OMS-28, the electron donor injections would be based upon the residual oil saturation that must be overcome to achieve distribution. EHC®-L (i.e., the engineered vegetable oil-based substrate with ZVI) would be delivered as two components, which would be mixed together in the field. The first component, a 25% liquid emulsion of carbon substrate, would be provided in 55-gal drums, with 50 gal per drum. The second component, EHC®-L mixture containing the ferrous iron powder, would be delivered as a dry powder and added to the liquid component in the field. For each injection point, the EHC®-L mixture would be proportioned as follows: one bag (24.5 lb) of EHC®-L mixture per drum. Approximately 500 gal of dilution and distribution water would be injected along with the EHC®-L at each point.

The biological/chemical reduction treatment would target TCE and PCE groundwater contamination within the 5-µg/L contours, as defined based on 2010 data, from approximately 10 to 20 ft BGS. Depending on the final depth of excavation, injection points within the source area would be screened to treat within the 5- to 30-ft BGS interval. A conceptual layout of proposed injection locations is shown on Figure 4-4. A total of approximately 165 temporary injection points, based upon 15-ft spacing, are estimated to be required for treatment of the target area. It is estimated that an injection rate of approximately 1 gal per minute (gpm) could be achieved.

Because anaerobic reductive dechlorination generates hydrochloric acid and the activity of bacteria is pH-sensitive, potassium bicarbonate also would be injected at each injection location. Natural pH conditions at the site are 5 to 6 standard units. Additional pH buffer will be needed to raise the pH of the groundwater to 7, which is more favorable to an active bacteria population. The appropriate quantity of bicarbonate should be determined during the remedial design process through a titration test of a site-specific soil and groundwater slurry if this alternative is selected as the preferred remedy. Costs presented in this FS assume an injection of approximately 25 lb of potassium bicarbonate per drum of EHC®-L injected.



NOTES:

1. HISTORICAL LOCATIONS DIGITIZED FROM BASE MAP PROVIDED BY AEROSTAR ENVIRONMENTAL SERVICES INC. (AEROSTAR 2007).
2. MONITORING WELL LOCATIONS PROVIDED BY AEROSTAR ENVIRONMENTAL SERVICES INC. (AEROSTAR 2008).
3. WELLS OMS-28-5, OMS-28-6, AND MW-8 WILL BE ABANDONED PRIOR TO EXCAVATION.
4. NEW MONITORING WELLS (4 TOTAL) WILL BE INSTALLED IN THE VICINITY OF FORMER WELLS MW-08 AND OMS-28-05 AND NORTH OF THE PLUME ADJACENT TO THE MAA PROPERTY.

LEGEND:

- RESIDENTIAL BUILDING
- COMMERCIAL BUILDING
- ASPHALT ROAD
- RAILROAD TRACKS
- CHAIN LINK FENCE
- PROPERTY BOUNDARY
- TREE LINE
- SHALLOW MONITORING WELL
- PROPOSED SHALLOW MONITORING WELL
- DEEP MONITORING WELL
- INJECTION POINT (15-FT ON CENTER)
- TCE CONTOUR (SEPT 2010)
- PCE CONTOUR (SEPT 2010)

AL STATE PLANE NAD 83 WEST

0 30 60
SCALE: 1" = 60'

leidos

FIGURE 4-4.
BIOLOGICAL/CHEMICAL REDUCTION PORTION OF ALTERNATIVE 4

OMS - 28
ALABAMA ARMY NATIONAL GUARD
MOBILE, ALABAMA

DRAWN BY:	REV. NO./DATE:	CAD FILE:
R. BEELER	0/01-06-14	/11013/DWGS/P53_BIO_ALT4-01

Bioaugmentation is typically accomplished by simple injection of cultures into the groundwater after the carbon source injection. The most common bioaugment for solvent degradation is mixed bacterial cultures that contain DHC bacteria, which are the sole bacterium shown to have the ability for PCE; TCE; 1,2-DCE; and VC degradation by anaerobic reductive dechlorination. Because these bacteria are only effective under anaerobic conditions, they are typically injected into the subsurface only sometime after the electron donor injection. This provides time for the naturally occurring facultative bacteria population to turn the environment completely anaerobic to ensure the survivability of the injected DHC population.

Approximately 1 L of DHC inoculants with a concentration of approximately $5x10^{10}$ colony-forming units per liter would be injected in each well following the initial substrate injection to provide a DHC density of $1x10^{6}$ colony-forming units per liter.

4.2.4.4 Groundwater performance monitoring

Following excavation, groundwater monitoring would be used to show that biological/chemical reduction is reducing contamination as predicted. The monitoring well network would include seven existing shallow monitoring wells (OMS-28-2, OMS-28-3, OMS-28-7, MW-5, MW-6, MW-9, and MW-12), two shallow replacement monitoring wells, and four new shallow monitoring wells. Deep wells would not be included in the monitoring program because historical sampling has shown that these wells are not contaminated. Shallow replacement monitoring wells would be installed in the vicinity of former wells MW-8 and OMS-28-5, which would have been abandoned prior to excavation. Following review of the groundwater results of the baseline groundwater sampling event, approximately four new wells would be installed at the site. It is anticipated that two of these groundwater monitoring wells would be installed downgradient of the groundwater plume adjacent to the MAA property boundary north of existing well OMS-28-4 and soil boring B-17, and two of these wells would be installed downgradient of the soil source area in the vicinity of MW-8 for better coverage of the existing groundwater plume. It is estimated that both PCE and TCE in groundwater would be reduced to below MCLs within approximately 5 years. Groundwater performance monitoring would be conducted quarterly for the first 3 years or until the concentrations were below the MCLs, and then semiannual groundwater sampling would be performed for a minimum of three sampling events to confirm that the concentrations were below MCLs. Field parameters and laboratory chemical analyses would be used to establish baseline conditions. Field parameters would include pH, specific conductivity, temperature, DO, ORP, and static water level. Laboratory analyses would include analysis for VOCs, metals, TOC, alkalinity, hardness, biochemical oxygen demand, chemical oxygen demand, sulfate, nitrate/nitrite, methane, ethane, ethene, and hydrogen. Samples from two wells per monitoring event also would be analyzed for DHC with gene analysis, phospholipid fatty acids, and volatile fatty acids.

4.2.4.5 Five-year reviews

Five-year reviews would be conducted as described in Alternative 2 (Section 4.2.2.4). For the purpose of this FS, it is assumed that 5-year reviews would be conducted for approximately 5 years under this alternative.

4.2.5 Alternative 5 – In-Situ Chemical Oxidation of Groundwater with Excavation of Soil

Actions for groundwater at OMS-28 under this alternative are as follows:

- in-situ chemical oxidation (ISCO) of contaminated groundwater, and
- excavation of soil exceeding the SSLs for protection of groundwater.

This alternative consists of ISCO of groundwater until the MCLs for TCE and PCE are achieved. To expedite the MNA timeframe, this alternative also includes the excavation of the residual soil mass acting as a continuing source for groundwater contamination and transportation of the resulting waste to a permitted municipal solid waste landfill for disposal. There are two areas within the TCE and PCE groundwater plumes where the residual contaminant mass in the vadose zone soil is acting as a secondary source to groundwater.

4.2.5.1 Remedial design

A remedial design work plan would be developed prior to the initiation of remedial actions, as described in Alternative 3 (Section 4.2.3.1). This plan would also include details regarding the groundwater injection activities.

Review of the historical documents provided limited information regarding the current aquifer geochemistry conditions. Other than VOC concentration data, only pH, temperature, conductivity, and DO data were available. The most significant parameter in ISCO design, with respect to the quantity of oxidant necessary for remediation, is the natural oxidant demand (NOD). NOD is a site-specific value that can range from below 0.1 g/kg to more than 100 g/kg. High soil organic matter will generally increase the NOD significantly, as will substantial amounts of biomass, organic growth substrates, or reduced minerals. If ISCO is selected as the preferred remedy for groundwater, a baseline groundwater sampling event would be conducted to collect groundwater samples for VOCs, metals, TOC, alkalinity, hardness, biochemical oxygen demand, chemical oxygen demand, sulfate, nitrate/nitrite, methane, ethane, ethene, hydrogen. In addition, field parameters, including pH, temperature, conductivity, DO, and ORP, would be collected. The NOD at OMS-28 should be analytically determined during the remedial design phase and appropriate adjustments made to the quantities presented in this proposed alternative.

4.2.5.2 Soil excavation, confirmatory sampling, disposal, and site restoration

Soil excavation, confirmatory sampling, and disposal activities would be conducted as described in Alternative 3 (Section 4.2.3.2). Restoration activities would be conducted as described in Alternative 3 (Section 4.2.3.3).

4.2.5.3 Chemical oxidation

The chemical oxidant permanganate is a longer-lived oxidant than Fenton’s reagent, hydrogen peroxide, or ozone, and is, therefore, a recommended oxidant for this alternative. However, if ISCO is selected as a remedy, any appropriate chemical oxidant or combination of oxidants may be used in the final remedy. The radius of influence for ISCO is expected to be similar to that of the amendments for biological/chemical reduction, which is estimated to be 5 to 8 ft in the OMS-28 soils. Therefore, the optimum injection spacing would be approximately 15 ft. There are two common forms of permanganate – potassium permanganate and sodium permanganate. Potassium permanganate is a crystalline solid; aqueous solutions of concentrations up to 4% can be prepared on-site. Sodium permanganate is usually supplied as a concentrated liquid (40%) and diluted on-site for application at lower concentrations. Although the use of sodium permanganate would avoid the dust hazards associated with potassium permanganate, costs presented in Appendix A assume the use of potassium permanganate; the cost for sodium permanganate is much higher.

Following excavation, a strong oxidizing agent, such as permanganate, would be injected into the subsurface via injection wells. This ISCO treatment would target TCE and PCE groundwater contamination within the 5-µg/L contours from approximately 10 to 20 ft BGS. Depending on the final depth of excavation, injection points within the source area may be screened to treat the 5- to 30-ft BGS interval. A conceptual layout of the proposed injection wells is shown in Figure 4-5. A total of approximately 165 injection locations, based upon a 15-ft spacing, are estimated to be required for treatment of the target area. It is estimated that an injection rate of approximately 1 gpm could be achieved.

Based upon stoichiometric demands, approximately 2.4 lb of potassium permanganate are required to oxidize 1 lb of TCE, and approximately 1.3 lb of potassium permanganate are required to oxidize 1 lb of PCE. In addition to the stoichiometric demand, sufficient oxidant must be supplied to satisfy the NOD. The amount of permanganate estimated for injection in the initial injection event, based upon stoichiometric demand and an assumed NOD of 10 g per 1 kg soil, is approximately 200,000 lb. Approximately 500 gal of dilution and distribution water would be injected at each injection well.

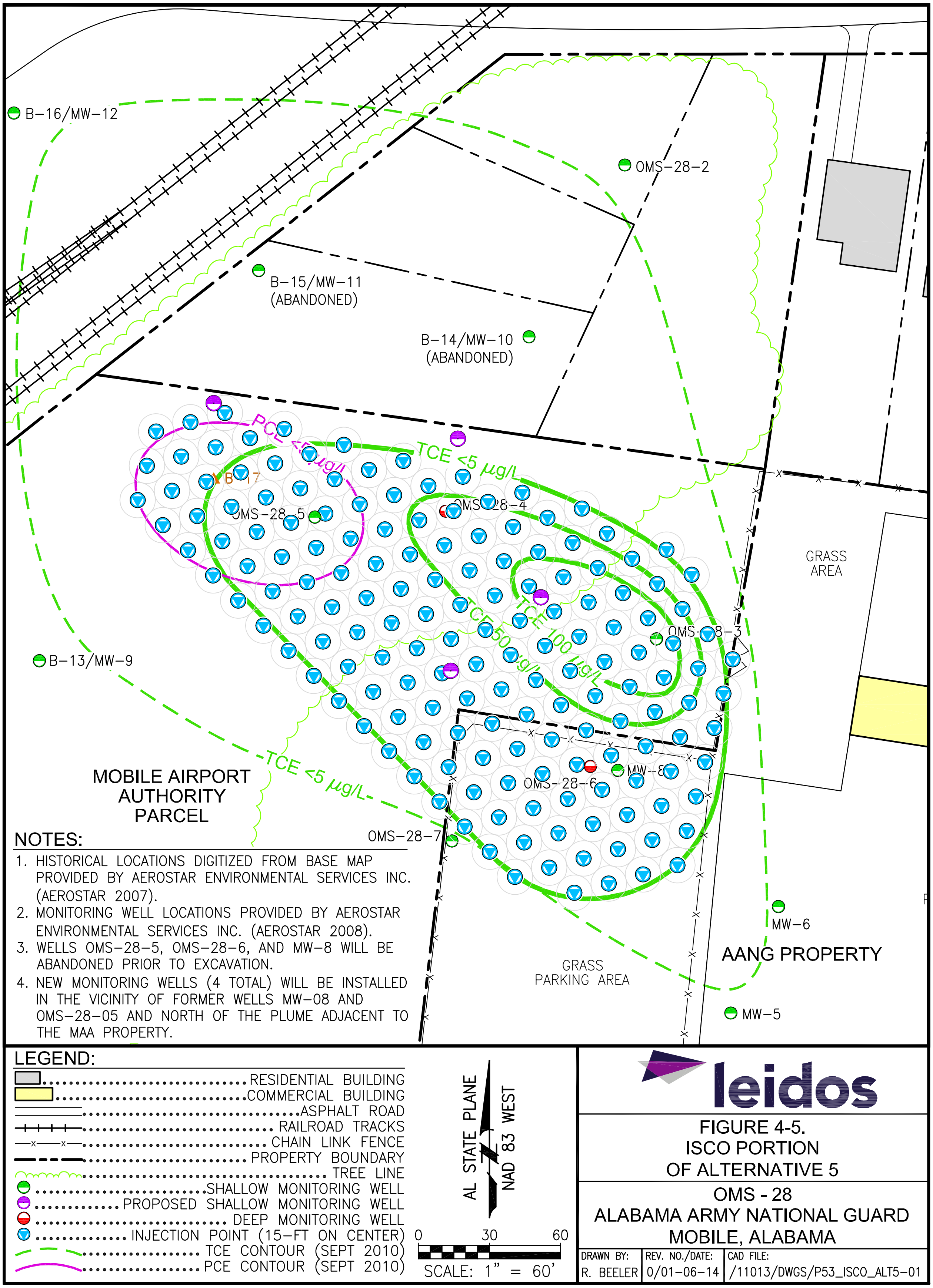
One or more polishing steps may be required to ensure complete remediation to RLs. Subsequent injections would require less permanganate than the initial injection and might require injecting into only a limited number of injection wells. Depending on the initial results, additional injection wells might be required to focus the subsequent injections.

4.2.5.4 Groundwater performance monitoring

Following excavation, groundwater monitoring would be used to show that ISCO is reducing contamination as predicted. The monitoring well network would include seven existing shallow monitoring wells (OMS-28-2, OMS-28-3, OMS-28-7, MW-5, MW-6, MW-9, and MW-12), two shallow replacement monitoring wells, and four new shallow monitoring wells. Deep wells would not be included in the monitoring program because historical sampling has shown that these wells are not contaminated. Shallow replacement monitoring wells would be installed in the vicinity of former wells MW-8 and OMS-28-5, which would have been abandoned prior to excavation. Following review of the groundwater results of the baseline groundwater sampling event, approximately four new wells would be installed at the site. It is anticipated that two of these groundwater monitoring wells would be installed downgradient of the groundwater plume adjacent to the MAA property boundary north of existing well OMS-28-4 and soil boring B-17, and two of these wells would be installed downgradient of the soil source area in the vicinity of MW-8 for better coverage of the existing groundwater plume. It is estimated that both PCE and TCE in groundwater would be reduced to below MCLs following the polishing step within approximately 6 years of implementation. Groundwater performance monitoring would be conducted quarterly for the first 3 years or until the concentrations were below the MCLs, and then semiannual groundwater sampling would be performed for a minimum of three sampling events to confirm that the concentrations were below MCLs. Field parameters and laboratory chemical analyses would be used to establish baseline conditions. The results of baseline sampling would permit subsequent identification of potential byproducts caused by oxidation reactions. Field parameters would include pH, specific conductivity, temperature, DO, ORP, and static water level. Laboratory analyses would include analysis for VOCs and metals. Analysis for metals is important as redox-sensitive metals, including arsenic, barium, cadmium, chromium, copper, iron, lead, and selenium, may be oxidized to a more soluble state and become mobilized during ISCO treatment. In most cases, these metals will return to background conditions following ISCO.

4.2.5.5 Five-year reviews

Five-year reviews would be conducted as described in Alternative 2 (Section 4.2.2.4). For the purpose of this FS, it is assumed that 5-year reviews would be conducted for approximately 5 years under this alternative.


B-16/MW-12
OMS-28-2
B-15/MW-11
(ABANDONED)
B-14/MW-10
(ABANDONED)
PCE <5 µg/L
TCE <5 µg/L
B-17
OMS-28-5
OMS-28-4
TCE 50 µg/L
TCE 100 µg/L
OMS-28-3
GRASS
AREA
B-13/MW-9
MW-8
OMS-28-6
TCE <5 µg/L
MOBILE AIRPORT
AUTHORITY
PARCEL
OMS-28-7
MW-6
AANG PROPERTY
GRASS
PARKING AREA
MW-5
NOTES:
1. HISTORICAL LOCATIONS DIGITIZED FROM BASE MAP PROVIDED BY AEROSTAR ENVIRONMENTAL SERVICES INC. (AEROSTAR 2007).
2. MONITORING WELL LOCATIONS PROVIDED BY AEROSTAR ENVIRONMENTAL SERVICES INC. (AEROSTAR 2008).
3. WELLS OMS-28-5, OMS-28-6, AND MW-8 WILL BE ABANDONED PRIOR TO EXCAVATION.
4. NEW MONITORING WELLS (4 TOTAL) WILL BE INSTALLED IN THE VICINITY OF FORMER WELLS MW-08 AND OMS-28-05 AND NORTH OF THE PLUME ADJACENT TO THE MAA PROPERTY.
LEGEND:
RESIDENTIAL BUILDING
COMMERCIAL BUILDING
ASPHALT ROAD
RAILROAD TRACKS
CHAIN LINK FENCE
PROPERTY BOUNDARY
TREE LINE
SHALLOW MONITORING WELL
PROPOSED SHALLOW MONITORING WELL
DEEP MONITORING WELL
INJECTION POINT (15-FT ON CENTER)
TCE CONTOUR (SEPT 2010)
PCE CONTOUR (SEPT 2010)
AL STATE PLANE
NAD 83 WEST
0 30 60
SCALE: 1" = 60'
leidos
FIGURE 4-5.
ISCO PORTION
OF ALTERNATIVE 5
OMS - 28
ALABAMA ARMY NATIONAL GUARD
MOBILE, ALABAMA
DRAWN BY: R. BEELER
REV. NO./DATE: 0/01-06-14
CAD FILE: /11013/DWGS/P53_ISCO_ALT5-01

5.0 DETAILED ANALYSIS OF ALTERNATIVES

5.1 CRITERIA FOR DETAILED ANALYSIS OF ALTERNATIVES

This chapter presents a detailed analysis of the remedial alternatives for OMS-28. Under the CERCLA remedy selection process, the preferred remedial alternative will be suggested in the Proposed Plan and set forth in final form in a Decision Document (DD). A detailed evaluation of each alternative is performed in this chapter to provide the basis and rationale for identifying a preferred remedy and preparing the Proposed Plan.

To ensure the analysis of alternatives provides information of sufficient quality and quantity to justify the selection of a remedy, it is helpful to understand the requirements of the remedy selection process. This process is driven by the requirements set forth in CERCLA Section 121. In accordance with these requirements (EPA 1988b), remedial actions must

- be protective of human health and the environment;
- attain ARARs;
- be cost effective;
- use permanent solutions and alternative treatment technologies to the maximum extent practicable; and
- satisfy the preference for treatment that, as a principle element, reduces volume, toxicity, or mobility.

CERCLA emphasizes long-term effectiveness and related considerations for each remedial alternative. These statutory considerations include the following:

- long-term uncertainties associated with land disposal;
- the goals, objectives, and requirements of the Solid Waste Disposal Act;
- the persistence, toxicity, and mobility of hazardous substances and their propensity to bioaccumulate;
- short- and long-term potential for adverse health effects from human exposure;
- long-term maintenance costs;
- the potential for future remedial action costs if the remedial alternative in question was to fail; and
- the potential threat to human health and the environment associated with excavation, transportation, and re-disposal or containment.

These statutory requirements are implemented through the use of nine evaluation criteria presented in the NCP. These nine criteria are grouped into threshold criteria, balancing criteria, and modifying criteria, as described below. A detailed analysis of each alternative against the evaluation criteria is contained in the following sections. The detailed analysis includes further definition of each alternative, if necessary; compares the alternatives against one another; and presents considerations common to alternatives.

5.1.1 Threshold Criteria

Two of the NCP evaluation criteria relate directly to statutory findings that must be made in the DD. These criteria are considered to be threshold criteria that must be met by any remedy to be selected. The criteria are

- overall protection of human health and the environment, and
- compliance with ARARs.

Overall protection of human health and the environment considers how an alternative achieves and maintains protection of human health and the environment. An alternative is considered to be protective of human health and the environment if it complies with media-specific RLs. This overall assessment draws upon the assessments conducted under the other evaluation criteria, especially compliance with ARARs, long-term effectiveness and permanence, and short-term effectiveness.

Compliance with ARARs considers how an alternative complies with ARARs or, if a waiver is required, an explanation of why a waiver is justified.

5.1.2 Balancing Criteria

The five balancing criteria represent the primary criteria upon which the detailed analysis of alternatives and the comparison of alternatives are based. They are

- long-term effectiveness and permanence;
- reduction of toxicity, mobility, or volume through treatment;
- short-term effectiveness;
- implementability; and
- cost.

Long-term effectiveness and permanence is an evaluation of the magnitude of residual risk (risk remaining after implementation of the alternative) and the adequacy and reliability of controls used to manage the remaining waste (untreated waste and treatment residuals) over the long term. Alternatives that provide the highest degree of long-term effectiveness and permanence leave little or no untreated waste at the site, make long-term maintenance and monitoring unnecessary, and minimize the need for LUCs.

Reduction of toxicity, mobility, or volume through treatment is an evaluation of the ability of the alternative to reduce the toxicity, mobility, or volume of the waste. The irreversibility of the treatment process and the type and quantity of residuals remaining after treatment also are assessed.

Short-term effectiveness addresses the protection of workers and the community during the remedial action, the environmental effects of implementing the action, and the time required to achieve media-specific preliminary cleanup goals.

Implementability addresses the technical and administrative feasibility of implementing an alternative and the availability of various services and materials required during implementation. Technical feasibility assesses the ability to construct and operate a technology, the reliability of the technology, the ease in undertaking additional remedial actions, and the ability to monitor the effectiveness of the alternative. Administrative feasibility is addressed in terms of the ability to obtain approval from federal, state, and local agencies.

Cost analyses provide an estimate of the dollar cost of each alternative. The cost estimates are for guidance in project evaluation and implementation and are believed to be accurate within a range of -30 to +50 % in accordance with EPA guidance (EPA 1988b). Actual costs could be higher than estimated due to unexpected conditions or potential delays.

The remedial alternatives presented within this FS would occur over different time periods; therefore, the costs have been converted to present value. This allows for cost comparisons of different remedial alternatives on the basis of a single cost figure for each alternative. This single number, referred to as present value, is the amount needed to be set aside at an initial point in time (base year) to assure that funds will be available in the future as they are needed. The present value estimates involve four basic steps: (1) defining the period of analysis, (2) calculating the cash outflow for each year, (3) selecting a discount rate (i.e., interest rate), and (4) calculating the present value using standard economic formulas. The OMS-28 alternatives were evaluated using up to 30 periods of analysis depending upon the alternative. The real discounted rates used to calculate present values were based on the Office of Management and Budget Circular Number A-94 memorandum dated December 2012. The real interest rate used was 1.1% for Alternative 2, 0.8% for Alternative 3, and -0.8% for Alternatives 4 and 5. The capital costs occurring in the first year were not discounted due to their relatively short implementation duration.

5.1.3 Modifying Criteria

The two modifying criteria below will be evaluated as part of the DD after the public has had an opportunity to comment on the Proposed Plan. They are

- state acceptance, and
- community acceptance.

State acceptance considers comments received from agencies of the state of Alabama. The primary state agency supporting the investigation and remediation of OMS-28 is ADEM. Comments will be obtained from ADEM on the FS, and the preferred remedy presented in the Proposed Plan. Responses to comments from state regulators will be addressed in the DD.

Community acceptance considers comments received from the community in response to the Proposed Plan. Responses to comments from the community will be addressed in the DD.

Because the actions above have not yet taken place, the detailed analysis of alternatives presented below cannot account for these criteria at this time. Therefore, the detailed analysis is carried out only for the first seven of the nine criteria.

5.2 INDIVIDUAL ANALYSIS OF ALTERNATIVES

Detailed analyses of the remedial alternatives for OMS-28 are presented below. Each alternative is described and evaluated against the criteria outlined in Section 5.1. At present, elevated PCE and TCE concentrations in groundwater exist at OMS-28 that could result in potential adverse health effects for future adult and child residents exposed to groundwater under an unrestricted land use scenario.

5.2.1 Alternative 1 – No Action

Under this alternative, contaminated groundwater would remain in place. No action would be taken to prevent exposure to the contaminated media. Evaluation of the no action alternative is required under the NCP to provide a comparative baseline for other alternatives.

5.2.1.1 Overall protection of human health and the environment

The no action alternative would not eliminate or reduce the potential risks to future adult and child residents exposed to groundwater and would not institute LUCs to ensure only industrial use. The no action alternative is not protective of human health and the environment.

5.2.1.2 Compliance with applicable or relevant and appropriate requirements

The no action alternative does not trigger action- or location-specific ARARs (EPA 1994). The concentrations in groundwater would remain above MCLs and, although natural attenuation would occur, the aquifer would not be sampled to confirm that it had been restored to beneficial use. Thus, the no action alternative would not comply with the chemical-specific ARAR.

5.2.1.3 Long-term effectiveness and permanence

The no action alternative is not protective of the current exposure scenario; there is an unacceptable risk to the future adult and child residents exposed to groundwater. The site is located within a logistics/manufacturing district of the Brookley Aeroplex, and site use is unlikely to change in the near future. However, residential properties border the OMS-28 site to the north. The no action alternative would have no long-term effectiveness or permanence. The no action alternative would not remove, isolate, or treat contaminated groundwater at OMS-28. Contaminants in groundwater would not be addressed by this alternative. Thus, the residual risks presented by the affected media would be equivalent to the current levels of risk presented by the site.

No long-term operations, maintenance, or monitoring are required for the no action alternative. Under the no action alternative, there are no requirements for replacement of technical components or risks associated with their failure.

5.2.1.4 Reduction of toxicity, mobility, or volume through treatment

There would be no reduction in toxicity, mobility, or volume as a result of implementing the no action alternative.

5.2.1.5 Short-term effectiveness

Risks, or potential risks, to human receptors would remain unchanged under the no action alternative. The no action alternative would not remove, isolate, or treat contaminated groundwater. There would be no risks to remedial workers because no site activities would result from implementation of the no action alternative. No additional short-term health risks to the community would occur because no remedial actions would be implemented.

5.2.1.6 Implementability

The no action alternative would be easy to implement because no remedial action would be taken.

5.2.1.7 Cost

The present value cost of Alternative 1 is estimated to be $0 because there would be no action.

5.2.1.8 State acceptance

Comments will be obtained from ADEM on the FS, and the preferred remedy presented in the Proposed Plan. Responses to comments from state regulators will be addressed in the DD.

5.2.1.9 Community acceptance

Community acceptance will be based upon the results of a public meeting and comments received from the public on the Proposed Plan. Responses to comments from the community will be addressed in the DD.

5.2.2 Alternative 2 – Monitored Natural Attenuation of Groundwater

Under this alternative, groundwater monitoring would be used to show that natural attenuation is reducing contamination as predicted.

5.2.2.1 Overall protection of human health and the environment

This alternative would protect human health and the environment in the long-term following completion of the MNA period by restoring contaminated groundwater to below MCLs. Risks associated with the residual groundwater contamination during the MNA period may be managed by appropriate institutional controls to limit access/exposure to contaminated groundwater.

5.2.2.2 Compliance with applicable or relevant and appropriate requirements

Potential ARARs were presented in Chapter 3.0. This alternative would potentially trigger chemical-, location-, and/or action-specific ARARs.

Compliance with the chemical-specific ARAR for groundwater (i.e., MCLs) would be achieved upon completion of the MNA period.

The well installation component of this alternative would potentially trigger location- and action-specific ARARs. Action-specific requirements identified as ARARs deal primarily with the characterization, management, and disposal of contaminated soil generated during well installation.

Location-specific standards also must be considered during the implementation of this alternative. Although not anticipated within the area of impact, considerations for the potential presence of endangered species must be considered during the design to ensure impacts to such species or their habitats do not occur.

5.2.2.3 Long-term effectiveness and permanence

This alternative would be protective in the long term. The effectiveness of this approach is related to the adequacy and reliability of MNA of groundwater. MNA would be used to demonstrate groundwater contaminant reduction to RLs. The effectiveness of the alternative is related to natural degradation rates at OMS-28. LUCs would be implemented to restrict access to groundwater during the MNA timeframe.

Because groundwater contaminants would remain on-site above RLs until the end of the MNA timeframe, reviews would need to be conducted every 5 years pursuant to CERCLA requirements. These reviews would demonstrate the reliability and effectiveness of MNA. It is anticipated that six 5-year reviews would be required for this alternative.

Groundwater is anticipated to meet criteria for unrestricted use at the completion of this remedy. Soil already meets the criteria for unrestricted use.

5.2.2.4 Reduction of toxicity, mobility, or volume through treatment

MNA would result in the reduction in volume and toxicity of PCE and TCE in groundwater. This reduction would be monitored through groundwater sampling until RLs are achieved. However, no active treatment would be performed. Mobility of the contaminants would not be reduced; however, mobility is not very high at this site because of the low groundwater velocity.

5.2.2.5 Short-term effectiveness

There would be low potential for unacceptable exposure to workers during implementation of this alternative. Contaminants in groundwater could pose a hypothetical risk to workers during sampling. Workers also would be exposed to general safety risks during well installation and groundwater sampling, which include, but are not limited to, heavy equipment hazards, fall and trip hazards, and heat stress for operations that occur within the summer months. These risks would be minimized through the use of accepted construction practices and adherence to health and safety plans developed during the implementation of this alternative.

5.2.2.6 Implementability

MNA is readily implementable. The level of activity at the site would be minimal, limited to monitoring events. Materials, equipment, and labor for well installation and groundwater sampling are readily available.

5.2.2.7 Cost

The capital cost (discounted) to implement Alternative 2 is estimated at $141,775; the 30-year O&M and periodic costs are estimated at $1.69 million. The total present value of the capital, O&M, and periodic costs (discount rate 1.1%) is estimated at $1.83 million. Details are presented in Appendix A.

5.2.2.8 State acceptance

Comments will be obtained from ADEM on the FS, and the preferred remedy presented in the Proposed Plan. Responses to comments from state regulators will be addressed in the DD.

5.2.2.9 Community acceptance

Community acceptance will be based upon the results of a public meeting and comments received from the public on the Proposed Plan. Responses to comments from the community will be addressed in the DD.

5.2.3 Alternative 3 – Monitored Natural Attenuation of Groundwater with Excavation of Soil

Under this alternative, groundwater monitoring would be used to show that natural attenuation is reducing contamination as predicted. In addition, the residual soil contaminant mass in the vadose zone acting as a secondary source to groundwater would be excavated to reduce the MNA timeframe.

5.2.3.1 Overall protection of human health and the environment

This alternative would protect human health and the environment in the long-term following completion of the MNA period by restoring contaminated groundwater to below MCLs. Risks associated with the residual groundwater contamination during the MNA period may be managed by appropriate institutional controls to limit access/exposure to contaminated groundwater.

5.2.3.2 Compliance with applicable or relevant and appropriate requirements

Potential ARARs were presented in Chapter 3.0. This alternative would potentially trigger chemical-, location-, and/or action-specific ARARs.

Compliance with the chemical-specific ARAR for groundwater (i.e., MCLs) would be achieved upon completion of the MNA period.

The excavation portion of this alternative would potentially trigger location- and action-specific ARARs. Excavated soil would be tested to demonstrate that the material does not exhibit a characteristic of a hazardous waste. Due to historical concentrations observed at the site, the soil is expected to be non-hazardous. Action-specific standards associated with construction activities also may be triggered as a result of excavation and backfilling. This includes the requirement to control particulate emissions and the migration of sediment from the disturbed area under the stormwater protection requirements.

Location-specific standards also must be considered during the implementation of this alternative. Although not anticipated within the area of impact, considerations for the potential presence of endangered species must be considered during the design to ensure impacts to such species or their habitats do not occur.

5.2.3.3 Long-term effectiveness and permanence

This alternative would be protective in the long term. The effectiveness of this approach is related to the adequacy and reliability of two distinct actions: removal of residual contaminant mass in soil and MNA of groundwater. Soil removal is expected to be effective in protecting human health and the environment by removing residual contaminant mass and disposing of it off-site at a licensed disposal facility. MNA would be used to demonstrate groundwater contaminant reduction to RLs. The effectiveness of the groundwater MNA portion of this alternative is related to natural degradation rates at OMS-28. LUCs would be implemented to restrict access to groundwater during the MNA timeframe.

Because groundwater contaminants would remain on-site above RLs until the end of the MNA timeframe, reviews would need to be conducted every 5 years pursuant to CERCLA requirements. These reviews would demonstrate the reliability and effectiveness of the MNA portion of this alternative. It is anticipated that five 5-year reviews would be required for this alternative.

Groundwater is anticipated to meet the criteria for unrestricted use at the completion of this remedy. Soil already meets the criteria for unrestricted use.

5.2.3.4 Reduction of toxicity, mobility, or volume through treatment

This alternative would permanently remove nearly 100% of the residual contaminant mass above the SSL for the protection of groundwater, thus reducing the on-site volume of contaminated soil by approximately 1,400 yd^3 (in-situ). There would be no reduction in total volume, toxicity, or mobility because no treatment would be performed prior to shipment to the landfill.

The MNA portion of this alternative would result in the reduction in volume and toxicity of PCE and TCE in groundwater. This reduction would be monitored through groundwater sampling until RLs are achieved. However, no active treatment would be performed. Mobility of the contaminants would not be reduced; however, mobility is not very high at this site because of the low groundwater velocity.

5.2.3.5 Short-term effectiveness

There would be low potential for unacceptable exposure to workers during implementation of this alternative. Contaminants in soil could pose a hypothetical risk to workers due to ingestion of dust. Contaminants in groundwater could pose a hypothetical risk to workers during sampling. Workers also would be exposed to general safety risks during excavation, waste shipment operations, well installation, and groundwater sampling, which include, but are not limited to, heavy equipment hazards, fall and trip hazards, and heat stress for operations that occur within the summer months. These risks would be minimized through the use of accepted construction practices and adherence to health and safety plans developed during the implementation of this alternative.

There would be low potential for risk or impact to the community due to the increased traffic to haul waste soil material to an off-site landfill. These impacts could be minimized through designation of specific times of day to avoid high traffic volume and routes that may be used to protect communities through which the hauling would occur. These risks would be further minimized through the use of proper waste containerization or covering and adherence to transportation safety plans in accordance with U. S. Department of Transportation (DOT) regulations.

5.2.3.6 Implementability

Soil excavation is technically feasible because it is a conventional construction technology with few impediments to implementation. This portion of the alternative would require a few pieces of heavy equipment and materials to be on-site, such as an excavator, front-end loader, dump trucks, and a compactor. Soil would not have to be stockpiled, but it could be directly placed into lined and covered dump trucks or roll-off containers for transport to the landfill. Implementability would require appropriate waste characterization and documentation for ultimate disposal at a permitted landfill.

The excavation portion of this alternative could be completed within 6 to 12 months following approval of the DD. Because no contaminated soil would be left on-site, no long-term O&M activities related to soil would need to be conducted once surface grade has been re-established.

MNA also is readily implementable. The level of activity at the site would be minimal, limited to monitoring events. Materials, equipment, and labor for groundwater sampling are readily available.

5.2.3.7 Cost

The capital cost (discounted) to implement Alternative 3 is estimated at $761,013; the 25-year O&M and periodic costs are estimated at $1.32 million. The total present value of the capital, O&M, and periodic costs (discount rate 0.8%) is estimated at $2.08 million. Details are presented in Appendix A.

5.2.3.8 State acceptance

Comments will be obtained from ADEM on the FS, and the preferred remedy presented in the Proposed Plan. Responses to comments from state regulators will be addressed in the DD.

5.2.3.9 Community acceptance

Community acceptance will be based upon the results of a public meeting and comments received from the public on the Proposed Plan. Responses to comments from the community will be addressed in the DD.

5.2.4 Alternative 4 – Biological/Chemical Reduction of Groundwater with Excavation of Soil

Under this alternative, anaerobic bioremediation (i.e., biological reduction) may be coupled with abiotic chemical reduction via an engineered vegetable oil-based substrate package to reduce PCE and TCE in groundwater to below MCLs. In addition, the residual soil contaminant mass in the vadose zone acting as a secondary source to groundwater would be excavated to reduce the MNA timeframe.

5.2.4.1 Overall protection of human health and the environment

This alternative would protect human health and the environment would be protected with respect to groundwater in the long term upon completion of the biological/chemical reduction treatment and achievement of groundwater RLs.

5.2.4.2 Compliance with applicable or relevant and appropriate requirements

Potential ARARs were presented in Chapter 3.0. This alternative would potentially trigger chemical-, location-, and/or action-specific ARARs.

Compliance with the chemical-specific ARAR for groundwater (i.e., MCLs) would be achieved upon completion of treatment by biological/chemical reduction.

The excavation portion of this alternative would potentially trigger location- and action-specific ARARs. Excavated soil would be tested to demonstrate that the material does not exhibit a characteristic of a hazardous waste. Due to historical concentrations observed at the site, the soil is expected to be non-hazardous. Action-specific standards associated with construction activities also may be triggered as a result of excavation and backfilling. This includes the requirement to control particulate emissions and the migration of sediment from the disturbed area under the stormwater protection requirements. The groundwater portion of this alternative would require an underground injection well permit.

Location-specific standards also must be considered during the implementation of this alternative. Although not anticipated within the area of impact, considerations for the potential presence of endangered species must be considered during the design to ensure impacts to such species or their habitats do not occur.

5.2.4.3 Long-term effectiveness and permanence

This alternative would be protective in the long term. The effectiveness of this approach is related to the adequacy and reliability of two distinct actions: removal of residual contaminant mass in soil and treatment of contaminated groundwater by biological/chemical reduction. Soil removal is expected to be effective in protecting human health and the environment by removing residual contaminant mass and disposing of it off-site at a licensed disposal facility. Active treatment of groundwater through biological/chemical reduction would achieve RLs within approximately 5 years. Groundwater monitoring during the biological/chemical reduction treatment timeframe would be used to demonstrate groundwater contaminant reduction to RLs.

Because groundwater contaminants would remain on-site above RLs for a period of time, reviews would need to be conducted every 5 years pursuant to CERCLA requirements. It is anticipated that only one 5-year review would be required for this alternative.

Groundwater is anticipated to meet the criteria for unrestricted use at the completion of this remedy. Soil already meets the criteria for unrestricted use.

5.2.4.4 Reduction of toxicity, mobility, or volume through treatment

This alternative would permanently remove nearly 100% of the residual contaminant mass above the SSL for the protection of groundwater, thus reducing the on-site volume of contaminated soil by approximately 1,400 yd^3 (in-situ). There would be no reduction in total volume, toxicity, or mobility because no treatment would be performed prior to shipment to the landfill.

The biological/chemical reduction portion of this alternative would meet the statutory preference for employing a treatment technology and would effectively reduce the toxicity and volume of PCE and TCE in groundwater at the site to below RLs during the approximate 5-year treatment timeframe. Although the overall contaminant mass will be reduced, there will be a temporary toxicity increase as VC is formed as a byproduct of the biodegradation process. As the degradation process proceeds through VC to ethene, the VC concentrations will decrease. Once VC concentrations start to decrease, the associated toxicity also will decrease.

Mobility of the contaminants would not be reduced; however, mobility is not very high at this site because of the low groundwater velocity.

5.2.4.5 Short-term effectiveness

There would be low potential for unacceptable exposure to workers during implementation of this alternative. Contaminants in soil could pose a hypothetical risk to workers due to ingestion of dust. Contaminants in groundwater could pose a hypothetical risk to workers during sampling. Workers also would be exposed to general safety risks during excavation, waste shipment operations, well installation, injection activities, and groundwater sampling, which include, but are not limited to, heavy equipment hazards, fall and trip hazards, and heat stress for operations that occur within the summer months. These risks would be minimized through the use of accepted construction practices and adherence to health and safety plans developed during the implementation of this alternative.

There would be low potential for risk or impact to the community due to the increased traffic to haul waste soil material to an off-site landfill. These impacts could be minimized through designation of specific times of day to avoid high traffic volume and routes that may be used to protect communities through which the hauling would occur. These risks would be further minimized through the use of proper waste containerization or covering and adherence to transportation safety plans in accordance with DOT regulations.

There would be low potential risk associated with the injectants required for this alternative. The electron donor materials that would be injected are food-grade products, and the pH buffer is potassium bicarbonate.

5.2.4.6 Implementability

Soil excavation is technically feasible because it is a conventional construction technology with few impediments to implementation. This portion of the alternative would require a few pieces of heavy equipment and materials to be on-site, such as an excavator, front-end loader, dump trucks, and a compactor. Soil would not have to be stockpiled, but it could be directly placed into lined and covered dump trucks or roll-off containers for transport to the landfill. Implementability would require appropriate waste characterization and documentation for ultimate disposal at a permitted landfill.

The excavation portion of this alternative could be completed within 6 to 12 months following approval of the DD. Because no contaminated soil would be left on-site, no long-term O&M activities related to soil would need to be conducted once surface grade has been re-established.

Biological/chemical reduction also is readily implementable. Because the remedial action is in-situ, the level of activity at the site is minimal and would be primarily limited to mobile equipment present during injection point installation and injection events. Materials, equipment, and labor for injection point installation, biostimulation injections, and groundwater sampling are readily available.

5.2.4.7 Cost

The capital cost (discounted) to implement Alternative 4 is estimated at $2.1 million; the 5-year O&M and periodic costs are estimated at $866,013. The total present value of the capital, O&M, and periodic costs (discount rate 0.8%) is estimated at $2.97 million. Details are presented in Appendix A.

5.2.4.8 State acceptance

Comments will be obtained from ADEM on the FS, and the preferred remedy presented in the Proposed Plan. Responses to comments from state regulators will be addressed in the DD.

5.2.4.9 Community acceptance

Community acceptance will be based upon the results of a public meeting and comments received from the public on the Proposed Plan. Responses to comments from the community will be addressed in the DD.

5.2.5 Alternative 5 – In-Situ Chemical Oxidation of Groundwater with Excavation of Soil

Under this alternative, ISCO would reduce PCE and TCE in groundwater to below MCLs. In addition, the residual soil contaminant mass in the vadose zone acting as a secondary source to groundwater would be excavated to reduce the MNA timeframe.

5.2.5.1 Overall protection of human health and the environment

This alternative would protect human health and the environment would be protected with respect to groundwater in the long term upon completion of the ISCO treatment and achievement of groundwater RLs.

5.2.5.2 Compliance with applicable or relevant and appropriate requirements

Potential ARARs were presented in Chapter 3.0. This alternative would potentially trigger chemical-, location-, and/or action-specific ARARs.

Compliance with the chemical-specific ARAR for groundwater (i.e., MCLs) would be achieved upon completion of treatment by biological/chemical reduction.

The excavation portion of this alternative would potentially trigger location- and action-specific ARARs. Excavated soil would be tested to demonstrate that the material does not exhibit a characteristic of a hazardous waste. Due to historical concentrations observed at the site, the soil is expected to be non-hazardous. Action-specific standards associated with construction activities also may be triggered as a result of excavation and backfilling. This includes the requirement to control particulate emissions and the migration of sediment from the disturbed area under the stormwater protection requirements. The groundwater portion of this alternative would require an underground injection well permit.

Location-specific standards also must be considered during the implementation of this alternative. Although not anticipated within the area of impact, considerations for the potential presence of endangered species must be considered during the design to ensure impacts to such species or their habitats do not occur.

5.2.5.3 Long-term effectiveness and permanence

This alternative would be protective in the long term. The effectiveness of this approach is related to the adequacy and reliability of two distinct actions: removal of residual contaminant mass in soil and treatment of contaminated groundwater by ISCO. Soil removal is expected to be effective in protecting human health and the environment by removing residual contaminant mass and disposing of it off-site at a licensed disposal facility. Active treatment of groundwater through ISCO would achieve RLs within approximately 6 years. Groundwater monitoring during the ISCO treatment timeframe would be used to demonstrate groundwater contaminant reduction to RLs.

Because groundwater contaminants would remain on-site above RLs for a period of time, reviews would need to be conducted every 5 years pursuant to CERCLA requirements. It is anticipated that only one 5-year review would be required for this alternative.

Groundwater is anticipated to meet the criteria for unrestricted use at the completion of this remedy. Soil already meets the criteria for unrestricted use.

5.2.5.4 Reduction of toxicity, mobility, or volume through treatment

This alternative would permanently remove nearly 100% of the residual contaminant mass above the SSL for the protection of groundwater, thus reducing the on-site volume of contaminated soil by approximately 1,400 yd^3 (in-situ). There would be no reduction in total volume, toxicity, or mobility because no treatment would be performed prior to shipment to the landfill.

The ISCO portion of this alternative would meet the statutory preference for employing a treatment technology and would effectively reduce the toxicity and volume of PCE and TCE in groundwater at the site to below RLs during the approximate 6-year treatment timeframe. PCE and TCE would be degraded to water, carbon dioxide, and harmless chloride salts.

Mobility of the contaminants would not be reduced; however, mobility is not very high at this site because of the low groundwater velocity. Redox-sensitive metals may become mobilized under the oxidized conditions but are expected to return to background following the ISCO treatment.

5.2.5.5 Short-term effectiveness

There would be moderate potential for unacceptable exposure to workers during implementation of this alternative. Contaminants in soil could pose a hypothetical risk to workers due to ingestion of dust. Contaminants in groundwater could pose a hypothetical risk to workers during sampling. Workers also would be exposed to general safety risks during excavation, waste shipment operations, well installation, injection activities, and groundwater sampling, which include, but are not limited to, heavy equipment hazards, fall and trip hazards, and heat stress for operations that occur within the summer months. These risks would be minimized through the use of accepted construction practices and adherence to health and safety plans developed during the implementation of this alternative.

There would be low potential for risk or impact to the community due to the increased traffic to haul waste soil material to an off-site landfill. These impacts could be minimized through designation of specific times of day to avoid high traffic volume and routes that may be used to protect communities through which the hauling would occur. These risks would be further minimized through the use of proper waste containerization or covering and adherence to transportation safety plans in accordance with DOT regulations.

Exposure of workers to the strong oxidant during implementation would be a concern. Significant care in the handling, transport, and pumping of chemical oxidant materials or solutions would be necessary due to the reactivity and corrosiveness of these materials. Secondary containment of storage vessels and spill response would be necessary.

5.2.5.6 Implementability

Soil excavation is technically feasible because it is a conventional construction technology with few impediments to implementation. This portion of the alternative would require a few pieces of heavy equipment and materials to be on-site, such as an excavator, front-end loader, dump trucks, and a compactor. Soil would not have to be stockpiled, but it could be directly placed into lined and covered dump trucks or roll-off containers for transport to the landfill. Implementability would require appropriate waste characterization and documentation for ultimate disposal at a permitted landfill.

The excavation portion of this alternative could be completed within 6 to 12 months following approval of the DD. Because no contaminated soil would be left on-site, no long-term O&M activities related to soil would need to be conducted once surface grade has been re-established.

ISCO also is readily implementable. Because the remedial action is in-situ, the level of activity at the site is minimal and would be primarily limited to mobile equipment present during injection well installation and injection events. Materials, equipment, and labor for injection well installation, ISCO injections, and groundwater sampling are readily available.

5.2.5.7 Cost

The capital cost (discounted) to implement Alternative 5 is estimated at $3.4 million; the 6-year O&M and periodic costs are estimated at $726,655. The total present value of the capital, O&M, and periodic costs (discount rate 0.8%) is estimated at $4.12 million. Details are presented in Appendix A.

5.2.5.8 State acceptance

Comments will be obtained from ADEM on the FS, and the preferred remedy presented in the Proposed Plan. This criterion will be addressed in the responsiveness summary of the DD.

5.2.5.9 Community acceptance

Community acceptance will be based upon the results of a public meeting and comments received from the public on the Proposed Plan. Responses to comments from the community will be addressed in the DD.

5.3 COMPARATIVE ANALYSIS OF ALTERNATIVES

This section contains a comparative evaluation of the remedial alternatives for OMS-28. This comparative evaluation is summarized in Table 5-1.

Alternative 1 (no action) would not be protective of human health and the environment as there would be no change from current site conditions. The remaining alternatives provide varying degrees of overall protection of human health and the environment based primarily on the length of time anticipated to achieve RLs. Alternatives 2 and 3 would each attain the RAOs within approximately 30 and 25 years, respectively, at the end of the MNA period. Alternatives 4 and 5 would each attain the RAOs within approximately 5 to 6 years at the restoration of groundwater to below the RLs. Based upon the anticipated time to achieve RLs in groundwater, among these four alternatives, Alternative 2 is the least protective of human health and the environment. Alternatives 3 through 5 would achieve full protectiveness at the end of the remedy.

Alternative 1 (no action) would not trigger any action- or location-specific ARARs. However, Alternative 1 would not comply with the chemical-specific ARAR (i.e., MCLs) for groundwater. Alternatives 2 through 5 would each comply with the ARARs identified in Table 5-1. The primary difference in achieving ARARs among these four alternatives is based upon the anticipated time to achieve RLs in groundwater. Based upon the anticipated time to achieve RLs in groundwater, among Alternatives 2 through 5, Alternative 2 would take the longest time to achieve compliance with MCLs. Alternatives 4 and 5 are fairly close in the time required to achieve RLs at approximately 5 and 6 years, respectively.

Alternative 1 (no action) would have no long-term effectiveness or permanence because risks to human health and the environment would not be reduced. Alternatives 3 through 5 would employ a removal technology to remove the residual contaminant mass in soil above the SSLs for the protection of groundwater. Alternatives 4 and 5 also would use active treatment to reduce risk in groundwater over similar time periods, approximately 5 and 6 years, respectively. Alternatives 2 and 3 would take the longest to achieve long-term effectiveness and permanence, after an MNA period of approximately 30 and 25 years, respectively.

Alternative 1 (no action) would not result in the reduction of toxicity, mobility, or volume through treatment. Alternatives 2 and 3 would result in the reduction of toxicity and volume of PCE and TCE in groundwater through MNA, not active treatment. Alternatives 3 through 5 would each result in a nearly 100% reduction in volume of on-site soil exceeding SSLs for the protection of groundwater but through removal, not treatment. Only Alternatives 4 and 5 would employ an active treatment technology to reduce toxicity and volume of PCE and TCE in groundwater. If biological reduction treatment was used without chemical reduction, then Alternative 4 would result in a temporary toxicity increase during the production of VC in the biodegradation process; VC concentrations, and associated toxicity, would subsequently decrease as biodegradation processes continued to completion. Alternative 5 might cause an increase in the mobility of redox-sensitive metals under the oxidizing conditions during ISCO treatment; any such mobilized metals would be expected to return to background conditions when oxidizing conditions end.

Table 5-1. Comparative Analysis of Alternatives

Criterion	Alternative 1 – No Action	Alternative 2 – MNA of Groundwater	Alternative 3 – MNA of Groundwater with Excavation of Soil	Alternative 4 – Biological/Chemical Reduction of Groundwater with Excavation of Soil	Alternative 5 – ISCO of Groundwater with Excavation of Soil
Major Components	None; no change from initial site conditions	MNA of groundwater until RLs are achieved	Excavation of soil exceeding SSLs for the protection of groundwater and shipment off-site to a permitted landfill. MNA of groundwater until RLs are achieved	Excavation of soil exceeding SSLs for the protection of groundwater and shipment off-site to a permitted landfill. Biological/chemical reduction treatment to achieve RLs in groundwater	Excavation of soil exceeding SSLs for the protection of groundwater and shipment off-site to a permitted landfill. ISCO treatment to achieve RLs in groundwater
Overall Protection of Human Health and the Environment	Not protective of human health and the environment	Protective of human health and the environment at the conclusion of the MNA timeframe once MCLs are achieved	Protective of human health and the environment at the conclusion of the MNA timeframe once MCLs are achieved	Protective of human health and the environment at the conclusion of the biological/chemical reduction remediation timeframe once MCLs are achieved	Protective of human health and the environment at the conclusion of the ISCO remediation timeframe once MCLs are achieved
Compliance with ARARs	Would not comply with chemical-specific ARARs for groundwater	Would comply with • chemical-specific ARARs for groundwater upon completion of MNA, and • location- and action-specific ARARs for waste disposal (soil portion associated with well installation activities)	Would comply with • chemical-specific ARARs for groundwater upon completion of MNA, and • location- and action-specific ARARs for excavation and waste disposal (soil portion)	Would comply with • chemical-specific ARARs for groundwater upon completion of the biological/chemical reduction treatment, • location- and action-specific ARARs for excavation and waste disposal (soil portion), and • action-specific ARARs for Class V injection wells (groundwater portion)	Would comply with • chemical-specific ARARs for groundwater upon completion of the ISCO treatment, • location- and action-specific ARARs for excavation and waste disposal (soil portion), and • action-specific ARARs for Class V injection wells (groundwater portion)
Long-Term Effectiveness	Would not meet RAOs or reduce residual risks	Would meet the RAOs upon completion of the MNA period of approximately 30 years, thus reducing residual risks to acceptable levels	Would meet the RAOs upon completion of the MNA period of approximately 25 years, thus reducing residual risks to acceptable levels	Would meet the RAOs following biological/chemical reduction treatment in approximately 5 years, thus reducing residual risks to acceptable levels	Would meet the RAO following ISCO treatment in approximately 6 years, thus reducing residual risks to acceptable levels
Reduction of Toxicity, Mobility, or Volume Through Treatment	None	• MNA would demonstrate reduction in toxicity and volume but not through active treatment	• Volume of on-site soil above SSLs for the protection of groundwater reduced 100%, although not through treatment; and • MNA would demonstrate reduction in toxicity and volume but not through active treatment	• Volume of on-site soil above SSLs for the protection of groundwater reduced 100%, although not through treatment; • Biological/chemical reduction would reduce toxicity and volume of PCE and TCE through treatment; and • Temporary increases in toxicity due to the production of VC if only biological reduction is used	• Volume of on-site soil above SSLs for the protection of groundwater reduced 100%, although not through treatment; • ISCO would reduce toxicity and volume of PCE and TCE through treatment; and • Increases in the mobility of certain metals may occur under oxidizing conditions

Table 5-1. Comparative Analysis of Alternatives (continued)

Criterion	Alternative 1 – No Action	Alternative 2 – MNA of Groundwater	Alternative 3 – MNA of Groundwater with Excavation of Soil	Alternative 4 – Biological/Chemical Reduction of Groundwater with Excavation of Soil	Alternative 5 – ISCO of Groundwater with Excavation of Soil
Short-Term Effectiveness	No short-term impacts	• Low potential for contaminated groundwater exposure and general safety hazards to workers during implementation	• Low potential for contaminated dust exposure, contaminated groundwater exposure, and general safety hazards to workers during implementation	• Low potential for contaminated dust exposure, contaminated groundwater exposure, and general safety hazards to workers during implementation; and • Low potential for negative impact due to exposure to food-grade injectant and potassium bicarbonate	• Low potential for contaminated dust exposure, contaminated groundwater exposure, and general safety hazards to workers during implementation; and • Moderate potential for negative impact due to exposure to oxidants
Implementability	Readily implemented	Readily implemented	Soil excavation can be readily implemented with proper disposal; MNA is readily implemented	Soil excavation can be readily implemented with proper disposal; biological/chemical reduction is readily implemented	Soil excavation can be readily implemented with proper disposal; ISCO is readily implemented
Cost (present value)	$0	$1.83 million	$2.08 million	$2.97 million	$4.12 million
State Acceptance	Responses to state comments will be addressed in the DD				
Community Acceptance	Input from the community will be solicited during the public comment period prior to selection of a remedy and addressed in the DD				

ARAR = Applicable or relevant and appropriate requirement.
DD = Decision Document.
ISCO = In-situ chemical oxidation.
MCL = Maximum contaminant level.
MNA = Monitored natural attenuation.
PCE = Tetrachloroethene.
RAO = Remedial action objective.
RL = Remediation level.
SSL = Soil screening level.
TCE = Trichloroethene.
VC = Vinyl chloride.

With the slow groundwater velocity at the site, it is not anticipated that any mobilized metals would migrate during treatment. None of the alternatives would reduce mobility of the contaminants in groundwater; however, mobility is not very high at OMS-28.

Alternative 1 (no action) has a high degree of short-term effectiveness as there would be no impacts to workers, the community, or the environment. The four remaining alternatives share potential for negative impacts due to construction and operational hazards related to well installation, abandonment, excavation, and/or soil disposal. Alternative 5 has the highest potential for negative impacts to workers and the environment during implementation, primarily due to the hazardous nature of oxidants proposed for injection. Alternative 4 has a lower potential for negative impacts due to the benign nature of the engineered vegetable oil-based substrate package amendments proposed for injection. Alternative 2 presents the lowest potential for negative impacts as no injection or excavation activities would be performed.

Alternative 1 (no action) would be the easiest alternative to implement because no action would be taken. Alternatives 2 through 5 are each readily implementable with slight variations. All of these alternatives would involve well installation and groundwater sampling. Alternatives 3, 4, and 5 would involve excavation and well abandonment. Alternatives 4 and 5 would require additional injection well installation and injection activities.

The estimated capital costs (i.e., discounted or present value) to implement each alternative range from a low of $0 for the no action alternative to a high of $3.4 million for Alternative 5. O&M and periodic costs range from a low of $0 for the no action alternative to a high of $1.69 million for Alternative 2. Total present value costs for each alternative are provided in Table 5-2.

Table 5-2. Comparison of Alternative Costs

Alternative	Duration (years)	Discounted or Present Value		
		Capital Cost	**O&M/Periodic Cost**	**Total Cost**
1: No Action	30	$0	$0	$0
2: Monitored Natural Attenuation of Groundwater	30	$141,775	$1,685,777	$1,827,553
3: Monitored Natural Attenuation of Groundwater with Excavation of Soil	25	$761,013	$1,317,577	$2,078,591
4: Biological/Chemical Reduction of Groundwater with Excavation of Soil	5	$2,104,540	$866,013	$2,970,553
5: In-situ Chemical Oxidation of Groundwater with Excavation of Soil	6	$3,396,464	$726,655	$4,123,119

O&M = Operation and maintenance.

Comments will be obtained from ADEM on this FS, and the preferred remedy presented in the Proposed Plan. Input from the community will be solicited during a public meeting and the public comment period following a notice of availability for the Proposed Plan. Responses to comments from state regulators and the community regarding these alternatives will be addressed in the DD.

5.4 SELECTION OF PREFERRED ALTERNATIVE

The recommended alternative is Alternative 4 – Biological/Chemical Reduction of Groundwater with Excavation of Soil. This alternative is recommended because it will achieve substantial risk reduction by active groundwater treatment followed by performance monitoring. This combination reduces risk sooner and costs less than the other active treatment alternative. The other MNA-related alternatives were less costly; however, the timeframe to achieve risk reduction and site closure was 25 to 30 years or longer.

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APPENDIX A
COST ESTIMATE

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OMS-28, Organizational Maintenance Shop 28, Alabama Army National Guard
Feasibility Study - Cost Estimate
Summary of Remedial Alternatives

Alternatives		Duration (years)	Non-Discounted Cost		
			Capital Cost	O&M/Periodic Costs	Total
1	No Action	0	$0	$0	$0
2	Monitored Natural Attenuation	30	$141,775	$1,654,773	$1,796,549
3	Monitored Natural Attenuation of Groundwater with Excavation of Soil	25	$761,013	$1,442,133	$2,203,147
4	Biological/Chemical Reduction of Groundwater with Excavation of Soil	5	$2,104,540	$846,976	$2,951,516
5	In-situ Chemical Oxidation of Groundwater with Excavation of Soil	6	$3,401,250	$697,872	$4,099,122

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Alternatives		Duration (years)	Discounted Cost			
			Capital Cost	O&M/Periodic Costs	Total	Discount Factor[1] (%)
1	No Action	0	$0	$0	$0	NA
2	Monitored Natural Attenuation	30	$141,775	$1,685,777	$1,827,553	1.1
3	Monitored Natural Attenuation of Groundwater with Excavation of Soil	25	$761,013	$1,317,577	$2,078,591	0.8
4	Biological/Chemical Reduction of Groundwater with Excavation of Soil	5	$2,104,540	$866,013	$2,970,553	-0.8
5	In-situ Chemical Oxidation of Groundwater with Excavation of Soil	6	$3,396,464	$726,655	$4,123,119	-0.8

[1]Discount factors for CY 2013 from Office of Management and Budget Circular A-94, Appendix C, dated December 2012.

OMS-28, Organizational Maintenance Shop 28, Alabama Army National Guard
Feasibility Study - Cost Estimate
Summary of Areas and Volumes

	Alternatives	Surface Area (sq ft)	Thickness (ft)	In situ Volume Soil (cu ft)	In situ with Constructability[a] Soil (cy)	Ex situ Volume[a,b] Soil (cy)	Total Mass (tons)[c]
1	No Action	Not Applicable					
2	Monitored Natural Attenuation	Not Applicable					
3	Vicinity of Well MW-08	5,600	6	33,600	1,431	1,646	2,777
	Vicinity of Boring B-17	400	10	4,000	170	196	331
	Total Soil	6,000		37,600	1,601	1,842	3,108
4	Vicinity of Well MW-08	5,600	6	33,600	1,431	1,646	2,777
	Vicinity of Boring B-17	400	10	4,000	170	196	331
	Total Soil	6,000		37,600	1,601	1,842	3,108
5	Vicinity of Well MW-08	5,600	6	33,600	1,431	1,646	2,777
	Vicinity of Boring B-17	400	10	4,000	170	196	331
	Total Soil	6,000		37,600	1,601	1,842	3,108

[a] Includes 15% constructability factor for soil

[b] Includes 15% swell factor for soil

[c] Unit Weight = 125 pounds per square foot for ex situ soil

OMS-28, Organizational Maintenance Shop 28, Alabama Army National Guard
Alternative 1 - No Action
Key Parameters and Assumptions

Item	Unit	Value	Notes
Capital Cost			There are no capital costs for under the No Action Alternative.
Operation & Maintenance (O&M) Cost			There are no O&M costs for under the No Action Alternative.
Periodic Costs (Years 0 to 30)			There are no periodic costs for under the No Action Alternative.

OMS-28, Organizational Maintenance Shop 28, Alabama Army National Guard
Alternative 1 - No Action
Cost Estimate

Capital Cost	**$0**

Activity (unit)	**Quantity**	**Unit Cost**	**Total**
Capital Cost			
Subtotal			$0
Office Overhead		0%	$0
Field Overhead		0%	$0
Subtotal			$0
Profit		0%	$0
Contingency		0%	$0
Total			$0

Operational and Maintenance (O&M) and Periodic Costs	**$0**

Activity (unit)	**Quantity**	**Unit Cost**	**Total**
Operation and Maintenance (O&M) Cost			
Periodic Costs			
Subtotal			$0
Office Overhead		0%	$0
Field Overhead		0%	$0
Subtotal			$0
Profit		0%	$0
Contingency		0%	$0
Total			$0

TOTAL ALTERNATIVE CAPITAL AND O&M COST	**$0**

OMS-28, Organizational Maintenance Shop 28, Alabama Army National Guard
Alternative 2 - Monitored Natural Attenuation
Key Parameters and Assumptions

Item	Unit	Value	Notes
Capital Cost			
Additional Monitoring Wells for LTM	ea	4	No. of additional monitoring wells installed (4 new)
Wells in Monitoring Plan	ea	13	9 existing and 4 new wells
Plans			
RA Work Plan	hrs	160	Assume 160 hours for technical, CAD, word processing, and
RA Work Plan	$/hr	100	review cycles.
H&S Plan	hrs	100	Assume 100 hours for technical, CAD, word processing, and
H&S Plan	$/hr	100	review cycles.
Institutional Controls			
Environmental Covenant	hrs	60	Assume 60 hrs for technical and legal professional services
Environmental Covenant	$/hr	200	Added $20 per hour for travel and misc expenses
Survey	ea	1	Legal survey of propery for deed restrictions and recording
Survey	$/ea	3,000	
Land Use Control Implementation Plan	hrs	200	Assume 200 hrs for technical, CAD, word processing, and
Land Use Control Implementation Plan	$/hr	100	review cycles
Monitoring Well installation			
Drill Rig Mobilization/Demobilization	$/ea	3,200	Engineering estimate for mobilization/demobilization of drilling rig and well construction materials
Decontamination Pad	$/ea	750	based on historical costs
New Monitoring Wells	ea	4	10 foot screen for each monitoring well
Monitoring Well Installation Duration	days	4	Assume completion of 1 well per day
Monitoring Well Installation Unit Cost	$/well	2,300	Unit rate calculated based on the cost details below
Monitoring Well Completion Depth	ft/well	30	Well TD 30 feet
Monitoring Well Drilling Cost	$/ft	30	Average drilling costs for hollow stem auger
2" Monitoring Well Installation Cost	$/ft	30	Average well well installation costs (2" PVC with 10 ft screen)
Surface Completion at each MW location	$/well	400	Surface completion cost for each monitoring well
55-gallon drum cost	$/drum	50	
55-gallon drums for soil cuttings	ea	2	assume 1 drum for every 15 ft of borehole or 2 drums/ 30 ft well
Well Development	$/day	1,365	Assumes 1 person, 1 well per day, 1 drum per well.
Drill Crew Per Diem	$/day	300	Assume $150 per day per person; 2-person drilling crew
Stand-by Charge	$/day	130	Assume 1 hr of standby time per day @ $130/hr
IDW Management	$/lot	3,200	Unit rate calculated based on the cost details below
IDW Drums	ea	14	For soil IDW - assume two soil drums per well for HSA installation activities For water IDW - assume 25 gallons of decon water per day and 55 gallons per monitoring well
IDW Sampling	$/sample	100	Assume 1 composite sample for every drum for waste characterization. Costs based on lab quote.
IDW Disposal (hazardous)	$/drum	175	Assume 0% of total IDW generated will be characteristically hazardous.
IDW Disposal (non-hazardous)	$/drum	50	Assume 100% of total IDW generated will be characteristically non-hazardous.
IDW Transportation and Pickup	$/event	1,100	Based on 60 drums per truckload
Field Oversight - Daily Rate	$/day	2,330	Field oversight (2-person crew)
Field Vehicle	$/day	80	Assume 1 vehicles at $80/day
Technician	$/day	750	Assume 10-hr workday at $75/hr
Geologist/Engineer	$/day	1,000	Assume 10-hr workday at $100/hr
Per Diem	$/day	300	Assume $150 per person; 2-person crew

OMS-28, Organizational Maintenance Shop 28, Alabama Army National Guard
Alternative 2 - Monitored Natural Attenuation
Key Parameters and Assumptions

Item	Unit	Value	Notes
Expendables	$/day	200	Miscellaneous expendables
Field Oversight - No. of Days	days	4	
Reporting			
Well Installation Report	hours	80	Includes report preparation and reviewing construction
Technical Labor	$/hr	80	QA/QC data.
Operation & Maintenance (O&M) Cost			Monitoring for a period of 30 years
No. of wells for monitoring	ea	13	Number of wells sampled at each event
Well Sampling Unit Cost	$/well	1047	Unit Cost based on sampling 3 monitoring wells per day
Laboratory Analytical Costs	$/well	305	Assume 1 sample each of VOCs, MNA Anions, MNA TOC, and MNA MEE per well
VOCs	$/sample	80	Based on historical laboratory rates
MNA Anions	$/sample	50	Based on historical laboratory rates
MNA TOC	$/sample	25	Based on historical laboratory rates
Alkalinity	$/sample	50	Based on historical laboratory rates
MNA MEE	$/sample	100	Based on historical laboratory rates
IDW pickup and disposal costs			
IDW per sampling events	drums	2	Assumes 5 gallons per well sampled
IDW pickup and disposal costs per event	$/event	1,200	Based on disposal rates (assumes non-hazardous)
Field Sampling Costs	$/day	2225	
Field Vehicle	$/day	75	Assume 1 vehicle at $75/day
Technician	$/day	750	Assume 10-hr workday at $75/hr
Senior Technician	$/day	1,000	Assume 10-hr workday at $100/hr
Per Diem	$/day	300	Per diem $150 per person; crew of 2
Expendables	$/day	100	Miscellaneous expendables
Sampling Cost per event	$/event	13,607	
Number of years of semi-annual monitoring	years	10	
Number of semi-annual events	events	20	
Number of years of annual monitoring	years	10	
Number of annual events	events	10	
Number of years of biannual monitoring	years	10	
Number of biannual events	events	5	
Total Remedial timeframe	years	30	assume 30 years in accordance with the planning and budget purposes specified in USACE ER 200-3-1
Reporting			
Monitoring Report	ea	20	Includes report preparation and reviewing QA/QC data
Monitoring Report	$/ea	$9,600	Assume 120 hrs @ $80/hr
Periodic Costs (Years 0 to 30)			
CERCLA Reviews			
CERCLA 5-Year Review	ea	6	Five-year reviews for 30 years
CERCLA-5-Year Review	$/ea	$30,000	Assume 375 hrs @ $80/hr

OMS-28, Organizational Maintenance Shop 28, Alabama Army National Guard
Alternative 2 - Monitored Natural Attenuation
Cost Estimate

Capital Cost	**$141,775**

Activity (unit)	Quantity	Unit Cost	Total
Capital Cost			
Plans			
RA Work Plan	160	$100	$16,000
H&S Plan	100	$100	$10,000
Institutional Controls			
Environmental Covenant	60	$200	$12,000
Survey	1	$3,000	$3,000
Land Use Control Implementation Plan	200	$100	$20,000
Well Installation			
Mobilization/Demobilization (ea)	1	$3,200	$3,200
Decontamination Pad (ea)	1	$750	$750
Monitoring Well Installation (ea)	4	$2,300	$9,200
Well Development (ea)	4	$1,365	$5,460
Drill Crew Per Diem; 2-person crew (days)	4	$300	$1,200
Standby Charge (days)	4	$130	$520
IDW Management (lot)	1	$3,200	$3,200
Field Oversight for Well Installation Activities			
Field Oversight (days)	4	$2,325	$9,300
Reporting			
Well Installation Report (hrs)	80	$80	$6,400
Subtotal			$100,230
Office Overhead		5%	$5,012
Field Overhead		10%	$10,023
Subtotal			$115,265
Profit		8%	$9,221
Contingency		15%	$17,290
Total			$141,775

Operational and Maintenance (O&M) and Periodic Costs Cost	**$1,654,773**

OMS-28, Organizational Maintenance Shop 28, Alabama Army National Guard
Alternative 2 - Monitored Natural Attenuation
Cost Estimate

Activity (unit)	Quantity	Unit Cost	Total
Operation and Maintenance (O&M) Cost			
Semi-annual Sampling of 13 wells (Years 0 through 10)			
Semi-annual Sampling (no. of wells)	260	$1,047	$272,133
Monitoring Report (ea)	20	$9,600	$192,000
IDW disposal (per sampling event)	20	$1,200	$24,000
Annual Sampling of 13 wells (Years 11 through 20)			
Annual Sampling (no. of wells)	130	$1,047	$136,067
Monitoring Report (ea)	10	$9,600	$96,000
IDW disposal (per sampling event)	10	$1,200	$12,000
Biannual Sampling of wells (Years 21 through 30)			
Biannual Sampling (no. of wells)	65	$1,047	$68,033
Monitoring Report (ea)	5	$9,600	$48,000
IDW disposal (per sampling event)	5	$1,200	$6,000
Periodic Costs			
Five-year CERCLA review (ea)	6	$30,000	$180,000
Subtotal			$1,034,233
Office Overhead		10%	$103,423
Field Overhead		15%	$155,135
Subtotal			$1,292,792
Profit		8%	$103,423
Contingency		20%	$258,558
Total			$1,654,773

TOTAL ALTERNATIVE CAPITAL AND O&M COST	**$1,796,549**

OMS-28, Organizational Maintenance Shop 28, Alabama Army National Guard
Alternative 3 - Monitored Natural Attenuation of Groundwater with Excavation of Soil
Key Parameters and Assumptions

Item	Unit	Value	Notes
Capital Cost			
Excavation Area	sf	6,000	see Volumes tab
Excavation Volume (ex situ)	cy	1,842	see Volumes tab
Additional Monitoring Wells for LTM	ea	6	No. of additional monitoring wells installed (4 new, 2 replacement)
Monitoring Wells to be abandoned	ea	3	No. of monitoring wells requiring abandonment
Wells in Monitoring Plan	ea	13	7 existing, 2 replacement, and 4 new wells
Plans			
RA Work Plan	hrs	200	Assume 160 hours for technical, CAD, word processing, and
RA Work Plan	$/hr	100	review cycles.
H&S Plan	hrs	120	Assume 100 hours for technical, CAD, word processing, and
H&S Plan	$/hr	100	review cycles.
Monitoring Well Abandonment			
No. of wells to abandon	ea	3	No. of monitoring wells requiring abandonment
No. of days to abandon monitoring wells	days	1	Assume abandonment of up to 5 wells per day
Driller Mobilization/Demobilization	$/lump sum	1,500	Engineering estimate for mobilization of well abandonment equipment
Monitoring Well Abandonment Unit Cost	$/well	385	Unit rate calculated based on the cost details below
Monitoring well depth (average)	ft	37	MW-8 @16 ft, OMW-28-6 @ 76 ft, OMW-28-5 @ 20 ft
Monitoring Well abandonment cost per foot	$/ft	5	Average abandonment costs
Surface Completion Removal	$/well	200	Surface completion removal cost at each monitoring well
Drill Crew Per Diem	$/day	300	Assume $150 per day per person; 2-person drilling crew
Soil Excavation			
Soil Excavation Surface Area	sf	6,000	see Volumes tab
Impacted Soil Volume (in situ)	cy	1,393	see Volumes tab
Impacted Soil Volume (ex situ)	cy	1,842	
Total Soil Volume	cy	1,842	includes soil volume to be transported and disposed
Total Soil Mass	tons	3,108	includes soil mass to be transported and disposed
Mobilization/Demobilization	lump sum	5,000	includes mob/demob of excavation equipment and preparing submittals
Excavate Soils			
Clearing	days	1	RSMeans cost assumes minimum of one day; rate of 6.4 acres per day.
Clearing	acre	0.6	Assumes clearing of approx. 160' x 160'.
Clearing	$/day	1,984	
Fence Removal and Reinstall	LF	300	
Fence Removal and Reinstall	$/lf	18.5	RSMeans unit cost.
Excavate Soils	days	5	
Excavation Production Rate	cy/day	400	excavation rate per day
Excavate Soils	$/day	2,846	Includes 3/4 cy excavator, 1 O.E., 2 L.S. spotter and to prep trucks and support excavation activities. RSMeans Crew B12F.
Transport and Offsite Disposal			
Disposal weight	tons	3,108	approximate soils weight in tons
Offsite disposal costs - non-hazardous soils	$/ton	100	typical non-hazardous soils disposal costs

OMS-28, Organizational Maintenance Shop 28, Alabama Army National Guard
Alternative 3 - Monitored Natural Attenuation of Groundwater with Excavation of Soil
Key Parameters and Assumptions

Item	Unit	Value	Notes
Soil Confirmational Sampling & Analysis			
TCLP Soil Samples	ea	10	assume one composite sample per 200 cy
TCLP VOC analysis	$/sample	100	historical laboratory rates
Confirmatory Soil Samples	ea	20	assume 2 per sidewall and 2 per floor at each excavation area
VOC analysis	$/sample	100	Based on historical laboratory rates
Sampling Duration	days	3	
Data Management	hrs	30	Data validation
Data Management	$/hr	90	
Restoration			
Restoration Duration	days	6	
Clean soil backfill	cy	1,842	
Clean soil backfill	$/cy	18.0	
Compaction	cy	1,842	Compaction, structural, common fill, 8" lifts, vibratory plate.
Compaction	$/cy	1.5	RSMeans 31232324 0600.
Top soil	cy	112	excavation area to a depth of 0.5 ft
Top soil	$/cy	28	
Seeding	sf	6,000	excavation area
Seeding	$/sf	1.0	
Monitoring and Injection Well installation			
Drill Rig Mobilization/Demobilization	$/ea	4,000	Engineering estimate for mobilization/demobilization of drilling rig and well construction materials
Decontamination Pad	$/ea	750	based on historical costs
New Monitoring Wells	ea	6	10 foot screen for each monitoring well
Monitoring Well Installation Duration	days	6	Assume completion of 1 well per day
Monitoring Well Installation Unit Cost	$/well	2,300	Unit rate calculated based on the cost details below
Monitoring Well Completion Depth	ft	30	Well TD 30 feet
Monitoring Well Drilling Cost	$/ft	30	Average drilling costs
2" Monitoring Well Installation Cost	$/ft	30	Average well well installation costs (2" PVC with 10 ft screen)
Surface Completion	$/well	400	Surface completion cost for each monitoring well
55-gallon drum cost	$/drum	50	
55-gallon drums for soil cuttings	ea	2	assume 1 drum for every 15 ft of borehole or 2 drums/ 30 ft
Well Development	$/day	1,465	Assumes 1 person, 1 well per day, 1 drum per well.
Drill Crew Per Diem	$/day	300	Assume $150 per day per person; 2-person drilling crew
Stand-by Charge	$/day	130	Assume 1 hr of standby time per day @ $130/hr
IDW Management	$/lot	4,250	Unit rate calculated based on the cost details below
IDW Drums	ea	21	For soil IDW - assume two soil drums per well for HSA installation activities For water IDW - assume 25 gallons of decon water per day and 55 gallons per monitoring well
IDW Sampling	$/sample	100	Assume 1 composite sample for every drum for waste characterization. Costs based on lab quote.
IDW Disposal (hazardous)	$/drum	175	Assume 0% of total IDW generated will be characteristically hazardous.
IDW Disposal (non-hazardous)	$/drum	50	Assume 100% of total IDW generated will be characteristically non-hazardous.
IDW Transportation and Pickup	$/event	1,100	Based on 60 drums per truckload
Field Oversight - Daily Rate	$/day	2,330	Field oversight
Field Vehicle	$/day	80	Assume 1 vehicles at $80/day
Technician	$/day	750	Assume 10-hr workday at $75/hr
Geologist/Engineer	$/day	1,000	Assume 10-hr workday at $100/hr

OMS-28, Organizational Maintenance Shop 28, Alabama Army National Guard
Alternative 3 - Monitored Natural Attenuation of Groundwater with Excavation of Soil
Key Parameters and Assumptions

Item	Unit	Value	Notes
Per Diem	$/day	300	Assume $150 per person; 2-person crew
Expendables	$/day	200	Miscellaneous expendables
Field Oversight - No. of Days	days	24	Assume 2 days waste management in addition to excavation, sampling, restoration, well install and abandonment
Reporting			
Construction Completion Reports	hours	300	Includes report preparation and reviewing construction QA/QC data.
Technical Labor	$/hr	80	
Operation & Maintenance (O&M) Cost			Monitoring for a period of 25 years
No. of wells for monitoring	ea	10	Number of wells sampled at each event
Well Sampling Unit Cost	$/well	1072	Unit Cost based on sampling 3 monitoring wells per day
Laboratory Analytical Costs	$/well	330	Assume 1 sample each of VOCs, MNA Anions, MNA TOC, and MNA MEE per well
VOCs	$/sample	80	Based on historical laboratory rates
MNA Anions	$/sample	75	Based on historical laboratory rates
MNA TOC	$/sample	25	Based on historical laboratory rates
Alkalinity	$/sample	50	Based on historical laboratory rates
MNA MEE	$/sample	100	Based on historical laboratory rates
IDW pickup and disposal costs			
IDW per sampling events	drums	1	Assumes 5 gallons per well sampled
IDW pickup and disposal costs per event	$/event	1,150	Based on disposal rates (assumes non-hazardous)
Field Sampling Costs	$/day	2225	
Field Vehicle	$/day	75	Assume 1 vehicle at $75/day
Technician	$/day	750	Assume 10-hr workday at $75/hr
Senior Technician	$/day	1,000	Assume 10-hr workday at $100/hr
Per Diem	$/day	300	Per diem $150 per person; crew of 2
Expendables	$/day	100	Miscellaneous expendables
Number of years of semi-annual monitoring	years	10	
Number of semi-annual events	events	20	
Number of years of annual monitoring	years	15	
Number of annual events	events	15	
Total Remedial timeframe	years	25	
Reporting			
Monitoring Report	ea	35	Includes report preparation and reviewing QA/QC data
Monitoring Report	$/ea	$9,600	Assume 120 hrs @ $80/hr
Periodic Costs (Years 0 to 25)			
CERCLA Reviews			
CERCLA 5-Year Review	ea	5	Five-year reviews for 25 years
CERCLA-5-Year Review	$/ea	$30,000	Assume 375 hrs @ $80/hr

OMS-28, Organizational Maintenance Shop 28, Alabama Army National Guard
Alternative 3 - Monitored Natural Attenuation of Groundwater with Excavation of Soil
Cost Estimate

Capital Cost	$761,013

Activity (unit)	Quantity	Unit Cost	Total
Capital Cost			
Plans			
RA Work Plan (hrs)	200	$100	$20,000
H&S Plan (hrs)	120	$100	$12,000
Monitoring Well Abandonment			
Mobilization/Demobilization (ea)	1	$1,500	$1,500
Monitoring Well Abandonment (ea)	3	$385	$1,155
Drill Crew Per Diem; 2-person crew (days)	1	$300	$300
Soil Excavation			
Clearing (day)	1	$1,984	$1,984
Fence Removal and Reinstall (LF)	300	$18.50	$5,550
Excavate Soil (days)	5	$2,846	$14,229
Transport and Offsite Disposal			
Offsite Soil Transport & Disposal (tons)	3,108	$100	$310,788
Soil Confirmatory Sampling & Analysis			
Sample Analyses - Confirmatory (ea)	20	$100	$2,000
Sample Analyses - Waste Management (ea)	10	$100	$1,000
Data Management	30	$90	$2,700
Restoration			
Backfill (cy)	1,842	$18	$33,151
Compaction (cy)	1,842	$1.54	$2,836
Top Soil (cy)	112	$28	$3,136
Hydroseed (sf)	6,000	$1	$6,000
Well Installation			
Mobilization/Demobilization (ea)	1	$4,000	$4,000
Decontamination Pad (ea)	1	$750	$750
Monitoring Well Installation (ea)	6	$2,300	$13,800
Well Development (ea)	6	$1,465	$8,790
Drill Crew Per Diem; 2-person crew (days)	6	$300	$1,800
Standby Charge (days)	49	$130	$6,370
IDW Management (lot)	1	$4,250	$4,250
Field Oversight for Excavation & Well Abandonmant/Installation Activities			
Field Oversight (days)	24	$2,330	$55,920
Reporting			
Construction Completion Reports (hrs)	300	$80	$24,000

OMS-28, Organizational Maintenance Shop 28, Alabama Army National Guard
Alternative 3 - Monitored Natural Attenuation of Groundwater with Excavation of Soil
Cost Estimate

Subtotal			$538,009
Office Overhead		5%	$26,900
Field Overhead		10%	$53,801
Subtotal			$618,710
Profit		8%	$49,497
Contingency		15%	$92,807
Total			$761,013

Operational and Maintenance (O&M) and Periodic Costs **$1,442,133**

Activity (unit)	Quantity	Unit Cost	Total
Operation and Maintenance (O&M) Cost			
Semi-Annual Monitoring of 10 wells (First 10 Years)			
Semi-annual Sampling (10 of wells)	200	$1,072	$214,333
Monitoring Report (ea)	20	$9,600	$192,000
IDW disposal (per sampling event)	20	$1,150	$23,000
Annual Sampling of 10 wells (Years 11 through 25)			
Annual Sampling (no. of wells)	150	$1,072	$160,750
Monitoring Report (ea)	15	$9,600	$144,000
IDW disposal (per sampling event)	15	$1,150	$17,250
Periodic Costs			
Five-year CERCLA review (ea)	5	$30,000	$150,000
Subtotal			$901,333
Office Overhead		10%	$90,133
Field Overhead		15%	$135,200
Subtotal			$1,126,667
Profit		8%	$90,133
Contingency		20%	$225,333
Total			$1,442,133

TOTAL ALTERNATIVE CAPITAL AND O&M COST **$2,203,147**

OMS-28, Organizational Maintenance Shop 28, Alabama Army National Guard
Alternative 4 - Biological/Chemical Reduction of Groundwater with Excavation of Soil
Key Parameters and Assumptions

Item	Unit	Value	Notes
Capital Cost			
Excavation Area	sf	6,000	See Volumes tab
Excavation Volume (ex situ)	cy	1,842	See Volumes tab
Biostimulation Injection Wells	ea	165	No. of temporary injection wells based upon a 15-ft spacing
Additional Monitoring Wells for LTM	ea	6	No. of additional monitoring wells installed (4 new, 2 replacement)
Monitoring Wells to be abandoned	ea	3	No. of monitoring wells requiring abandonment
Wells in Monitoring Plan	ea	13	7 existing, 2 replacement, and 4 new wells
Plans			
RA Design Data Collection	$/lump sum	64,040	Unit rate calculated based on the cost details below
Driller Mobilization/Demobilization	$/lump sum	1,500	Engineering estimate for mobilization of geoprobe rig
Drill Crew Per Diem	$/day	300	Assume $150 per day per person; 2-person drilling crew
Drilling unit cost	$/ft	10	DPT drilling
Drilling footage	ft	60	Assumes 3 DPT locations, 20 ft depth each
Field Oversight	days	2	Assumes 2 days for drilling activities
Bench Scale Treatablity Study	ea	35,000	Based on historical laboratory rates
Baseline Groundwater Sampling	ea	7	Sampling of existing shallow wells only
Well Sampling Unit Cost (labor)	$/well	1,570	See O&M assumptions below. Unit Cost based on sampling 3 monitoring wells per day.
Laboratory Analytical Costs	$/well	1570	See O&M assumptions below. Assume 1 sample each of VOCs, Metals, MNA Anions, MNA TOC, MNA MEEH, BOD, COD, Alkalinity, hardness, VFA, PFLA, and DHC per well.
RA Work Plan	hrs	300	Assume 160 hours for technical, CAD, word processing, and review cycles.
RA Work Plan	$/hr	100	
H&S Plan	hrs	160	Assume 100 hours for technical, CAD, word processing, and review cycles.
H&S Plan	$/hr	100	
Monitoring Well Abandonment			
No. of wells to abandon	ea	3	No. of monitoring wells requiring abandonment
No. of days to abandon monitoring wells	days	1	Assume abandonment of up to 5 wells per day
Driller Mobilization/Demobilization	$/lump sum	1,500	Engineering estimate for mobilization of well abandonment equipment
Monitoring Well Abandonment Unit Cost	$/well	673	Unit rate calculated based on the cost details below
Surface Completion Removal	$/well	300	Surface completion removal cost at each monitoring well
Monitoring well depth (average)	ft	37	MW-8 @16 ft, OMW-28-6 @ 76 ft, OMW-28-5 @ 20 ft
Monitoring Well abandonment cost per foot	$/ft	10	Average abandonment costs
Drill Crew Per Diem	$/day	300	Assume $150 per day per person; 2-person drilling crew
Soil Excavation			
Soil Excavation Surface Area	sf	6,000	See Volume tab
Impacted Soil Volume (in situ)	cy	1,393	See Volume tab
Impacted Soil Volume (ex situ)	cy	1,842	See Volume tab
Total Soil Volume for Disposal	cy	1,842	includes soil volume to be transported and disposed
Total Soil Mass for Disposal	tons	3,108	includes soil mass to be transported and disposed
Mobilization/Demobilization	$/lump sum	5,000	includes mob/demob of excavation equipment
Excavate Soils			
Clearing	days	1	RSMeans cost assumes minimum of one day; rate of 6.4 acres per day.

OMS-28, Organizational Maintenance Shop 28, Alabama Army National Guard
Alternative 4 - Biological/Chemical Reduction of Groundwater with Excavation of Soil
Key Parameters and Assumptions

Item	Unit	Value	Notes
Clearing	acre	0.6	Assumes clearing of approx. 160' x 160'.
Clearing	$/day	1,984	
Fence Removal and Reinstall	LF	300	
Fence Removal and Reinstall	$/lf	18.5	RSMeans unit cost.
Excavate Soils	days	5	
Excavation Production Rate	cy/day	400	excavation rate per day
Excavate Soils	$/day	2,846	Includes 3/4 cy excavator, 1 O.E., 2 L.S. spotter and to prep trucks and support excavation activities. RSMeans Crew B12F.
Transport and Offsite Disposal			
Disposal weight	tons	3,108	approximate soils weight in tons
Offsite disposal costs - non-hazardous soils	$/ton	100	typical non-hazardous soils disposal costs
Soil Confirmational Sampling & Analysis			
TCLP Soil Samples	ea	10	assume one composite sample per 200 cy
TCLP VOC analysis	$/sample	100	historical laboratory rates
Confirmatory Soil Samples	ea	20	assume 2 per sidewall and 2 per floor at each excavation area
VOC analysis	$/sample	100	Based on historical laboratory rates
Sampling Duration	days	3	
Data Management	hrs	30	Data validation
Data Management	$/hr	90	
Restoration			
Restoration Duration	days	6	
Clean soil backfill	cy	1,842	
Clean soil backfill	$/cy	18.00	
Compaction	cy	1,842	Compaction, structural, common fill, 8" lifts, vibratory plate.
Compaction	$/cy	1.54	RSMeans 31232324 0600.
Top soil	cy	112	
Top soil	$/cy	28	
Seeding	sf	9,000	assume area 50% larger than excavation areas.
Seeding	$/sf	1.00	
Monitoring and Injection Well installation			
Drill Rig Mobilization/Demobilization	$/ea	5,000	Engineering estimate for mobilization/demobilization of drilling rig, monitoring well and injection well construction materials
Decontamination Pad	$/ea	750	Based on historical drilling costs
New Monitoring Wells	ea	6	
Monitoring Well Installation Duration	days	6	Assume completion of 1 well per day
Monitoring Well Installation Unit Cost	$/well	2,300	Unit rate calculated based on the cost details below
Monitoring Well Completion Depth	ft	30	Well TD 30 feet
Monitoring Well Drilling Cost	$/ft	30	Based on historical drilling costs
2" Monitoring Well Installation Cost	$/ft	30	Average well well installation costs (2" PVC with 10 ft screen)
Surface Completion	$/well	400	Surface completion cost for each monitoring well
55-gallon drum cost	$/drum	50	
55-gallon drums for soil cuttings	ea	2	assume 1 drum for every 15 ft of borehole or 2 drums/ 30 ft
Well Development	$/day	1,465	Assumes 1 person, 1 well per day, 1 drum per well.
No. of Injection Wells	ea	165	No. of temporary injection wells based upon a 30-ft spacing
Injection Well Installation Duration	days	43	Assume completion of 4 temporary injection wells per day
Temporary Injection Well Installation Unit Cost	$/well	940	Unit rate calculated based on the cost details below
Injection Well Completion Depth	ft	30	Well TD 30 feet

OMS-28, Organizational Maintenance Shop 28, Alabama Army National Guard
Alternative 4 - Biological/Chemical Reduction of Groundwater with Excavation of Soil
Key Parameters and Assumptions

Item	Unit	Value	Notes
Injection Well DPT Drilling Cost	$/ft	10.75	Based on historical drilling costs
Injection Well Completion Unit Cost	$/ft	12	Based on historical drilling costs
1" PVC Well Screen Unit Cost	$/ft	11	Based on historical drilling costs
1" PVC Well Screen	ft	20	20 feet of well screen
1" PVC Well Riser Unit Cost	$/ft	2.50	Based on historical drilling costs
1" PVC Well Riser	ft	15	Based on historical drilling costs
Drill Crew Per Diem	$/day	300	Assume $150 per day per person; 2-person drilling crew
Stand-by Charge	$/day	130	Assume 1 hr of standby time per day @ $130/hr
IDW Management	$/lot	13,300	
IDW Drums	ea	74	For soil IDW - assume two soil drums per well for HSA installation activities, one soil drum per 5 wells for DPT installation activities For water IDW - assume 25 gallons of decon water per day and 55 gallons per monitoring well
IDW Sampling	$/sample	100	Assume 1 composite sample for every drum for waste characterization. Costs based on lab quote.
IDW Disposal (hazardous)	$/drum	175	Assume 0% of total IDW generated will be characteristically hazardous.
IDW Disposal (non-hazardous)	$/drum	50	Assume 100% of total IDW generated will be characteristically non-hazardous.
IDW Transportation and Pickup	$/event	2,200	Based on 60 drums per truckload
Field Oversight - Daily Rate	$/day	2,330	Field oversight
Field Vehicle	$/day	80	Assume 1 vehicles at $80/day
Technician	$/day	750	Assume 10-hr workday at $75/hr
Geologist/Engineer	$/day	1,000	Assume 10-hr workday at $100/hr
Per Diem	$/day	300	Assume $150 per person; 2-person crew
Expendables	$/day	200	Miscellaneous expendables
Field Oversight - No. of Days	days	67	Assume 2 days waste management in addition to excavation, restoration, well install and abandonment
Biostimulation Injection Operation			
No. of Injection Points	ea	165	
pH Buffer ($KHCO_3$) Unit Cost	$/lb	2.50	Based on FMC Environmental Solutions price estimate
pH Buffer (KHCO3)	lb	4,425	Based on FMC Environmental Solutions reagent demand calculations
EHC-L Unit Cost	$/lb	1.71	Based on FMC Environmental Solutions price estimate. Includes $0.20/pound in shipping costs
EHC-L	lb	74,340	Based on FMC Environmental Solutions reagent demand calculations
DHC Inoculum Unit Cost	$/Liter	104	Based on FMC Environmental Solutions price estimate. Includes $13.4/pound in shipping costs
DHC Inoculum	Liter	165	
Field Oversight - Daily Rate	$/day	2,730	Field oversight of Biological/Chemical Injection Operation
Field Vehicle	$/day	80	Assume 1 vehicles at $80/day
Technician	$/day	900	Assume 12-hr workday at $75/hr
Senior Technician	$/day	1,200	Assume 12-hr workday at $100/hr
Per Diem	$/day	300	Assume $150 per person; 2-person crew
Expendables	$/day	250	Miscellaneous expendables

OMS-28, Organizational Maintenance Shop 28, Alabama Army National Guard
Alternative 4 - Biological/Chemical Reduction of Groundwater with Excavation of Soil
Key Parameters and Assumptions

Item	Unit	Value	Notes
Field Oversight - No. of Days	days	27	Assume 12-hr workday
Volume of water+EHC-L solution	gal	89,100	Assume approx. 450 gallons of water plus EHC-L per injection well
Number of injections at one time	ea	6	Based on maximum number of injection manifolds operating at one time
Time to complete injection operations	days	21	Assume injection rate of 1 gal/min is required per injection well (12 hr/day injections)
Time for system setup and breakdown	days	6	Based on 2-person crew for 3 days; assume 10-hr working day
Injection System Misc Parts	$/well	150	Professional judgement and past experience
Reporting			
Construction Completion Reports	hours	600	Includes report preparation and reviewing construction QA/QC data. Assumes that two separate reports will be generated; one for soil excavation activities and one for biostimulation injection activities.
Technical Labor	$/hr	80	
Operation & Maintenance (O&M) Cost			Monitoring for a period of 5 years
No. of wells for monitoring	ea	13	Number of wells sampled at each event
Well Sampling Unit Cost	$/well	1570	Unit Cost based on sampling 3 monitoring wells per day
Laboratory Analytical Costs	$/well	620	Assume 1 sample each of VOCs, MNA Anions, MNA TOC, MNA MEEH, BOD, COD, Alkalinity, and Hardness per well
VOCs	$/sample	80	Based on historical laboratory rates
Metals	$/sample	65	Based on historical laboratory rates
MNA Anions	$/sample	75	Based on historical laboratory rates
MNA TOC	$/sample	25	Based on historical laboratory rates
MNA MEEH	$/sample	250	Based on historical laboratory rates
BOD, COD	$/sample	50	Based on historical laboratory rates
Alkalinity, Hardness	$/sample	75	Based on historical laboratory rates
Volatile Fatty Acids	$/sample	300	Based on historical laboratory rates, two wells sampled per event
Phospholipid Fatty Acids	$/sample	300	Based on historical laboratory rates, two wells sampled per event
DHC with gene analysis	$/sample	350	Based on historical laboratory rates, two wells sampled per event
IDW pickup and disposal costs			
IDW per sampling events	drums	2	Assumes 5 gallons per well sampled
IDW pickup and disposal costs per event	$/event	1,200	Based on disposal rates (assumes non-hazardous)
Field Sampling Costs	$/day	2280	
Field Vehicle	$/day	80	Assume 1 vehicles at $80/day
Technician	$/day	750	Assume 10-hr workday at $75/hr
Senior Technician	$/day	1,000	Assume 10-hr workday at $100/hr
Per Diem	$/day	300	Per diem $150 per person; crew of 2
Expendables	$/day	150	Miscellaneous expendables

OMS-28, Organizational Maintenance Shop 28, Alabama Army National Guard
Alternative 4 - Biological/Chemical Reduction of Groundwater with Excavation of Soil
Key Parameters and Assumptions

Item	Unit	Value	Notes
Number of years of quarterly monitoring	years	3	
Number of Quarterly events	events	12	
Number of years of semi-annual monitoring	years	2	
Number of semi-annual events	events	4	
Total Remedial timeframe	years	5	
Reporting			
Monitoring Report	ea	16	Includes report preparation and reviewing QA/QC data
Monitoring Report	$/ea	$9,600	Assume 120 hrs @ $80/hr
Periodic Costs (Years 0 to 5)			
CERCLA Reviews			
CERCLA 5-Year Review	ea	1	One 5-year review (year 5)
CERCLA-5-Year Review	$/ea	$30,000	Assume 375 hrs @ $80/hr

OMS-28, Organizational Maintenance Shop 28, Alabama Army National Guard
Alternative 4 - Biological/Chemical Reduction of Groundwater with Excavation of Soil
Cost Estimate

Capital Cost	$2,104,540

Activity (unit)	Quantity	Unit Cost	Total
Capital Cost			
Plans			
RA Design Data Collection	1	$64,040	$64,040
RA Work Plan (hrs)	300	$100	$30,000
H&S Plan (hrs)	160	$100	$16,000
Monitoring Well Abandonment			
Mobilization/Demobilization (ea)	1	$1,500	$1,500
Monitoring Well Abandonment (ea)	3	$673	$2,020
Drill Crew Per Diem; 2-person crew (days)	1	$300	$300
Soil Excavation			
Clearing (day)	1	$1,984	$1,984
Fence Removal and Reinstall (LF)	300	$18.50	$5,550
Excavate Soil (days)	5	$2,846	$14,229
Transport and Offsite Disposal			
Offsite Soil Transport & Disposal (tons)	3,108	$100	$310,788
Soil Confirmatory Sampling & Analysis			
Sample Analyses - Confirmatory (ea)	20	$100	$2,000
Sample Analyses - Waste Management (ea)	10	$100	$1,000
Data Management	30	$90	$2,700
Restoration			
Backfill (cy)	1,842	$18	$33,151
Compaction (cy)	1,842	$1.54	$2,836
Top Soil (cy)	112	$28	$3,136
Hydroseed (sf)	9,000	$1	$9,000
Well Installation			
Mobilization/Demobilization (ea)	1	$5,000	$5,000
Decontamination Pad (ea)	1	$750	$750
Monitoring Well Installation (ea)	6	$2,300	$13,800
Temporary Injection Well Installation (ea)	165	$940	$155,100
Well Development (ea)	6	$1,465	$8,790
Drill Crew Per Diem; 2-person crew (days)	49	$300	$14,700
Standby Charge (days)	49	$130	$6,370
IDW Management (lot)	1	$13,300	$13,300
Field Oversight for Excavation & Well Abandonmant/Installation Activities			
Field Oversight (days)	67	$2,330	$156,110

OMS-28, Organizational Maintenance Shop 28, Alabama Army National Guard
Alternative 4 - Biological/Chemical Reduction of Groundwater with Excavation of Soil
Cost Estimate

Biostimulation Injection Operation			
pH Buffer (lbs)	4,425	$2.50	$11,063
EHC-L (lbs)	74,340	$1.71	$126,997
DHC Inoculum (liters)	165	$104	$17,160
Field Oversight: System Set-up, Injection Operations, System Breakdown (days)	27	$2,730	$73,710
Injection System Misc Parts	165	$150	$24,750
Reporting			
Construction Completion Reports (hrs)	600	$600	$360,000
Subtotal			$1,487,833
Office Overhead		5%	$74,392
Field Overhead		10%	$148,783
Subtotal			$1,711,008
Profit		8%	$136,881
Contingency		15%	$256,651
Total			$2,104,540

Operational and Maintenance (O&M) and Periodic Costs **$846,976**

Activity (unit)	Quantity	Unit Cost	Total
Operation and Maintenance (O&M) Cost			
Quarterly Monitoring of 13 wells (First 3 Years)			
Quarterly Sampling (no. of wells)	156	$1,570	$244,920
Monitoring Report (ea)	12	$9,600	$115,200
IDW disposal (per sampling event)	12	$1,200	$14,400
Semi-annual Sampling of 13 wells (Years 4 through 5)			
Semi-annual Sampling (no. of wells)	52	$1,570	$81,640
Monitoring Report (ea)	4	$9,600	$38,400
IDW disposal (per sampling event)	4	$1,200	$4,800
Periodic Costs			
Five-year CERCLA review (ea)	1	$30,000	$30,000
Subtotal			$529,360
Office Overhead		10%	$52,936
Field Overhead		15%	$79,404
Subtotal			$661,700
Profit		8%	$52,936
Contingency		20%	$132,340
Total			$846,976

TOTAL ALTERNATIVE CAPITAL AND O&M COST **$2,951,516**

OMS-28, Organizational Maintenance Shop 28, Alabama Army National Guard
Alternative 5 - In-Situ Chemical Oxidation of Groundwater with Excavation of Soil
Key Parameters and Assumptions

Item	Unit	Value	Notes
Capital Cost			
Excavation Area	sf	6,000	See Volumes tab
Excavation Volume (ex situ)	cy	1,842	See Volumes tab
Biostimulation Injection Wells	ea	165	No. of temporary injection wells based upon a 15-ft spacing
Additional Monitoring Wells for LTM	ea	6	No. of additional monitoring wells installed (4 new, 2 replacement)
Monitoring Wells to be abandoned	ea	3	No. of monitoring wells requiring abandonment
Wells in Monitoring Plan	ea	13	7 existing, 2 replacement, and 4 new wells
Plans			
RA Design Data Collection	$/lump sum	49,410	Unit rate calculated based on the cost details below
Driller Mobilization/Demobilization	$/lump sum	1,500	Engineering estimate for mobilization of geoprobe rig
Drill Crew Per Diem	$/day	300	Assume $150 per day per person; 2-person drilling crew
Drilling unit cost	$/ft	10	DPT drilling
Drilling footage	ft	60	Assumes 3 DPT locations, 20 ft depth each
Field Oversight	days	2	Assumes 2 days for drilling activities
Bench Scale Treatablity Study	ea	35,000	Based on historical laboratory rates
Baseline Groundwater Sampling	ea	7	Sampling of existing shallow wells only
Well Sampling Unit Cost (labor)	$/well	905	See O&M assumptions below. Unit Cost based on sampling 3 monitoring wells per day.
Laboratory Analytical Costs	$/well	145	See O&M assumptions below. Assume 1 sample each of VOCs and metals per well.
RA Work Plan	hrs	300	Assume 160 hours for technical, CAD, word processing, and review cycles.
RA Work Plan	$/hr	100	
H&S Plan	hrs	160	Assume 100 hours for technical, CAD, word processing, and review cycles.
H&S Plan	$/hr	100	
Monitoring Well Abandonment			
No. of wells to abandon	ea	3	No. of monitoring wells requiring abandonment
No. of days to abandon monitoring wells	days	1	Assume abandonment of up to 5 wells per day
Driller Mobilization/Demobilization	$/lump sum	1,500	Engineering estimate for mobilization of well abandonment equipment
Monitoring Well Abandonment Unit Cost	$/well	680	Unit rate calculated based on the cost details below
Surface Completion Removal	$/well	300	Surface completion removal cost at each monitoring well
Monitoring well depth (average)	ft	38	MW-8 @16 ft, OMW-28-6 @ 76 ft, OMW-28-5 @ 20 ft
Monitoring Well abandonment cost/ft	$/ft	10	Average abandonment costs
Drill Crew Per Diem	$/day	300	Assume $150 per day per person; 2-person drilling crew
Soil Excavation			
Soil Excavation Surface Area	sf	6,000	See Volume tab
Impacted Soil Volume (in situ)	cy	1,393	See Volume tab
Impacted Soil Volume (ex situ)	cy	1,842	See Volume tab
Total Soil Volume for Disposal	cy	1,842	includes soil volume to be transported and disposed
Total Soil Mass for Disposal	tons	3,108	includes soil mass to be transported and disposed
Mobilization/Demobilization	$/lump sum	5,000	includes mob/demob of excavation equipment
Excavate Soils			
Clearing	days	1	RSMeans cost assumes minimum of one day; rate of 6.4 acres per day.
Clearing	acre	0.6	Assumes clearing of approx. 160' x 160'.
Clearing	$/day	2,000	

OMS-28, Organizational Maintenance Shop 28, Alabama Army National Guard
Alternative 5 - In-Situ Chemical Oxidation of Groundwater with Excavation of Soil
Key Parameters and Assumptions

Item	Unit	Value	Notes
Fence Removal and Reinstall	LF	300	
Fence Removal and Reinstall	$/lf	18.5	RSMeans unit cost.
Excavate Soils	days	5	
Excavation Production Rate	cy/day	400	excavation rate per day
Excavate Soils	$/day	2,846	Includes 3/4 cy excavator, 1 O.E., 2 L.S. spotter and to prep trucks and support excavation activities. RSMeans Crew B12F.
Transport and Offsite Disposal			
Disposal weight	tons	3,108	approximate soils weight in tons
Offsite disposal costs - non-hazardous soils	$/ton	100	typical non-hazardous soils disposal costs
Soil Confirmational Sampling & Analysis			
TCLP Soil Samples	ea	10	assume one composite sample per 200 cy
TCLP VOC analysis	$/sample	100	historical laboratory rates
Confirmatory Soil Samples	ea	20	assume 2 per sidewall and 2 per floor at each excavation area
VOC analysis	$/sample	100	Based on historical laboratory rates
Sampling Duration	days	3	
Data Management	hrs	30	Data validation
Data Management	$/hr	90	
Restoration			
Restoration Duration	days	6	
Clean soil backfill	cy	1,842	
Clean soil backfill	$/cy	18.0	
Compaction	cy	1,842	Compaction, structural, common fill, 8" lifts, vibratory plate.
Compaction	$/cy	1.54	RSMeans 31232324 0600.
Top soil	cy	112	
Top soil	$/cy	28	
Seeding	sf	9,000	assume area 50% larger than excavation areas.
Seeding	$/sf	1.0	
Monitoring and Injection Well installation			
Drill Rig Mobilization/Demobilization	$/ea	5,000	Engineering estimate for mobilization/demobilization of drilling rig, monitoring well and injection well construction materials
Decontamination Pad	$/ea	750	Based on historical drilling costs
New Monitoring Wells	ea	6	
Monitoring Well Installation Duration	days	6	Assume completion of 1 well per day
Monitoring Well Installation Unit Cost	$/well	2,300	Unit rate calculated based on the cost details below
Monitoring Well Completion Depth	ft	30	Well TD 30 feet
Monitoring Well Drilling Cost	$/ft	30	Based on historical drilling costs
2" Monitoring Well Installation Cost	$/ft	30	Average well well installation costs (2" PVC with 10 ft screen)
Surface Completion	$/well	400	Surface completion cost for each monitoring well
55-gallon drum cost	$/drum	50	
55-gallon drums for soil cuttings	ea	2	assume 1 drum for every 15 ft of borehole or 2 drums/ 30 ft
Well Development	$/day	1,465	Assumes 1 person, 1 well per day, 1 drum per well.
No. of Injection Wells	ea	165	No. of temporary injection wells based upon a 30-ft spacing
Injection Well Installation Duration	days	43	Assume completion of 4 temporary injection wells per day
Temporary Injection Well Installation Unit Cost	$/well	940	Unit rate calculated based on the cost details below
Injection Well Completion Depth	ft	30	Well TD 30 feet
Injection Well DPT Drilling Cost	$/ft	10.75	Based on historical drilling costs
Injection Well Completion Unit Cost	$/ft	12	Based on historical drilling costs

OMS-28, Organizational Maintenance Shop 28, Alabama Army National Guard
Alternative 5 - In-Situ Chemical Oxidation of Groundwater with Excavation of Soil
Key Parameters and Assumptions

Item	Unit	Value	Notes
1" PVC Well Screen Unit Cost	$/ft	11	Based on historical drilling costs
1" PVC Well Screen	ft	20	20 feet of well screen
1" PVC Well Riser Unit Cost	$/ft	2.50	Based on historical drilling costs
1" PVC Well Riser	ft	15	Based on historical drilling costs
Drill Crew Per Diem	$/day	300	Assume $150 per day per person; 2-person drilling crew
Stand-by Charge	$/day	130	Assume 1 hr of standby time per day @ $130/hr
IDW Management	$/lot	13,300	
IDW Drums	ea	74	For soil IDW - assume two soil drums per well for HSA installation activities, one soil drum per 5 wells for DPT installation activities For water IDW - assume 25 gallons of decon water per day and 55 gallons per monitoring well
IDW Sampling	$/sample	100	Assume 1 composite sample for every drum for waste characterization. Costs based on lab quote.
IDW Disposal (hazardous)	$/drum	175	Assume 0% of total IDW generated will be characteristically hazardous.
IDW Disposal (non-hazardous)	$/drum	50	Assume 100% of total IDW generated will be characteristically non-hazardous.
IDW Transportation and Pickup	$/event	2,200	Based on 60 drums per truckload
Field Oversight - Daily Rate	$/day	2,330	Field oversight
Field Vehicle	$/day	80	Assume 1 vehicles at $80/day
Technician	$/day	750	Assume 10-hr workday at $75/hr
Geologist/Engineer	$/day	1,000	Assume 10-hr workday at $100/hr
Per Diem	$/day	300	Assume $150 per person; 2-person crew
Expendables	$/day	200	Miscellaneous expendables
Field Oversight - No. of Days	days	67	Assume 2 days waste management in addition to excavation, restoration, well install and abandonment
ISCO Initial Injection Operation			
No. of Injection Points	ea	165	
Potassium permanganate Unit Cost	$/lb	3.00	historical costs
Potassium permanganate	lb	200,000	Based upon mass of TCE (0.2 kg), PCE (0.004 kg), and assumed NOD of 10 g/kg
Field Oversight - Daily Rate	$/day	2,730	Field oversight of ISCO Operations
Field Vehicle	$/day	80	Assume 1 vehicles at $80/day
Technician	$/day	900	Assume 12-hr workday at $75/hr
Senior Technician	$/day	1,200	Assume 12-hr workday at $100/hr
Per Diem	$/day	300	Assume $150 per person; 2-person crew
Expendables	$/day	250	Miscellaneous expendables
Field Oversight - No. of Days	days	26	Assume 12-hr workday
Volume of water+permanganate solution	gal	82,500	Assume 500 gallons of water per injection well
Number of injections at one time	ea	6	Based on maximum number of injection manifolds operating at one time
Time to complete injection operations	days	19	Assume injection rate of 1 gal/min is required per injection well (12 hr/day injections)
Time for system setup and breakdown	days	6	Based on 2-person crew for 3 days; assume 10-hr working day
Injection System Misc Parts	$/well	150	Professional judgement and past experience

OMS-28, Organizational Maintenance Shop 28, Alabama Army National Guard
Alternative 5 - In-Situ Chemical Oxidation of Groundwater with Excavation of Soil
Key Parameters and Assumptions

Item	Unit	Value	Notes
ISCO Initial Injection Operation			
No. of Injection Points	ea	116	Assumes a 30% reduction from initial injection
Potassium permanganate Unit Cost	$/lb	3.00	
Potassium permanganate	lb	140,000	Assumes a 30% reduction from initial injection
Field Oversight - No. of Days	days	19	Assumes a 30% reduction from initial injection
Reporting			
Construction Completion Reports	hours	600	Includes report preparation and reviewing construction QA/QC data. Assumes that two separate reports will be generated; one for soil excavation activities and one for biostimulation injection activities.
Technical Labor	$/hr	80	
Operation & Maintenance (O&M) Cost			Monitoring for a period of 5 years
No. of wells for monitoring	ea	13	Number of wells sampled at each event
Well Sampling Unit Cost	$/well	905	Unit Cost based on sampling 3 monitoring wells per day
Laboratory Analytical Costs	$/well	145	Assume 1 sample each of VOCs and metals per well
VOCs	$/sample	80	Based on historical laboratory rates
Metals	$/sample	65	Based on historical laboratory rates
IDW pickup and disposal costs			
IDW per sampling events	drums	2	Assumes 5 gallons per well sampled
IDW pickup and disposal costs per event	$/event	1,200	Based on disposal rates (assumes non-hazardous)
Field Sampling Costs	$/day	2280	
Field Vehicle	$/day	80	Assume 1 vehicles at $80/day
Technician	$/day	750	Assume 10-hr workday at $75/hr
Senior Technician	$/day	1,000	Assume 10-hr workday at $100/hr
Per Diem	$/day	300	Per diem $150 per person; crew of 2
Expendables	$/day	150	Miscellaneous expendables
Number of years of quarterly monitoring	years	3	
Number of Quarterly events	events	12	
Number of years of semi-annual monitoring	years	3	
Number of semi-annual events	events	6	
Total Remedial timeframe	years	6	
Reporting			
Monitoring Report	ea	18	Includes report preparation and reviewing QA/QC data
Monitoring Report	$/ea	$9,600	Assume 120 hrs @ $80/hr
Periodic Costs (Years 0 to 6)			
CERCLA Reviews			
CERCLA 5-Year Review	ea	1	One 5-year review (year 5)
CERCLA-5-Year Review	$/ea	$30,000	Assume 375 hrs @ $80/hr

OMS-28, Organizational Maintenance Shop 28, Alabama Army National Guard
Alternative 5 - In-Situ Chemical Oxidation of Groundwater with Excavation of Soil
Cost Estimate

Capital Cost	**$3,401,250**

Activity (unit)	Quantity	Unit Cost	Total
Capital Cost			
Plans			
RA Design Data Collection	1	$49,410	$49,410
RA Work Plan (hrs)	300	$100	$30,000
H&S Plan (hrs)	160	$100	$16,000
Monitoring Well Abandonment			
Mobilization/Demobilization (ea)	1	$1,500	$1,500
Monitoring Well Abandonment (ea)	3	$680	$2,040
Drill Crew Per Diem; 2-person crew (days)	1	$300	$300
Soil Excavation			
Clearing (day)	1	$2,000	$2,000
Fence Removal and Reinstall (LF)	300	$18.50	$5,550
Excavate Soil (days)	5	$2,846	$14,229
Transport and Offsite Disposal			
Offsite Soil Transport & Disposal (tons)	3,108	$100	$310,788
Soil Confirmatory Sampling & Analysis			
Sample Analyses - Confirmatory (ea)	20	$100	$2,000
Sample Analyses - Waste Management (ea)	10	$100	$1,000
Data Management	30	$90	$2,700
Restoration			
Backfill (cy)	1,842	$18	$33,151
Compaction (cy)	1,842	$1.54	$2,836
Top Soil (cy)	112	$28	$3,136
Hydroseed (sf)	9,000	$1	$9,000
Well Installation			
Mobilization/Demobilization (ea)	1	$5,000	$5,000
Decontamination Pad (ea)	1	$750	$750
Monitoring Well Installation (ea)	6	$2,300	$13,800
Temporary Injection Well Installation (ea)	165	$940	$155,100
Well Development (ea)	6	$1,465	$8,790
Drill Crew Per Diem; 2-person crew (days)	49	$300	$14,700
Standby Charge (days)	49	$130	$6,370
IDW Management (lot)	1	$13,300	$13,300
Field Oversight for Excavation & Well Abandonmant/Installation Activities			
Field Oversight (days)	67	$2,330	$156,110

OMS-28, Organizational Maintenance Shop 28, Alabama Army National Guard
Alternative 5 - In-Situ Chemical Oxidation of Groundwater with Excavation of Soil
Cost Estimate

Initial ISCO Injection Operation			
Potassium permanganate (lbs)	200,000	$3	$600,000
Field Oversight: System Set-up, Injection Operations, System Breakdown (days)	26	$2,730	$70,980
Injection System Misc Parts	165	$150	$24,750
ISCO Reinjection Operations (Assumes 70% of initial Injection Effort			
Potassium permanganate (lbs)	140,000	$3	$420,000
Field Oversight: System Set-up, Injection Operations, System Breakdown (days)	19	$2,730	$51,870
Injection System Misc Parts	116	$150	$17,400
Reporting			
Construction Completion Reports (hrs)	600	$600	$360,000
Subtotal			$2,404,560
Office Overhead		5%	$120,228
Field Overhead		10%	$240,456
Subtotal			$2,765,244
Profit		8%	$221,220
Contingency		15%	$414,787
Total			$3,401,250

Operational and Maintenance (O&M) Cost **$697,872**

Activity (unit)	Quantity	Unit Cost	Total
Operation and Maintenance (O&M) Cost			
Quarterly Monitoring of 13 wells (First 3 Years)			
Quarterly Sampling (no. of wells)	156	$905	$141,180
Monitoring Report (ea)	12	$9,600	$115,200
IDW disposal (per sampling event)	12	$1,200	$14,400
Semi-annual Sampling of 13 wells (Years 4 through 6)			
Semi-annual Sampling (no. of wells)	78	$905	$70,590
Monitoring Report (ea)	6	$9,600	$57,600
IDW disposal (per sampling event)	6	$1,200	$7,200
Periodic Costs			
Five-year CERCLA review (ea)	1	$30,000	$30,000
Subtotal			$436,170
Office Overhead		10%	$43,617
Field Overhead		15%	$65,426
Subtotal			$545,213
Profit		8%	$43,617
Contingency		20%	$109,043
Total			$697,872

TOTAL ALTERNATIVE CAPITAL AND O&M COST **$4,099,122**

APPENDIX B
FATE AND TRANSPORT MODELING

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Fate and Transport Modeling at Organizational Maintenance Shop-28
Alabama Army National Guard, Mobile, Alabama

Fate and Transport Modeling. Performed leachate modeling using the Seasonal Soil (SESOIL) compartment model and saturated flow and transport modeling using the Analytical Transient 1-, 2-, 3-Dimensional (AT123D) model to evaluate the natural attenuation of tetrachloroethene (PCE) and trichloroethene (TCE) contamination in the groundwater at Organizational Maintenance Shop (OMS) 28 at the Brookley Aeroplex based on remediation to the maximum contaminant level (MCL), which will provide the requisite level of protectiveness for unlimited use and unrestricted exposure conditions.

Chlorinated solvents were the primary constituents detected in soil samples exceeding protection of groundwater soil screening levels (SSLs). PCE and TCE were the only constituents in groundwater observed in significant quantities above MCLs. The presence of PCE; TCE; and *cis*-1,2-dichloroethene in the unsaturated soil at concentrations above SSLs protective of groundwater is serving as a continuing source of groundwater contamination. AT123D models were developed by utilizing the predicting PCE and TCE concentrations in groundwater at monitoring wells MW-8, OMS-28-3, and OMS-28-5 and boring B-17. The primary assumption is that the residual concentrations of PCE and TCE in unsaturated soil (0 to 10 ft below ground surface [BGS]) would be excavated and disposed off-site. Three models were developed.

- **Scenario 1** – AT123D model of TCE in groundwater assuming the residual soil mass in the vicinity of MW-8 is removed to a depth of 10 ft BGS. Figure B-1 indicates that natural attenuation of TCE in groundwater will continue for approximately 25 to 30 years to be below the TCE MCL, assuming that the soil source is removed.

- **Scenario 2** – AT123D model of PCE in groundwater assuming the residual soil mass in the vicinity of MW-8 and B-17 is removed to a depth of 10 ft BGS. Figure B-2 indicates that natural attenuation of PCE in groundwater will continue for approximately 10 to 15 years to be below the PCE MCL, assuming that the soil source is removed.

- **Scenario 3** – AT123D model of TCE in groundwater based on leaching from residual soil concentrations predicted by SESOIL. Leachate concentrations of TCE were predicted by SESOIL based on the observed soil concentrations at the site in the vicinity of MW-8. The results predicted by SESOIL were utilized in the AT123D model. The AT123D modeling result presented in Figure B-3 indicates that natural attenuation of TCE in groundwater will continue for approximately 35 to 40 years to be below the TCE MCL, assuming leaching from the soil source.

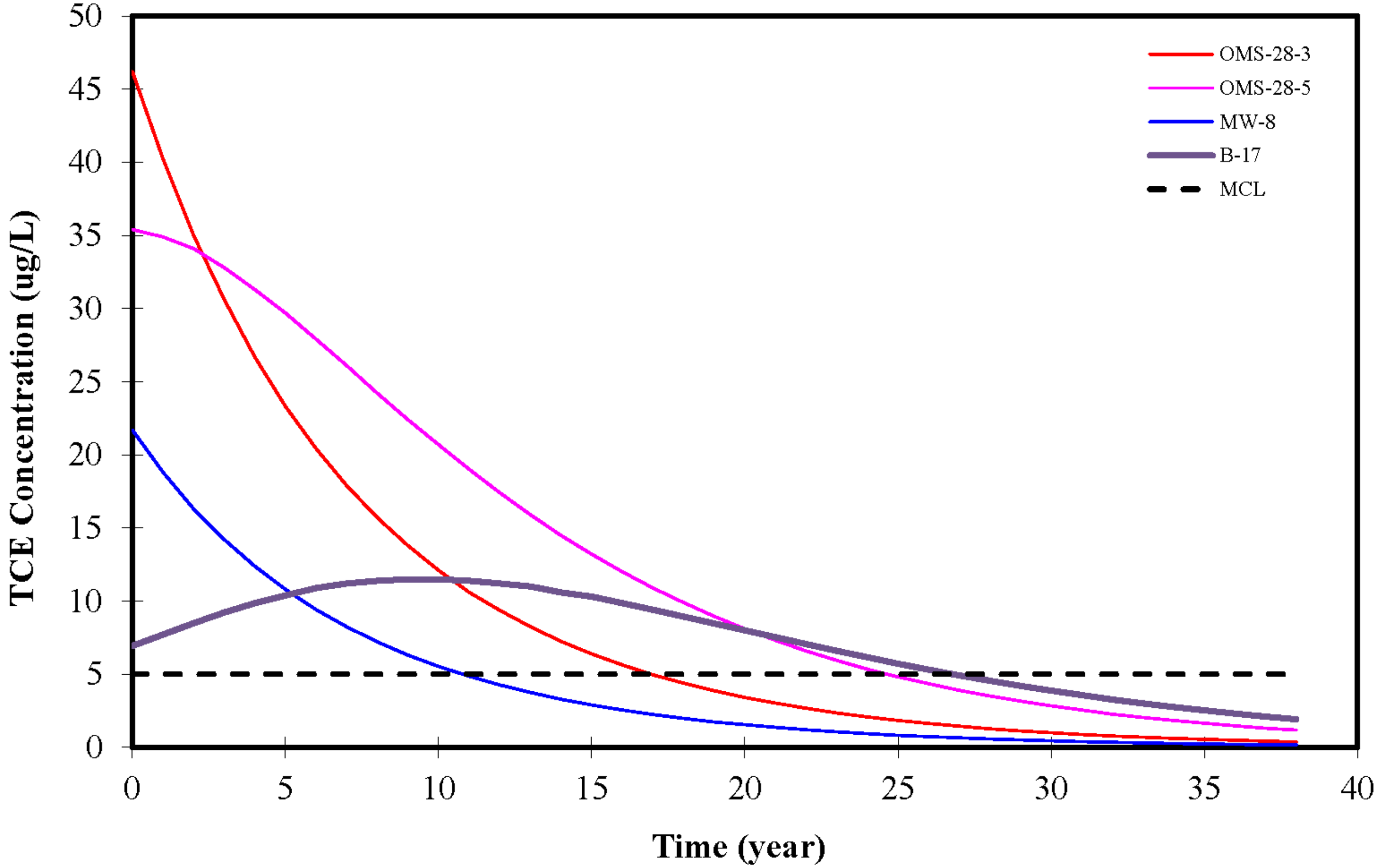

Figure B-1. Predicted TCE Concentrations in Groundwater at OMS-28 Based on Removal of the Residual Soil Concentrations Between 0 and 10 ft BGS

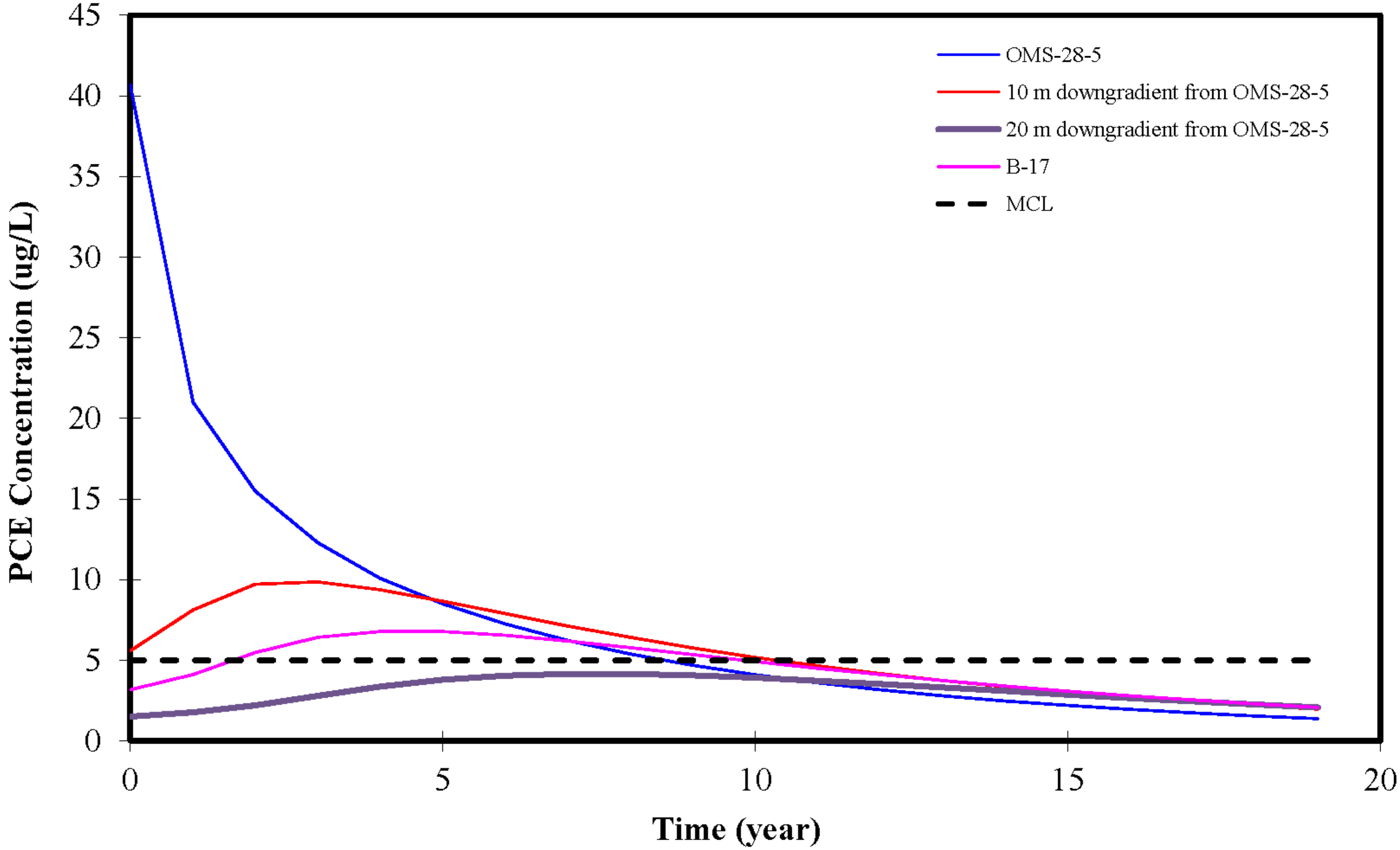

Figure B-2. Predicted PCE Concentrations in Groundwater at OMS-28 Based on Removal of the Residual Soil Concentrations Between 0 and 10 ft BGS

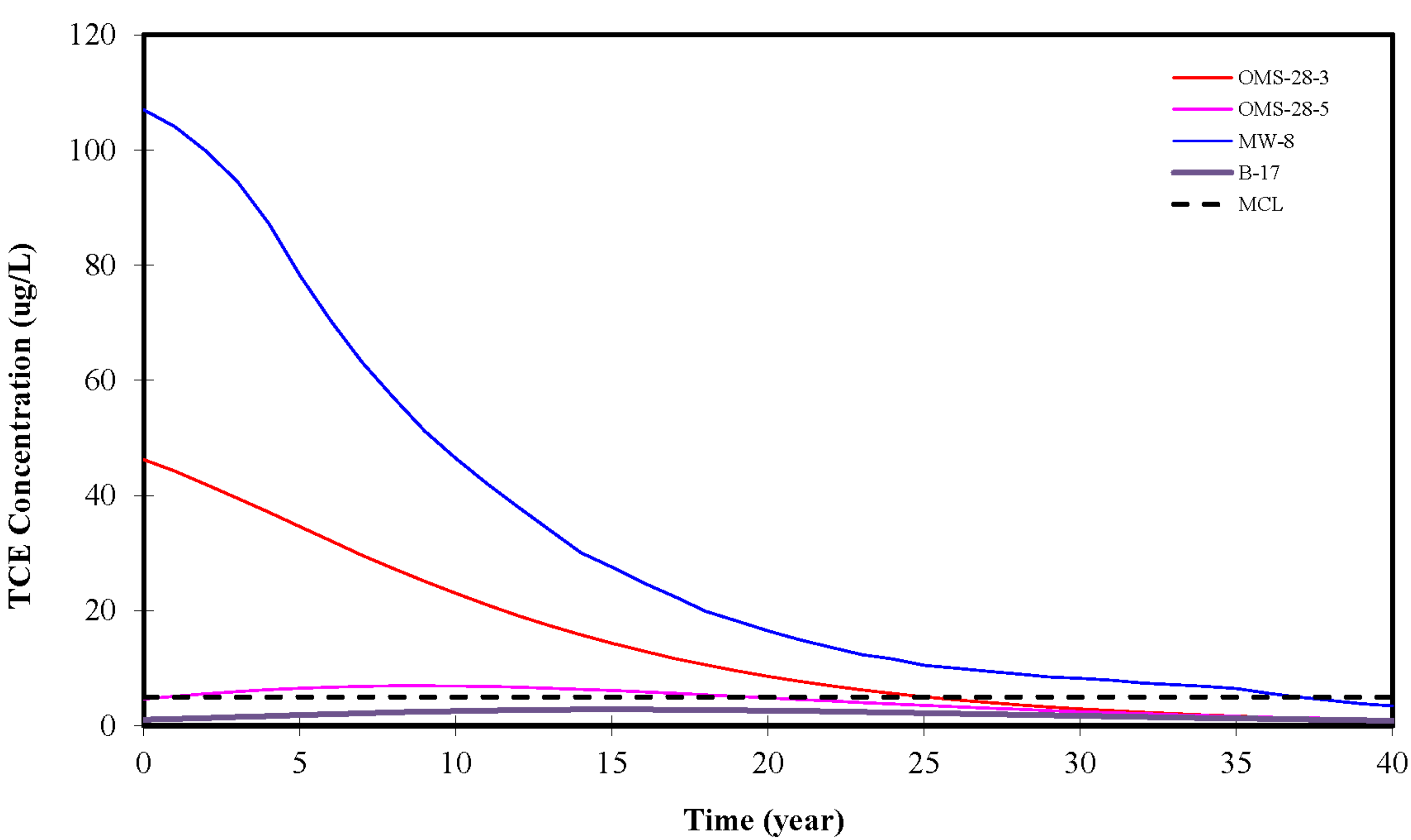

Figure B-3. Predicted TCE Concentrations in Groundwater at OMS-28 Based on Leaching From the Soil Source