RCRA RECORDS CENTER
FACILITY Jones Environmental
I.D. NO. MAD047115121
FILE LOC. R-9
OTHER # 103333

PHASE III IDENTIFICATION, EVALUATION AND SELECTION OF COMPREHENSIVE REMEDIAL ACTION ALTERNATIVES REPORT

263 Howard Street
Lowell, Massachusetts 01852

RTN 3-0601

June 19, 2002

Lightship Engineering Project No. 542.1.1

RDMS DocID 103333

Prepared for:

Jones Environmental Services (Northeast), Inc.
461 Cooke Street
Farmington, Connecticut 06032

Prepared by:

Lightship Engineering, LLC
36 Cordage Park Circle – Suite 312
Plymouth, Massachusetts 02360

LIGHTSHIP ENGINEERING
ENVIRONMENTAL & LAND-USE CONSULTANTS

LSP SERVICES • CIVIL ENGINEERING • ASSESSMENT • PERMITTING • REMEDIATION • CONSTRUCTION MANAGEMENT

TABLE OF CONTENTS

1.0 INTRODUCTION 1-1

2.0 SITE HISTORY 2-1

3.0 NATURE AND EXTENT OF OHM AND REMDIAL APPROACH 3-1

4.0 INITIAL SCREENING OF REMEDIAL ACTION ALTERNATIVES FOR THE DISPOSAL SITE 4-1

4.1 INITIAL SCREENING OF REASONABLY LIKELY OPTIONS 4-1

4.1.1 Enhanced Biodegradation *(in-situ)* 4-1
4.1.2 Natural Attenuation *(in-situ)* 4-2
4.1.3 Phytoremediation *(in-situ)* 4-2
4.1.4 Air Sparging *(in-situ)* 4-3
4.1.5 BioSlurping *(in-situ)* 4-3
4.1.6 Chemical Oxidation *(in-situ)* 4-3
4.1.7 Dual-Phase Extraction *(in-situ)* 4-4
4.1.8 Thermal Treatment *(in-situ)* 4-4
4.1.9 Hydrofracturing *(in-situ)* 4-5
4.1.10 In-Well Air Stripping *(in-situ)* 4-5
4.1.11 Permeable Reactive Barrier *(in-situ)* 4-6
4.1.12 Groundwater Extraction *(in-situ)* / Groundwater Pump and Treat *(ex-situ)* 4-6
4.1.13 Bio-Reactors (*ex-situ*, assumes groundwater recovery) 4-7
4.1.14 Constructed Wetlands (*ex-situ*, assumes groundwater recovery) 4-7
4.1.15 Adsorption/ Absorption (*ex-situ*, assumes groundwater recovery) 4-8
4.1.16 UV Oxidization (*ex-situ*, assumes groundwater recovery) 4-9
4.1.17 Air Stripping (*ex-situ*, assumes groundwater recovery) 4-9
4.1.18 Liquid Phase Carbon Adsorption (*ex-situ*, assumes groundwater recovery) 4-10
4.1.19 Separation (*ex-situ*, assumes groundwater recovery) 4-11
4.1.20 Sprinkler Irrigation (*ex-situ*, assumes groundwater recovery) 4-11
4.1.21 Physical Barriers 4-12
4.1.22 Deep Well Injection 4-12
4.1.23 BioFiltration (off-gas treatment) 4-13
4.1.24 High Energy Destruction (*off-gas treatment*) 4-13
4.1.25 Separation (off-gas treatment) 4-13
4.1.26 Thermal/Catalytic Oxidation (*off-gas treatment*) 4-14
4.1.27 Vapor-Phase Carbon Absorption (*off-gas treatment*) 4-15

Main Office: 36 Cordage Park Circle • Suite 312 • Plymouth, Massachusetts 02360 • (508) 830-3344 • Fax: (508) 830-3360
Cape Cod Office: P.O. Box 681• Sandwich Massachusetts 02537 • Phone (508) 833-3950
North Shore Office: P.O. Box 517 • North Andover Massachusetts 01845 • Phone (978) 557-5888
WWW.LIGHTSHIPENGINEERING.COM

TABLE OF CONTENTS (Continued)

4.2 RESULTS OF INITIAL SCREENING 4-15

5.0 EVALUATION OF REMEDIAL ACTION ALTERNATIVES 5-1
5.1 SELECTION OF REMEDIAL ACTION ALTERNATIVE 5-1
5.2 SUMMARY OF THE REMEDIAL ACTION ALTERNATIVE EVALUATION 5-1
5.3 RECOMMENDED REMEDIAL ACTION ALTERNATIVE 5-2
5.4 FEASIBLITY EVALUATION 5-2
5.4.1 Feasibility of Implementing a Permanent Solution 5-2
5.4.2 Feasibility of Achieving or Approaching Background Conditions 5-3
5.4.3 Feasibility of Reducing Concentrations of Oil and/or Hazardous Materials to Levels at or below Upper Concentration Limits 5-3
5.5 ELIMINATION OF SUBSTANTIAL HAZARDS 5-3
5.6 DEFINITIVE AND ENTERPRISING STEPS TOWARD ACHIEVING A PERMANENT SOLUTION 5-4

6.0 PROJECTED SCHEDULE FOR PHASE IV 6-1

7.0 LIMITATIONS 7-1

Main Office: 36 Cordage Park Circle • Suite 312 • Plymouth, Massachusetts 02360 • (508) 830-3344 • Fax: (508) 830-3360
Cape Cod Office: P.O. Box 681 • Sandwich Massachusetts 02537 • Phone (508) 833-3950
North Shore Office: P.O. Box 517 • North Andover Massachusetts 01845 • Phone (978) 557-5888
WWW.LIGHTSHIPENGINEERING.COM

APPENDICES

APPENDIX A FIGURES

Figure 1-1 Site Locus Map
Figure 1-2 Disposal Site Map

APPENDIX B FEDERAL REMEDIATION TECHNOLOGIES ROUNDTABLE SCREENING MATRIX

APPENDIX C DETAILED REMEDIATION COST ANALYSIS

Main Office: 36 Cordage Park Circle • Suite 312 • Plymouth, Massachusetts 02360 • (508) 830-3344 • Fax: (508) 830-3360
Cape Cod Office: P.O. Box 681• Sandwich Massachusetts 02537 • Phone (508) 833-3950
North Shore Office: P.O. Box 517 • North Andover Massachusetts 01845 • Phone (978) 557-5888
WWW.LIGHTSHIPENGINEERING.COM

1.0 INTRODUCTION

On behalf of Jones Environmental Services (Northeast), Inc., Lightship Engineering, LLC ("Lightship Engineering") has prepared this Phase III Identification, Evaluation and Selection of Comprehensive Remedial Action Alternatives Report (the "Phase III report") pursuant to the Massachusetts Contingency Plan ("MCP") 310 CMR 40.0850. The Phase III report documents the identification, evaluation and selection of a remedial action alternative for the release of oil and/or hazardous material ("OHM") in the vicinity of a former containment sump in Building No. 2 ("AOC3 former containment sump") of the Temporary Storage and Disposal Facility ("TSDF") located at 263 Howard Street, Lowell, Massachusetts (the "Site"). A Site Locus Map and a Disposal Site Map are attached as Figures 1-1 and 1-2, respectively, at Appendix A. The property is currently operated as a TSDF by Jones Environmental Services (Northeast), Inc.

This Phase III report summarizes the disposal site history; compounds-of-concern ("COCs"); nature and extent of impacted media; and the identification, evaluation and selection of remedial action alternatives. Lightship Engineering reviewed the following reports associated with the disposal site:

- *Tier Classification,* prepared by Phoenix Environmental Services, Inc., February 1999;
- *Phase I Initial Site Investigation Report volume I and II* ("Phase I"), prepared by Phoenix Environmental Services, Inc., February 1999; and
- *Phase II Comprehensive Site Assessment Report* ("Phase II"), prepared by URS Corporation, August 14, 2001.

An outline of the Phase III report is set forth below.

- Section 2.0 summarizes the disposal site background and history, including subsurface investigations, which support the Phase III report.

- Section 3.0 summarizes the nature and extent of OHM impact within the disposal site. Details supporting the nature and extent are provided in the Phase II report.

- Section 4.0 presents the results of the initial screening of remedial alternatives.

- Section 5.0 presents the selection of the recommended remediation technology

- Section 6.0 presents a projected schedule for the implementation of the recommended remedial alternative for the disposal site.

Main Office: 36 Cordage Park Circle • Suite 312 • Plymouth, Massachusetts 02360 • (508) 830-3344 • Fax: (508) 830-3360
Cape Cod Office: P.O. Box 681 • Sandwich Massachusetts 02537 • Phone (508) 833-3950
North Shore Office: P.O. Box 517 • North Andover Massachusetts 01845 • Phone (978) 557-5888
WWW.LIGHTSHIPENGINEERING.COM

2.0 SITE HISTORY

The Site is presently utilized as a Resource Conservation and Recovery Act ("RCRA") TSDF operating under an Interim Part B License. Prior to 1976 the Site was utilized as a railroad yard, boiler maintenance and repair, and metal recycling facility. Since 1976 the Site has been utilized as a TSDF that included the reclamation, distillation and storage of solvents, acids, alkalis, volatile and non-volatile organic compounds, plating and metal waste, and still bottoms. The Site is presently utilized for the treatment and temporary storage of hazardous waste prior to off-Site disposal. The buildings at the Site are utilized for office space, an on-Site laboratory and hazardous waste treatment and storage.

The facility is abutted by commercial properties and the River Meadow Brook directly adjacent to and northwest of the Site. The Silresin Chemical Corporation (Federal Superfund site), is located southwest of the facility.

A historical release of OHM to soil and groundwater occurred at the Site in connection with a former containment sump located in Building No. 2. The Department of Environmental Protection ("DEP") was notified of a release of OHM January 15, 1990. The response actions at the Site are also subject to the RCRA Corrective Action Program. The COCs primarily consist of chlorinated solvent related compounds and their degradation products and toluene. Soil, groundwater, surface water, sediment and soil gas samples have been collected and submitted for laboratory analysis as set forth in the Phase I and II Reports. The Site is classified as a Tier II disposal site by DEP. A detailed description of the nature and extent of OHM impacted media is set forth in Section 3.0.

Main Office: 36 Cordage Park Circle • Suite 312 • Plymouth, Massachusetts 02360 • (508) 830-3344 • Fax: (508) 830-3360
Cape Cod Office: P.O. Box 681• Sandwich Massachusetts 02537 • Phone (508) 833-3950
North Shore Office: P.O. Box 517 • North Andover Massachusetts 01845 • Phone (978) 557-5888
WWW.LIGHTSHIPENGINEERING.COM

3.0 NATURE AND EXTENT OF OHM AND REMDIAL APPROACH

A summary of the nature and extent of OHM-impacted soil and groundwater at the disposal site is set forth below. Details regarding the nature and extent of OHM impact are provided in the Phases I and II reports.

- A former spill containment sump located in Building No. 2 (AOC3 Former Sump) appears to be the source of OHM at this location. As set forth in the Phase II, in 1992 approximately 26 drums of liquid hazardous material and 3 drums of impacted sediment/soil were removed from the catch basin that was utilized as a spill containment sump. Following cleanup activities the catch basin was closed and monitoring well MW-4 installed at this location.

- As part of the Phase I and II assessment activities soil, groundwater, surface water, sediment and soil gas samples were collected to assess the extent of OHM-impacted media at the disposal site.

- Concentrations of 1,1,1-trichloroethane ("TCA") and toluene were detected above DEP Upper Concentration Limits ("UCLs") in groundwater at monitoring well MW-4. Concentrations of 1,1-dichloroethane ("DCA"), tetrachloroethene ("PCE") and trichloroethene ("TCE") were also detected in groundwater at MW-4 above Method 1 GW-2 Groundwater Cleanup Standards. Concentrations of chlorinated solvents were detected in groundwater at monitoring wells URS-2 and GZA-4 above Method 1 GW-2 Groundwater Cleanup Standards.

- As set forth in the Phase II report, a Method 3 Risk Characterization was conducted for the Site that concluded that a level of No Significant Risk ("NSR") to human health exists at the Site with the continued use of the property for commercial or industrial purposes. The Site may pose a significant risk to public welfare and the environment under the current use as a result of the compounds that exceeded UCLs in groundwater at MW-4.

- Depth to groundwater is 8 to 9 feet below grade (floor elevation) and groundwater is migrating to the northwest towards the River Meadow Brook.

The objective of remedial actions at the disposal site is to reduce concentrations of chlorinated solvents detected in groundwater to below UCLs in order to achieve a level of NSR with respect to public welfare and the environment, thereby, eliminating the "source" of the impacts to groundwater. Therefore, the project approach is to remediate the source of OHM at

Main Office: 36 Cordage Park Circle • Suite 312 • Plymouth, Massachusetts 02360 • (508) 830-3344 • Fax: (508) 830-3360
Cape Cod Office: P.O. Box 681 • Sandwich Massachusetts 02537 • Phone (508) 833-3950
North Shore Office: P.O. Box 517 • North Andover Massachusetts 01845 • Phone (978) 557-5888
WWW.LIGHTSHIPENGINEERING.COM

the Site. Upon remediation of the source of OHM, the concentration of OHM at other locations should decrease over time as a result of natural attenuation and result in a level of NSR at the Site.

Main Office: 36 Cordage Park Circle • Suite 312 • Plymouth, Massachusetts 02360 • (508) 830-3344 • Fax: (508) 830-3360
Cape Cod Office: P.O. Box 681 • Sandwich Massachusetts 02537 • Phone (508) 833-3950
North Shore Office: P.O. Box 517 • North Andover Massachusetts 01845 • Phone (978) 557-5888
WWW.LIGHTSHIPENGINEERING.COM

4.0 INITIAL SCREENING OF REMEDIAL ACTION ALTERNATIVES FOR THE DISPOSAL SITE

Pursuant to 310 CMR 40.0855, a description of all remedial action alternatives initially identified for the disposal site, and the results of the initial screening, are set forth in this section. The objective of remedial actions at the disposal site is to reduce concentrations of chlorinated solvents detected in groundwater below UCLs in order to achieve a level of NSR with respect to public welfare and the environment. Pursuant to 310 CMR 40.0856(1)(a)(b), the selection of remedial action alternatives initially evaluated was based upon the criteria set forth below:

- The technologies employed by the alternative are reasonably likely to achieve a permanent or temporary solution; and
- Individuals with the expertise needed to effectively implement available solutions would be available, regardless of arrangements for securing their services.

Feasible remedial action alternatives for the remediation of halongenated volatile organic compounds ("VOCs") in groundwater were selected utilizing the Federal Remediation Technologies Roundtable ("FRTR") *Treatment Technologies Screening Matrix* (the FRTR matrix). Twenty-seven of the thirty remediation technologies listed to treat halongenated VOCs in groundwater appear to be applicable to the disposal site, as set forth in Appendix B.

4.1 INITIAL SCREENING OF REASONABLY LIKELY OPTIONS

4.1.1 Enhanced Biodegradation *(in-situ)*

Enhanced *in-situ* Biodegradation increases the rate of bioremediation of organic contaminants through microbial action by increasing the concentration of electron acceptors and nutrients in groundwater. Oxygen is the main electron acceptor for aerobic bioremediation. Nitrate serves as an alternative electron acceptor under anoxic conditions.

The elevated concentrations of chlorinated solvents at the Site may prove toxic to biological organisms in groundwater, therefore, this technology is not likely to achieve a temporary or permanent solution. The individuals with the expertise needed to effectively implement available solutions would be available.

Main Office: 36 Cordage Park Circle • Suite 312 • Plymouth, Massachusetts 02360 • (508) 830-3344 • Fax: (508) 830-3360
Cape Cod Office: P.O. Box 681 • Sandwich Massachusetts 02537 • Phone (508) 833-3950
North Shore Office: P.O. Box 517 • North Andover Massachusetts 01845 • Phone (978) 557-5888
WWW.LIGHTSHIPENGINEERING.COM

4.1.2 Natural Attenuation *(in-situ)*

Natural subsurface processes such as dilution, volatilization, biodegradation, adsorption, and chemical reactions with subsurface materials can reduce low-level contaminant concentrations to acceptable levels. Consideration of this option usually requires modeling and evaluation of contaminant degradation rates and pathways and predicting contaminant concentrations at down-gradient receptors, especially when the plume has not stabilized and is still expanding/migrating. The primary objective of site modeling is to demonstrate that natural processes of contaminant degradation will reduce contaminant concentrations below regulatory standards or risk-based levels before potential exposure pathways are completed. In addition, long-term monitoring is required throughout the process to confirm that degradation is proceeding at rates consistent with meeting cleanup objectives.

Based on the elevated concentrations of chlorinated solvents and the proximity to the River Meadow Brook, it is unlikely that natural dilution, volatilization, biodegradation, adsorption and chemical reaction within the subsurface will significantly reduce chlorinated solvent concentrations in groundwater prior to migrating to the River Meadows Brook.

This technology is not likely to achieve a temporary or permanent solution in a timely manner without source abatement. The individuals with the expertise needed to effectively implement available solutions would be available.

4.1.3 Phytoremediation *(in-situ)*

Phytoremediation is a set of processes that uses plants to reduce OHM impacts in groundwater and surface water. Phytoremediation includes enhanced rhizosphere biodegradation, hydraulic control, phyto-degradation and phyto-volatilization. Phyto-degradation is the metabolism of contaminants within plant tissues. Plants produce enzymes, such as dehalogenase and oxygenase that help catalyze degradation. Investigations are proceeding to determine if both aromatic and chlorinated aliphatic compounds are amenable to phyto-degradation.

The elevated concentrations of chlorinated solvents in groundwater may prove toxic to biological organisms. In addition, the area required to sustain a plant mass large enough to treat the mass of chlorinated solvents is not available on the Site, therefore, this technology is not likely to achieve a temporary or permanent solution. The individuals with the expertise needed to effectively implement available solutions would be available.

Main Office: 36 Cordage Park Circle • Suite 312 • Plymouth, Massachusetts 02360 • (508) 830-3344 • Fax: (508) 830-3360
Cape Cod Office: P.O. Box 681 • Sandwich Massachusetts 02537 • Phone (508) 833-3950
North Shore Office: P.O. Box 517 • North Andover Massachusetts 01845 • Phone (978) 557-5888
WWW.LIGHTSHIPENGINEERING.COM

4.1.4 Air Sparging (*in-situ*)

Air Sparging ("AS") is an *in-situ* remediation technology that utilizes the injection of clean air into an OHM-impacted aquifer to remediate dissolved phase VOCs in groundwater. Injected air traverses horizontally and vertically in channels through the saturated soil column, creating an *in-situ* air stripper that removes contaminants by volatilization. The injected air promotes the flushing of contaminants up into the unsaturated zone where a soil vapor extraction ("SVE") system is typically implemented in conjunction with AS to remove the generated vapor phase contamination. This technology is designed to operate at high flow rates to maintain increased contact between groundwater and soil and strip more groundwater by sparging. Oxygen added to impacted groundwater and vadose zone soils can also enhance biodegradation of contaminants below and above the water table.

This technology is likely to achieve a temporary or permanent solution and the individuals with the expertise needed to effectively implement available solutions would be available.

4.1.5 BioSlurping (*in-situ*)

Bioslurping combines the two remedial approaches of bioventing and vacuum-enhanced free-product recovery. Bioventing stimulates the aerobic bioremediation of hydrocarbon-impacted soils. Vacuum-enhanced free product recovery extracts light non-aqueous phase liquid ("LNAPLs") from the capillary fringe and the water table.

This technology is not likely to achieve a temporary or permanent solution in a timely and cost effective manner and LNAPL has not been identified at the Site. The individuals with the expertise needed to effectively implement available solutions would be available.

4.1.6 Chemical Oxidation (*in-situ*)

Chemical oxidation converts hazardous compounds to non-hazardous or less toxic compounds that are more stable, less mobile, and/or inert. The oxidizing agents most commonly used are ozone, hydrogen peroxide, hypochlorites, chlorine, and chlorine dioxide. Field applications have affirmed that matching the oxidant and *in-situ* delivery system to the COC and the site conditions is the key to successful implementation and achieving performance goals.

Main Office: 36 Cordage Park Circle • Suite 312 • Plymouth, Massachusetts 02360 • (508) 830-3344 • Fax: (508) 830-3360
Cape Cod Office: P.O. Box 681 • Sandwich Massachusetts 02537 • Phone (508) 833-3950
North Shore Office: P.O. Box 517 • North Andover Massachusetts 01845 • Phone (978) 557-5888
WWW.LIGHTSHIPENGINEERING.COM

This technology is likely to achieve a temporary or permanent solution but risks associated with handling large volumes of strong oxidizing chemicals, exothermic/explosive reactions and production of harmful by-products make this technology not desirable at the disposal site. The individuals with the expertise needed to effectively implement available solutions would be available.

4.1.7 Dual-Phase Extraction *(in-situ)*

Dual-phase extraction ("DPE"), also known as multi-phase extraction or vacuum-enhanced extraction uses a high-vacuum system to recover impacted groundwater, separate-phase petroleum product, and hydrocarbon vapor from the subsurface. Extracted liquids and vapor are treated and collected for disposal, or re-injected to the subsurface. In DPE systems for liquid/vapor treatment, a high vacuum system is utilized to remove liquid and gas from low permeability or heterogeneous formations. The vacuum extraction well includes a screened section in the zone of impacted soils and groundwater. It removes contaminants from above and below the water table. The system lowers the water table around the well, exposing more of the formation. Contaminants in the newly exposed vadose zone are then accessible to vapor extraction. Once above ground, the extracted vapors or liquid-phase organics and groundwater are separated and treated.

This technology is not likely to achieve a temporary or permanent solution in a timely and cost effective manner. The individuals with the expertise needed to effectively implement available solutions would be available.

4.1.8 Thermal Treatment *(in-situ)*

In this *in-situ* technology, steam is forced into an aquifer through injection wells to vaporize VOCs and semi-volatile organic compounds ("SVOCs"). Vaporized components rise to the unsaturated zone where they are typically removed by vacuum extraction and then treated *ex-situ*. Hot water or steam-based techniques for treatment of VOCs included Steam Injection and Vacuum Extraction ("SIVE"), *In-situ* Steam-Enhanced Extraction ("ISEE"), and Steam-Enhanced Recovery Process ("SERP").

This technology is likely to achieve a temporary or permanent solution and the individuals with the expertise needed to effectively implement available solutions would be available.

Main Office: 36 Cordage Park Circle • Suite 312 • Plymouth, Massachusetts 02360 • (508) 830-3344 • Fax: (508) 830-3360
Cape Cod Office: P.O. Box 681 • Sandwich Massachusetts 02537 • Phone (508) 833-3950
North Shore Office: P.O. Box 517 • North Andover Massachusetts 01845 • Phone (978) 557-5888
WWW.LIGHTSHIPENGINEERING.COM

4.1.9 Hydrofracturing *(in-situ)*

Hydrofracturing is an enhancement technology that utilizes pressurized water that is injected into the subsurface to increase the permeability of consolidated material or relatively impermeable unconsolidated material. Fissures created in the process are filled with a porous medium that can facilitate bioremediation and/or improve extraction efficiency. Fractures promote more uniform delivery of treatment fluids and accelerated extraction of mobilized contaminants. Typical applications are linked with soil vapor extraction ("SVE"), *in-situ* bioremediation, and pump-and-treat systems. The fracturing process begins with the injection of water into a sealed borehole until the pressure of the water exceeds the overburden pressure and a fracture is created. Slurry composed of a coarse-grained sand and guar gum gel or a similar substitute is then injected as the fracture grows away from the well. After pumping, the sand grains hold the fracture open while an enzyme additive breaks down the viscous fluid. The thinned fluid is pumped from the fracture, forming a permeable subsurface channel suitable for delivery or recovery of a vapor or liquid.

The hydraulic fracturing process can be used in conjunction with SVE technology to enhance OHM recovery. Hydraulically-induced fractures are used to deliver fluids, substrates and nutrients for *in-situ* bioremediation applications.

Based on the soil boring logs, the soils at the Site are moderately permeable; therefore hydrofracturing would not be applicable and this technology is not likely to achieve a temporary or permanent solution in a timely manner. The individuals with the expertise needed to effectively implement available solutions would be available.

4.1.10 In-Well Air Stripping *(in-situ)*

In-well air stripping is an *in-situ* remediation technology that utilizes pressurized air to lift groundwater within a vertical well that is screened at multiple depths. The lower screen of the well is set in the groundwater and the upper screen is set in the unsaturated zone. Pressurized air is injected into the well below the water table, aerating the water. The aerated water rises in the well and flows out of the system at the upper screen. Impacted groundwater is drawn into the system at the lower screen. VOCs within the groundwater in the well are volatized and drawn off by a vapor recovery system. The partially treated groundwater is not pumped to the surface; it is re-circulated into the unsaturated zone, and the process is repeated as water follows a hydraulic circulation pattern or cell that allows continuous cycling of groundwater. As groundwater circulates through the treatment system *in-situ*, contaminant concentrations are gradually reduced.

Main Office: 36 Cordage Park Circle • Suite 312 • Plymouth, Massachusetts 02360 • (508) 830-3344 • Fax: (508) 830-3360
Cape Cod Office: P.O. Box 681 • Sandwich Massachusetts 02537 • Phone (508) 833-3950
North Shore Office: P.O. Box 517 • North Andover Massachusetts 01845 • Phone (978) 557-5888
WWW.LIGHTSHIPENGINEERING.COM

This technology is not likely to achieve a temporary or permanent solution in a cost effective manner. The individuals with the expertise needed to effectively implement available solutions would be available.

4.1.11 Permeable Reactive Barrier *(in-situ)*

A permeable reactive barrier ("PRB") can be installed across the flow path of a contaminant plume, allowing the water portion of the plume to passively move through the wall. These barriers allow the passage of water while prohibiting the movement of contaminants by employing such agents as zero-valent metals, chelators (ligands selected for their specificity for a given metal), sorbents, microbes, and others. The contaminants will either be degraded or retained in a concentrated form by the barrier material. The wall could provide permanent containment for relatively benign residues or provide a decreased volume of the more toxic contaminants for subsequent treatment.

An iron treatment wall consists of iron granules or other iron bearing minerals for the treatment of chlorinated contaminants such as TCE, DCE, and Vinyl Chloride. As the iron is oxidized, a chlorine atom is removed from the compound by one or more reductive de-chlorination mechanisms, using electrons supplied by the oxidation of iron. The iron granules are dissolved by the process, but the metal disappears so slowly that the remediation barriers can be expected to remain effective for many years, possibly even decades. Passive treatment walls are generally intended for long-term operation to control migration of contaminants in groundwater.

This technology is not likely to achieve a temporary or permanent solution in a timely manner. The individuals with the expertise needed to effectively implement available solutions would be available.

4.1.12 Groundwater Extraction *(in-situ)*/Groundwater Pump and Treat *(ex-situ)*

Groundwater extraction/groundwater pump and treat include the removal of dissolved contaminants from the subsurface, and containment of impacted groundwater to prevent migration. Groundwater pumping remediates impacted saturated soil and groundwater through the mass removal of contaminant via the dissolved phase. Impacted saturated soils release contaminants bound to the soil particles via the concentration gradient created by the contact of lower concentration groundwater past higher concentration soils. Inherently this process is

Main Office: 36 Cordage Park Circle • Suite 312 • Plymouth, Massachusetts 02360 • (508) 830-3344 • Fax: (508) 830-3360
Cape Cod Office: P.O. Box 681 • Sandwich Massachusetts 02537 • Phone (508) 833-3950
North Shore Office: P.O. Box 517 • North Andover Massachusetts 01845 • Phone (978) 557-5888
WWW.LIGHTSHIPENGINEERING.COM

limiting due to the reverse effect as "clean" groundwater migrates into the impacted area and is impacted by saturated soils, thereby, reducing the concentration gradient between the impacted saturated soils and the migrating groundwater, which decreases the transfer reaction from soil to groundwater within the impacted area. Empirical data indicates that "groundwater pumping" systems have required extended time periods to meet remedial goals.

This technology is not likely to achieve a temporary or permanent solution in a timely manner. The individuals with the expertise needed to effectively implement available solutions would be available.

4.1.13 Bio-Reactors (*ex-situ*, assumes groundwater recovery)

Bioreactors are an *ex-situ* groundwater treatment technology used in conjunction with *in-situ* groundwater recovery technologies. Bioreactors degrade contaminants in recovered groundwater with microorganisms through attached or suspended biological systems. In suspended growth systems, such as activated sludge, fluidized beds, or sequencing batch reactors, impacted groundwater is circulated in an aeration basin where a microbial population aerobically degrades organic matter and produces CO_2, H_2O, and new cells. The cells form a sludge, which is settled out in a clarifier, and is either recycled to the aeration basin or disposed. In attached growth systems, such as up flow fixed film bioreactors, rotating biological contactors ("RBCs"), and trickling filters, microorganisms are established on an inert support matrix to aerobically degrade water contaminants.

Bioreactors are used primarily to treat SVOCs, petroleum hydrocarbons, and any biodegradable organic material. The process may be less effective for some pesticides. Successful pilot-scale field studies have been conducted on some halongenated compounds, such as chlorobenzene and dichloro-benzene isomers. Bioreactors with cometabolites are used to treat polychlorinated biphenyls ("PCBs"), halogenated VOCs, and SVOCs in extracted groundwater.

Based on the elevated levels of VOCs detected in groundwater, this technology is not-likely to achieve a temporary or permanent solution. The individuals with the expertise needed to effectively implement available solutions would be available.

4.1.14 Constructed Wetlands (*ex-situ*, assumes groundwater recovery)

The constructed wetlands-based treatment technology uses natural geochemical and biological processes inherent in an artificial wetland ecosystem to accumulate and remove metals, explosives, and other contaminants from influent waters. The process can use a filtration

Main Office: 36 Cordage Park Circle • Suite 312 • Plymouth, Massachusetts 02360 • (508) 830-3344 • Fax: (508) 830-3360
Cape Cod Office: P.O. Box 681 • Sandwich Massachusetts 02537 • Phone (508) 833-3950
North Shore Office: P.O. Box 517 • North Andover Massachusetts 01845 • Phone (978) 557-5888
WWW.LIGHTSHIPENGINEERING.COM

or degradation process. Although the technology incorporates principal components of wetland ecosystem; including organic soils, microbial fauna, algae, and vascular plants, microbial activity is responsible for most of the remediation.

Constructed wetlands have most commonly been used in wastewater treatment for controlling organic matter; nutrients, such as nitrogen and phosphorus; and suspended sediments. The wetlands process is also suitable for controlling trace metals, and other toxic materials. Additionally, the treatment has been used to treat acid mine drainage generated by metal or coal mining activities. These wastes typically contain high metals concentrations and are acidic. The process can be adapted to treat neutral and basic tailings solutions.

Based on the COCs, this technology is not likely to achieve a temporary or permanent solution and the individuals with the expertise needed to effectively implement available solutions would be available.

4.1.15 Adsorption/ Absorption (*ex-situ*, assumes groundwater recovery)

Adsorption/absorption are *ex-situ* treatment technologies used in conjunction with groundwater recovery. Adsorption mechanisms are generally categorized as physical adsorption, chemisorption, or electrostatic adsorption. Weak molecular forces, such as Van der Waals forces, provide the driving force for physical adsorption, while a chemical reaction forms a chemical bond between the compound and the surface of the solid in chemisorption. Electrostatic adsorption involves the adsorption of ions through Coulombic forces, and is normally referred to as ion exchange. In liquids, interactions between the solute and the solvents play an important role in establishing the degree of adsorption.

The most common adsorbent is granular activated carbon ("GAC"). Other natural and synthetic adsorbents include: activated alumina, forage sponge, lignin adsorption, sorption clays, and synthetic resins. Synthetic resins are more expensive than GAC, but can be designed to achieve higher degrees of selectivity and adsorption capacity for certain compounds than activated carbon. Resins are typically regenerated using acids, bases, or organic solvents, instead of thermal methods, so they are better suited for thermally unstable compounds such as explosives, and are resistant to deactivation due to the adsorption of dissolved solids. Additionally, resins tend to be more resistant to abrasion than activated carbon, increasing their service life.

This technology is not likely to achieve a temporary or permanent solution in a timely

Main Office: 36 Cordage Park Circle • Suite 312 • Plymouth, Massachusetts 02360 • (508) 830-3344 • Fax: (508) 830-3360
Cape Cod Office: P.O. Box 681 • Sandwich Massachusetts 02537 • Phone (508) 833-3950
North Shore Office: P.O. Box 517 • North Andover Massachusetts 01845 • Phone (978) 557-5888
WWW.LIGHTSHIPENGINEERING.COM

manner when combined with groundwater recovery. The individuals with the expertise needed to effectively implement available solutions would be available.

4.1.16 UV Oxidization (*ex-situ*, assumes groundwater recovery)

Ultra-Violet ("UV") Oxidation is an *ex-situ* treatment technology used in conjunction with groundwater recovery. UV oxidation is a destruction process that oxidizes organic and explosive constituents in wastewater by the addition of strong oxidizers and irradiation with UV light. Oxidation of target contaminants is caused by direct reaction with the oxidizers, UV photolysis, and through the synergistic action of UV light, in combination with ozone and/or hydrogen peroxide ("H_2O_2"). If complete mineralization is achieved, the final products of oxidation are carbon dioxide, water, and salts. The main advantage of UV oxidation is that it is a destruction process, as opposed to air stripping or carbon adsorption, for which contaminants are extracted and concentrated in a separate phase, which require off-site disposal.

Organic contaminants that are reactive with the hydroxyl radicals can potentially be treated via UV oxidation. A wide variety of organic and explosive contaminants are susceptible to destruction by UV/oxidation, including petroleum hydrocarbons; chlorinated hydrocarbons used as industrial solvents and cleaners; and ordinance compounds such as TNT, RDX, and HMX. In many cases, chlorinated hydrocarbons that are resistant to biodegradation may be effectively treated by UV/oxidation. Typically, oxidized organic compounds, such as those with double bonds (e.g., TCE, PCE, and vinyl chloride), as well as aromatic compounds (e.g., toluene, benzene, xylene, and phenol), are rapidly destroyed in UV/oxidation processes.

This technology is not likely to achieve a temporary or permanent solution in a timely manner when combined with groundwater recovery. The individuals with the expertise needed to effectively implement available solutions would be available.

4.1.17 Air Stripping (*ex-situ*, assumes groundwater recovery)

Air stripping is a full-scale technology in which VOCs are partitioned from groundwater by increasing the surface area of the impacted water exposed to air. Types of aeration methods include packed towers, diffused aeration, tray aeration, and spray aeration.

Air stripping involves the mass transfer of volatile contaminants from water to air. For groundwater remediation, this process is typically conducted in a packed tower or an aeration tank. The typical packed tower air stripper includes a spray nozzle at the top of the tower to

Main Office: 36 Cordage Park Circle • Suite 312 • Plymouth, Massachusetts 02360 • (508) 830-3344 • Fax: (508) 830-3360
Cape Cod Office: P.O. Box 681 • Sandwich Massachusetts 02537 • Phone (508) 833-3950
North Shore Office: P.O. Box 517 • North Andover Massachusetts 01845 • Phone (978) 557-5888
WWW.LIGHTSHIPENGINEERING.COM

distribute impacted water over the packing in the column, a fan to force air countercurrent to the water flow, and a sump at the bottom of the tower to collect treated water. Auxiliary equipment that can be added to the basic air stripper includes an air heater to improve removal efficiencies; automated control systems with sump level switches and safety features, such as differential pressure monitors, high sump level switches, and explosion-proof components; and air emission control and treatment systems, such as activated carbon units, catalytic oxidizers, or thermal oxidizers. Packed tower air strippers are installed either as permanent installations on concrete pads or on a skid or a trailer.

Air stripping is used to separate VOCs from water. Air stripping is ineffective for inorganic contaminants. Henry's Law constants are used to determine whether air stripping will be effective. Generally, organic compounds with constants greater than 0.01 atmospheres – cubic meters per mole ("m^3/mol") are considered amenable to stripping. Some compounds that have been successfully separated from water using air stripping include benzene, toluene, ethyl-benzene and xylenes ("BTEX"), chloroethane, TCE, DCE, and PCE.

This technology is <u>not likely</u> to achieve a temporary or permanent solution in a timely manner when combined with groundwater recovery. The individuals with the expertise needed to effectively implement available solutions would be available.

4.1.18 <u>Liquid Phase Carbon Adsorption (*ex-situ*, assumes groundwater recovery)</u>

Liquid phase carbon adsorption is a full-scale technology in which groundwater is pumped through one or more vessels containing activated carbon to which dissolved organic contaminants adsorb. When the concentration of contaminants in the effluent from the liquid phase carbon exceeds a certain level, the carbon can be regenerated in place; removed and regenerated at an off-site facility; or removed and disposed.

The target contaminant groups for carbon adsorption are hydrocarbons, SVOCs and explosives. Limited effectiveness may be achieved on halogenated VOCs and pesticides. Liquid phase carbon adsorption is effective for removing contaminants at low concentrations (less than 10 milligrams per liter "mg/L") from water at nearly any flow rate, and for removing higher concentrations of contaminants from water at low flow rates (typically 2 to 4 liters per minute or 0.5 to 1 gallons per minute ("gpm"). Carbon adsorption is particularly effective for polishing water discharges from other remedial technologies to attain regulatory compliance. Carbon adsorption systems can be deployed rapidly, and contaminant removal efficiencies are high. Logistic and economic disadvantages arise from the need to transport and decontaminate spent carbon.

Main Office: 36 Cordage Park Circle • Suite 312 • Plymouth, Massachusetts 02360 • (508) 830-3344 • Fax: (508) 830-3360
Cape Cod Office: P.O. Box 681• Sandwich Massachusetts 02537 • Phone (508) 833-3950
North Shore Office: P.O. Box 517 • North Andover Massachusetts 01845 • Phone (978) 557-5888
WWW.LIGHTSHIPENGINEERING.COM

Based on the elevated concentrations of VOCs in groundwater at the Site this technology is not likely to achieve a temporary or permanent solution in a timely and cost effective manner. The individuals with the expertise needed to effectively implement available solutions would be available.

4.1.19 Separation (*ex-situ*, assumes groundwater recovery)

The separation processes seek to detach contaminants from their medium (*i.e.*, groundwater and/or binding material). *Ex-situ* separation of waste stream can be performed by many processes: (1) distillation, (2) filtration/ultrafiltration/microfiltration, (3) freeze crystallization, (4) membrane pervaporation and (5) reverse osmosis. The *ex-situ* separation process is used mainly as a pretreatment or post-treatment process to remove contaminants from wastewater. *Ex-situ* separation can be applied to aqueous waste streams such as groundwater, lagoons, leachate, and rinse water. Industrial waste streams may also be treated with these processes. The target contaminant groups for *ex-situ* separation processes are VOCs, SVOCs, pesticides, and suspended particles. Solvents may be recovered for reuse.

Based on the elevated concentrations of VOCs in the groundwater this technology is not likely to achieve a temporary or permanent solution in a timely and cost effective manner. The individuals with the expertise needed to effectively implement available solutions would be available.

4.1.20 Sprinkler Irrigation (*ex-situ*, assumes groundwater recovery)

Sprinkler irrigation is a technology utilized to volatilize VOCs from impacted wastewater. The process involves the pressurized distribution of VOC-laden water through a standard sprinkler irrigation system. Sprinkler irrigation transfers VOCs from the dissolved aqueous phase to the vapor phase, whereby the VOCs are released directly to the atmosphere.

Due to the limited space available at the Site, irrigation by sprinklers is not feasible. In addition, the elevated concentrations of VOCs would most likely result in the exceedence of off-gas emission standards if volatized to the atmosphere. Therefore, this technology is not likely to achieve a temporary or permanent solution and the individuals with the expertise needed to effectively implement available solutions would be available.

Main Office: 36 Cordage Park Circle • Suite 312 • Plymouth, Massachusetts 02360 • (508) 830-3344 • Fax: (508) 830-3360
Cape Cod Office: P.O. Box 681 • Sandwich Massachusetts 02537 • Phone (508) 833-3950
North Shore Office: P.O. Box 517 • North Andover Massachusetts 01845 • Phone (978) 557-5888
WWW.LIGHTSHIPENGINEERING.COM

4.1.21 Physical Barriers

Physical barriers (or slurry walls) are used to contain impacted groundwater, divert impacted groundwater from the drinking water intake, divert un-impacted groundwater flow, and/or provide a barrier for the groundwater treatment system.

These subsurface barriers consist of a vertically excavated trench that is filled with slurry. The slurry hydraulically shores the trench to prevent collapse and forms a filter cake to reduce groundwater flow. Slurry walls often are used where the waste mass is too large for treatment and where soluble and mobile constituents pose an imminent threat to a source of drinking water.

Based on the physical limitations of the source of OHM being located beneath an active TSDF facility and the interruption of on-Site operations associated with the installation, this remedial approach would not be feasible. Therefore, this technology is not likely to achieve a temporary or permanent solution. The individuals with the expertise needed to effectively implement available solutions would be available.

4.1.22 Deep Well Injection

Deep well injection is a liquid waste disposal technology. This alternative uses injection wells to place treated or untreated liquid waste into geologic formations that have no potential to allow migration of contaminants into potential potable water aquifers. A typical injection well consists of concentric pipes, which extend several thousand feet down from the surface level into highly saline, permeable injection zones that are confined vertically by impermeable strata.

The target contaminant groups for deep well injection are VOCs, SVOCs, fuels, explosives, and pesticides. However, existing permitted deep well injection facilities are limited to a narrow range of specific wastes. Success at expanding existing permits to manage hazardous wastes seems unlikely.

Based on the unlikely success in acquiring a permit for a deep injection well, this technology is not likely to achieve a temporary or permanent solution and the individuals with the expertise needed to effectively implement available solutions would be available.

Main Office: 36 Cordage Park Circle • Suite 312 • Plymouth, Massachusetts 02360 • (508) 830-3344 • Fax: (508) 830-3360
Cape Cod Office: P.O. Box 681 • Sandwich Massachusetts 02537 • Phone (508) 833-3950
North Shore Office: P.O. Box 517 • North Andover Massachusetts 01845 • Phone (978) 557-5888
WWW.LIGHTSHIPENGINEERING.COM

4.1.23 BioFiltration (off-gas treatment)

Biofiltration is a low-cost air pollution control technology in which vapor-phase organic contaminants are passed through a bed of porous media that sorb to the media surface where they are degraded by microorganisms in the media. Specific strains of bacteria may be introduced into the filter and optimal conditions provided to preferentially degrade specific compounds. The biofilter provides several advantages over conventional activated carbon adsorbers. First, bio-regeneration maintains the maximum adsorption capacity available, therefore, the mass transfer zone remains stationary and relatively short. The filter does not require regeneration, and the required bed length is greatly reduced. These features reduce capital and operating expenses. Additionally, contaminants are destroyed not separated, as with GAC technologies.

As with other biological treatment processes, biofiltration is highly dependent upon the biodegradability of the contaminant. Under proper conditions, biofilters can remove virtually all selected contaminants to harmless products. Biofiltration is used primarily to treat non-halogenated VOCs and petroleum hydrocarbons.

Based on the COCs, this technology is not likely to achieve a temporary or permanent solution. The individuals with the expertise needed to effectively implement available solutions would be available.

4.1.24 High Energy Destruction (*off-gas treatment*)

The high-energy destruction technology is one of many approaches toward decontaminating of air emissions off-gases prior to atmospheric release. The objective of the HEC technology is to provide a standalone, field-portable means of treating off-gases produced during other remedial operations. The High Energy Corona ("HEC") process uses high-voltage electricity to destroy VOCs at room temperature. The equipment consists of an HEC reactor in where VOCs are destroyed.

This technology is currently in the pilot stage, therefore, this technology is not likely to achieve a temporary or permanent solution and the individuals with the expertise needed to effectively implement available solutions may not be available.

4.1.25 Separation (off-gas treatment)

This organic vapor/air separation technology involves the preferential transport of organic

Main Office: 36 Cordage Park Circle • Suite 312 • Plymouth, Massachusetts 02360 • (508) 830-3344 • Fax: (508) 830-3360
Cape Cod Office: P.O. Box 681 • Sandwich Massachusetts 02537 • Phone (508) 833-3950
North Shore Office: P.O. Box 517 • North Andover Massachusetts 01845 • Phone (978) 557-5888
WWW.LIGHTSHIPENGINEERING.COM

vapors through a nonporous gas separation membrane. A high-pressure membrane separation system has been designed by the Department of Energy ("DOE") to treat feed-streams that contain dilute concentrations of VOCs. The organic vapor/air separation technology involves the preferential transport of organic vapors through a nonporous gas separation membrane (a diffusion process analogous to pumping saline water through a reverse osmosis membrane). This technology is currently in the pilot stage and is tailored for low-level concentrations.

Based on the elevated levels of VOCs in groundwater at the Site this technology is not likely to achieve a temporary or permanent solution. Based on the "pilot status" the individuals with the expertise needed to effectively implement available solutions may not be available.

4.1.26 Thermal/Catalytic Oxidation (*off-gas treatment*)

Oxidation equipment (thermal or catalytic) is used for destroying contaminants in the exhaust gas from vapor recovery systems. Thermal oxidation units are typically single chamber, refractory-lined oxidizers equipped with a propane or natural gas burner and a stack. Lightweight ceramic blanket refractory is used because many of these units are mounted on skids or trailers. If gasoline is the contaminant, heat exchanger efficiencies are limited to 25 to 35%, and preheat temperatures are maintained below 180 °C (530 °F) to minimize the possibility of ignition occurring in the heat exchanger. Flame arrestors are always installed between the vapor source and the thermal oxidizer. Burner capacities in the combustion chamber range from 0.5 to 2 million Btus per hour. Operating temperatures range from 760 to 870 °C (1,400 °C to 1,600 °F), and gas residence times are typically 1 second or less.

Catalytic oxidation is a relatively recently applied alternative for the treatment of VOCs in air streams resulting from remedial operations. The addition of a catalyst accelerates the rate of oxidation by adsorbing the oxygen and the contaminant on the catalyst surface where they react to form carbon dioxide, water, and hydrochloric gas. The catalyst enables the oxidation reaction to occur at much lower temperatures than required by a conventional thermal oxidation. VOCs are thermally destroyed at temperatures typically ranging from 320° to 540° C (600° to 1,000° F) by using a solid catalyst. First, the impacted air is directly preheated (electrically or, more frequently, using natural gas or propane) to reach a temperature necessary to initiate the catalytic oxidation [310 °C to 370 °C (600 °C to 700 °F)] of the VOCs. Then the preheated VOC-laden air is passed through a bed of solid catalysts where the VOCs are rapidly oxidized. Thermal oxidizers can often be converted to catalytic units after initially high influent contaminant concentrations decrease to less than 1,000 to 5,000 ppmv.

Main Office: 36 Cordage Park Circle • Suite 312 • Plymouth, Massachusetts 02360 • (508) 830-3344 • Fax: (508) 830-3360
Cape Cod Office: P.O. Box 681 • Sandwich Massachusetts 02537 • Phone (508) 833-3950
North Shore Office: P.O. Box 517 • North Andover Massachusetts 01845 • Phone (978) 557-5888
WWW.LIGHTSHIPENGINEERING.COM

This technology is likely to achieve a temporary or permanent solution and the individuals with the expertise needed to effectively implement available solutions would be available.

4.1.27 Vapor-Phase Carbon Absorption (*off-gas treatment*)

Vapor-phase carbon absorption is a remediation technology in which VOCs are removed from air by physical adsorption onto activated carbon grains. Carbon is "activated" for this purpose by processing the carbon to create porous particles with a large internal surface area (300 to 2,500 square meters or 3,200 to 27,000 square feet per gram of carbon) that attracts and adsorbs organic molecules as well as certain metal and inorganic molecules.

Commercial grades of activated carbon are available for specific use in vapor-phase applications. The granular form of activated carbon is typically used in packed beds through which the impacted air flows until the concentration of contaminants in the effluent from the carbon bed exceeds an acceptable level. GAC systems typically consist of one or more vessels filled with carbon connected in series and/or parallel operating under atmospheric, negative, or positive pressure. The carbon can then be regenerated in place, regenerated at an off-Site regeneration facility, or disposed of, depending upon economic considerations.

Based on the elevated concentrations of VOCs in groundwater at the Site this technology is not likely to achieve a temporary or permanent solution in a timely and cost effective manner. The individuals with the expertise needed to effectively implement available solutions would be available.

4.2 RESULTS OF INITIAL SCREENING

Three of the 27 remedial technologies initially screened technologies are likely to achieve a permanent or temporary solution in a timely manner. The individuals with the expertise needed to effectively implement available solutions would be available as set forth below.

In-situ

- Air Sparging with SVE and Thermal/Catalytic Oxidation
- Chemical Oxidation
- Thermal Treatment with SVE and Thermal/Catalytic Oxidation

Main Office: 36 Cordage Park Circle • Suite 312 • Plymouth, Massachusetts 02360 • (508) 830-3344 • Fax: (508) 830-3360
Cape Cod Office: P.O. Box 681 • Sandwich Massachusetts 02537 • Phone (508) 833-3950
North Shore Office: P.O. Box 517 • North Andover Massachusetts 01845 • Phone (978) 557-5888
WWW.LIGHTSHIPENGINEERING.COM

5.0 EVALUATION OF REMEDIAL ACTION ALTERNATIVES

Pursuant to 310 CMR 40.0857(2) a detailed evaluation of remedial action alternatives is not required if a remedial alternative identified during the initial screening, set forth above, meets the following criteria:

- the remedial alternative is proven to be effective in remediating the types of OHM present at the disposal site, based upon experience gained at other disposal sites with similar site and contaminant conditions;
- the remedial alternative results in reuse, recycling, destruction, detoxification, treatment or any combination thereof of OHM present at the disposal site;
- the remedial alternative can be implemented in a manner that will not pose a significant risk of harm to health, safety, public welfare or the environment; and
- the remedial alternative is likely to result in the reduction and/or control of OHM at the disposal site to a degree and in a manner that the requirements of a Class A RAO Statement will be met.

As set forth above, the initial screening identified 3 *in-situ* remedial technologies that meet the criteria set forth in 310 CMR 40.0857, therefore, a detailed remedial action evaluation is not required for the disposal site.

5.1 SELECTION OF REMEDIAL ACTION ALTERNATIVE

Pursuant to 310 CMR 40.0859 and 40.0861(2)(b), the selection of a remedial action alternative is set forth below.

5.2 SUMMARY OF THE REMEDIAL ACTION ALTERNATIVE EVALUATION

The estimated costs of the reasonably feasible remediation alternatives is $ 96, 400.00 (chemical oxidation), $ 137,878 (SVE/AS and thermal/catalytic oxidation) to $ 221,048.00 (thermal treatment with SVE and Catalytic oxidation) to remediate OHM-impacted groundwater. Detailed remediation cost analysis tables are set forth in Appendix C. Based on the FRTR matrix, AS had a "better" rating in reliability over thermal treatment and chemical oxidation that were rated as "average."

Main Office: 36 Cordage Park Circle • Suite 312 • Plymouth, Massachusetts 02360 • (508) 830-3344 • Fax: (508) 830-3360
Cape Cod Office: P.O. Box 681 • Sandwich Massachusetts 02537 • Phone (508) 833-3950
North Shore Office: P.O. Box 517 • North Andover Massachusetts 01845 • Phone (978) 557-5888
WWW.LIGHTSHIPENGINEERING.COM

Lightship Engineering has selected AS to remediate the source area OHM-impacted groundwater combined with SVE to recover vapors generated by the AS system which will be treated by thermal/catalytic oxidation. This remedial approach had a "better" reliability rating and lower costs over thermal treatment. Although chemical oxidation had a lower estimated cost, the reliability of this technology was "average" and the risks associated with handling large volumes of strong oxidizers, potential for explosive conditions and production of harmful by-products was severe.

5.3 RECOMMENDED REMEDIAL ACTION ALTERNATIVE

The SVE/AS and thermal/catalytic oxidation remedial system will be utilized to remediate the source of OHM-impacted groundwater. Concentrations of OHM at the other locations should decrease over time as a result of natural attenuation and result in a level of NSR at the Site.

5.4 FEASIBILITY EVALUATION

Pursuant to 310 CMR 40.0860 and 40.0861(2)(d), the feasibility of implementing the recommended remedial action alternative is evaluated below.

5.4.1 Feasibility of Implementing a Permanent Solution

Pursuant to 310 CMR 40.0860(2) and 40.0861(2)(e), an evaluation of the feasibility of implementing a Permanent Solution shall be performed in all cases where the selected Comprehensive Remedial Action alternative is a Temporary Solution and it can not be demonstrated through a detailed evaluation using the criteria described in 310 CMR 40.0858 that the implementation of a Temporary Solution is a more cost-effective and timely remedial alternative than the implementation of a feasible Permanent Solution.

As set forth above, the recommended remedial action alternative will result in a permanent solution. Therefore, an evaluation of the feasibility of implementing a Permanent Solution is not required.

Main Office: 36 Cordage Park Circle • Suite 312 • Plymouth, Massachusetts 02360 • (508) 830-3344 • Fax: (508) 830-3360
Cape Cod Office: P.O. Box 681 • Sandwich Massachusetts 02537 • Phone (508) 833-3950
North Shore Office: P.O. Box 517 • North Andover Massachusetts 01845 • Phone (978) 557-5888
WWW.LIGHTSHIPENGINEERING.COM

5.4.2 Feasibility of Achieving or Approaching Background Conditions

Pursuant to 310 CMR 40.0860(3), an evaluation of the feasibility of reducing the concentrations of OHM to levels that achieve or approach background shall be conducted in all cases where a Permanent Solution is selected as the Comprehensive Remedial Action alternative, unless the Permanent Solution selected is designed to achieve background and a Class A-1 Response Action Outcome pursuant to 310 CMR 40.1000.

As set forth above, the remedial response actions evaluated are technologically feasible for approaching background conditions. The costs of implementing the appropriate remedial response actions in order to achieve background conditions could increase the estimated cost by an order of magnitude. The cost far outweighs the benefits. Therefore, achieving background conditions at the disposal site is likely economically infeasible.

5.4.3 Feasibility of Reducing Concentrations of Oil and/or Hazardous Materials to Levels at or below Upper Concentration Limits

Pursuant to 310 CMR 40.0860(4) and 40.0861(2)(g), an evaluation of the feasibility of reducing the concentrations of OHM in soil at the disposal site to levels at or below the applicable soil Upper Concentration Limits shall be conducted before a Comprehensive Remedial Action alternative is selected as a Permanent Solution which would leave oil and/or hazardous material in soil at concentrations above the soil Upper Concentration Limits at a depth greater than 15 feet below the ground surface or beneath an engineered barrier, as that term is defined in 310 CMR 40.0996.

As set forth above, the recommend remedial action alternative will likely result in reducing concentrations of OHM below UCLs.

5.5 ELIMINATION OF SUBSTANTIAL HAZARDS

Pursuant to 310 CMR 40.0861(2)(f), if a Temporary Solution is selected, a discussion of how the alternative is likely to achieve a level of NSR at the disposal site is set forth below.

As set forth above, the recommended remedial action alternative will likely result in a Permanent Solution. Therefore, a discussion of how the alternative is likely to achieve a level of NSR at the disposal site is not required.

Main Office: 36 Cordage Park Circle • Suite 312 • Plymouth, Massachusetts 02360 • (508) 830-3344 • Fax: (508) 830-3360
Cape Cod Office: P.O. Box 681 • Sandwich Massachusetts 02537 • Phone (508) 833-3950
North Shore Office: P.O. Box 517 • North Andover Massachusetts 01845 • Phone (978) 557-5888
WWW.LIGHTSHIPENGINEERING.COM

5.6 DEFINITIVE AND ENTERPRISING STEPS TOWARD ACHIEVING A PERMANENT SOLUTION

Pursuant to 310 CMR 40.0580 and 40.0861(2)(h), a discussion of definitive and enterprising steps to identify and develop an alternative that is likely to achieve a permanent solution is set forth below.

As set forth above, the recommended remedial action alternative will likely result in a permanent solution. Therefore, a discussion of definitive and enterprising steps to identify and develop an alternative that is likely to achieve a permanent solution is not required.

Main Office: 36 Cordage Park Circle • Suite 312 • Plymouth, Massachusetts 02360 • (508) 830-3344 • Fax: (508) 830-3360
Cape Cod Office: P.O. Box 681• Sandwich Massachusetts 02537 • Phone (508) 833-3950
North Shore Office: P.O. Box 517 • North Andover Massachusetts 01845 • Phone (978) 557-5888
WWW.LIGHTSHIPENGINEERING.COM

6.0 PROJECTED SCHEDULE FOR PHASE IV

Pursuant to 310 CMR 40.0861 (2)(I), the installation and operation of the SVE/AS remediation system are scheduled to be implemented in the Fall of 2002.

Main Office: 36 Cordage Park Circle • Suite 312 • Plymouth, Massachusetts 02360 • (508) 830-3344 • Fax: (508) 830-3360
Cape Cod Office: P.O. Box 681 • Sandwich Massachusetts 02537 • Phone (508) 833-3950
North Shore Office: P.O. Box 517 • North Andover Massachusetts 01845 • Phone (978) 557-5888
WWW.LIGHTSHIPENGINEERING.COM

7.0 LIMITATIONS

1. Lightship Engineering is not responsible for the accuracy of information provided to Lightship Engineering by third-parties. Except as otherwise stated in this report, Lightship Engineering did not attempt to verify the accuracy or completeness of any such information.

2. The data presented in this report and Lightship Engineering's opinions based on such data are provided in accordance with Lightship Engineering's proposal for professional services. The data reported and findings, observations and conclusions expressed in this report are limited by Lightship Engineering's scope of work, including the extent of subsurface exploration and other tests.

3. This report is for the sole use of Jones Environmental Services (Northeast), Inc. Any reuse or reliance on this report by any other third party shall be done only with the written consent of Lightship Engineering.

4. The findings, observations, opinions, conclusions, and recommendations are not intended to and do not imply a warranty or a guarantee and are based solely upon site conditions at the time of Lightship Engineering's investigation. The findings, observations, opinions, conclusions, and recommendations should not be considered an opinion concerning the compliance of any past or present owner or operator of the disposal site with any federal, state or local law or regulation. Nothing in this report constitutes a legal opinion or legal service and should not be relied upon as such.

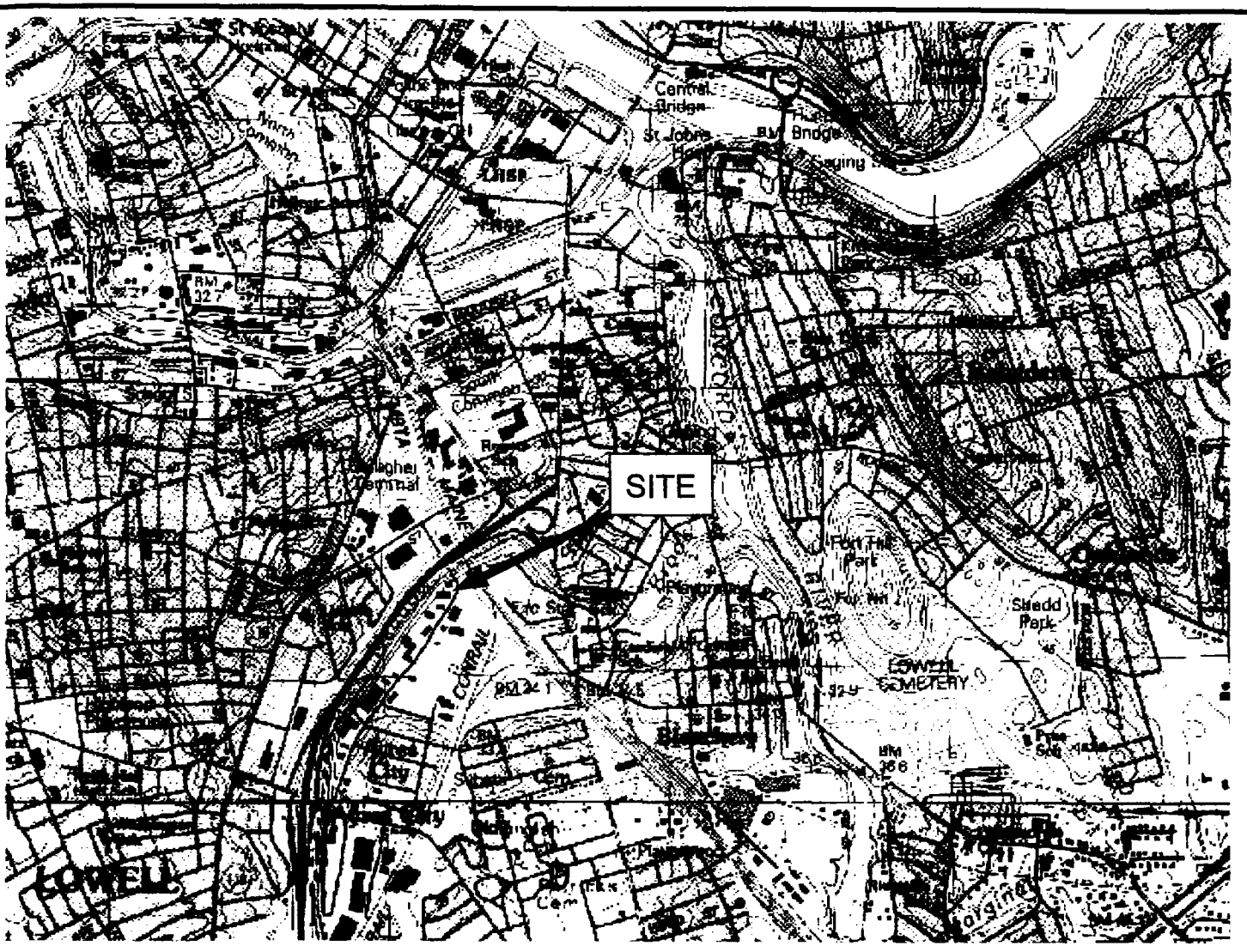
5. Nothing contained in this Phase III report is or shall be deemed an admission by either Jones Environmental Services (Northeast), Inc. as to any liability regarding the disposal site or otherwise.

Main Office: 36 Cordage Park Circle • Suite 312 • Plymouth, Massachusetts 02360 • (508) 830-3344 • Fax: (508) 830-3360
Cape Cod Office: P.O. Box 681 • Sandwich Massachusetts 02537 • Phone (508) 833-3950
North Shore Office: P.O. Box 517 • North Andover Massachusetts 01845 • Phone (978) 557-5888
WWW.LIGHTSHIPENGINEERING.COM

APPENDIX A

FIGURES

Figure 1-1 Site Locus Map
Figure 1-2 Disposal Site Map



N
W E
S

FIGURE 1-1

SITE LOCUS MAP

263 Howard Street, Lowell, Massachusetts

PREPARED FOR

Jones Environmental Services (Northeast), Inc.

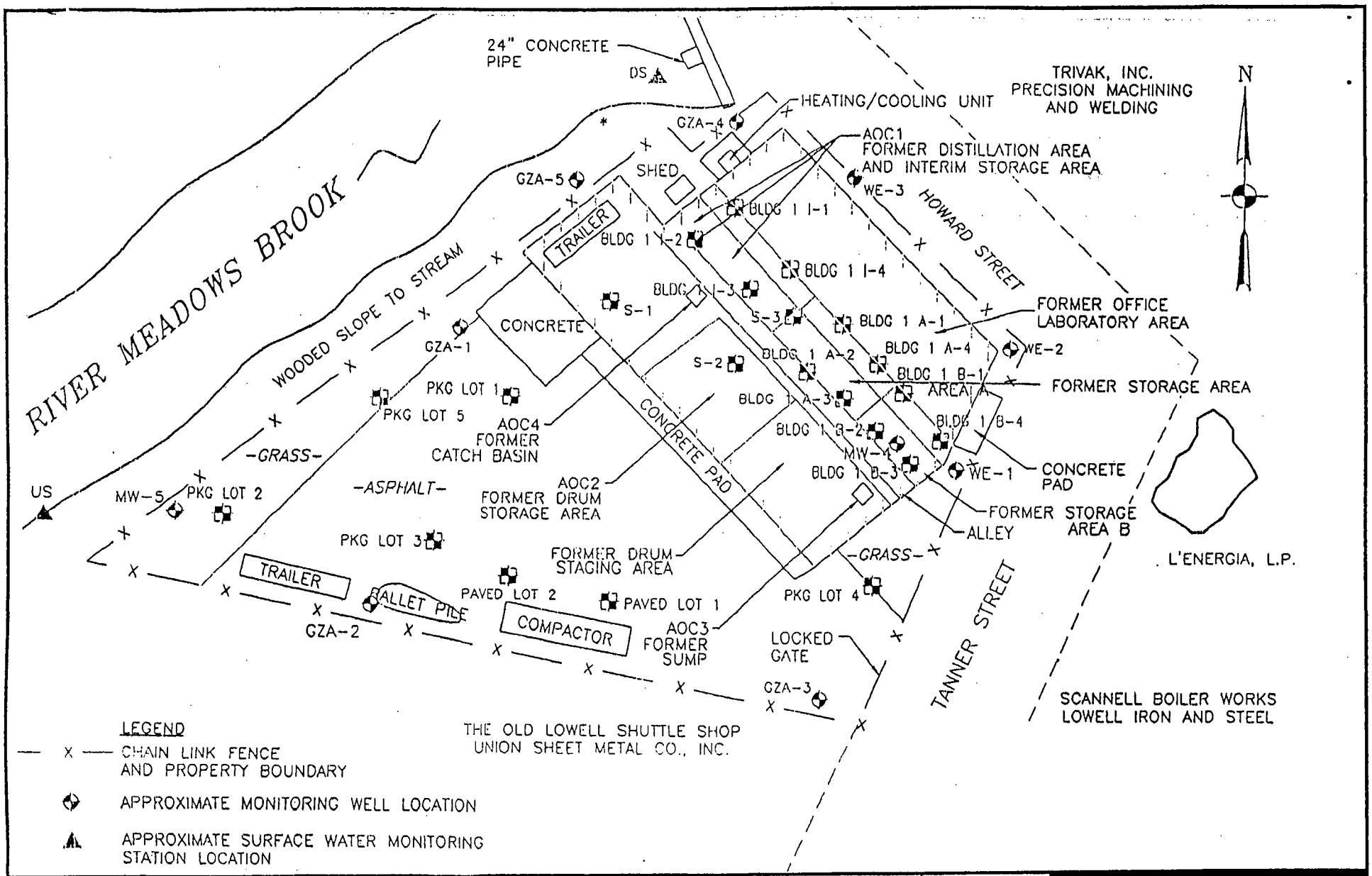
SOURCE:
MASSACHUSETTS U.S. G.S. QUADRANGLE No. 221930.

SCALE:
1" = 1,850 FEET

LIGHTSHIP ENGINEERING

ENVIRONMENTAL & LAND-USE CONSULTANTS

36 CORDAGE PARK CIRCLE, SUITE 312, PLYMOUTH, MA 02360



N
W E
S

FIGURE 1-2

DISPOSAL SITE MAP

263 Howard Street, Lowell, Massachusetts

PREPARED FOR

Jones Environmental Services (Northeast), Inc.

SOURCE:
PHASE II MCP SITE INVESTIGATION, URS CORPORATION 6/22/01

LIGHTSHIP
ENGINEERING

ENVIRONMENTAL & LAND-USE CONSULTANTS
36 CORDAGE PARK CIRCLE, SUITE 312, PLYMOUTH, MA 02360

APPENDIX B

FEDERAL REMEDIATION TECHNOLOGIES ROUNDTABLE SCREENING MATRIX

TABLE 2-2 TREATMENT TECHNOLOGIES SCREENING MATRIX: TREATMENT OF HALOGENATED VOLATILE ORGANIC COMPOUNDS

NOTE: Specific site and contaminant characteristics may limit the applicability and effectiveness of any of the technologies and treatments listed below. This matrix is optimistic in nature and should always be used in conjunction with the referenced text sections, which contain additional information that can be useful in identifying potentially applicable technologies.

*The following rankings are discussed on Table 3-1 and Figure 3-1.

	Technology (Section & Title)	Development Status	Use Rating	Applicability*	Reliability*	Cleanup Time*	Technology Function*
SOIL, SEDIMENT, BEDROCK AND SLUDGE section of this table now begins:							
3.1 IN SITU BIOLOGICAL TREATMENT technologies now listed:							
	Bioventing	Full	Limited	Refer to profile	Refer to profile	Refer to profile	Destruct
	Enhanced Bioremediation	Full	Limited	Better	Refer to profile	Refer to profile	Destruct
	Phytoremediation	Full	Limited	Average	Average	Worse	Destruct
3.2 IN SITU PHYSICAL/CHEMICAL TREATMENT technologies now listed:							
	Chemical Oxidation	Full	Limited	Refer to Profile	Average	Better	Destruct
	Electrokinetic Separation	Full	Limited	Average	Average	Average	Destruct
	Fracturing	Full	Limited	Refer to profile	Refer to profile	Refer to profile	Extract
	Soil Flushing	Full	Limited	Better	Average	Average	Extract
	Soil Vapor Extraction	Full	Wide[b]	Better	Better	Average	Extract
	Solidication/ Stabilization	Full	Limited	Better	Better	Better	Extract/ Destruct
3.3 IN SITU THERMAL TREATMENT technologies now listed:							
	Thermal Treatment	Full	Limited	Better	Better	Better	Extract
3.4 EX SITU BIOLOGICAL TREATMENT (ASSUMING EXCAVATION) technologies now listed:							
	Biopiles	Full	Limited	Better	Better	Average	Destruct
	Composting	Full	Limited	Average	Better	Average	Destruct
	Landfarming	Full	Limited	Average	Better	Average	Destruct
	Slurry Phase Bio. Treatment	Full	Limited	Better	Average	Average	Destruct
3.5 EX SITU PHYSICAL/CHEMICAL TREATMENT (ASSUMING EXCAVATION) technologies now listed:							
	Chemical Extraction	Full	Limited	Average	Average	Average	Extract/ Destruct
	Chemical Reduction/ Oxidation	Full	Limited	Average	Better	Better	Destruct
	Dehalogenation	Full	Limited	Better	NA	NA	Destruct
	Separation	Full	Limited	Average	Better	Better	Extract

	Soil Washing	Full	Limited	Average	Better	Better	Extract
	Solidification/ Stabilization	Full	Limited	Average	Better	Better	Immob.
3.6 EX SITU THERMAL TREATMENT (ASSUMING EXCAVATION) technologies now listed:							
	Hot Gas Decontamination	Full	Limited	Worse	Better	Better	Destruct
	Incineration	Full	Wide[b]	Better	Average	Better	Destruct
	OB/OD	Full	Limited	Worse	Better	Better	Destruct
	Pyrolysis	Full	Limited	Average	Worse	Better	Destruct
	Thermal Desorption (High & Low)	Full	Wide[b]	Better	Average	Better	Extract
3.7 CONTAINMENT							
	Landfill Cap	Full	Refer to Profile	Refer to Profile	Refer to Profile	Refer to Profile	Refer to Profile
	Landfill Cap Enhancemnents	Full	Refer to Profile	Refer to Profile	Refer to Profile	Refer to Profile	Refer to Profile
3.8 OTHER TREATMENT technologies now listed:							
	Excavation and Off-Site Disp.	NA	Limited	Average	Better	Better	Extract/ Immob.
GROUND WATER, SURFACE WATER AND LEACHATE section of this table now begins:							
3.9 IN SITU BIOLOGICAL TREATMENT technologies now listed:							
	Enhanced Biodegradation	Full	Limited	Refer to profile	Refer to profile	Refer to profile	Destruct
	Natural Attenuation	Full	Limited	Refer to profile	Refer to profile	Refer to profile	Destruct
	Phytoremediation	Full	Limited	Average	Average	Worse	Extract/ Destruct
3.10 IN SITU PHYSICAL/CHEMICAL TREATMENT technologies now listed:							
	Air Sparging	Full	Limited	Average	Better	Better	Extract
	Bioslurping	Full	Limited	Average	Average	Average	Destruct
	Chemical Oxidation	Full	Limited	Average	Average	Better	Destruct
	Directional Wells (enhancement)	Full	Limited	Refer to Profile	Refer to Profile	Refer to Profile	Extract/Destruct
	Dual Phase Extraction	Full	Limited	Better	Average	Average	Extract
	Thermal Treatment	Full	Limited	Better	Average	Better	Extract
	Hydrofracturing Enhancements	Full	Limited	Refer to Profile	Refer to Profile	Refer to Profile	Refer to Profile

	In Well Air Stripping	Full	Limited	Average	Average	Worse	Extract
	Passive Treatment Walls	Full	Limited	Better	NA	Worse	Destruct
3.11 EX SITU BIOLOGICAL TREATMENT (ASSUMING PUMPING) technologies now listed:							
	Bioreactors	Full	Limited	Better	Average	Average	Destruct
	Constructed Wetlands	Full	Limited	Average	NA	NA	Immob. /Destruct
3.12 EX SITU PHYSICAL/CHEMICAL TREATMENT (ASSUMING PUMPING) technologies now listed:							
	Adsorption/Absorption	Full	Limited	Average	Average	Worse	Extract
	Advanced Oxidation Processes	Full	Limited	Better	Average	Worse	Destruct
	Air Stripping	Full	Wide	Better	Better	Worse	Extract
	Granulated Activated Carbon (GAC)/Liquid Phase Carbon Adsorption	Full	Wide	Better	Better	Worse	Extract
	Ground Water Pumping	Full	Limited	Average	Better	Worse	Extract
	Ion Exchange	Full	Limited	Worse	Better	Worse	Extract
	Prec./Coag./Flocc.	Full	Limited	Worse	Better	Worse	Extract
	Separation	Full	Limited	Better	Better	Better	Extract
	Sprinkler Irrigation	Full	Limited	Better	Better	Worse	Extract
3.13 CONTAINMENT technologies now listed:							
	Physical Barriers	Full	Limited	Better	Better	Worse	Immob.
	Deep Well Injection	Full	Wide	Average	Average	NA	Immob.
AIR EMISSIONS/OFF-GAS section of this table now begins:							
3.14 AIR EMISSIONS/OFF-GAS technologies now listed:							
	Biofilitration	Full	Limited	Refer to profile	Refer to profile	Better	Extract/ Destruct
	High Energy Destruction	Pilot	Limited	Better	Worse	NA	Destruct
	Membrane Seperation	Pilot	Limited	Better	Worse	NA	Extract
	Oxidation	Full	Wide	Better	Better	NA	Destruct
	Scrubbers						
	Vapor Phase Carbon Adsorp.	Full	Wide	Better	Better	NA	Extract

[b]Presumptive remedy.

NA = Not Available.

APPENDIX C

DETAILED REMEDIATION COST ANALYSIS TABLES

Detailed Remediation Cost Analysis
Air Sparging combined with Soil Vapor Extraction

Task Description	Quantity	Unit	Unit Cost	Total Cost	Subtotal
DESIGN COSTS					**$5,000.00**
INSTALLATION COSTS					**$32,950.00**
Air Sparging Well Installation	3	ea.	$1,500.00	$4,500.00	
SVE Well Installation	5	ea.	$1,000.00	$5,000.00	
Air Sparging Piping Installation	250	l.f.	$18.00	$4,500.00	
SVE Piping Installation	150	l.f.	$18.00	$2,700.00	
AS Wellhead Installation	3	ea.	$250.00	$750.00	
SVE Wellhead Installation	5	ea.	$200.00	$1,000.00	
Air Sparging Pressure Blower	1	ea.	$4,000.00	$4,000.00	
SVE Vacuum Blower	1	ea.	$3,000.00	$3,000.00	
Control Panel	1	ea.	$5,000.00	$5,000.00	
Equipment Building	1	ea.	$2,500.00	$2,500.00	
OPERATION COSTS (18 Months)					**$25,380.00**
Oversight and Management	18	months	$500.00	$9,000.00	
Monitoring Equipment	18	months	$160.00	$2,880.00	
Power Costs (10 h.p @ $75/h.p)	18	months	$750.00	$13,500.00	
REGULATORY COSTS					**$7,200.00**
Reporting	18	months	$250.00	$4,500.00	
DEP Fees	2	annual	$1,350.00	$2,700.00	
					$70,530.00

Detailed Remediation Cost Analysis
Chemical Oxidation

Task Description	Quantity	Unit	Unit Cost	Total Cost	Subtotal
DESIGN COSTS					**$5,000.00**
INSTALLATION COSTS					**$27,500.00**
Injection Well Installation	10	ea.	$2,500.00	$25,000.00	
Injection Wellhead Installation	10	ea.	$250.00	$2,500.00	
OPERATION COSTS (2 YEARS)					**$52,800.00**
Oversight and Management	24	months	$500.00	$12,000.00	
Applications	8	l.s.	$2,500.00	$20,000.00	
Injection Equipment	8	l.s.	$1,000.00	$8,000.00	
Personel Protective Equipment	8	l.s.	$500.00	$4,000.00	
Oxidant Costs (8 injections @ 550 gallons)	4400	gals	$2.00	$8,800.00	
REGULATORY COSTS					**$11,100.00**
Reporting	24	months	$350.00	$8,400.00	
DEP Fees	2	annual	$1,350.00	$2,700.00	
					$96,400.00

Detailed Remediation Cost Analysis
Thermal Treatment combined with Soil Vapor Extraction

Task Description	Quantity	Unit	Unit Cost	Total Cost	Subtotal
DESIGN COSTS					**$15,000.00**
INSTALLATION COSTS					**$68,650.00**
Steam Injection Well Installation	3	ea.	$3,500.00	$10,500.00	
SVE Well Installation	6	ea.	$2,500.00	$15,000.00	
Steam Injection Piping Installation	200	l.f.	$20.00	$4,000.00	
SVE Piping Installation	150	l.f.	$18.00	$2,700.00	
Steam Injection Wellhead Installation	3	ea.	$750.00	$2,250.00	
SVE Wellhead Installation	6	ea.	$200.00	$1,200.00	
Steam Injection Boiler/Compressor	1	ea.	$15,000.00	$15,000.00	
SVE Vacuum Blower	1	ea.	$3,000.00	$3,000.00	
Moisture Separator	1	ea.	$2,500.00	$2,500.00	
Control Panel	1	ea.	$10,000.00	$10,000.00	
Equipment Building	1	ea.	$2,500.00	$2,500.00	
OPERATION COSTS (12 Months)					**$64,500.00**
Oversight and Management	12	months	$1,000.00	$12,000.00	
Site Visits (2 per month)	12	months	$1,500.00	$18,000.00	
Monitoring Equipment	12	months	$160.00	$1,920.00	
Power Costs (25 KW Boiler @ 0.13/KW/hr.)	12	months	$2,340.00	$28,080.00	
Power Costs (5 h.p @ $75/h.p)	12	months	$375.00	$4,500.00	
REGULATORY COSTS					**$5,550.00**
Reporting	12	months	$350.00	$4,200.00	
DEP Fees	1	annual	$1,350.00	$1,350.00	
					$153,700.00

Detailed Remediation Cost Analysis
Off-gas Treatment - Thermal/Catalytic Oxidation

Task Description	Quantity	Unit	Unit Cost	Total Cost	Subtotal
DESIGN COSTS					**$10,000.00**
INSTALLATION COSTS					**$27,900.00**
Catalytic Oxidizer (electric fired-100 SCFM)	1	ea.	$23,000.00	$23,000.00	
Dry Scrubber	1	ea.	$2,400.00	$2,400.00	
Piping and Appurtenances	1	l.s.	$2,500.00	$2,500.00	
OPERATION COSTS (18 months)					**$29,448.00**
Oversight and Management	18	months	$500.00	$9,000.00	
Off-Gas Monitoring	18	months	$200.00	$3,600.00	
Power Costs (10 KW @ 0.13/KW/hr.)	18	months	$936.00	$16,848.00	
					$67,348.00