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U.S. Army Environmental Center

Feasibility Study for Functional Area II

Fort Devens, Massachusetts

January 1997
Contract No. DAAA15-90-D-0012
Delivery Order No. 0003

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Prepared for:
Commander
U.S. Army Environmental Center
Aberdeen Proving Ground, Maryland 21010-5401

Prepared by:
ecology and environment, inc.
1700 North Moore Street
Arlington, Virginia 22209

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FEASIBILITY STUDY
FOR
FUNCTIONAL AREA II
(AOC 32 AND AOC 43A)
FORT DEVENS, MASSACHUSETTS

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Arlington, Virginia 22209

Hussein Aldis

Hussein Aldis
E & E Project Manager, Feasibility Study

Lewis A. Welzel
E & E Program Manager

Robert J. King
E & E Project Manager

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PREFACE

In 1991, the United States Department of the Army and the United States Environmental Protection Agency signed a Federal Facility Agreement (Inter-Agency Agreement) under Section 120 of the Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA) for environmental investigations and remedial actions at Fort Devens. The agreement requires that Feasibility Studies (FSs) be undertaken at each Area of Contamination (AOC) to develop and analyze potential remedial alternatives leading to a Record of Decision.

In 1991, Fort Devens was identified for closure by July 1997, under Public Law 101-510, the Defense Base Closure and Realignment Act of 1990 (BRAC). This has resulted in accelerated schedules for the environmental investigations at Fort Devens. As a means of meeting the accelerated schedule, portions of the FSs were released for review as they were developed. This allowed reviewers to evaluate and agree upon decisions concerning which AOCs would qualify for a full FS. The first portion of the FS released was the draft Initial Screening of Alternatives, which was followed by the draft Detailed Analysis of Alternatives. After interagency reviews of these drafts, it was determined that the Functional Area I AOCs (AOCs 25, 26, and 27) be dropped from consideration for a full FS. Functional Area II AOCs, the Defense Reutilization and Marketing Office (DRMO) Yard (AOC 32) and the Petroleum, Oil, and Lubricants (POL) Storage Area (AOC 43A), were retained for a full FS.

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LIST OF ACRONYMS AND ABBREVIATIONS

AOC	Area of Contamination
APEG	A combination of alkaline earth metal hydroxides and polyethylene glycol
ARAR	Applicable or Relevant and Appropriate Requirement
AST	Above Ground Storage Tank
BCD	Base-Catalyzed Dechlorination
BGS	Below Ground Surface
BNA	base/neutral and acid extractable organic compounds
BTEX	Benzene, Toluene, Ethylbenzene, and Xylene
CERCLA	Comprehensive Environmental Response, Compensation, and Liability Act
CMR	Code of Massachusetts Regulations
COPC	Contaminant of Potential Concern
CWA	Clean Water Act
DDD	dichlorodiphenyldichloroethane
DDE	dichlorodiphenyldichloroethylene
DDT	dichlorodiphenyltrichloroethane
DNB	Dinitrobenzene
DNT	Dinitrotoluene
DOI	United States Department of the Interior
DRMO	Defense Reutilization and Marketing Office
E & E	Ecology and Environment, Inc.
EF	Exposure Frequency
EMO	Environmental Management Office
EPA	United States Environmental Protection Agency
FS	Feasibility Study
HA	Health Advisory
HDPE	High Density Polyethylene
HEAST	Health Effects Assessment Summary Tables
HI	Hazard Index
HMX	cyclotetramethylene tetranitramine
IEUBK	integrated exposure uptake biokinetic model
LDR	Land Disposal Restriction
MA SMCLs	Massachusetts Secondary Maximum Contaminant Levels
MCL	Maximum Contaminant Level
MCLG	Maximum Contaminant Level Goal
MCP	Massachusetts Contingency Plan
MDEP	Massachusetts Department of Environmental Protection
MGL	Massachusetts General Law
MMCL	Massachusetts Maximum Contaminant Level
MNHESP	Massachusetts Natural Heritage and Endangered Species Program
NCP	National Oil and Hazardous Substances Pollution Contingency Plan

NPDES	National Pollutant Discharge Elimination System
O&M	Operation and Maintenance
ORSG	Office of Research and Standards Guidelines
OSHA	Occupational Safety and Health Administration
OSWER	Office of Solid Waste and Emergency Response
PAH	Polynuclear Aromatic Hydrocarbon
PCB	Polychlorinated Biphenyl
PETN	Pentaerythritol Tetranitrate
POL	Petroleum, Oil, and Lubricant
POTW	Publicly-Owned Treatment Works
PPE	Personal Protection Equipment
QA/QC	Quality Assurance/Quality Control
RAO	Remedial Action Objectives
RBC	Risk-based Concentrations
RCRA	Resource Conservation and Recovery Act
RF	Radio Frequency
RfD	Reference dose
RI	Remedial Investigation
RI/FS	Remedial Investigation/Feasibility Study
RME	Reasonable Maximum Exposure
ROD	Record of Decision
SARA	Superfund Amendments and Reauthorization Act of 1986
SDWA	Safe Drinking Water Act
SI	Site Investigation
SMCLs	Secondary Maximum Contaminant Levels
TAL	Target Analyte List
TBC	To Be Considered
TCE	trichloroethene
TCL	Target Compound List
TCLP	Toxicity Characteristic Leaching Procedure
TMV	Toxicity, Mobility, or Volume
TNB	Trinitrobenzene
TOC	Total Organic Carbon
TPHC	Total Petroleum Hydrocarbons
TSCA	Toxic Substances Control Act
TSS	Total Suspended Solids
UCL	Upper Control Limit
USAEC	United States Army Environmental Center (formerly USATHAMA)
USDOD	United States Department of Defense
UST	Underground Storage Tank
UV	Ultraviolet
VOC	Volatile Organic Compound
WQC	Water Quality Control

UNITS OF MEASURE

°C	degree(s) Celsius
cfs	cubic feet per second
cm	centimeter(s)
cm/sec	centimeters per second
°F	degree(s) Fahrenheit
ft	foot (feet)
ft^2	square foot (feet)
ft^3	cubic foot (feet)
g	gram(s)
gal	gallon(s)
gpm	gallons per minute
kg	kilogram
L	liter(s)
m	meter(s)
mg	milligram(s)
mi	mile(s)
µg	microgram(s)
µm	micrometer
ppb	part(s) per billion
ppm	part(s) per million
ton	short ton(s) (i.e., 2,000 pounds)
yd^3	cubic yard(s)

EXECUTIVE SUMMARY

Under contract with the United States Army Environmental Center (USAEC), Ecology and Environment, Inc. (E & E) conducted this Feasibility Study (FS) for two Areas of Contamination (AOCs) at Fort Devens, Massachusetts: AOC 32 and AOC 43A. These AOCs are in Functional Area II, the Main Post. This FS is intended to identify and establish cleanup objectives for contaminated media, to evaluate and refine a list of alternative technologies that are being considered to remediate the contaminated sites, and to analyze in detail a short list of feasible alternatives.

E & E conducted a Remedial Investigation (RI) of AOCs 32 and 43A and collected samples of environmental media to characterize the sites and to support ecological and human health risk assessments. Future use of the AOCs in Functional Area II (the Main Post) is expected to be of an industrial nature, similar to the current use of the sites. These expected uses were considered when the risk assessments for Functional Area II were developed.

As part of this FS, remedial action objectives were formulated for the contaminated soils and groundwater in Functional Area II. Cleanup goals were developed based on an evaluation of applicable or relevant and appropriate requirements (ARARs), other criteria and guidelines to be considered (TBCs), findings of the site-specific baseline risk assessment and ecological assessment, and background data compiled from Fort Devens. Several distinct areas within the AOCs, were identified that exceeded cleanup goals.

At the Defense Reutilization and Marketing Office (DRMO) underground storage tank (UST) area, the groundwater was found to be contaminated with petroleum hydrocarbons, chlorobenzenes, chlorinated ethylenes, and several other organics. The soil near the UST contained one sample of elevated lead and one of elevated arsenic. However, soils have since been removed. In the soil surrounding the DRMO Yard, the following contaminants were detected at levels above their cleanup goals: arsenic, cadmium, lead, pesticides, polychlorinated biphenyls (PCBs), and total petroleum hydrocarbons (TPHC). Groundwater at the DRMO Yard exceeded cleanup goals for manganese and TCE. However, manganese, which was highest in an upgradient well, is clearly natural, and TCE, which was not found in wells immediately downgradient of DRMO, is clearly of very limited extent. TCE levels in the groundwater are close to drinking water standards but groundwater is proposed as an operable unit.

In the groundwater and saturated soil of the Petroleum, Oil, and Lubricant (POL) Storage Area, RI screening data suggested the presence of three distinct hydrocarbon plumes in subsurface soils (below 16 feet from ground surface). Although screening samples analyzed for benzene, toluene, ethylbenzene, and xylene (BTEX) compounds showed concentrations of all four aromatics above cleanup goals, confirmation sampling of soils and groundwater did not confirm any exceedances of cleanup goals for these compounds. TPHC and 2-methylnaphthalene levels exceeded regulatory levels in both the soil and groundwater.

These exceedances were sporadic and isolated and because of their location they represent no threat to human health or the environment at present. This was confirmed by contaminant transport modeling for the zone of capture of the McPherson well. Except for one isolated occurrence of arsenic in surface soil, attributed to natural variation, no soil sample exceeded screening values where exposures to any population can occur. Remediation is proposed for the POL site groundwater because of exceedances of ARARs and the need to confirm that intrinsic remediation will result in reductions of human health risks to acceptable levels.

General response actions were developed for soil (at the DRMO Yard) and groundwater (at both the POL and the DRMO Yard). For soil the general response actions are: no further action, institutional action, containment, excavation, ex situ treatment, in situ treatment, and disposal. For groundwater the general response actions are: no further action, institutional action, intrinsic remediation (with long-term monitoring), containment, extraction, ex situ treatment, in situ treatment, and disposal.

Within each general response action, there are several technologies that address the remedial action objectives. The technologies are screened based on applicability to the wastes present in a given medium, effectiveness, and implementability. Technologies that passed this screening were then assembled into complete remedial alternatives. These complete alternatives are then screened again based on effectiveness and implementability. The alternatives that passed this screening are developed and analyzed further in the detailed analysis section.

Remedial alternatives were developed for each of three operable units: the DRMO Yard soils, the DRMO UST 13 groundwater, and the POL Storage Area/DRMO Yard groundwater. Five alternatives are analyzed in detail for DRMO Yard soils:

- No Further Action;
- Institutional Actions;
- Containment with Capping;
- Excavation, Solidification, and On-Site Disposal; and
- Excavation and Off-Site Disposal.

Three alternatives are analyzed in detail for DRMO UST 13 groundwater and the POL Storage Area/DRMO Yard groundwater:

- No Further Action;
- Institutional Actions; and
- Intrinsic Remediation (with long-term monitoring).

1. INTRODUCTION

1.1 PURPOSE AND ORGANIZATION OF REPORT

The United States Army Environmental Center (USAEC) tasked Ecology and Environment, Inc. (E & E) to conduct a Remedial Investigation/Feasibility Study (RI/FS) at two areas of contamination (AOCs) at Fort Devens, Massachusetts (Figure 1-1), under Contract No. DAAA15-90-D-0012, Delivery Order No. 0003. The two sites are located within Functional Area II (the Main Post), which includes AOC 32, the Defense Reutilization and Marketing Office (DRMO) Yard; and AOC 43A, the Petroleum, Oil, and Lubricant (POL) Storage Area (Figure 1-2). This work was performed in accordance with the Federal Facility Agreement (Inter-Agency Agreement) between the United States Army and the United States Environmental Protection Agency (EPA) under Section 120 of the Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA) as amended by the Superfund Amendments and Reauthorization Act (SARA).

The detailed results of the RI conducted at these sites are documented in the Remedial Investigation Report for Functional Area II (E & E 1994). The RI results, including human health and ecological risk assessment, were used in preparing this FS. The FS is conducted in accordance with the EPA's *Guidance for Conducting Remedial Investigations and Feasibility Studies under CERCLA* (EPA 1988b). In accordance with the Federal Facility Agreement for Fort Devens, the FS report has been prepared in three stages. The first stage was the Draft Initial Screening of Alternatives, and included the development and screening of remedial alternatives. The second submittal was the Detailed Analysis of Alternatives report. The third stage is this FS report, which incorporates the final versions of the Initial Screening of Alternatives and the Detailed Analyses of Alternatives documents.

This FS report includes six sections and three Appendices. Section 1 provides a brief site description and history, a summary of the nature and extent of contamination, and summaries of the human health and ecological risk assessments from the RI report. Section 2 defines the remedial action objectives for each of the sites, and develops clean-up goals for each site included in the FS process. The identification and screening of technologies are presented in Section 3 and alternatives to remediate each site are developed in Section 4. Section 5 presents a more detailed analysis of the alternatives that are retained in Section 4. References cited or consulted are provided in Section 6. A particle tracking analysis for the groundwater flow system of the POL Storage Area is provided in Appendix A. Appendices B and C contain the back-up cost calculations used for the detailed analysis of alternatives and responses to comments on the draft FS, respectively.

1.2 SITE DESCRIPTIONS

This section presents brief discussions of site descriptions including site geology and the nature and extent of contamination found, as well as summaries of the human health and ecological risk assessments for the two sites on the Main Post identified for inclusion in the FS process.

1.2.1 Defense Reutilization and Marketing Office (DRMO) Yard - (AOC 32)

1.2.1.1 Site Description

AOC 32, the DRMO Yard, is located in the northeast corner of the Main Post at Fort Devens, just to the south of Shepley's Hill Landfill. AOC 43A, the POL Storage Area, is just to the south of the DRMO Yard site, across Market Street (see Figure 1-2). The DRMO Yard consists of two fenced enclosures on either side of Cook Street, which serves as the access road to the Shepley's Hill Landfill. The two enclosed areas are paved with asphalt. Together the paved surface totals approximately 250,000 square feet (see Figure 1-3). Also associated with AOC 32 is a 30,000 square foot fenced area used to store and recycle used tires. This unpaved yard is located immediately north of the eastern DRMO Yard.

The DRMO Yard is an active materials storage facility, and has been operational in its current location for several decades. The yard on the west side of Cook Street contained various types of used equipment. The northwest corner of the yard was dedicated to used lead-acid battery storage. All battery acid was drained from the batteries by the generator prior to arrival. Batteries were stacked on pallets, with the top of the battery turned sideways to avoid any accumulation of precipitation. About 40,000 pounds of batteries passed through the DRMO per month. The nature of the material that is processed in this yard varies considerably. As Fort Devens continues to move toward closure and elements of the tenant commands are either deactivated or transferred to new installations, the DRMO Yard will receive more office and administrative equipment.

In the yard on the east side of Cook Street, vehicles were cut-up and disassembled to recover usable parts. This yard formerly contained scrap metal, tires, stored items that are ready for sale, and was the accumulation point for used photographic solution. The recovery of scrap precious metals (silver and platinum) from the solution was performed by a subcontractor off site (Berry 1988). Because of the history of vehicle scrap, a radiation survey was performed by ABB Environmental Services, Inc. (ABB), primarily to find radium dials. The Army identified three "affected" areas: the tire recycling yard, the north portion of the east yard, and the combined area of a 12 meter by 31 meter concrete pad east of Building T204, with a 10 meter wide perimeter around the pad.

One hundred percent of the "affected" areas was scanned using a sodium iodide detector, and 10 percent of the remainder of the DRMO Yard was scanned as well. Measurements of total alpha and total beta/gamma surface activity were made at all locations showing elevated count rates (hot spots), and soil samples were collected and analyzed to determine Radium-226 levels in both background soils and unpaved areas of the yards. Twelve hot spots were found; all were in the north end of the east yard and all were remediated by the removal of radium contaminated soil or radium dials (ABB 1996). Just north of the east yard is a fenced area that is used to hold used tires. Tires are accumulated over a period of time and then when the quantity is sufficient, the DRMO shreds them and ships out the shredded material. In the east yard, there is an excavation trench which was reported to be part of the remediation of a polychlorinated biphenyl (PCB) contaminated rectifier oil spill that was reported to the Environmental Management Office (EMO) by DRMO personnel on 5 April 1990. In 1992, an underground storage tank (UST) used for the storage of waste oil was removed from a location just to the east of the DRMO Yard.

The enclosure for the two sections of the DRMO Yard and the tire storage area consists of a 6-foot tall chain-link fence, surmounted with barbed wire. The paved asphalt surfaces of the two main yards drain to the north into a 36-inch storm drain, with a catch basin just to the north of the eastern yard and two catch basins located in the separately fenced tire recycling area. The storm drain extends southeast along the edge of Shepley's Hill Landfill, and discharges via a 48-inch pipe to a man-made drainage ditch. The drainage ditch carries storm runoff north towards Plow Shop Pond.

Overall, this site does not support an abundance or diversity of wildlife species. However, a few species-of-concern, including the grasshopper sparrow, upland sandpiper, Cooper's hawk, and bald eagle, have been known to occur on the grassland habitat adjacent to the study area (i.e., on Shepley's Hill Landfill). An additional 12 state- and federally-listed species of concern are known to occur within 1.5 miles of the site, but none were observed during the field survey. One area located within 1.5 miles of the site is identified as an estimated habitat of state-listed rare wetlands wildlife by the Massachusetts Natural Heritage and Endangered Species Program (MNHESP 1993); it is located approximately 3,000 feet north of the site, adjacent to Nonacoicus Brook.

1.2.1.2 Geology and Hydrology

The DRMO Yard area is fairly level. The soil layer in the area is thin, and the soils are sandy and well drained. Bedrock beneath the site is Ayer's granite (granodiorite). The site lies within a north-northeast trending terrace fragment that connects the entrance to Shepley's Hill Landfill with the POL Storage Area, and lies between Shepley's Hill to the west and other bedrock outcrops to the east and southeast. Borings at the DRMO Yard show bedrock becoming shallower to the north and east. Under the DRMO Yard, bedrock ranges from 10 to 30 feet below ground surface (BGS).

Groundwater was encountered from 12.7 to 28 feet BGS at the DRMO Yard as measured in November 1993. It is probable that there is no permanent aquifer in some of the unconsolidated deposits above bedrock at the DRMO Yard, both because the soil is thin and well drained and because it is near a watershed divide between the Willow Creek drainage to the west and Plow Shop Pond to the east. Bedrock topography is the major influence on groundwater hydrology. An east-west groundwater divide is present at the north end of the DRMO Yard. North of the divide, flow is to the northeast towards Shepley's Hill Landfill; south of the divide, flow is to the south and west, through the POL Storage Area. The hydraulic gradient is also directly related to bedrock topography. Another groundwater divide runs under Building T204, running north-south. The UST area, which is east of Building T204, is in a separate groundwater regime from the DRMO Yard itself. The water table is in the bedrock under the former UST, and the hydraulic conductivity is low. Flow appears to be both easterly and southerly around a small knob of bedrock just east of the UST site (near location of well 32M-92-05X).

1.2.1.3 Nature and Extent of Contamination

During the RI, screening values were compiled by E & E for each analyte for comparison against sampling results. Most screening values were based on chemical-specific applicable or relevant and appropriate requirements (ARARs) identified for this project by Oak Ridge National Laboratories, although where no ARARs existed, other levels to be considered (TBCs) were used. E & E developed a set of numerical criteria, entered the values into the Site Master Database, and ran a comparison of analytical results for each medium against the screening values. Screening values are not intended to be cleanup goals, i.e. goals used to identify areas requiring remediation. These are developed in Section 2 of the FS. Screening values are merely used to identify areas where contamination may exceed regulatory levels and to assist in the nature and extent of contamination discussions.

A detailed discussion of the ARAR selection process and the development of screening values can be found in Section 7 of Volumes II and III of the Functional Area II RI report (E & E 1994). A summary of ARARs by medium is provided here:

- Soils: Massachusetts Contingency Plan (MCP) Method I was identified by Oak Ridge National Laboratories as an ARAR, and was used for the screening values of contaminants in soil. Where no values existed, the EPA Region III risk-based concentrations (RBCs) for commercial/industrial soils were used as screening values. For lead, the EPA Interim Guidance on Soil Lead Cleanup levels at Superfund sites was used.

- Sediment: There are no promulgated maximum allowable concentrations for chemicals in sediments under Massachusetts or Federal Law. Therefore, results were compared to screening values developed for soils.

- Surface Water: From surface water, the lowest of two levels identified in the Clean Water Act (CWA) Ambient Water Quality Criteria (AWQC) was chosen: one for the protection of human health from risks due to water and fish consumption, and a second for the protection of aquatic organisms in freshwater due to chronic effects. The AWQC criteria were identified as ARARs by Oak Ridge National Laboratory.

- Groundwater: Screening values in groundwater were based on the lowest of the following criteria: Safe Drinking Water Act (SDWA) Maximum Contaminant Levels (MCLs), the Massachusetts MCL (MMCL), MCP GW-1 water standards, the SDWA MCL Goal (MCLG) and Massachusetts Secondary MCL (SMCL). All were identified as chemical specific ARARs by Oak Ridge. Where no ARAR existed, SDWA SMCLs, EPA Office of Water Lifetime Health Advisories (HA), and Massachusetts Office of Research and Standards Guidelines (ORSG) were reviewed. Although these standards are only TBC guidance, the lowest value was selected.

Surface Soils

A total of 20 surface soil samples were collected in the AOC 32 area. Samples were analyzed for target analyte list (TAL) metals, target compound list (TCL) pesticides/PCBs, and total petroleum hydrocarbons (TPHC). A large number of inorganics were detected at levels above background in the soils, including the following metals of significance: antimony, arsenic, barium, beryllium, cadmium, chromium, cobalt, copper, iron, lead, mercury, nickel, silver, vanadium, and zinc. The RI report identifies cadmium, lead, and beryllium as exceeding various standards. Although cadmium does not exceed the screening value used in the RI report, it is quite elevated in two samples. Lead exceeds the screening value in seven samples. Beryllium does not exceed the screening value used in the RI report. Arsenic exceeded its screening value in two samples, mercury exceeded its screening value once, and nickel also exceeded its screening value in one sample.

The pesticide dichlorodiphenyltrichloroethane (DDT), and its derivatives dichlorodiphenyldichloroethylene (DDE) and dichlorodiphenyldichloroethane (DDD), were detected in AOC 32 soils, particularly around the perimeter of the east yard. DDD and DDE were detected in approximately half of the samples, but all below screening values. Gamma-Chlordane was also detected below its screening value. Three PCBs (PCB-1016, PCB-1254, and PCB-1260) were detected, sometimes exceeding screening values. PCB-1016 was detected in five of the samples, PCB-1254 in seven samples, and PCB-1260 in 10 samples. TPHCs were detected in all but two of the soil samples. Six of the samples exceeded the screening value. These samples are all from around the perimeter of the east DRMO Yard and in the tire recycling area.

To summarize, the soils surrounding AOC 32 show some contamination with petroleum hydrocarbons, heavy metals, PCBs, and pesticides. The pesticide levels are very low, except for two DDT hits. All are below screening values. DDT is detected throughout the site, particularly in areas near roads and buildings. Therefore, the DDT contamination at AOC 32 may or may not be site-related. The hits of TPHC, metals, and PCBs are very likely related both to each other, and to site-usage. The higher detections of these compounds are found in the same five samples, all around the east DRMO Yard and tire recycling area. These locations are all possible drainage points for the asphalt-covered east yard. It appears likely that the contaminated soil is due to site drainage, perhaps from oil laden with heavy metals and PCBs. This northeast portion of the east yard is also the area where PCB oils were spilled from stored rectifiers.

Subsurface Soils

Boreholes were advanced at 15 locations during the RI. Samples were taken at 1 foot, 5 feet, and 10 feet, except for one borehole, which was sampled at the surface instead of the 1 foot depth because that location is unpaved. Borehole samples were analyzed for TAL metals, TCL pesticides/PCBs, and TPHC. Three test pits were excavated in the removed UST area east of AOC 32 and were sampled at approximately 6 feet. Subsurface samples from the test pits were analyzed for TAL metals, TCL pesticides/PCBs, TCL volatile organic compounds (VOCs), and TPHC. A large number of metals were detected in the 1-foot, 5-foot, and even 10-foot samples, although with decreasing frequency at greater depths, including: antimony, arsenic, barium, beryllium, cadmium, chromium, cobalt, copper, lead, mercury, nickel, silver, and zinc. Lead exceeded the screening value level for subsurface soil at the 1-foot depth in two boreholes. The arsenic screening value level was exceeded at the 5-foot depth in one borehole, and at the 10-foot depth in a second borehole. Two of the test pits showed elevated metals. Arsenic exceeded a screening value in one sample. Lead exceeded a screening value in one test pit. The high lead level in this sample corresponded to a high level of TPHC.

No organics at any depth exceeded screening value levels for subsurface soil. However, at one borehole, elevated levels of DDD, DDE, and DDT were detected at 1 foot. TPHC was elevated in five boreholes. In general, there does not appear to be significant contamination in the subsurface soils at AOC 32, with one exception. One borehole showed elevated levels of almost every metal, as well as elevated pesticide and TPHC hits at 1 foot. This may be due to the boring's location, adjacent to the area where PCB-laden oil was spilled into the soil, and then later excavated (E & E 1992).. This is particularly likely, because the 1-foot samples in this borehole and a nearby borehole showed PCBs. The other sporadic elevated levels of TPHC and metals are probably the cumulative result of very localized incidents at the DRMO Yard. In the test pits near the UST, the high lead level could be related to the elevated TPHC.

Asphalt Samples

A total of 15 asphalt samples were taken at AOC 32. These samples were analyzed for pesticides and PCBs and compared to soil screening values. Low levels of p,p-DDE and p,p-DDT were found in 8 of the 15 samples. The higher levels of pesticides were found in the center of the DRMO Yard, and roughly correlated to higher levels of PCBs detected. No pesticides were detected above screening values. PCBs were found in the 12 asphalt samples taken in the east DRMO Yard. PCB-1254 was the most prevalent, detected in 9 of the 12 samples, and exceeding its screening value in 4 samples. PCB-1248 was detected in three samples. PCB-1260 was detected in two samples. Based on the PCB hits, the soil contamination at the DRMO Yard, and the history of site usage, it appears that there may be some site-related PCB contamination in the asphalt, particularly because some of the PCB hits are found in the area of the known rectifier oil spill.

Groundwater

Groundwater samples were collected in three rounds in November 1992, March 1993, and June 1993. The samples from the first two rounds were analyzed for TCL organics, TAL metals, TPHC, and hardness, with several samples also analyzed for dissolved TAL metals. Samples from the third round were analyzed for both total and dissolved (i.e., filtered) TAL metals, explosives, and hardness. Because of the content of silt and clay in the water from all of the DRMO Yard wells, which are only bailed and sampled at long intervals (three months or more), the metals levels in unfiltered samples frequently exceed screening values. To distinguish those metals levels from the levels of metals dissolved in groundwater or on colloidal particles, additional samples were taken in the June 1993 round, and filtered through 0.45 micron glass filters. In all cases, the non-soluble metals such as aluminum and iron are dramatically reduced, while soluble metals such as sodium are little affected. Toxic heavy metals such as arsenic, cadmium, chromium, and copper, often correlate with levels of aluminum and iron, suggesting that the heavy metals may be present in suspended sediment or may be sorbed onto aluminum or iron oxides.

All the wells in the DRMO Yard tend to show aluminum, iron, and manganese in unfiltered samples. Where there are high levels of iron and aluminum, there are also likely to be high levels of other metals associated with particulates in the groundwater. Metals whose maximum levels exceed MCLs are: arsenic, beryllium, chromium, lead, sodium, and nickel. Sodium is obviously high in one monitoring well because of its proximity to sources of runoff carrying road salt. The fact that all the other metals are highest in the two wells showing highest aluminum and iron is indicative of the role that particulates play in affecting groundwater quality data with respect to many metals. When the filtered samples from the same wells are reviewed, sodium is still high in the one monitoring well because it is highly soluble as sodium chloride. In addition, the following exceedances of MCLs for other dissolved metals were noted in several wells: manganese, aluminum, and iron. Manganese is as high or higher in a filtered sample from the upgradient well as it is in unfiltered samples from the same well, or in unfiltered samples from downgradient wells. It appears that there are high levels of soluble manganese naturally occurring in the groundwater at this site. The maximum level of iron in filtered samples is less than one percent of the average level in three unfiltered samples from the same well. Another filtered sample taken 3 months later shows non-detect for iron. The highest level of aluminum in filtered samples is 392 micrograms per liter (μg/L). Again, a filtered sample taken three months later shows non-detect for aluminum. Apart from the elevated dissolved manganese which appears to be background, there is no convincing evidence that AOC 32 has any levels of dissolved metals above screening values. Overall, it appears that groundwater quality downgradient of the DRMO Yard has not been impacted by the activities of the DRMO Yard with respect to metals, considering the data from the filtered samples.

The upgradient well contains several organics, including *bis*(2-ethylhexyl)phthalate, a common contaminant from sample-handling. The same organics do not appear in the wells most directly downgradient of this well, and appear to be local contaminants. The other wells downgradient of AOC 32 show scattered hits from eight organics. These are 6-aminohexanoic acid lactam, dodecanoic acid, di-n-butylphthalate, 1,2-dichloroethane, acetone and toluene, chloroform, and trichloroethene (TCE). TCE is the only chemical exceeding its screening value, which it does by over 300 percent in one well (POL-3) located immediately downgradient of the DRMO Yard.

The three wells placed immediately adjacent to the UST Area excavation site, from which the UST was removed, an additional well placed south of the tank excavation and south of Market Street to monitor potential flow in that direction, and an existing Shepley's Hill Landfill well used to monitor downgradient flow to the east, are considered as one group, separate from the other DRMO Yard wells. They are in a separate groundwater flow system, east of a groundwater divide running north-south under the DRMO office at Building T-204. Inorganics in these wells show the same characteristics as the other wells. Unfiltered samples are typically high in aluminum, iron, and manganese, and show exceedances of MCLs for lead and arsenic. Filtered samples show no exceedances for aluminum, but one well shows exceedances for arsenic and manganese. It appears that the manganese could possibly be natural, given the levels noted in other DRMO wells, but it does not appear in filtered samples from either downgradient well. It appears that both arsenic and manganese could reflect impacts from the former UST; however, these impacts do not appear to extend off site.

The two wells immediately adjacent to the UST excavation (32M-92-04X and 32M-92-06X) showed high levels of petroleum hydrocarbons greatly exceeding screening values, by nearly 1,000 times, in one case. They also showed a wide range of organics, dominated by dichlorobenzenes, which exceeded screening values. Both showed a variety of other compounds: 13 other organics were found in one well, and 10 other organics were found in the second well. The most marked differences between the two wells were the presence of PCB-1260 and 1,1,1-trichloroethane in 32M-92-04X, and the presence of 1,2-dichloroethene and of TCE (in excess of screening values) in 32M-92-06X. Both wells showed sharp declines in levels of organics between November 1992 and March 1993. However, an additional sampling event conducted in July 1995 showed TPHC concentrations similar to the November 1992 rounds.

The monitoring well in what appears to be the downgradient direction (32M-92-05X) shows non-detect for both total hydrocarbons and chlorinated benzenes in the first sample round, and only a small hit of total hydrocarbons in the second sample round. Organics detected in the second round include 1,1,1-TCA and 1,2-dichloroethane. The monitoring well south of Market Street showed non-detect for total petroleum hydrocarbons, but a slight trace of 1,1,1-TCA suggesting a connection between this well and the monitoring well to the north. As the data currently exist, only the two wells closest to the tank excavation exceed MCLs, but they both have multiple exceedances which imply the requirement to assess remedial alternatives. The groundwater regime in this area is complex, so the ultimate transport of the organics is difficult to predict. However, it appears that groundwater from west of the UST area flows both to the east and south around a small knob of low conductivity bedrock into which 32M-92-05X was placed. Flow then continues to the east and northeast, toward Shepley's Hill Landfill. This would explain the lack of organics detection in 32M-92-05X. However, the organics also were not detected in SHL-25, which is further east. The waste material spilled at this site was oil containing a number of other contaminants, primarily chlorinated aromatics. These have a much higher solubility in the oil than in water and partition very unequally between the oil and water. Because the oil was apparently spilled at the surface (the oil tank was excavated intact), it had to migrate through the unsaturated sands of the glacial outwash overburden to reach the bedrock. Since the bedrock matrix is essentially impermeable it must have migrated into the fractures in the bedrock in order to reach the water table in the bedrock and to be found in the monitoring wells. The fracture porosity of largely unweathered granodioritic gneiss is of the order of one to five percent, and only the two wells closest (within 20 feet) of the tank excavation showed high levels of TPHC and chlorinated aromatics; it appears clear that only a small area of bedrock was invaded by the waste oil. Because the oil-soaked overburden was excavated and removed at the time of the tank removal, there is now no longer any mass of additional waste oil to move into and replenish the oil in the bedrock. This means that the remaining oily phase in the bedrock must consist of a small volume of material that is not being increased by further movement from the overburden, and is not moving, since it is in residual saturation. Furthermore, the area of contamination is located at a groundwater divide, with little or no natural groundwater flow gradients. This information strongly implies that groundwater contamination is not migrating from the location of the spill.

Surface Water

Because there is no naturally occurring surface water at the DRMO Yard, the only surface water sample taken was from a storm drain catchment basin, north of the east yard. The storm drain discharges to the surface at the drainage ditch and the water seldom, if ever, reaches the end of the ditch leading to Plow Shop Pond. It is likely that all the discharge from the DRMO Yard drain sinks into the very sandy soil and becomes part of the groundwater, except during very exceptional storms, or during snow melt over frozen ground. The surface water sample was analyzed for TAL metals, TCL pesticides/PCBs, and water quality parameters. The one sample collected from the storm drain catch basin showed elevated antimony, cadmium, copper, lead, and zinc, when compared to background surface waters for Fort Devens. Cadmium was detected at 16.2 μg/L, approximately four times the limit of detection (which ranged from 4 to 6 μg/L). The detection limit was assumed to be the upper limit of the background concentration, since cadmium was not detected in background samples. Zinc was detected at eight times the maximum background level.

Sediments

Four sediment samples were collected at AOC 32, two from the storm drain system, and two from the drainage ditch south of Shepley's Hill Landfill, into which the storm drain discharges. The two storm drain sediment samples were from two locations: one from the catchment basin north of the east yard on the east side of Cook Road, and the second from the outlet of the drain where it discharges into the drainage ditch. The catch basin sample was collected in duplicate, and showed numerous exceedances of background levels for metals as well as TPHC and total organic carbon. Metals of particular concern were cadmium and lead. Barium, iron, nickel, and zinc also exceeded background levels on average, as did calcium and potassium, although they are not of concern for human health or the environment. The second sample from the storm drain discharge showed even higher levels of most metals, as well as greatly increased total organic carbon, but identical TPHC. Metals elevated above background included: antimony, barium, cadmium, calcium, chromium, copper, iron, lead, mercury, nickel, potassium, silver, vanadium, and zinc. The levels were higher at the discharge than in the catch basin, apparently as a result of the greatly increased organic carbon of the sediment, onto which the metals are likely to sorb.

In the sediment samples taken from the drainage ditch, the following metals are elevated above background: aluminum, antimony, barium, cadmium, calcium, chromium, cobalt, copper, iron, lead, magnesium, nickel, potassium, vanadium, and zinc. The levels are in the same range or higher than those in the storm drain, which probably reflects the high cation exchange capacity of clay in the sediment, which has apparently sorbed metals from the storm drain discharge. It appears that discharge of runoff from the DRMO storm drain has contributed metals to the sediment along the drainage ditch and also metals to the groundwater recharge in this area, since much of the discharge sinks into the ground and recharges groundwater. This, in turn, discharges to Plow Shop Pond. The pesticide/PCB results show hits of DDD, DDT, and PCB-1254 in the storm drain sediments. The ditch sediments showed lindane and DDD. The PCB evidently migrated from the DRMO Yard after a spill of PCB transformer oil, but the low level pesticide hits may reflect general pest control activities around the base in the past.

1.2.1.4 Human Health Risk Assessment Summary

The main yards of the DRMO (east and west yards) have been used for storage of used equipment, vehicles, automotive batteries, and containerized hazardous waste, and for the processing and sorting of used parts and scrap metal. Spills from storage yard operations have contaminated the asphalt pavement in the yards and the surrounding surface soils with PCBs and metals, some of which have infiltrated to groundwater. Additionally, subsurface soils and groundwater to the east of the DRMO are contaminated with metals and petroleum constituents, probably by spills around the waste oil underground storage tank that once was located there.

There are two main exposure pathways under current site conditions.

- Direct Contact (dermal contact and incidental ingestion) with contaminated asphalt, surface soils, and sediment; and

- Inhalation of vapors released to ambient air at the soil surface.

Potential receptors include DRMO workers and site visitors, both authorized (customers) and unauthorized (trespassers). Normally, inhalation of contaminated dust is not regarded as a major exposure pathway because wind erosion of surface soil at this AOC is limited by pavement and vegetative cover. However, if the cover were removed and soils were excavated (i.e., maintenance of utility lines that run under the site), workers could potentially inhale airborne dust from surface and subsurface soils, and come into direct contact with subsurface contaminants for a short period, probably several days.

Under current EPA Superfund Policy (USEPA 1992), acceptable exposure levels for carcinogens are those that represent an excess upper bound lifetime cancer risk of between 10^{-4} and 10^{-6}. For noncarcinogens, acceptable exposures are those with a hazard index (HI) of 1.0 or less.

The estimated cancer risk to current site workers from exposure to contamination in the asphalt paving and surface soil at AOC 32 is 9.2×10^{-5} for the reasonable maximum exposure (RME) case and 1.8×10^{-5} for the average exposure case, within the EPA range of 10^{-4} to 10^{-6}. Estimated cancer risks for site trespassers are approximately an order of magnitude lower, because of their lower exposure frequency (EF). Most of the estimated cancer risk (over 90 percent) is due to dermal absorption and ingestion of PCBs and arsenic in soil. The only HI exceeding 1.0 under current site conditions is associated with the RME case of worker soil exposure; the HI for dermal absorption and ingestion of PCBs is 4.4, while the HI for exposure to lead by these routes is 0.9. Lead and PCBs cause different types of adverse health effects. Therefore, the HIs for exposure to these two chemicals should not be summed. It should be noted that these chemicals do not have EPA-approved reference doses (RfDs), and that these HIs are based on RfDs recommended by the Massachusetts Department of Environmental Protection (MDEP) in its Risk Assessment shortform (MDEP 1992).

Several alternative exposure scenarios that could occur under possible future site conditions were evaluated. Two scenarios (Scenario 3 — Future Construction Workers and Scenario 4 — Future Site Workers Outdoors) address potential exposure to contaminants in soils by direct contact and by inhalation of ambient air; one scenario (Scenario 5 — Future Site Workers Indoors) addresses potential exposure to volatile groundwater contaminants that could infiltrate to indoor air; and the last scenario (Scenario 6 — Groundwater Usage) addresses potential ingestion of contaminants in groundwater.

Future permanent site workers could be exposed to contaminants in both the soil and the groundwater; therefore, the estimated soil and groundwater risks should be summed for this group of potential receptors. However, only one of the two soil exposure scenarios (indoors or outdoors), and one of the five sets of groundwater risk estimates can apply to these receptors at a time. The highest estimated soil risks are for a future outdoor worker, and the highest estimated groundwater risks are for unfiltered groundwater from the DRMO Yard. Combining these risk estimates gives a maximum estimated RME cancer risk of 6×10^{-3}, due almost entirely to the groundwater. When metals data from filtered groundwater samples are used to remove the effects of suspended sediments, estimated cancer risks dropped two orders of magnitude. The highest plausible combined soil and groundwater RME risks for future workers are for outdoor workers using filtered groundwater from the UST area. Any future use of area groundwater as drinking water is unlikely because of the existing public water supply system and the very low yield of wells at the DRMO Yard; therefore, the highest realistic future worker risks are those for outdoor workers from potential exposure to soil contaminants alone.

The site contaminants estimated to pose potential excess lifetime cancer risks greater than 10^{-6} include arsenic, beryllium, 1,4-dichlorobenzene, PCBs, and TCE. Arsenic is classified as a Group A, human carcinogen. Beryllium, PCBs, and TCE are classified as Group B2, probable human carcinogens, and 1,4-dichlorobenzene is classified as a Group C, possible human carcinogen, based on carcinogenicity in animals. Site contaminants that pose potentially significant noncarcinogenic adverse health effects via ingestion or dermal routes include arsenic, lead, manganese, and PCBs. Inhalation of chromium (VI) potentially present in airborne soil particles could potentially pose adverse health effects during excavation/construction activities. Chromium (VI) is an irritant which can cause damage to the nasal mucosa if inhaled in sufficient amounts.

The major factors driving estimated site risks are:

- The presence of PCBs, arsenic, and lead in site soils and potential exposures by site workers and visitors; and

- The presence of elevated concentrations of metals (primarily arsenic), PCB, and 1,4-dichlorobenzene in the groundwater coupled with the possible future use of groundwater as a drinking water source.

Exposures to soil contaminants are either currently occurring or could reasonably be expected under current land use conditions; however, the conservative (health protective) exposure assumptions used may overestimate actual exposures. Because Fort Devens is scheduled to close in the near future, the exposure duration of current site workers could be less than the default value of 25 years that was used to estimate risks under current site conditions. The Massachusetts Government Land Bank (Devens Reuse Plan, November 1996) has proposed the area for rail, industrial, and trade-related uses. Groundwater in the vicinity of the site is not a current, future water supply source because there is an existing public water supply system, and the aquifers are thin and not productive. Therefore, the probability of exposure to site contaminants in groundwater is extremely small. There is a drinking water well, the McPherson well, approximately 4,000 feet hydraulically downgradient from the DRMO Yard. However, as discussed in the RI Functional Area II Report, Volume III, Section 6 (E & E 1994a), it would take hundreds of years for benzene, toluene, ethylbenzene, and xylene (BTEX) contaminated groundwater to reach this well. Given the volatility and biodegradation rates of BTEX, it will not persist long enough to do so. This is confirmed by a contaminant transport model conducted after completion of the RI, which showed xylene degrading completely before leaving the POL Storage Area just downgradient of the DRMO Yard (see Appendix A). It would take approximately 10 times longer for TCE to reach this well, based on its retardation factor. TCE has already declined to below detection limits even in AOC 43A wells less than 500 feet downgradient of the DRMO Yard.

1.2.1.5 Ecological Risk Assessment Summary

Field studies were conducted and the ecology of AOC 32 and surrounding areas was characterized. This characterization involved the identification of plant and animal communities, as well as observations of any actual or potential effects of chemical and/or physical stress on these biological resources. In general, four different plant community types were identified; three upland communities and one wetland area.

Based on the field surveys and data collected during the RI sampling effort, other than the human disturbance/development in the area, there appear to be only chemical stressors present at AOC 32. Since the human activities (i.e., roads, buildings, mowing, etc.) have been present for a number of years, the vegetation and wildlife have adapted to these changes. Therefore, the presence of human activity in the area is not considered a physical stressor to the ecological community, but rather a defining character of the existing community. No species of concern were identified on site during the field surveys, and none of these species were considered likely to be significantly exposed to site contaminants. Therefore, risks to federal- or state-listed species were not quantitatively evaluated.

AOC 32 is a potential source of environmental contamination in drainage ditch sediment. The drainage ditch is a narrow, linear area surrounded by areas of human activity. Therefore, the site will support only a few individuals that are tolerant of human activity, and the potential impacts to plant or animal populations as a whole are minimal. Furthermore, wildlife are not likely to be adversely affected due to the comparatively limited extent of the contamination. Contamination of the drainage ditch does not appear to be extensive. The maximum concentrations of contaminants of potential concern (COPCs) were found within 60 yards of the culvert, and the sample taken furthest downgradient showed significantly lower concentrations of COPCs. Therefore, the ecological significance of this contamination is considered to be minimal.

Metals and organic chemicals in drainage ditch sediments at the DRMO Yard are not considered to pose significant risks to ecological receptors. Levels of cadmium and nickel exceed reference values for invertebrates, but these exceedances are not likely to be ecologically significant, due to the limited extent of contamination. Potential risks of contaminants to wildlife species such as small mammals and carnivores are minimal. Therefore, no further action is considered necessary at the DRMO Yard to further investigate or to mitigate ecological risks of sediment contamination at the site.

1.2.2 Petroleum, Oil, and Lubricant (POL) Storage Area - (AOC 43A)

1.2.2.1 Site Description

The POL Storage Area is in the northeast portion of the Main Post adjacent to Shepley's Hill Landfill. It is located across Market Street from the DRMO Yard and is bounded on the south, west, and north by Antietam Street, Cook Street, and Market Street (Figure 1-4). The POL Storage Area served as the central distribution point for all gasoline stations at Fort Devens during the 1940s to 1950s. It was subsequently used to store fuels for various purposes and is currently used to store fuel for military vehicles. The distribution facility formerly consisted of a main gasoline station building (T-401), a pump house, three 12,000 gallon USTs, two 12,000-gallon above ground storage tanks (ASTs), and two 8,000-gallon ASTs. Gasoline was delivered to the facility by rail cars where it was transferred to the tanks. Tanker trucks delivered the gasoline to the other stations on base.

Four ASTs originally located in a pit behind T-401 were removed between 1965 and 1972. The three USTs located beneath the pump house were excavated from the site in 1989 and 1990 (*Fort Devens Tank Replacement Project Final Report*, Environmental Applications, Inc. [EA 1990]). After removal of the USTs and 800 cubic yards of contaminated soil, confirmatory soil samples were collected from the excavation and analyzed for TPHC. The highest TPHC concentration was 237 milligrams per kilogram (mg/kg) (EA 1990). The excavations were backfilled and no further soil removal has occurred at this area. Five new USTs were installed in the POL Storage Area in 1991. These USTs are used to store fuel for military vehicles.

The POL Storage Area consists of a fenced lot located within a developed industrial area of buildings, roads, and grass lots with the exception of the east side of the site, which is bounded by a wooded area on a rock outcrop. With the exception of the wooded area, the ground is flat, with only two or three feet of relief throughout. A set of railroad tracks, formerly used to transport gasoline to the site, is on the north side of the site. The UST area is fenced and an asphalt driveway leads from Antietam Street through a gate. The driveway is bermed to contain any spills. A pump station is located in the center of the fenced area and the new USTs, with associated filling points, are located on the eastern side.

The majority of the POL Storage Area site is developed and/or maintained and provides minimal habitat for wildlife. The centrally located portion of the AOC is paved, and it is surrounded by a grass area that is regularly mowed. Located to the east of this grass area is a small wooded lot that consists of mature oak trees. The remaining area includes buildings, roads, and parking lots. The paved area and buildings are fenced. Surface drainage is internal, as the POL Storage Area is in a shallow closed depression. Overall, this site does not support a variety of wildlife species due to the limited habitat types and the constant human activities. Approximately 14 species of concern are known to occur within 1.5 miles of the POL Storage Area site, but none were observed during the field survey. One area located approximately 0.5 mile north of the site is identified as an estimated habitat of state-listed rare wetlands wildlife (MNHESP 1993).

1.2.2.2 Geology and Hydrology

Bedrock beneath the site is Ayer's Granite (granodiorite or granodioritic gneiss). The site lies within a north-northeast trending glacial lake terrace fragment that connects the entrance to Shepley's Hill Landfill with the POL Storage Area. Shepley's Hill is located to the northwest and other bedrock outcrops are located to the east and northeast. Soils are all sandy or gravelly, but probably no natural soils occur undisturbed in this area because of construction activities.

Groundwater at the POL Storage Area is encountered at depths ranging from 17.4 feet BGS to 27.9 feet BGS as measured in March 1993. Groundwater at the site is found within the unconsolidated overburden with local flow directions probably influenced by bedrock surface configuration. The direction of groundwater flow is initially to the southwest toward Willow Brook and then turns north, around Shepley's Hill, to the Nashua River. A watershed divide is located north of the site, separating water draining to the west towards Willow Brook from water draining to the east towards Plow Shop Pond. The POL Storage Area is bounded on three sides by asphalt roads and on the east side by a wooded rock outcrop. The ground within these roads is a shallow depression which would have to flood in order to overflow into the storm drain catch basins located in the southwest corner of the area. Surface drainage off the site could occur only if the ground is frozen, or during very exceptional storm events.

1.2.2.3 Nature and Extent of Contamination

A discussion of screening values, which were used in the RI to evaluate the analytical data, appears at the beginning of Section 1.2.1.3.

Surface Soils

Ten surface soil samples were collected from the POL Storage Area. The samples were analyzed for TAL metals, TCL polynuclear aromatic hydrocarbons (PAHs), TCL pesticides/PCBs, and TPHC. Seven metals in surface soils exceed background: arsenic, calcium, cobalt, copper, lead, nickel, sodium, and zinc. Arsenic exceeded screening levels in one sample.

Organics in surface soils included DDT, DDE, DDD, alpha-BHC, nine PAHs, and heptadecane. Five PAHs exceeded screening values in one sample. The levels of TPHC are very low (less than 20 μg/g to 102 μg/g) considering their location within a POL area.

Subsurface Soils

One hundred eighty-three subsurface soil samples were collected from boreholes during field activities at the POL Storage Area. The samples were collected at intervals approximately 5 feet above the water table, at the water table, and 5 feet below the water table. Most of the samples underwent field screening analyses for BTEX and TPHC. Fifteen of the subsurface samples were collected in July 1993 and laboratory analyzed for TCL VOCs, TCL PAH, TCL pesticide/PCBs, TAL metals, and TPHC. Metals analyses were performed on all soil samples collected from confirmation (i.e., laboratory analyzed) borings to determine if they are also contaminants of concern at AOC 43A. Eighteen samples were collected from six confirmation boreholes, and metals were not elevated above screening values. No lead levels above background were noted, for example. Three of 18 soils showed arsenic slightly above background. Calcium and sodium exceeded background in six and one sample(s), respectively, but this is probably due to natural variations. The same can be said of cobalt (two above background), and nickel and zinc (one above background each). There is no evidence of site related contamination.

Subsurface soils from the confirmation boreholes showed relatively high TPHC in two boreholes. One of these samples (21,000 μg/g) exceeded the screening value of 5,000 μg/g. All other samples ranged from non-detect to 152 μg/g, with an average positively identified level of only 31 μg/g. Other organics noted include 2-methylnaphthalene and several other base/neutral and acid extractable organic compounds (BNAs) related to fuels, such as pentadecane, hexadecane, and phenanthrene at lower levels. Only one pesticide, DDT, was noted at trace levels in two samples.

Two large hydrocarbon plumes and one small one were detected in field screening data. The easternmost plume originates at the site of the removed USTs, inside the fenced area. A second plume originates on the western side of the POL Storage Area at the site of the former ASTs. The third plume apparently originates from the building across Antietam Street from the POL Storage Area. Isolated detections were made at other points in the vicinity; however, they appear to be unrelated to the three plumes.

The easternmost plume is approximately 120 feet long by 100 feet wide. This plume has the highest concentrations of TPHC at the POL Storage Area (30,000 mg/kg at 25 to 27 feet BGS). The water table is within this depth range in the area. No BTEX compounds in soil were detected within the boundaries of the easternmost plume. Two confirmation boreholes were drilled in this area. The data for TPHC correlated well between the field screened samples and those sent to the laboratory for analyses. A cross-section of the easternmost plume depicts a classic UST release. From about 10 feet to 20 feet, the plume is approximately 30 feet wide. It then flows southeast down the slope of the top of bedrock or of the less permeable sediments on top of the bedrock and appears to spread out on top of the water table, to both northeast and southwest. Because the hydraulic gradient slopes to the southwest the plume is deeper in this direction, but it appears not to have extended for more than seventy or eighty feet in that direction from where it encountered the water table (at B-21S).

The westernmost soil plume at the POL Storage Area is approximately 120 feet long by 90 feet wide. Concentrations of TPHC in screening samples from this plume are much lower than in the easternmost plume - the highest TPHC concentration was 520 mg/kg. BTEX compounds were detected in screening samples from three boreholes at the POL Storage Area and all of them were within this plume. BTEX levels were 100,000 mg/kg at one soil boring. No BTEX compounds were detected in the soil samples collected from the confirmation borehole or from the monitoring well, making the BTEX screening results questionable. The main difference between the origin of the two plumes is that the westernmost plume release occurred essentially at the surface whereas the easternmost release occurred below surface. From about 23 feet BGS (where the first sample was collected) to the top of the water table, the western plume is only 30 feet wide. As seen in the other plume on site, the product migrated vertically through the vadose zone before reaching groundwater. It is likely that the hydraulic gradient in the area of the release limited any movement to the northeast. The plume is migrating in a southwestern direction from the source area with the direction of groundwater flow.

A third plume also appears to exist at the site with its origin near the lawn machine maintenance building across Antietam Street from the POL Storage Area. During the screening sample program, BTEX compounds were detected at a high of 4,700 mg/kg. However, confirmation boreholes for these two borings did not confirm these results. Confirmation boreholes had TPHC detections of 23.7 mg/kg and <20 mg/kg, respectively, and no BTEX. The results suggest a high background was present during the screening analysis and that TPHC may not be a problem in this area.

Several boreholes, apparently unrelated to the identified plumes, showed TPHC. An isolated hit was detected in front of Building 213. Three soil borings in the parking lot across Antietam Street from the POL Storage Area had TPHC levels ranging from a high of 180 mg/kg to 56 mg/kg. However, two boreholes drilled between these borings did not have any measurable TPHC levels and the results suggest variability in the screening analysis and in the distribution of TPHC in soils.

Groundwater

Groundwater samples were collected from wells during five separate sampling rounds. Samples were analyzed for both total and dissolved TAL metals, TCL VOCs, pesticides/PCBs, and PAH, explosives, and TPHC. No BTEX levels exceed screening values and screening values for TPHC are exceeded in the eastern plume only, at 43MA-93-04X.

Filtered and unfiltered metals analyses were conducted on all water samples collected from the newly installed monitoring wells. Filtered metals were collected from all previously installed wells during the third round of sampling and only from selected wells during earlier rounds of sampling. Silt and clay particles in the water often result in metals levels in unfiltered samples that exceed MCLs. To determine the level of soluble constituents, the samples were filtered through a 0.45 micrometer (μm) barrel filter. Low solubility metals such as aluminum and iron were greatly reduced, while soluble metals such as sodium and calcium were much less affected.

All of the wells exceed screening values for aluminum, iron, manganese, and sodium in unfiltered samples. Except for one monitoring well, screening values for manganese are exceeded in all unfiltered samples. Other metals were detected at levels exceeding background or screening values. The wells with the highest aluminum and iron level also had the highest levels of other metals, which implies a relationship between the presence of particulates and the content of metals in groundwater.

Filtered samples from these wells have markedly lower levels of inorganics indicating that the majority of the metals are in the suspended solids. Levels of calcium, sodium, potassium, and magnesium show little change because their compounds are more soluble than those of iron and aluminum. The maximum level of iron in filtered samples was 1,560 μg/L (in 43MA-93-10X). This level is essentially the same as in the unfiltered sample. All other levels of iron in filtered samples decreased to less than 1 percent of the unfiltered levels. Aluminum levels exceeded background in four wells. Weathering of alumnosilicate bedrock may account for the levels of aluminum detected at AOC 43A. This is increased by low pH in poorly buffered soils such as those that occur at Fort Devens. Manganese levels are above background in all wells except two. Manganese was above background in one well, which although hydraulically upgradient to the POL Storage Area is downgradient of DRMO where it was concluded that elevated levels of naturally occurring manganese exist. With the exception of manganese, which apparently occurs naturally at the site, the data collected do not indicate the presence of dissolved metals resulting from site activities. The background level of dissolved iron is exceeded in one monitoring well, but this appears to be localized as samples from two nearby downgradient wells do not yield levels above background.

Groundwater samples, collected from the boreholes after soil samples were collected, were screened in the field for the presence of BTEX and TPHC. The screening samples suggest that BTEX and TPHC contaminated groundwater occurs as two plumes at AOC 43A. The contamination is apparently a result of the release of petroleum products from ASTs, USTs, and associated piping. The levels of contaminants in groundwater are distributed in the same general pattern as soil contamination. The groundwater plumes are longer and narrower due to the greater mobility of the contaminants in groundwater.

The eastern plume measures approximately 140 feet long by 80 feet wide. TPHC concentrations in groundwater range from 17,000 µg/L to 53 µg/L at the downgradient edge of the plume. Total BTEX concentrations range from a high of 3,550 µg/L to 85 µg/L. The western groundwater plume measures approximately 150 feet by 60 feet. TPHC concentrations range from 4,100 µg/L to 43 µg/L at the downgradient edge of the plume. BTEX concentrations are the highest contaminant concentrations on site ranging from 29,990 µg/L to 74 µg/L.

Isolated detections of TPHC and BTEX compounds were encountered in other boreholes during the screening program. The source of the TPHC material is unknown. These boreholes were located in the fork of the railroad tracks. Gasoline shipments were offloaded from rail cars to the various tanks at this point and it is likely that these detections are the result of spills. It is likely that BTEX and TPHC detected in screening samples were sorbed on particles in the inevitably turbid samples at the bottom of the boreholes. BTEX and TPHC may therefore exist at much lower levels as dissolved components of groundwater.

Samples collected from monitoring wells using USAEC procedures underwent analyses for TAL metals, VOCs, PAHs, explosives, and TPHC utilizing full laboratory methods. Generally, results for BTEX and TPHC were significantly lower than the screening results, indicating a poor correlation for the screening results. Only a few VOCs were detected in groundwater. Trichloroethene was detected in three wells, and exceeded its screening value in one but was not found in any wells downgradient of AOC 43A and is clearly coming from the DRMO Yard area. Acetone was detected at 23.0 µg/L, but this detection did not exceed any screening values. This compound was detected in one well only. The sample collected three months later was non-detect for acetone, which is a common laboratory contaminant. Xylene was detected at levels of 22 µg/L and 13 µg/L, respectively. The locations of the wells place them inside of the eastern BTEX plume. These levels are below the screening value for xylene. No BTEX compounds were found in any other wells.

2-Methylnapthalene was detected in two monitoring wells at levels exceeding screening values. 2-Methylnapthalene is a semivolatile component of gasoline and fuel oil. In the first well, the detection was in March 1993; a sample collected three months later was a non-detect. The detection in the second monitoring well took place in November 1993, the only round this well was sampled. TPHC was detected in all wells at the POL Storage Area either in or downgradient of the source areas. The maximum level of TPHC was 7,820 µg/L in a monitoring well which is in the eastern plume at the approximate point of the UST release. A monitoring well approximately 80 feet southeast had a TPHC level of 1,250 µg/L. Both of these levels exceed screening values. A monitoring well located approximately 1,000 feet west of the POL Storage Area had a TPHC concentration of 742 μg/L. The contamination detected does not appear to be related to activities at the POL Storage Area. A gravel-covered storage yard and an unpaved road are near this well and probably are the sources of this contamination.

Essentially, the BTEX and TPHC detections in screening samples were not confirmed in groundwater samples taken from completed monitoring wells (except for one TPHC hit of 7,820 μg/L). Wells were completed in the"hot spots" as revealed by the field screening, but the well samples showed only sporadic hits at concentrations much lower (by orders of magnitude) than field screening detections. In fact, the groundwater screening samples were determined to not be representative of the groundwater conditions, based on sampling methodology. Borings were advanced with an auger bit until the water table was reached. Groundwater filled the hole, and this water was sampled. Any contamination which may have been present in the soils would be free to fall down into the water in the bottom of the borehole. Therefore, it is not possible to differentiate between contamination in the groundwater and contamination in the soils (BTEX was also not confirmed in soil samples) from field screening samples. Furthermore, it was not possible to purge the water samples obtained from field screening methodology, as is normal protocol for well sampling. These are the reasons confirmatory sampling was planned. The fact that well samples did not confirm screening samples makes the screening sample results highly questionable as representative of groundwater quality.

Explosive compounds were detected in three wells at or near the POL Storage Area. Two of the wells are located at the site, while the third well is located approximately 950 feet west of these two wells. Nitroaromatics detected at the two site wells include: 1,3,5-trinitrobenzene (1,3,5-TNB), 2,6-dinitrotoluene, 2-amino-4,6-dinitrotoluene, 4-amino-2,6-dinitrotoluene, and 3- and 4-nitrotoluene. According to available information, the POL Storage Area has never treated, stored, or disposed of explosive compounds, and therefore the origin of these compounds is unknown. Levels detected at the third well were 1,3-dinitrobenzene (1,3-DNB), 2,6-dinitrotoluene, 2-amino-4,6-dinitrotoluene, 2-nitrotoluene, 3-nitrotoluene, and Cyclonite, at levels below any screening values. The origin of these detections are unknown. The detection of explosives in the groundwater correlates directly with high levels of TPHC and may not be related to explosive contamination. PAHs were detected in two wells. They are often found as a result of incomplete fossil fuel combustion. 2-Methylnaphthalene exceeded its screening value in two samples.

Surface Water and Sediment Samples

There are several storm drain catch basins at the junction of Cook Street and Antietam Street, with one on the southwest corner of the POL Storage Area. These inlets, and several others along Antietam Street convey storm water to Willow Brook adjacent to the primary school west of AOC 43A. Another storm drain, now only a surface ditch, began within the Coal Pile area across Cook Street (west) from the POL Storage Area. This passes north of the primary school and this drainage also discharges to Willow Brook. Arthur D. Little, Inc. sampled at the head and at the discharge points of these drains. Other samples were taken at various points in Willow Brook including from the outlet of Robbins Pond, below the pond, and opposite the base chapel.

All these sediments contain moderately high levels of organic carbon and TPHC above background. Of the locations that could be affected by AOC 43A or the DRMO Yard, the Coal Yard catch basin sample has the highest total organic carbon (TOC), and the sample at the junction of Cook and Antietam Streets has the highest TPHC. This is also the only sample in this sample set of a catch basin at a heavily travelled intersection, but it has a much lower TPHC than other catch basins further south down Cook Street that could not be affected by the AOCs. There are three groups of organics found, PAHs, pesticides, and phthalates, and a few hits of individual compounds such as toluene and dibenzofuran. No pattern of contamination attributable to a single source is observable, nor are there correlations between levels of contaminants within a sample. TOC does not correlate with TPHC or high levels of organic compounds nor do PAHs correlate with TPHC levels. There is no evidence of any specific impact from the DRMO Yard or the POL Storage Area on Willow Brook either via storm drain or groundwater discharge. In the brook, levels of PAHs, TPHC, total organics, and pesticides all rise from a lower level at Robbins Pond to a higher level at some intermediate point and then decline at the downgradient (north) end of the brook. TOC varies both up and down along the brook but the highest value is found at the downgradient end of the brook.

None of the levels of metals in these sediments is above background or seems to indicate contamination.

1.2.2.4 Human Health Risk Assessment Summary

The main exposure pathway under current site conditions is direct contact (dermal contact and incidental ingestion) with contaminated surface soils and sediment. Potential receptors include POL Storage Area workers and site visitors, which include trespassers. Because volatile and semivolatile compounds were detected infrequently and at low concentrations, vapor inhalation is not considered to be a significant exposure pathway at the site. Inhalation of contaminated dust is not regarded as a major exposure pathway under existing conditions because wind erosion of surface soil is limited by pavement and vegetative cover. However, if the cover was removed and soils were excavated for some reason, such as maintenance of utility lines that run under the site, workers could potentially inhale airborne dust from soils and come into direct contact with subsurface contaminants for a short period, probably several days. The area where the POL Storage Area is located will be released for redevelopment following installation closure, and the area is intended to be zoned for industrial/commercial use. If the site is redeveloped for commercial use, construction workers potentially could be exposed to surface and subsurface contamination by all of the pathways described above over a period of several months during excavation and construction. After redevelopment, future workers may be exposed by the same pathways as current workers, assuming similar soil coverage with pavement or vegetation.

Groundwater in the vicinity of the site currently is not used for water supply purposes, so direct contact with groundwater contamination is not possible under current conditions. However, future businesses could conceivably install private wells in the area, and future workers potentially could be directly exposed to groundwater contamination through ingestion of drinking water. The McPherson Well, a public supply well, is nearly 4,000 feet hydraulically downgradient from the POL Storage Area. As discussed in the RI Functional Area II Report, Volume III, Section 6, contaminated groundwater is not expected to reach this well (E & E 1994a) from either the DRMO Yard or the POL Storage Area. (The recently completed groundwater model, presented as Appendix A, confirms this expectation.)

Under current EPA Superfund Policy (USEPA 1992c), acceptable exposure levels for carcinogens are generally those that represent an excess upper bound lifetime cancer risk of between 10^{-4} and 10^{-6}. For noncarcinogens, acceptable exposures are those with a HI of 1 or less. The estimated cancer risk to current site workers from exposure to contamination in the surface soil at AOC 43A is 2.1×10^{-5} for the RME case, and 2.8×10^{-6} for the average exposure case, within the acceptable range of 10^{-4} to 10^{-6}. Estimated cancer risks for adult site trespassers were approximately half as great. Nearly all the estimated cancer risk is due to ingestion and dermal absorption of arsenic (85 percent) and ingestion of carcinogenic PAHs (15 percent). The noncarcinogenic HIs are less than 1 for the exposure scenarios under current site conditions.

Several alternative exposure scenarios that could occur under possible future site conditions were evaluated. Two scenarios (Scenario 3 - Future Construction Workers and Scenario 4 - Future Site Workers) address potential exposure to contaminants in soils by ingestion, dermal contact, and inhalation of ambient air (construction workers only). The last scenario (Scenario 5 - Groundwater Usage) addresses potential ingestion of contaminants in groundwater. Scenarios 3 and 4 were structured and evaluated as mutually exclusive alternatives. The site worker exposure scenarios assume permanent full-time employment. The construction workers are assumed to be a separate group of workers who move elsewhere to other construction projects once construction on the site is completed. While some construction workers conceivably could take permanent jobs at the site after construction work is completed, this is considered unlikely. Therefore, construction worker risks are not summed with the permanent worker risk estimates.

For future construction workers exposed to surface soil contaminants, estimated cancer risks are 2.2×10^{-5} for RME cases and 3.0×10^{-6} for the average case, which fall within the 10^{-4} to 10^{-6} range deemed acceptable by the EPA. The majority of this risk (83 percent) is due to arsenic; carcinogenic PAHs account for approximately 17 percent of the total cancer risk for the future construction worker scenario. PAHs were considered in risk calculation for the ingestion and inhalation pathways only as there is no approved slope factor for evaluating the dermal contact route. Noncancer HIs total 4.7 for the RME case and 0.75 for the average exposure case. Most of the RME total is due to ingestion and dermal absorption of arsenic, with a total HI of 4.1. Arsenic was the only COPC with an HI greater than 1.0. It should be noted that PAH and elevated arsenic detections were highly sporadic (one of each), and it appears that they represent ambient conditions and not site-related contamination.

Under potential future site conditions, the estimated potential cancer risk to future site workers from exposures to soil is 1.0×10^{-4} for the RME case and 1.4×10^{-5} for the average case. The future RME risk is higher than the current RME risk because the risk calculation assumes that the future workers will spend their entire work day at the site, whereas the current site worker is only at the POL Storage Area for approximately one hour per day. Under future conditions, the worker HIs were greater than the current exposure HIs, but were still less than 1.

The potential risks associated with the possible use of site groundwater as a potable water source by a business occupying the site in the future, a highly unlikely possibility due to the existence of a public water supply system in the area and the low yield of the local aquifer, was evaluated at AOC 43A. A large portion of the estimated groundwater risks were due to metals, and a large portion of many of the metal concentrations found in the unfiltered groundwater samples appear to be associated with suspended sediment (soil minerals) which would not be present in groundwater used as drinking water. Therefore, for the POL Storage Area, potential risks were estimated two ways:

- Using concentrations of COPCs detected in unfiltered groundwater; and

- Using metals data from filtered groundwater to exclude the effects of suspended sediment.

At the POL Storage Area, estimated potential cancer risks from consumption of groundwater based on data from unfiltered groundwater samples are 1.9×10^{-4} for the RME case, exceeding EPA's acceptable range, and 4.1×10^{-5} for the average exposure case. Almost all of the potential risk is due to ingestion of beryllium (>99 percent). However, the highest concentrations of beryllium detected in unfiltered groundwater are associated with high levels of suspended sediments, levels that would not be present in groundwater actually used as drinking water. When metals data from filtered groundwater samples are used to remove the effects of suspended sediment, estimated cancer risks drop more than an order of magnitude to 3.3×10^{-6} and 2.4×10^{-6} for the RME and average exposure cases, respectively. It should also be noted that the risk factors for beryllium are derived from laboratory experiments using soluble salts such as beryllium sulfate, while the beryllium at the POL Storage Area is almost certainly in the form of beryl (beryllium aluminum silicate) or beryllium oxide, which are very insoluble and therefore biologically inactive. So these risks are extremely unrealistic.

Total HIs for noncarcinogenic effects from consumption of groundwater at the POL Storage Area, based on data from unfiltered groundwater samples, are 21 for the RME case and 3.9 for the average exposure case, both above the acceptable HI of 1; the HI for the RME case is mostly due to manganese (HI = 16) and lead (HI = 3). However, the elevated concentrations of many metals in the groundwater are associated with high levels of suspended sediments. When the HIs are recalculated using metals data from filtered groundwater samples, the total HIs drop to 2.7 and 0.8 for the RME and average exposure cases. Manganese was the only COPC in filtered groundwater with a HI greater than 1.

Future permanent site workers could be exposed to contaminants in both the soil and the groundwater; therefore, the estimated soil and groundwater risks should be summed for this group of potential receptors. The highest estimated soil risks are for a future worker and the highest estimated groundwater risks are for unfiltered groundwater. Combining these risk estimates gives a maximum estimated RME risk of 2.9×10^{-4} due mostly to the ingestion of groundwater. The highest plausible future worker risk is the sum of risks from soil exposure and usage of filtered groundwater. Any future use of area groundwater as drinking water is unlikely because of the existing public water supply system and the low yield of the local aquifer; therefore, the most realistic future worker risks are those for the future site worker from potential exposure to soil contaminants alone.

The site contaminants estimated to pose potential excess lifetime cancer risks greater than 10^{-6} include arsenic, beryllium, and PAHs. Site contaminants that pose potentially significant noncarcinogenic adverse health effects via ingestion or dermal routes include arsenic, lead, and manganese.

The major factors driving estimated site risks are:

- The presence of arsenic in site soils and potential exposure to it by site workers and visitors; and

- The presence of elevated concentrations of metals (beryllium, lead, and manganese) in the groundwater coupled with the possible future use of groundwater as a drinking water source.

Exposures to soil contaminants are either currently occurring or could reasonably be expected under current land use conditions, however, the conservative (health protective) exposure assumptions used may overestimate actual exposures. For example, because Fort Devens is slated to close in the near future, the exposure duration of current site workers could be considerably less than the default value of 25 years that was used to estimate worker risks near current site conditions. Furthermore, the identified risks are due to arsenic and PAHs, which were detected very sporadically. Groundwater in the vicinity of the site is not a current or likely future water supply source because there is an existing public water supply system and the local aquifer is of low yield. Therefore, the probability of exposure to site contaminants in groundwater is extremely small.

1.2.2.5 Ecological Risk Assessment Summary

Field studies were conducted and the ecology of the POL Storage Area and surrounding areas was characterized. This characterization involved the identification of plant and animal communities as well as observations of any actual or potential effects of chemical and/or physical stress on these biological resources. Only two plant community types were identified, and both were upland communities.

Based on the field surveys and data collected during the RI sampling effort, other than the human disturbance/development, there appear to be only chemical stressors present at the POL Storage Area. Since the human activities have been present for a number of years, the vegetation and wildlife have adapted to these changes. Therefore, the presence of human activity in the area is not considered a physical stressor to the ecological community, but rather a defining character of the existing community.

The chemical stressors present within the POL Storage Area include metals and organic chemicals that were detected in soils and groundwater at levels exceeding background and ecological criteria. None of these contaminants are considered COPCs for ecological receptors due to the minimal likelihood of exposure. Based on the disturbed/developed nature of the site and the limited abundance and diversity of flora and fauna, there are very few ecologically sensitive receptors or pathways present at the site. The site consists of paved areas, roads, grass, an upland woodlot, and areas of dirt and/or gravel. The areas of dirt are not vegetated and are adjacent to the roads where vehicles park or drive. Some small mammals and songbirds may occasionally visit the grass area to feed, but their frequency of usage is minimal since there are numerous other suitable foraging areas in the general vicinity. Also, their exposure to contaminants while on site is considered to be minimal due to the limited areal extent of contamination. In addition, the vegetation observed in the POL Storage Area during the field survey did not exhibit any signs of stress. In addition, no state- or federally-listed plant or animal species are expected to occur at the site. There are no permanent surface water resources located on the site, and stormwater runoff is piped to Willow Brook. However, the POL Storage Area does not appear to impact Willow Brook. Similarly, the potential ecological risks of groundwater discharge are not evaluated due to the distance of the site from the potential groundwater discharge points.

Since there are no ecologically sensitive receptors exposed to contaminants at the POL Storage Area, no further evaluation of these contaminants is included in the risk assessment. No ecologically significant receptors or pathways are present at the POL Storage Area and, therefore, no risks from site contamination were identified for this site.

1.3 RECOMMENDATIONS FROM THE REMEDIAL INVESTIGATION

The RI report (E & E 1994a) presented recommendations for further action in Section 10 of Volumes II and III from Functional Area II. This Feasibility Study has been developed based on these RI recommendations and subsequent discussion with regulatory agencies.

At AOC 32 on the Main Post (Functional Area II), it was determined that contaminants in the soils of the DRMO Yard pose a potential risk of unacceptable exposure to site workers. This contamination appears to be related to the historical activities at the DRMO Yard and may have impacted the drainage pathways leading from the yard. Therefore, it was recommended that this FS consider remedial action for these soils.

It was determined that there could be a potential risk resulting from the future use of groundwater in this area. However, the risk assessment concluded that the use of groundwater is highly unlikely. Therefore, no remedial action was recommended despite exceedances of screening values at UST 13 and isolated low level exceedances at the DRMO Yard. As a result of discussions with the regulatory agencies, the FS will develop alternatives for UST 13 groundwater and POL Storage Area/DRMO Yard groundwater separately. Organic contaminants in DRMO groundwater have not apparently migrated downgradient into the POL Storage Area, and a recently completed model indicates that further migration of organics contamination will be at very low concentrations. Remedial alternatives will be developed for the POL Storage Area/DRMO Yard groundwater regime, with the continued monitoring of wells downgradient of the POL Storage Area/DRMO Yard.

At AOC 43A, a potential risk was identified under the highly unrealistic scenario of consumption of unfiltered groundwater. The risk is due to beryllium, which is most likely to exist in its insoluble form, and therefore be unavailable for biouptake. Potential risks were also identified in surficial soils, but these risks were due to arsenic and PAHs, which were detected very sporadically, and represent ambient conditions rather than site-related contamination. Field screening samples indicated plumes of BTEX and TPHC in subsurface soils and groundwater. BTEX detections were not confirmed in laboratory confirmation, and the screening data were therefore not considered usable in the risk assessment. Regardless, the existence of BTEX or TPHC in the subsurface (mostly 25 feet BGS) would not pose a risk to human health. Furthermore, it was demonstrated in the recently completed groundwater model that groundwater contaminants would not impact McPherson well. (The modeling was performed using xylene as the contaminant of concern, but would hold for all BTEX compounds, and even more so for TPHC, which is also biodegradable and characterized by more highly sorbing longer-chain hydrocarbons than xylene). The arsenic which was detected in groundwater is most likely to be naturally occurring, and in any case is not mobile enough to impact McPherson well. The POL Storage Area/DRMO Yard groundwater does not pose any realistic risks to human health or the environment and there will be no impact on the McPherson well, under present site conditions. The possibility of remedial action was assessed for AOC 43A/AOC 32, with continued long-term monitoring, because of future potential consumption of groundwater.

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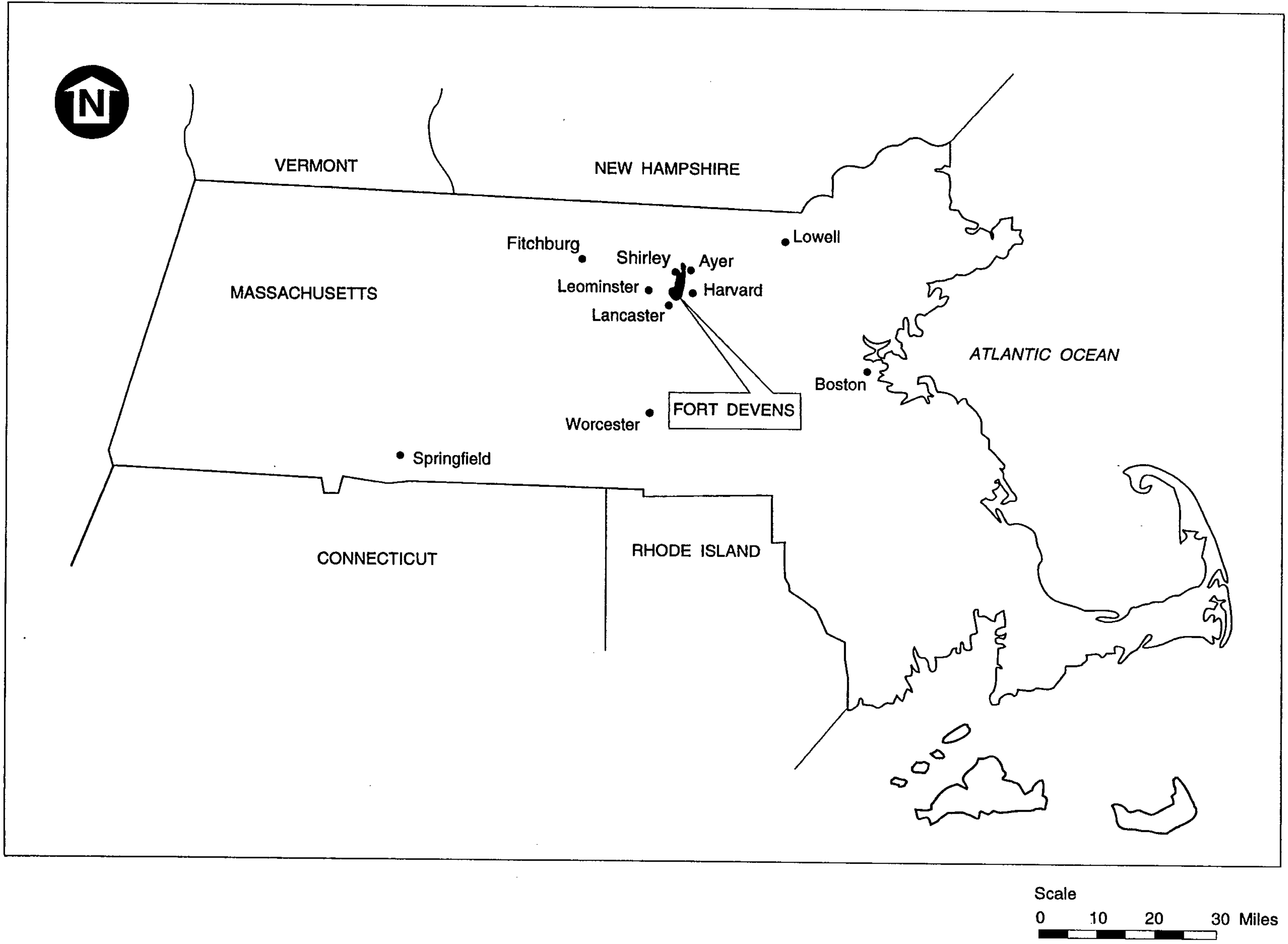

Figure 1-1 LOCATION OF FORT DEVENS IN MASSACHUSETTS

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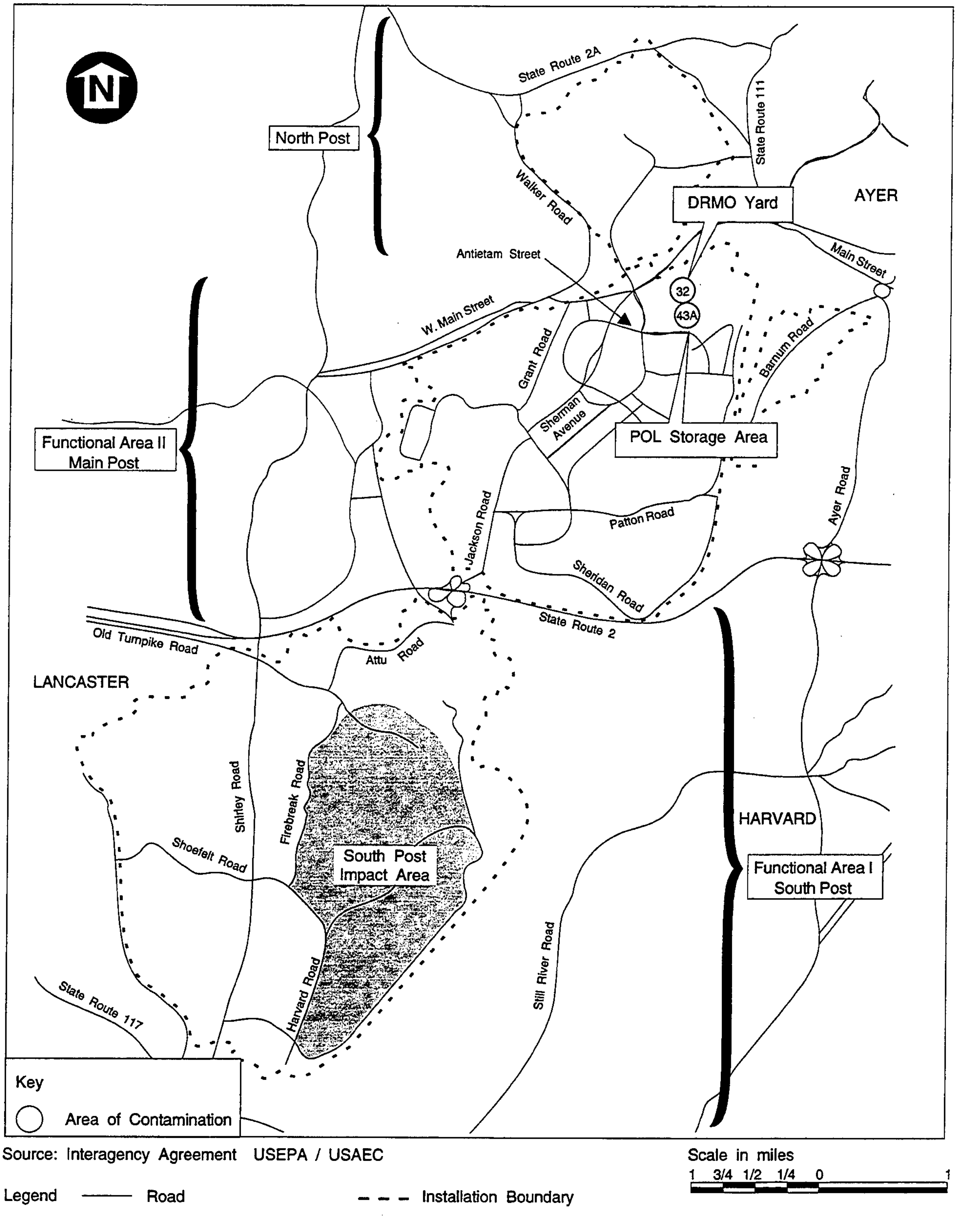

Source: Interagency Agreement USEPA / USAEC

Figure 1-2 LOCATION OF FUNCTIONAL AREA II SITES

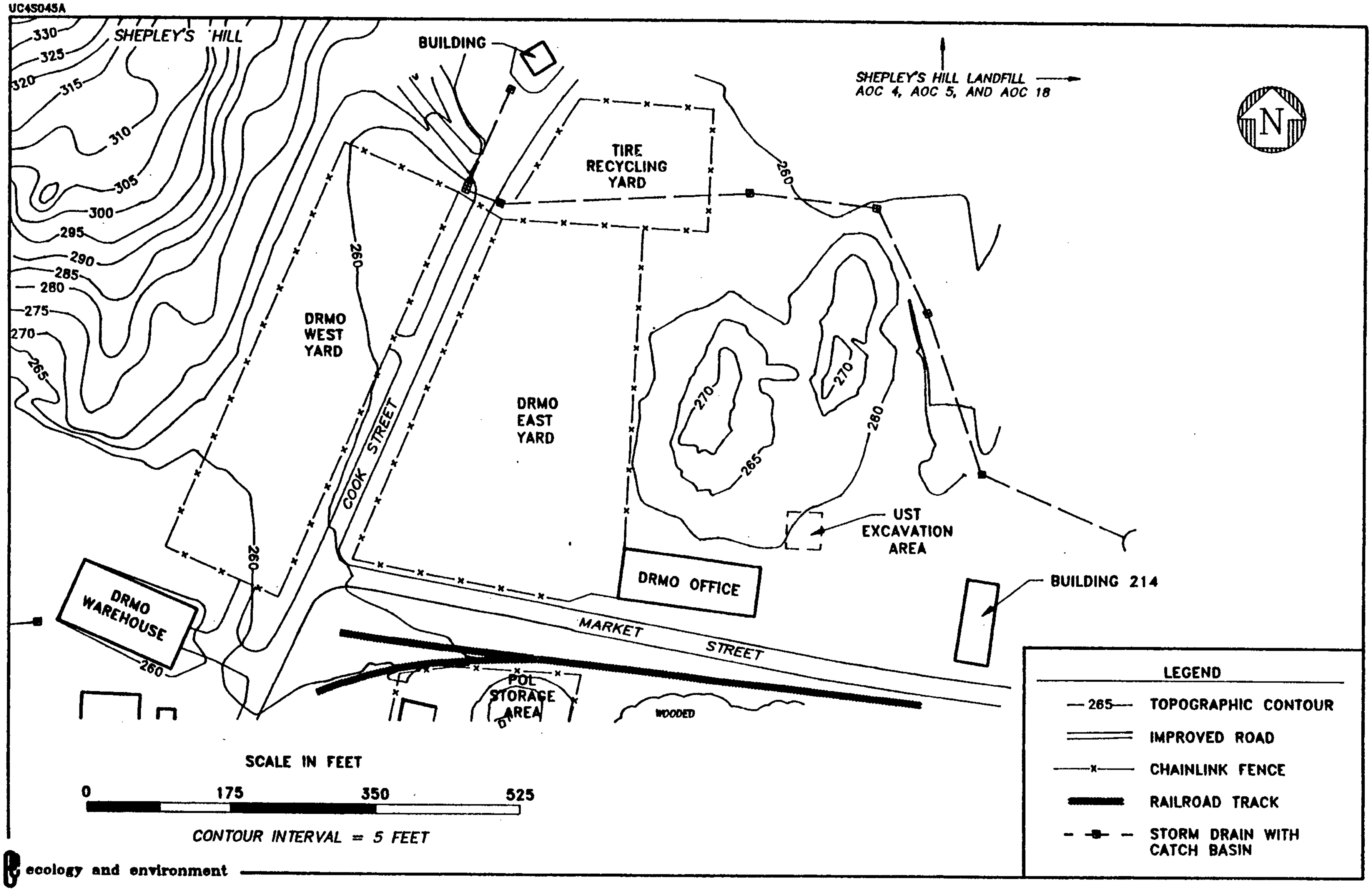

Figure 1-3 SITE MAP OF AOC 32 (DRMO YARD)

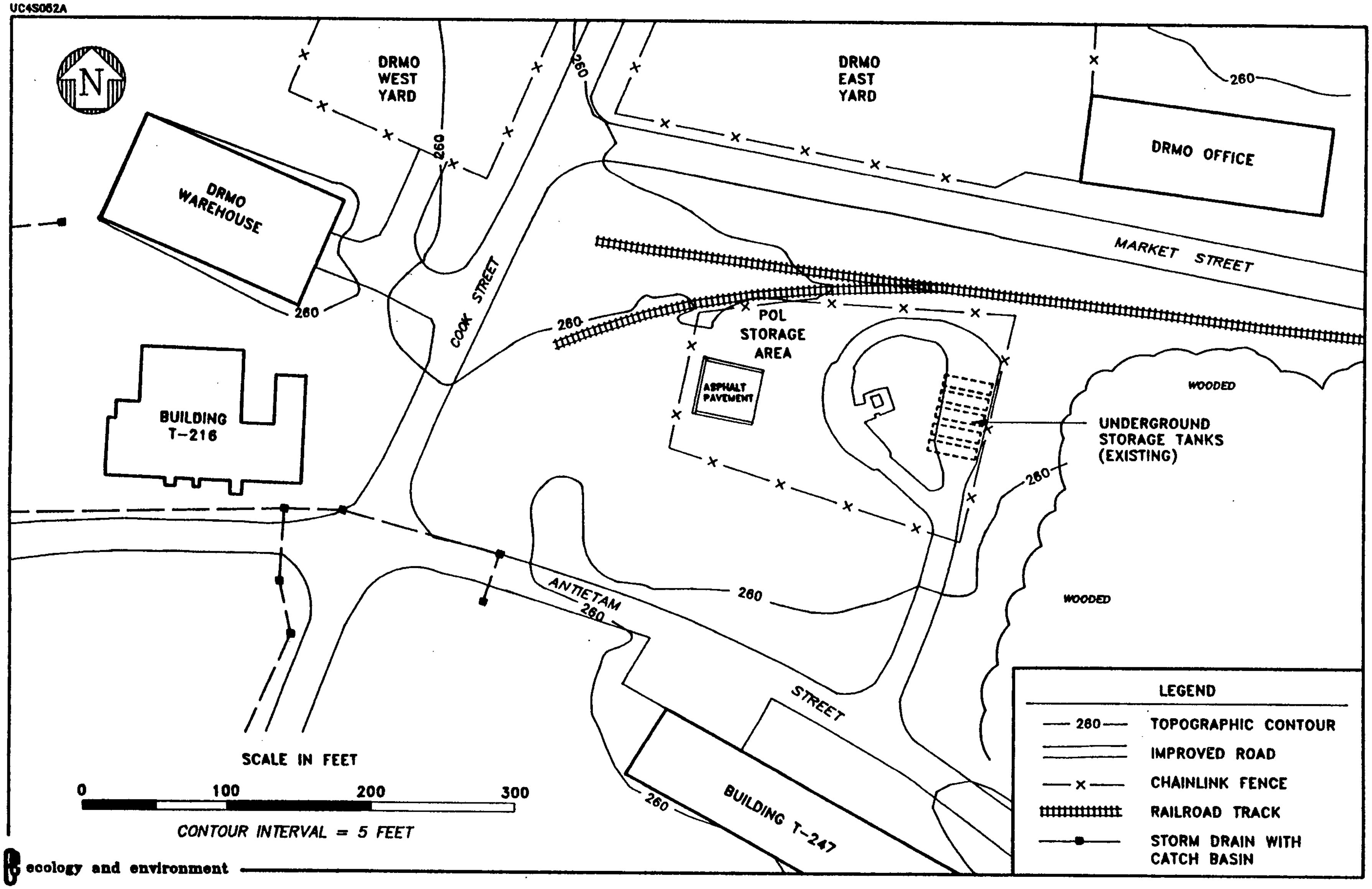

Figure 1-4 SITE MAP OF AOC 43A (POL STORAGE AREA)

2. REMEDIAL ACTION OBJECTIVES AND CLEANUP GOALS

2.1 INTRODUCTION

In this section, remedial action objectives are established for all media (soil, sediment, groundwater, and surface water) at the Fort Devens AOCs. Remedial action objectives exist for the protection of human health and the environment and are developed based on an evaluation of ARARs, TBCs, and findings of the site-specific baseline risk assessment and ecological risk assessment. This evaluation determines the numerical levels which each contaminant must not exceed. Each of these categories is discussed briefly below.

2.1.1 Applicable or Relevant and Appropriate Requirements (ARARs)

Compliance with ARARs is one of the CERCLA criteria to be evaluated for each of the alternatives screened for detailed analysis in Section 5. A remedial alternative must meet this criterion to be eligible for selection as a remedy. CERCLA was passed by Congress and signed into law on December 11, 1980 (Public Law 96-510). This act was intended to provide for "liability, compensation, cleanup, and emergency response for hazardous substances released into the environment and cleanup of inactive waste disposal sites." The Superfund Amendments and Reauthorization Act, adopted on October 17, 1986 (Public Law 99-499), did not substantially alter the original structure of CERCLA, but provided extensive amendments to it.

In particular, Section 121 of CERCLA specifies that remedial actions for cleanup of hazardous substances 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 circumstances at a site. Inherent in the interpretation of ARARs is the assumption that protection of human health and the environment is ensured.

Terms and Definitions

The following is an explanation of the terms used throughout this ARARs discussion:

Applicable requirements are "those cleanup standards, standards of control, and other substantive (non-administrative) environmental protection requirements, criteria, or limitations promulgated under federal or state law that specifically address a hazardous substance, pollutant, contaminant, remedial action, location, or other circumstances at a CERCLA site" (52 FR 32496, August 27, 1987).

Relevant and appropriate requirements are "those cleanup standards, standards of control, and other substantive (non-administrative) environmental protection requirements, criteria, or limitations promulgated under federal or state law that, while not applicable to a hazardous substance, pollutant, contaminant, remedial action, location, or other circumstances at a CERCLA site, address problems or situations sufficiently similar to those encountered at the CERCLA site that their use is well suited to the particular site" (52 FR 32496).

Requirements under federal or state law may be either applicable or relevant and appropriate to CERCLA cleanup actions, but not both. However, requirements must be both relevant and appropriate for compliance to be necessary. In the case where both a federal and a state ARAR are available, or where two potential ARARs address the same issue, the more stringent regulation must be selected. However, CERCLA Section 121(d)(4) provides several ARAR waiver options that may be invoked, providing that the basic premise of protection of human health and the environment is not ignored. A waiver is available for state standards that have not been uniformly applied in similar circumstances across the state. In addition, CERCLA Section (d)(2)(C) forbids state standards that effectively prohibit land disposal of hazardous substances.

CERCLA on-site remedial response actions must only comply with the substantive requirements of a regulation and not the administrative requirements such as obtaining permits and agency approvals, recordkeeping, reporting, and off-site activities such as waste disposal (CERCLA Section 121(e)). As noted in the ARARs guidance (USEPA 1988a):

> The CERCLA program has its own set of administrative procedures which assure proper implementation of CERCLA. The application of additional or conflicting administrative requirements could result in delay or confusion.

Substantive requirements pertain directly to the actions or conditions at a site, while **administrative requirements** facilitate their implementation. In order to ensure that CERCLA response actions proceed as rapidly as possible, the EPA has reaffirmed this position in the final National Oil and Hazardous Substances Pollution Contingency Plan (NCP) (55 FR 8756, March 8, 1990). The NCP defines on site as "the areal extent of contamination and all areas in very close proximity to the contamination necessary for implementation of the response action." The interagency agreement (IAG) provides additional guidance on the applicability of permitting requirements to response actions at Fort Devens (USEPA 1991c). The EPA recognizes that certain of the administrative requirements, such as consultation with state agencies and reporting, are accomplished through the state involvement and public participation requirements of the NCP.

The Army's interpretation of the applicability of the Massachusetts Contingency Plan (MCP) to AOCs 32 and 43A of Fort Devens parallels guidance provided by EPA in comments dated February 28, 1994 on the Draft Proposed Plan and Final Feasibility Study for AOCs 44 and 52 at Fort Devens (USEPA 1994). In its comments, EPA references the following sentences from the *CERCLA Compliance with Other Laws Manual* 310 CMR 40.0111(1)(a):

> The CERCLA program has its own set of administrative procedures which assure proper implementation of CERCLA. The application of additional or conflicting administrative requirements could result in delay or confusion.

Further reference is made to the MCP at 310 CMR 40.0111 which contains a specific provision for deferring application of the MCP at CERCLA sites. 310 CMR 40.0111(1)(a) provides that response actions at CERCLA sites shall be deemed adequately regulated for purposes of compliance with the MCP, provided the MDEP concurs in the CERCLA record of decision. Thus, it is the Army's interpretation in following EPA guidance that the MCP shall not be considered an ARAR.

ARARs are divided into the three categories listed below:

- **Location-specific ARARs** "set restrictions upon the concentration of hazardous substances or the conduct of activities solely because they are in special locations" (53 FR 51394). In determining the use of location-specific ARARs for selected remedial actions at CERCLA sites, one must investigate the jurisdictional prerequisites of each of the regulations. Basic definitions and exemptions, must be analyzed on a site-specific basis to confirm the correct application of the requirements.

- **Chemical-specific ARARs** are usually health- or risk-based numerical standards or methodologies that limit the concentration of a chemical found in or discharged to the ambient environment. They govern the extent of site remediation by providing either actual cleanup levels, or the basis for calculating such levels. For example, groundwater MCLs may provide the necessary cleanup goals for sites with contaminated groundwater. There are no direct chemical-specific ARARs for soils. Chemical-specific ARARs for the site may also be used to indicate acceptable levels of discharge in determining treatment and disposal requirements, and to access the effectiveness of future remedial alternatives.

- **Action-specific ARARs** set controls or restrictions on particular kinds of technologies or activities related to the management of hazardous waste (53 FR 51437). Selection of a particular remedial action at a site will invoke the appropriate action-specific ARARs that may specify particular performance standards or technologies, as well as specific environmental levels for discharged or residual chemicals. Action-specific ARARs are established under the Resource Conservation and Recovery Act (RCRA), the Clean Air Act, the Clean Water Act, the Safe Drinking Water Act, the Toxic Substances Control Act, and other laws.

Many regulations can fall into more than one category. For example, many location-specific ARARs are also action-specific because they are triggered if remedial activities affect site features. Likewise, many chemical-specific ARARs are also location specific. However, only chemical-specific ARARs are candidates for site cleanup goals. Action- and location-specific ARARs apply to the execution of remedial actions.

The Occupational Safety and Health Administration (OSHA) has promulgated standards for protection of workers at hazardous waste operations at RCRA or CERCLA sites (29 CFR Part 1910). These regulations are designed to protect workers who would be exposed to hazardous waste. Federal construction activities involving no potential for hazardous substance exposure are covered by the OSHA standards found at 29 CFR Part 1926. EPA, in the NCP (40 CFR 300.150), requires compliance with the OSHA standards. OSHA standards are not discussed in the FS, but typically would be addressed in the remedial action site-specific Health and Safety Plan.

The determinations of ARARs in this report have been made in accordance with Section 121(d)(2) of CERCLA. They are also consistent with EPA guidance set forth in the CERCLA NCP (40 CFR 300) (USEPA 1992b); the two-part guidance document entitled *CERCLA Compliance With Other Laws Manual*, Office of Solid Waste and Emergency Response (OSWER) Directives 9234.1-01 and 9234.1-02 (USEPA 1988a); and the document entitled *Guidance for Conducting Remedial Investigations and Feasibility Studies under CERCLA* (EPA-540/G-89/004) (USEPA 1988b).

2.1.2 "To Be Considered" (TBC) Guidance

TBCs are non-promulgated or nonapplicable Federal or State standards or guidance documents that are to be used on an "as appropriate" basis in developing cleanup standards in the absence of federal- or state-promulgated regulations. Because they are not promulgated or enforceable they do not have the same status as ARARs and are not considered required cleanup standards. TBCs include proposed standards, guidance values, criteria, and advisories that are not legally binding, but may serve as useful guidance for remedial actions. These are not ARARs but are "to be considered" guidance. These guidelines may be addressed as deemed appropriate.

2.1.3 Site-Specific Risk Assessments

CERCLA requires that remedial actions meet ARARs and be protective of human health and the environment. The results of the human health risk assessment conducted during the RI were used to calculate contaminant concentrations corresponding to an acceptable risk level. For noncarcinogens, concentrations corresponding to a hazard index of 1 were calculated. For carcinogens, the EPA specifies an "acceptable range" of 10^{-4} to 10^{-6} excess cancer risk to determine site-specific risk-based concentrations. Increasingly, EPA has recommended that a 10^{-4} excess cancer risk be used for risk-based cleanup goals. The MCP suggests that a 10^{-5} excess cancer risk be used for risk-based concentrations, but the MCP is a TBC rather than an ARAR.

Site-specific ecological risks were also evaluated as part of the RI. For the most part, no quantitative risks were identified for any of the Fort Devens sites, although some minimal quantitative risks were calculated for sediments along the storm drainage at AOC 32, discussed in Section 1.2.1. Therefore, for purposes of this FS, no cleanup goals have been established for the sediments.

2.2 DEVELOPMENT OF REMEDIAL ACTION OBJECTIVES

Remedial action objectives (RAOs) are intended to serve as qualitative guidelines for remediation. State and Federal laws, regulations, and guidance documents are reviewed to identify any ARARs or TBCs. Then, the risk assessments are consulted to identify complete exposure pathways. The RAOs are developed for specific media, but not for specific operable units.

The following are RAOs for site-related surface and subsurface soils:

- Prevent direct and indirect contact, ingestion, and inhalation of the soil contaminated with COPCs by human and ecological receptors at levels that could pose risks;

- Prevent erosion and migration of soil contaminated with COPCs to storm sewers and surface water bodies; and

- Prevent COPC migration to groundwater at levels that could adversely affect human health and the environment.

RAOs for site-related groundwater include:

- Prevent off-site migration of COPCs at levels that could adversely affect flora and fauna;

- Prevent lateral and vertical migration of COPCs at levels that could adversely affect potential and existing drinking water supply aquifers; and

- Prevent seepage of groundwater from the site that would result in surface water concentrations in excess of ambient water quality standards.

No RAOs are developed for surface water because it is impractical to remediate this medium directly. Rather, surface water contamination is addressed by proactive RAOs in other media (see soils and groundwater RAOs). RAOs are not developed for sediments because of minimal site impacts.

2.3 APPROACH TO CLEANUP GOAL DETERMINATION

To determine cleanup goals, tables of candidate cleanup criteria are developed and evaluated. A table is developed for each contaminated medium, where ARARs, TBCs, and site-specific risk values are presented for every contaminant found at the Fort Devens Functional Area II sites. These values are then compared, and the appropriate value selected as candidate cleanup goals, according to logic documented for each table. Figure 2-1 shows a generalized approach to selecting cleanup goals. Background values are considered during this process (generally, cleanup goals are not set to levels below background). These candidate goals are then compared to the highest values obtained at the sites for each contaminant. For those contaminants whose maximum concentration is above the candidate goals, the candidate goal is retained as the cleanup goal. For those compounds which are found exclusively below the candidate goal, no further action is warranted, and no cleanup goal is set. Once the cleanup goals are set, the analytical data and the fate and transport conclusions from the RI are reviewed to define the extent of contaminated media that requires remediation.

2.4 SOILS

2.4.1 ARARs

The only ARAR identified for soils is the Toxic Substance Control Act (TSCA) requirement for the remediation of soils contaminated with PCBs. Under 40 CFR 761.125(c)(4), soil contaminated with PCBs in unrestricted access areas are required to be treated or removed such that the PCB concentration in the upper 10 inches of soil is less than 1 mg/kg, and the concentration below this depth is less than 10 mg/kg. These requirements are considered relevant and appropriate for surface and subsurface soil, respectively.

2.4.2 TBCs

Four categories of TBCs have been identified for the Group 1B sites. These are the EPA Region III RBC values, Resource Conservation and Recovery Act (RCRA) corrective action levels, the interim EPA guidance on Soil Lead Concentrations, and background concentrations. Each of these is discussed below.

2.4.2.1 RBCs

The RBCs are listed in the "Risk-Based Concentration Table, January-June 1995" published by the EPA Region III. Although this site is in Region I, these values may be considered as candidates for establishing cleanup goals. These risk based concentrations have been calculated by Region III for nearly 600 chemicals. Toxicity constants from the EPA's Health Effects Assessment Summary Table (HEAST) are combined with standard (i.e., not site-specific) exposure scenarios to calculate chemical concentrations corresponding to a lifetime cancer risk of 10^{-6} or an HI of 1, which ever occurs at a lower concentration. As these represent generic exposure scenarios, they are not intended to be used directly as cleanup goals. However, in the absence of other criteria, they may be considered as candidates for cleanup criteria.

2.4.2.2 RCRA Corrective Action Levels

The proposed RCRA corrective-action regulations were published in 55 Federal Register (FR) 30798, 27 July 1990 (USEPA 1990) as the table "Examples of Concentrations Meeting Criteria for Action Levels" in Appendix A of the FR citation. In this Appendix, a number of "action levels" for contaminants in soils, including contaminants found at Fort

Devens Functional Area II sites, are identified. For purposes of this remediation goals evaluation, these action levels have been identified as TBCs for soils. Although these regulations by definition are intended to establish the need for a RCRA corrective measures study (rather than final cleanup goals), they are the most comprehensive listing of risk-based values for soils available, and thus are regarded as TBCs.

2.4.2.3 EPA Guidance on Soil Lead Concentrations

EPA has also published *Revised Interim Soil Lead Guidance for CERCLA Sites and RCRA Corrective Action Facilities,* EPA OSWER Directive No. 9355.4-12, July 1994. This guidance established a health-based lead soil screening value of 400 mg/kg in a residential area with children. This guidance was developed using the integrated exposure uptake biokinetic (IEUBK) model for exposure of children to lead and is likely to be more conservative than necessary at sites not frequented by children. This guidance contains no values for strictly adult-exposure scenarios.

2.4.2.4 Background Concentration

Also included in the TBC category are background concentrations. These are concentrations of chemicals found in areas known not to be contaminated by site activities. In general (though not exclusively), background concentrations are applicable only to metals. Background concentrations have been calculated for Fort Devens soil from 33 samples: Soil-1 through Soil-20 (August 1991), BKS-21 through BKS-30 (June 1993) and 25S-92-10, 25S-92-12, and 25S-92-13 (October 1992) (E & E 1994). Background concentrations were not considered with other TBCs in the selection of cleanup goals. Rather, the candidate cleanup goal was never set below background (see Section 2.4.4).

2.4.3 Site-Specific Human Health Risks

A site-specific human health risk assessment was conducted as part of the RI. From this assessment, concentrations can be calculated that correspond to carcinogenic health risks in the range of 10^{-4} to 10^{-6} and/or HIs of 1. The risk assessment examined all chemicals (for which slope factors and/or reference doses exist) detected at the Group 1B Functional Area II sites, and calculated carcinogenic and systemic risks for each. Risks above the threshold values were found. Quantitative values were calculated for risks corresponding to a 10^{-5} cancer risk and an HI of 1 for Main Post soils.

Risk-based cleanup levels were calculated by solving for the concentration that corresponds to a 10^{-4} to 10^{-6} estimated excess cancer risks or a hazard quotient equal to 1.0 using site-specific risk estimates and exposure point concentrations developed in the human health risk assessment:

$$RBCL = (Target\ Risk)\ \frac{EPC_{site}}{R_{site}}$$

Target Risk = 10^{-4} to 10^{-6} for carcinogens, 1 for systemic toxicants (unitless).
EPC_{site} = exposure point concentration derived from site data (μg/g).
R_{site} = medium-specific risk value for the EPC_{site}, exposure routes for each medium are summed. For example, risks associated with dermal contact are summed with risks associated with soil ingestion to obtain a total risk value for soil (unitless).
RBCL = risk-based cleanup level (μg/g).

2.4.4 Selection of Cleanup Goals

Table 2-1 presents the criteria discussed above for the Main Post. The following procedure was used to select the appropriate values. For all contaminants except PCBs, the values calculated from the risk assessment were used as candidate cleanup goals. For PCBs, an ARAR existed from TSCA and was selected as the cleanup goal. For any compounds that were not addressed by either of these sources, the lower value of the EPA Region III RBCs or the RCRA corrective action levels was selected as the candidate cleanup goal. If the possible candidate cleanup goal selected by the above procedure was below the background concentration, then the background concentration was selected as the candidate cleanup goal.

Once these candidate cleanup goals were identified, they were compared to the maximum value for each contaminant identified at the Main Post area. If the maximum value observed was less than the candidate cleanup goal, then no areas require remediation, and no cleanup goal needs to be set for that contaminant. If the maximum concentration detected was above the candidate cleanup goal, then the candidate cleanup goal became the cleanup goal.

2.5 GROUNDWATER REMEDIAL ACTION OBJECTIVES

There are several ARARs and TBCs that apply to groundwater at the Fort Devens sites. EPA has defined, as guidance, three levels of groundwater. Classes I and II represent current or potential drinking water sources. Class III represents groundwater that is unsuitable for human consumption (e.g., is very saline) and does not have the potential to affect drinkable water (*EPA Guideline for Groundwater Classification* final draft, December 1986, referenced in 55 FR 8732). The Main Post groundwater, which potentially is within the zone of influence of groundwater extraction wells, would be classified as Class I or II. For these types of groundwaters, several Federal ARARs would apply.

2.5.1 Main Post Groundwater Cleanup Goals

2.5.1.1 ARARs

Main Post groundwater ARARs include MCLs and MCLGs set by the Safe Drinking Water Act, and Massachusetts MCLs (MMCLs) and secondary MCLs (MA SMCLs). The Federal ARARs were originally intended to apply to water within drinking water distribution systems. However, the NCP sets MCLs and non-zero MCLGs as ARARs for potential or actual drinking water sources (40 CFR 300.430(e)(2)(i)(B)). The MMCLs and MA SMCLs are essentially identical to the Safe Drinking Water Act (SDWA) MCLs with a few exceptions.

2.5.1.2 TBCs

Several TBCs have also been identified as candidate cleanup goals for the Main Post sites. These include SDWA secondary MCLs (SMCLs), EPA Office of Drinking Water Health Advisories (HAs), EPA Region III tap water criteria, MDEP Office of Research and Standards Guidance (ORSG) for chemicals for which MMCLs have not been promulgated, and background values. SMCLs are not legally enforceable and address mainly non-health-related issues such as odor or taste. The HAs and Region III criteria are developed using a risk approach, with generic exposure scenarios. Background values are also included as TBCs. In general, it is not necessary to remediate groundwater to below background levels.

2.5.1.3 Site-specific Human Health Risks

Using site-specific exposure scenarios, a risk assessment was performed for the Main Post groundwater. From the results of this assessment, contaminant concentrations corresponding to a carcinogenic risk of 10^{-5} and/or an HI of 1 (which ever is lower) have been calculated.

2.5.1.4 Selection of Main Post Cleanup Goals

The ARARs, TBCs, and health risk values discussed above are presented on Table 2–2. Where available, the most stringent of the ARARs was picked as a potential candidate cleanup goal. If no ARAR was available, the site-specific risk value was selected as a potential candidate cleanup goal. If neither of these options was available for a given compound, then the most stringent of the HAs, Region III tap water criteria, or the MA ORSGs, was picked as the potential candidate cleanup goal. If any concentration selected by this process was below background concentrations, then the candidate cleanup goal was set at background instead. Finally, the candidate cleanup goals were compared against the maximum observed concentration for each compound. If the concentration was found to be above the candidate cleanup goal, then the candidate cleanup goal became the cleanup goal. If the candidate cleanup goal was above the maximum observed concentration, then no cleanup goal was set for that compound. For inorganic contaminants, data from filtered samples were used in the development of cleanup goals. This was done to distinguish between the naturally-occurring mineral presence of metals and dissolved contamination.

2.6 SURFACE WATER REMEDIAL ACTION OBJECTIVES

Three ARARs have been identified for surface water at the Group 1B sites. These ARARs are all ambient water quality criteria (WQC) established under the Clean Water Act (CWA). There are four categories of standards set under the CWA. These are for direct ingestion, consumption of aquatic organisms, acute toxicity to aquatic organisms, and chronic toxicity to aquatic organisms. The surface water at the sites is the Nashua River, and feeder streams and ponds such as Willow Brook and Plow Shop Pond. These water bodies are classified as Class B water bodies by the Massachusetts water quality regulations (314 CMR 4.06). Class B streams are designated as a habitat for fish, other aquatic life, and for primary and secondary recreation. They may also be suitable for use as a source of public water supply, providing appropriate treatment is used. Although some incidental ingestion of water may occur during primary contact recreation, in general, class B waters will not be subject to regular ingestion. Thus, human ingestion WQCs are not considered applicable or relevant and appropriate requirements. The remainder of the WQCs established by the CWA would, however, be appropriate. These ARARs are listed in Table 2-3. The strictest of these ARARs that are not below background concentrations are established as the candidate cleanup goals. The candidate cleanup goals are compared to the maximum observed concentrations; any candidate cleanup goals that are less than the maximum observed concentrations are established as the cleanup goals.

2.7 COMPARISON OF DATA TO CLEANUP GOALS

2.7.1 Definition of Operable Units

Operable units are components of an overall site that can be addressed individually, either as separate areas or as separate media in the same general area. Based on the comparison of the chemical data to the cleanup goals, seven separate operable units in three areas are defined for the Fort Devens sites. The three areas are the DRMO Yard, the UST 13 area, and the POL Storage Area. The UST 13 area was considered part of the DRMO Yard during the RI, but because it is hydraulically and physically isolated from the DRMO Yard, it is considered a separate area in the FS. Soil and groundwater operable units are present within each area. The seventh operable unit is DRMO Yard surface water.

2.7.2 Areas Exceeding Cleanup Goals

The cleanup goals developed have been screened against the contaminant levels found during previous investigations. This comparison provides a description of the areas at the Group 1B sites that require remediation. Samples from both the RI and the site investigation (SI) are included in this evaluation. The inclusion of SI data provide better definition of the extent of contamination at many areas, especially at the DRMO Yard (using the SI surface samples). Areas exceeding cleanup goals, and potentially requiring remediation, are discussed below for each operable unit.

2.7.2.1 UST 13 Soils

The soil at the UST 13 area showed one sample with lead at over 1,000 mg/kg, and another sample with arsenic at 120 mg/kg, both above cleanup goals. It should be noted that additional soils were excavated from the UST 13 area after these samples were taken. These sporadic detections do not warrant the development of remedial alternatives.

2.7.2.2 UST 13 Groundwater

At the DRMO UST area, 1,2-, 1,3-, and 1,4-dichlorobenzene, Aroclor 1260, DDT, 1,2-DCE, and TCE have been found to exceed groundwater standards near the location of the former (now removed) waste oil UST 13. These compounds exceeding standards were found in samples from monitoring wells 32M-92-04X and 32M-92-06X. In addition, benzene was detected just below its MCL in 32M-92-06X. This plume has not migrated far, because it is present in a low permeability bedrock aquifer which has a very low hydraulic gradient. The groundwater will be considered for remediation of these contaminants.

Although bis(2-ethylhexyl)phthalate was detected in one well at approximately seven times the groundwater standard, it is believed that this contamination is due to sample handling.

Metals, including arsenic and iron, were detected in filtered samples at the UST area above groundwater standards. It appears that arsenic reflects residual impacts from the former UST activities; however, these impacts do not appear to extend off site. Iron exceeded its cleanup goal in filtered samples, but at far lower concentrations than in unfiltered samples. This was the case in general indicating the natural presence of iron. Furthermore, based on the risk assessment, iron does not pose a risk to human health. These metals, therefore, will not be considered for remediation.

2.7.2.3 DRMO Soils

At the DRMO Yard, there were several miscellaneous exceedances of cleanup goals for a wide variety of chemicals at the northern perimeter, and on the surface of the asphalt yard (Figure 2-2). Lead was the most consistently detected contaminant, at levels up to 2,260 mg/kg in SI samples. Cadmium was detected above cleanup goals in three soil samples taken during the SI, to a maximum of 78.0 mg/kg. PCBs were also rather widespread in the SI soil samples, with concentrations of individual congeners of up to 5.22 mg/kg as well as in asphalt samples (up to 9.3 mg/kg). DDT and its degradation products DDD and DDE were detected above cleanup goals in two samples in the northeast corner of the DRMO east yard.

There are also two detections of arsenic above the cleanup goals. The cleanup goal is set at the human health risk level of 24 mg/kg. Neither of the detections (33 and 37 mg/kg) is much above this value. The consistency of arsenic detections in the 10 to 20 mg/kg range detections, suggests that they represent normal background arsenic levels. Furthermore, these concentrations represent a conservative risk estimate of just above 10^{-5} (which is in the EPA's acceptable risk range of 10^{-4} to 10^{-6}). Thus the areas to be remediated do not need to necessarily include the areas with arsenic detections. However, most areas where arsenic was detected would be addressed because of lead and/or PCB contamination.

The total estimated volume of contaminated soil requiring remediation at the DRMO Yard was determined, based on the comparison of data to soil cleanup goals and on the extent of contamination presented in the RI, to be approximately 1,300 cubic yards (see Figure 2-3). There are four smaller areas which make up this total contaminant volume. The soils of the southwestern portion of the tire storage area (adjacent to the northern border of the DRMO Yard) accounts for approximately 500 of the 1,300 total cubic yards of contaminated soils. The soils of the center portion of the east DRMO Yard account for approximately 330 cubic yards. The soils of the drainage swales along the western and eastern edges of the DRMO Yard account for approximately 220 and 250 cubic yards, respectively, of the total volume of contaminated soil. The depth of soil contamination in each of these four areas is estimated to be one foot. DRMO soils will be considered for remediation.

2.7.2.4 DRMO Groundwater

Two wells located just north of the DRMO Yard were found to contain manganese at 7,000 to 7,700 μg/L in filtered samples. However, these are upgradient wells, and thus considered background. Three wells, located between the DRMO yard and the POL area were found to contain low levels of TCE. Only one well, POL-3 exceeded the cleanup goal of 5 μg/L with detections of 15 to 19 μg/L. Although it is apparent that these contaminants came from the DRMO Yard, there is no apparent continuing source, nor does TCE appear in downgradient wells. DRMO groundwater will be addressed by the remedial alternatives, and continued monitoring of downgradient wells will be maintained to observe intrinsic natural remediation, and to ensure that cleanup goals will be met in the future.

2.7.2.5 DRMO Surface Water

Surface water at the main post was found to exceed cleanup goals for cadmium, copper, lead, and zinc. It is, however, not generally appropriate to remediate surface water. Rather, addressing the source of contamination is more appropriate. This "surface water" is, in fact, not truly surface water, but drainage runoff flow from the DRMO Yard. Addressing contamination at the DRMO Yard soils would improve the quality of the main post "surface water." The surface water will not be considered for remediation.

2.7.2.6 POL Soils

Isolated hits of arsenic were detected at several different POL Storage Area soil locations. However, only one greatly exceeded the cleanup goals, and no pattern or source of contamination is apparent. These hits include arsenic at a surface concentration of 210 mg/kg 150 feet southeast of the intersection of Cook and Antietam Streets, a low detection of 21 to 27 mg/kg just east of the removed USTs, and a very deep (33 feet) detection of arsenic adjacent to Building T-247 of 2 to 4 mg/kg. As these detections were isolated and/or only marginally above cleanup goals, no remedial action program will be developed.

2.7.2.7 POL Groundwater

Three wells at the POL Storage Area were found to have concentrations in filtered samples above cleanup goals of several naturally occurring metals, specifically, aluminum, iron, and sodium. The sodium was detected above its cleanup goal in wells near Antietam Street, and is expected to be due to street salting in the winter. This is an ongoing operation not subject to regulation, and thus cleanup would not be directed toward this element. Iron and aluminum are naturally occurring compounds, although they are not always detected above their cleanup goals in other wells on site. Iron is not a hazardous metal, and cleanup levels are set for aesthetic reasons (i.e., taste). As it is not considered to be a site contaminant, its cleanup will not be addressed. Aluminum, another naturally occurring metal, was also detected in one sample above its cleanup goal at the POL Storage Area. Its cleanup level is set at the background concentration of 390 μg/L. The POL Storage Area exceedance of 446 μg/L is judged to be within the realm of background concentrations. Thallium was detected in one well at 1.0 μg/L, just above the cleanup goal of 0.5 μg/L. However, this cleanup goal is based on an MCL goal (the MCL is 2). Regardless, it is not appropriate to develop remedial alternatives for such an isolated hit.

A possible explanation as to why naturally occurring metals were slightly higher at the POL Storage Area is from dissolution due to lower pH. Lower pHs were found in wells 43SA93-06X (as low as 4.74), 43SA93-04X (to 5.31), 43SA93-07X (to 5.64), and 43SA93-08X (to 5.16). These wells had the highest dissolved metals concentrations. The low pHs found may be the result of past anaerobic degradation of hydrocarbons released at the POL area prior to UST removal. These compounds degrade to organic acids, which reduce the pH of the groundwater.

Two wells in the center of the POL area had 1,3,5-TNB concentrations of 2.18 and 3.04 μg/L, slightly above the TBC-based cleanup goal of 1.8 μg/L. One well downgradient of the POL Storage Area had a detection of 1,3-DNB above its cleanup goal (also TBC-based) and extremely elevated chlorides (600 to 800 mg/L). DDT and α-BHC were detected above cleanup goals in the same well. This well, approximately 950 feet downgradient of the POL Storage Area, appears to be in a distinct area of contamination from unknown sources, but certainly unrelated to the POL area. Regardless of the source of contamination, these exceedances are not significant enough to warrant a remedial program for this groundwater. However, the groundwater under the POL/DRMO Yard will be addressed as a separate operable unit, to ensure that intrinsic remediation will be demonstrated and cleanup goals are attained.

2.8 ACTION-SPECIFIC AND LOCATION-SPECIFIC ARARS

Depending on which remedial actions are selected and conducted at the Main Post sites, several action-specific and location-specific ARARs may require consideration. Action-specific ARARs are requirements that may be triggered by certain remedial actions. Potential action-specific ARARs include TSCA regulations regarding handling of PCB-contaminated soil, and the Massachusetts National Pollutant Discharge Elimination System (NPDES) program requirements for discharges of treated water to surface water.

TSCA (40 CFR 761.60(a)(4)) requires that soil contaminated with PCBs at concentrations of 50 mg/kg or greater be disposed of in either a TSCA-permitted landfill, incinerator, or by some alternative method that achieves a level of performance equal to incineration. Soil samples taken during the RI did not reveal any concentrations above this level. However, higher concentrations may conceivably be encountered during a remedial program. If such soils are found and excavated, TSCA disposal/treatment standards would be applicable.

The Massachusetts Surface Water Discharge Permit Rules (314 CMR 3), regulate the discharges to State waters, including wetlands. Any alternative that would include extraction, treatment, and discharge of groundwater, or generates an aqueous waste stream of any type that is to be discharged to surface water, must comply with these regulations.

Other action-specific ARARs may apply depending on the nature of the remedial approach. For example, technologies that produce an offgas would be required to meet the requirements of the Massachusetts Air Pollution Control Regulations (310 CMR 7) for air pollution sources. These and other action-specific ARARs specific to certain technologies will be discussed in the Detailed Analysis of Alternatives (Section 5).

Location-specific ARARs are similar to action-specific ARARs in that they only apply when remedial action is being undertaken. However, these ARARs are invoked by the nature of the location of action, rather than type of action. The principal location-specific ARARs include restrictions on activities in floodplains and wetlands, wildlife protection, endangered species protection, and archaeological and cultural resources protection. These location-specific ARARs are summarized in Table 2-4.

2.9 CONCLUSIONS

Cleanup objectives have been developed from the ARARs, TBC guidance, and risk assessment results as discussed in the previous sections. The previous sections review all detected analytes which exceed cleanup goals, and discuss the patterns of contamination. Remedial alternatives need to be developed for two of the operable units discussed in Section 2.7.2.

The first operable unit is soils located in and around the DRMO Yard. The contaminants are diverse in this area, but are located near each other and are apparently from the same source — materials stored in the yard. Specifically, cadmium, lead, PCBs, DDT, DDD, and DDE are present above cleanup goals in the northern half of the east yard and the swales on either side of the east yard (Figure 2-2).

The second operable unit is the groundwater in the area of the removed UST 13. The contamination consists of 1,2-, 1,3-, and 1,4-DCB, PCB 1260, DDT, 1,2-DCE, and TCE which leaked from this UST and contaminated groundwater in its vicinity. No contaminated soil remains in this area. This area is apparently hydraulically and physically isolated from the rest of the DRMO Yard, and thus is addressed as a separate operable unit.

The third operable unit is the groundwater under and downgradient of the DRMO Yard proper (on either side of Cook Street) and the POL Storage Area. These are contiguous and groundwater originating on the DRMO Yard discharges through the POL Storage Area.

Remedial alternatives are developed in Section 4 to address the contamination in these operable units only. In the other operable units, there either are no exceedances of cleanup goals, or the exceedances that exist do not warrant remedial action, as discussed in Section 2.7.2. Specifically, in AOC 43A the identified risks in soils are due to arsenic and PAHs and in groundwater the identified risk is due to beryllium. Based on the highly sporadic nature of these detections, these "contaminants" are clearly associated with ambient conditions and not a contaminant source. The time and expense required to implement a remedial program for a non-existent source is clearly unwarranted, but organic contaminants in groundwater wells in and around the site are clearly related to site activities and will be addressed.

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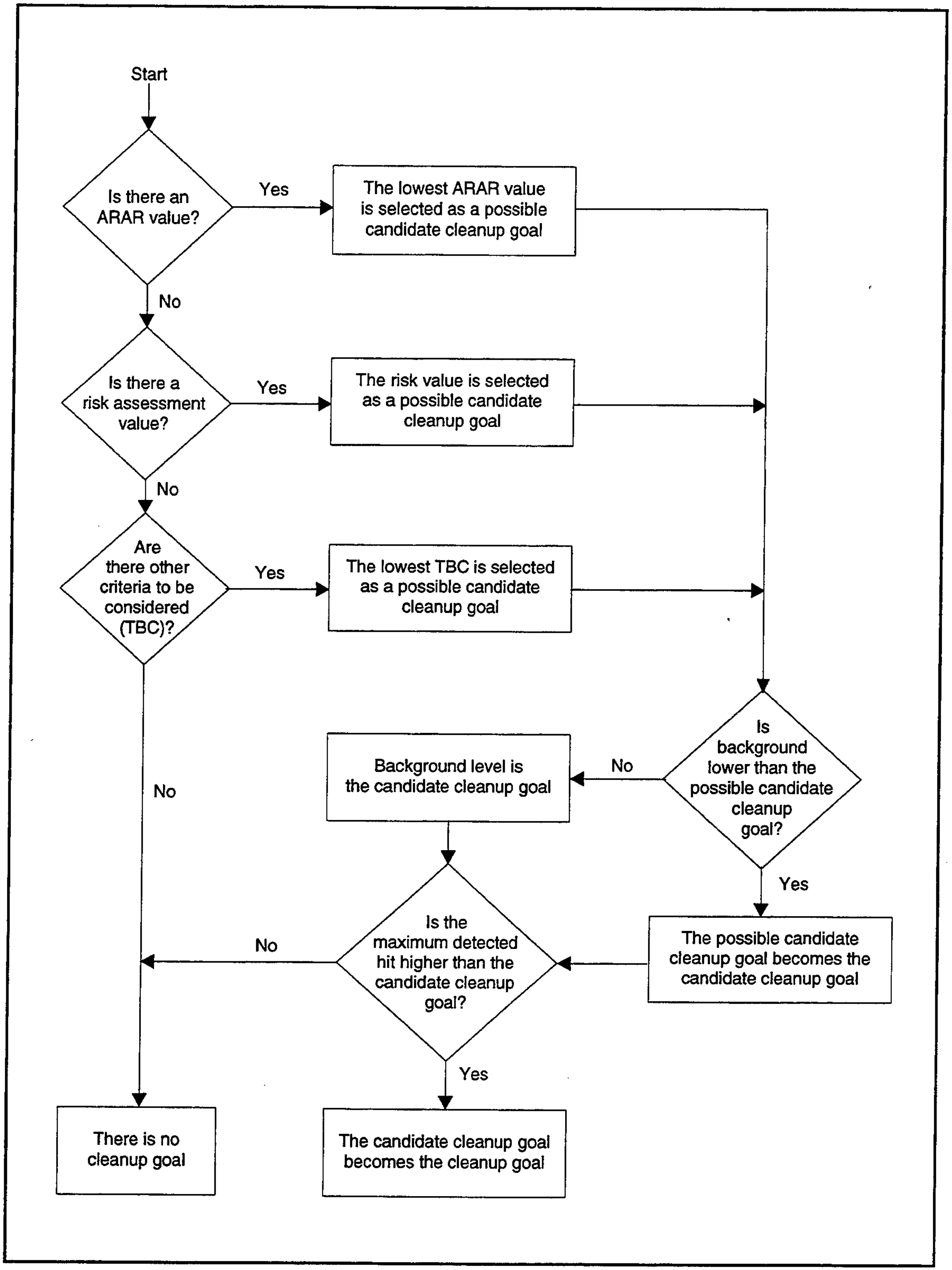

Figure 2-1 GENERALIZED APPROACH TO SELECTING CLEANUP GOALS

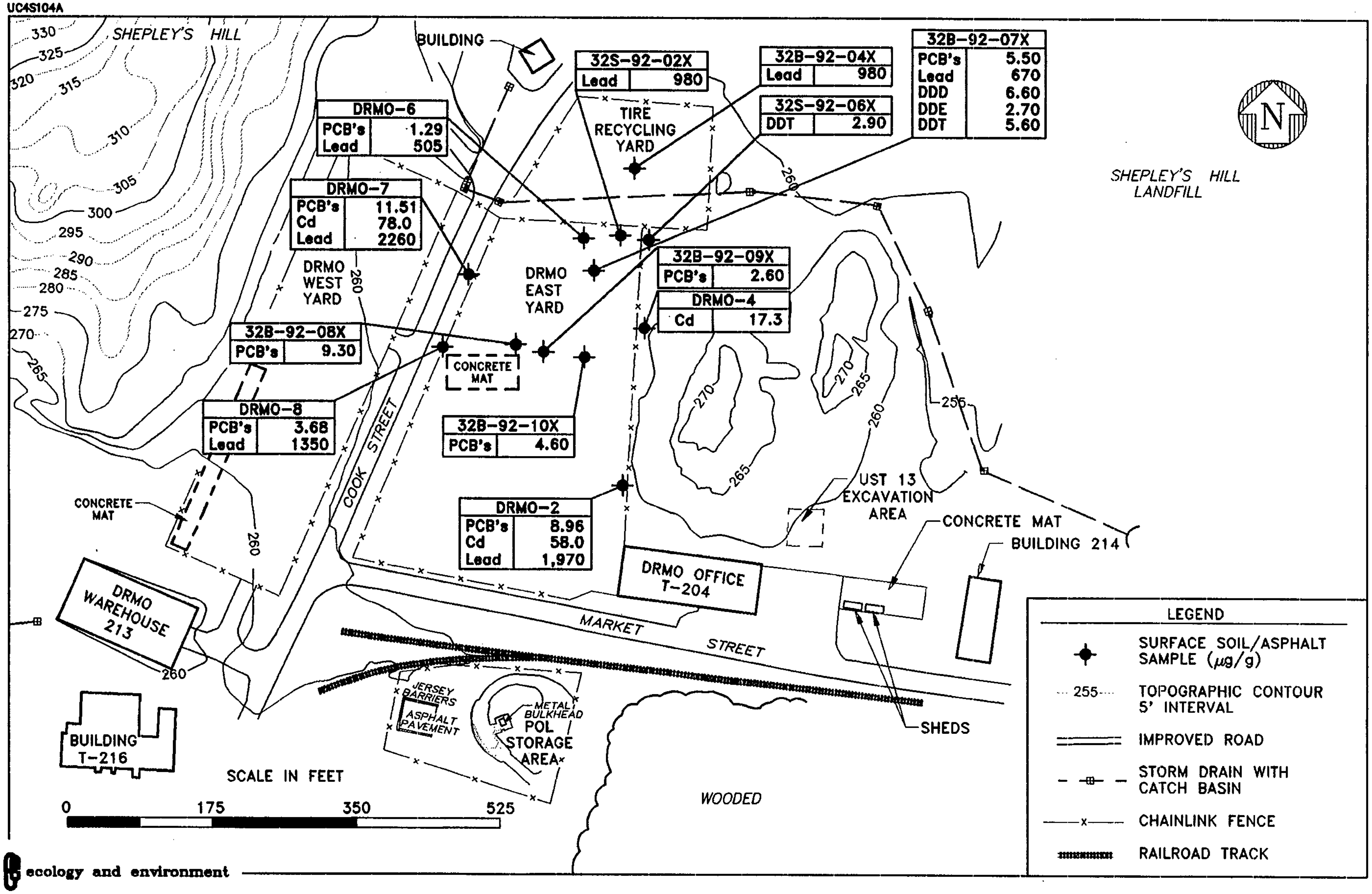

Figure 2-2 DETECTIONS ABOVE CLEANUP GOALS AT DRMO YARD

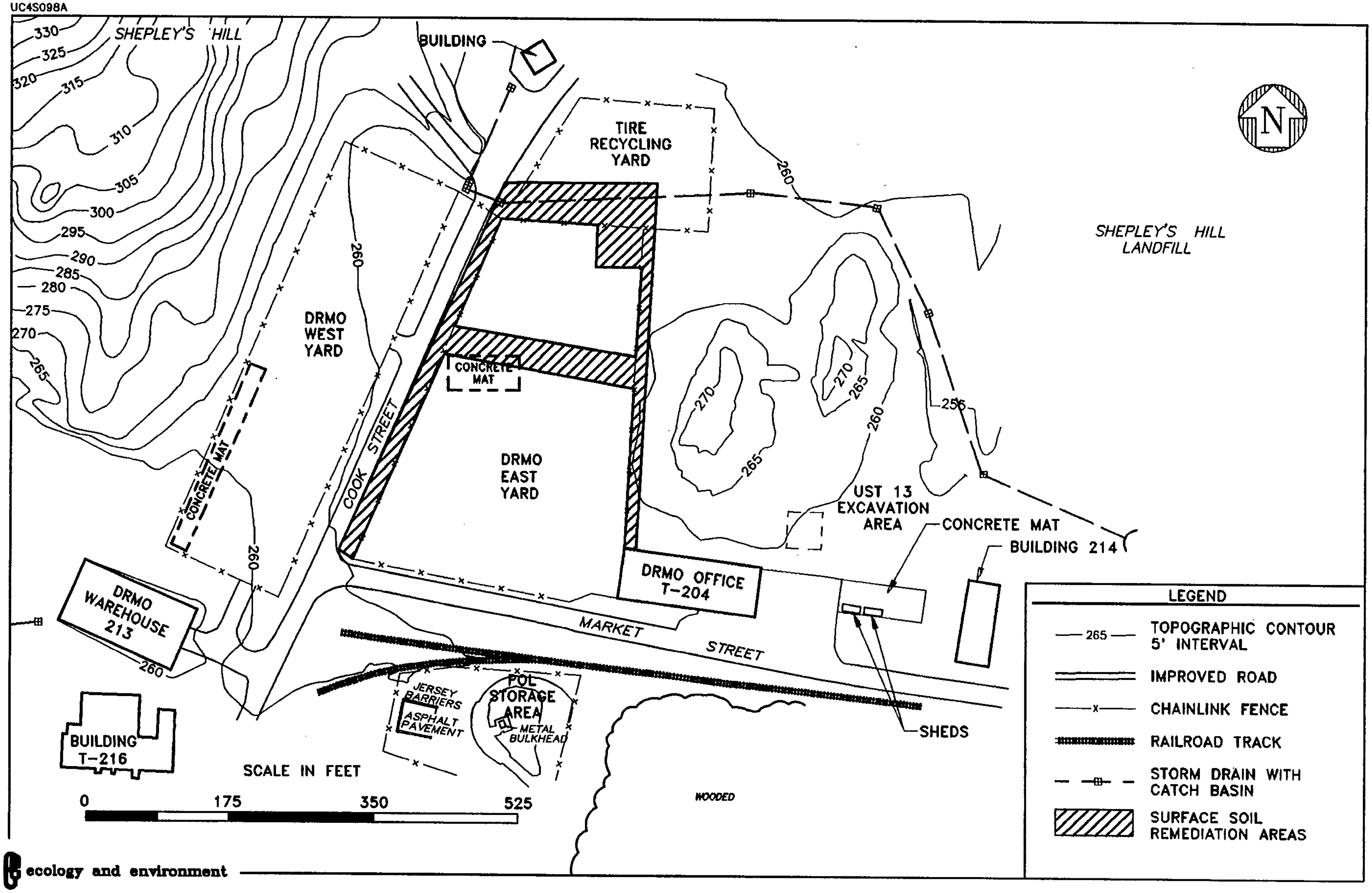

Figure 2–3 PROPOSED SURFACE SOIL REMEDIATION AREAS AT DRMO YARD

Table 2-1

MAIN POST SOIL CLEANUP GOAL DETERMINATION

Analytes	ARARs		TBCs			Fort Devens Background Level (Maximum)	Human Health Risk Assessment Levels Concentrations Corresponding to 10^{-5} risk or HI=1	Candidate Cleanup Goal	Maximum Observed Concentration		Cleanup Goal	
	TSCA											
	Surface Soil µg/g (a)	Subsurface Soil µg/g (a)	Reg. III RBC Commercial/ Industrial Levels µg/g (b)	RCRA Action Levels (Residential) µg/g (c)	EPA Interim Cleanup Level Superfund Sites µg/g (d)	µg/g (e)	µg/g (f, g)	µg/g (h)	Surface Soil µg/g (i)	Subsurface Soil µg/g (j)	Surface Soil µg/g	Subsurface Soil µg/g
Inorganics												
Aluminum			1000000			18000		1000000	10000	14000		
Antimony			820	6		0.5		40	3.5	23		
Arsenic			3.3	80		19	24(f)	24	210	37	24	24
Barium			140000	800		54		800	98	210		
Beryllium			1.3	0.2		0.81	1000(f)	1000	0.68	1.2		
Cadmium			1000	8		1.3		8	78	6.5	8	
Calcium						810			5200	4100		
Chromium (total)			10000			33		10000	36	54		
Cobalt			120000			4.7		120000	58	7.6		
Iron						18000			24000	3400		
Copper			76000			14		76000	52	380		
Lead					400	48	426(g)	426	2260	980	426	426
Magnesium						5500						
Manganese			10000	1600(k)		380		1600	530	450		
Mercury			610	4(inorg)		0.11	47(g)	47	0.23	0.34		
Nickel			41000	4000		15		4000	36	58		
Potassium						2400			1700	3300		
Selenium			10000	40-80		1		40	5.4	1.7		
Silver			10000	40		0.086		40		0.82		
Sodium						230			750	372		
Vanadium			14000	120(l)		32		120	34	32		
Zinc			610000	3200(l)		44		3200	260	980		
Volatile Organics												
Carbon Disulfide			200000					200000		0.13		
Decane										0.71		
2,4-Dimethylpentane										1.5		
2,3,4-Trimethylpentane										3.1		
Total Xylenes			1000000					1000000		0.12		
TPHC												
Total Petroleum Hydrocarbons									27500	21000		
Pesticides/PCBs												
alpha-Benzenehexachloride			0.91					0.91	0.011			
alpha-Endosulfan			12000					12000		0.006		
Aldrin			0.34					0.34		0.001		
beta-Benzenehexachloride			3.2					3.2		0.045		
delta-Benzenehexachloride									0.005			
DDD			24	3				3	0.018	6.6		3
DDE			17	2		0.26		2	0.4	2.7		2

Table 2-1

MAIN POST SOIL CLEANUP GOAL DETERMINATION (continued)

Analytes	ARARs		TBCs			Fort Devens Background Level (Maximum)	Human Health Risk Assessment Levels Concentrations Corresponding to 10^{-5} risk or HI=1	Candidate Cleanup Goal	Maximum Observed Concentration		Cleanup Goal	
	TSCA		Reg. III RBC Commercial/ Industrial Levels	RCRA Action Levels (Residential)	EPA Interim Cleanup Level Superfund Sites							
	Surface Soil	Subsurface Soil							Surface Soil	Subsurface Soil	Surface Soil	Subsurface Soil
	µg/g (a)	µg/g (a)	µg/g (b)	µg/g (c)	µg/g (d)	µg/g (e)	µg/g (f, g)	µg/g (h)	µg/g (i)	µg/g (j)	µg/g	µg/g
DDT			17	2		0.12		2	2.9	5.6	2	2
gamma-Chlordane			4.4					4.4	0.005			
gamma-BHC (Lindane)			4.4	0.5				0.5	0.003	0.002		
Heptachlor			1.3					1.3		0.01		
Heptachlor epoxide			0.63					2.63		0.006		
PCB1254	1	10	41	0.09			2(f)	1	9.3	0.23	1	
PCB1260	1	10	0.74	0.09			2(f)	1	4.35	0.68	1	
BNAs												
Benzo[A]anthracene			7.8				7(f)	7	2			
Benzo[A]pyrene			0.78				7(f)	7	2			
Benzo[B]flouranthene			7.8				7(f)	7	4			
Benzo[G,H,I]perylene									2			
Benzo[K]fluoranthene			78				78		0.14			
Chrysene			780				7(f)	7	3			
Dibenzofuran									4.5			
1,6-Dimethylindan										0.27		
4,6-Dimethylindan										0.21		
Fluoranthene			82000				82000		4			
Fluorene			82000				82000		0.7			
Heptadecane									0.27			
Hexadecane										0.18		
Indeno[1,2,3-C,D]pyrene			7.8				8(f)	8	2			
2-Methylnapthalene									30	10		
Napthalene			82000				82000		20			
Pentadecane										3		
Phenanthrene									10	2		
Pyrene			61000				61000		3			

Key:

(a) Toxic Substances Control Act (TSCA) (15 USC 2601) - The surface soil cleanup criterion is 1,000 µg/kg and the subsurface soil cleanup criterion is 10,000 µg/kg.

(b) EPA Region III Risk-Based Concentration Table (USEPA 1995 January-June) values for commercial/industrial soil.

(c) Calculated RCRA CMS Action Level as outlined in 55FR30798: 27 July 1990, corresponding to a hazard index of 0.2 in compliance with MDEP for residential soil.

(d) EPA Interim Guidance on Soil Lead Cleanup levels at Superfund Sites, EPA 1991, OSWER Directive 9355.4-02a, 29 August 1991.

(e) Background levels for soil derived from data compiled by E & E; (see Appendix K of the RI Report for Functional Area II (E & E 1994a) for background data rationale).

(f) Concentration corresponds to a cancer risk of 10^{-5}.

(g) Concentration corresponds to a hazard index of 1.

(h) Candidate cleanup goal was chosen as follows: Values calculated from the site-specific risk assessment, or ARARs, if available. If neither of these two values were available, the lowest value of the remaining TBCs was selected. If background concentration was higher than the selected value, the background concentration was used as the candidate cleanup goal.

(i) Maximum observed concentration based on RI surface soil data collected from DRMO Yard and POL Storage Area.

(j) Maximum observed concentration based on RI soil borings data collected from DRMO Yard and POL Storage Area.

(k) Proposed standard.

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Table 2-2

MAIN POST GROUNDWATER CLEANUP GOAL DETERMINATION

Analytes	ARARs				TBCs					Human Health Risk Assessment Levels Concentrations Corresponding to 10^{-5} risk or HI=1	Candidate Cleanup Goal	Maximum Observed Concentration	Cleanup Goal
	SDWA MCL (μg/L) (a)	MMCL (μg/L) (b)	SDWA MCLG (μg/L) (c)	MA SMCL (μg/L) (d)	SDWA SMCL (μg/L) (e)	EPA Drinking Water HAs (μg/L) (f)	EPA Reg III Tap Water Risk-Based Concentration (μg/L) (g)	MA ORSG (μg/L) (h)	Fort Devens Background (μg/L) (i)	(μg/L) (j,k)	(μg/L) (l)	(μg/L) (m)	(μg/L) (n)
Inorganics													
Aluminum	50(2)			50/200	50/200		37000		390		390	446	390
Arsenic	50(3)	50				0.02	0.038		3.4	1.6 (j)	50	56	50
Barium	2000	2000	2000			2000	2600		17		2000	64	
Beryllium	4	4(4)	4			0.0008	0.016	4		0.67 (j)	4	0.13	
Calcium									27000			39000	
Chromium (total)	100	100	100			100	180				100	28	
Cobalt							2200				2200	11	
Copper	1000(2)	1300(1)	1300	1000	1000		1400				1000	1.7	
Iron	300(2)			300	300				320		320	2800	320
Lead	15	15(1)	0							77(k)	15	2	
Magnesium									2600			3200	
Manganese	50(2)			50	50		180		3500	500(k)	3500	7700	3500
Nickel	100	100(4)	100			100	730	100			100	13	
Potassium									4300			29000	
Sodium		28000(4)				20000		28000	10000		28000	420000	28000
Thallium	2		0.5		0.4	0.4		2			0.5	1	0.5
Zinc	5000(2)			5000	5000	2000	11000		30.2		5000	260	
Volatile Organics													
Acetone		3000(4)					3700	3000			3000	52	
Benzene	5	5	0			1	0.36				5	4	5
Chloroform	100(14)	50(4)				6	0.15	5			50	1.3	
1,2-Dichloroethane	5	5	0			0.4	0.12				5	1.8	
Total 1,2-Dichloroethene							55				55	60	55
Ethylbenzene	700	700	700			700	1300				700	4	
Toluene	1000	1000	1000			1000	750				1000	3.6	
1,1,1-Trichloroethane	200	200	200			200	1300				200	60	
Trichloroethylene (TCE)	5	5	0				1.6			26(k)	5	200	5
Total Xylenes	10000	10000	10000			10000	12000				10000	13	
TPHC													
Total Petroleum Hydrocarbons												960000	

Key at end of table.

Table 2-2 (continued)

MAIN POST GROUNDWATER CLEANUP GOAL DETERMINATION

Analytes	ARARs					TBCs				Human Health Risk Assessment Levels Concentrations Corresponding to 10^{-5} risk or HI=1 (μg/L) (j,k)	Candidate Cleanup Goal (μg/L) (l)	Maximum Observed Concentration (μg/L) (m)	Cleanup Goal (μg/L) (n)
	SDWA MCL (μg/L) (a)	MMCL (μg/L) (b)	SDWA MCLG (μg/L) (c)	MA SMCL (μg/L) (d)	SDWA SMCL (μg/L) (e)	EPA Drinking Water HAs (μg/L) (f)	EPA Reg III Tap Water Risk-Based Concentration (μg/L) (g)	MA ORSG (μg/L) (h)	Fort Devens Background (μg/L) (i)				
Pesticides/PCBs													
alpha-Benzenehexachloride							0.011				0.011	20	0.011
DDD	0.5	0.5					0.28				0.5	0.39	
DDT	0.5						0.2				0.5	7.5	0.5
delta-Benzenehexachloride												3.3	
PCB1260	0.5	0.5	0				0.0087			0.39 (j)	0.5	7.6	0.5
Explosives													
2-Amino-4,6-dinitrotoluene												1.8	
4-Amino-2,6-dinitrotoluene												1.9	
Cyclonite (RDX)						2				26 (j)	26	1.2	
1,3-Dinitrobenzene						1	3.7				1	12.0	1
2,6-Dinitrobenzene						40					40	0.77	
2-Nitrotoluene						61					61	3	
3-Nitrotoluene						61					61	5.9	
4-Nitrotoluene						61					61	1.3	
1,3,5-Trinitrobenzene						1.8					1.8	3.04	1.8
BNAs													
Acenapthene							2200				2200	2.1	
Bis(2-ethylhexyl)phthalate	6	6(4)	0				4.8	6			6	40	6
4,4'-butyldencbis[2-(1,1-dimethylethyl)-5-phenol												24	
1,2-Dichlorobenzene	600		600			600	270				600	6000	600
1,3-Dichlorobenzene						600	540				600	1000	600
1,4-Dichlorobenzene	75		75			75	0.44			12(k)	75	600	75
Di-N-butyl phthalate							3700				3700	4	
2-Methylnapthalene												40	
Napthalene						20	1500				20	9	
Phenanthrene												20	
1,2,4-Trichlorobenzene	70		70			70	190	70			70	40	
Other Organics													
Caprolactam												100	
Lauric acid												20	
Tetracosane												8	

Key at end of table.

Table 2-2 (continued)

Key:
(a) EPA Drinking Water Regulations (USEPA 1991c), MCLs. 40 CFR 143.
(b) Massachusetts Drinking Water Standards and Guidelines (Massachusetts 1992) 310 CMR 22.
(c) Maximum Contaminant Level Goal. Note: MCLGs of zero are not considered ARARs in accordance with the NCP.
(d) Secondary Maximum Contaminant Goal, Code of Massachusetts Regulations, Title 310 Section 22, Effective 20 November 1992.
(e) National Secondary Drinking Water Standards designed to protect the aesthic quality of water (FR 42198, 19 July 1979; 51 FR 11396, 2 April 1986; 56FR 3526, 30 January 1991).
(f) EPA Office of Water Lifetime Health Advisories (HA), May 1993.
(g) EPA Region III, Risk-Based Concentration Table (USEPA 1993 Fourth Quarter), values for tap water.
(h) ORSG: Office of Research and Standard Guideline. Massachusetts Department of Environmental Protection, Spring 1993.
(i) Background levels based on maximum or average detected in upgradient wells or local background concentration as follows: Arsenic and barium based on DRMO Yard local background. Calcium, Iron, Magnesium, Manganese, Potassium, Sodium, and Zinc based on POL upgradient well.
(j) Concentration based on cancer risk of 10^{-5}.
(k) Concentration based on hazard index of 1.
(l) Remedial action objective was chosen as follows: lowest of ARARs, if no ARARs, then human health risk assessment value. If risk not calculated, then lowest value of the TBCs. If TBC or ARAR was lower than background level, background was used.
(m) Maximum observed concentration based on RI and SI groundwater data collected from DRMO and POL. Maximum observed concentration for metals is based on filtered data only.
(n) Cleanup goal is below detection limit for this element. Cleanup should be to a level below detection limit.
(o) Action level.
(2) Secondary standard.
(3) Proposed standard.
(4) Massachusetts Guidance value.

Table 2-3

MAIN POST SURFACE WATER CLEANUP GOAL DETERMINATION

	ARARs						
	MA/CWA WQC Human Health, Consumption of Aquatic Organisms (µg/L) (a,b)	Freshwater Acute MA/CWA WQC for Aquatic Organisms (µg/L) (b,c)	Freshwater Chronic MA/CWQ WQC for Aquatic Organisms (µg/L) (b,d)	Background Levels (µg/L) (f)	Candidate Cleanup Goal (µg/L) (g)	Maximum Observed Concentration (µg/L) (h)	Cleanup Goal (µg/L)
ANALYTES							
Inorganics							
Aluminum		750	87	730	730	530	
Antimony	4,300			3	4,300	5.8	
Arsenic	0.14	360	190	6.7	6.7	2	
Barium				40		20	
Cadmium		0.50 (e)	0.27 (e)	4	4	15	4
Calcium				21,000		5,000	
Copper		3.15 (e)	2.47 (e)	8.1	8.1	27	8.1
Iron			1,000	1,600	1,600	1,000	
Lead		7.92 (e)	0.31 (e)	8.7	8.7	41	8.7
Magnesium				3,300		970	
Manganese				360		77	
Potassium				3,200		2,600	
Sodium				36,000		3,000	
Zinc		24.8 (e)	22.4 (e)	33	33	260	33

(a) Concentrations for potential carcinogens correspond to a risk of 10^{-6}.

(b) WQC = Water Quality Criteria from Code of Massachusetts Regulation, Title 314, Section 4.05(5)(e)/Environmental Protection Agency, 57 FR 60848, 22 December 1992.

(c) One-hour average concentration not to be exceeded more than once every three years.

(d) Four-hour average concentration not to be exceeded more than once every three years.

(e) Water hardness dependent criteria site-specific value of 16 mg/L used.

(f) Background levels for surface water derived from data compiled by E & E.

(g) Remedial action objective chosen as follows: MA/CWA WQC Human Health if available; if not, then aquatic organism criteria were used. If background was higher than lowest ARAR value, background level was used. If background value was lower than ARAR, then ARAR was used.

(h) Maximum observed concentration based on RI surface water data collected from DRMO Yard.

Table 2-4

LOCATION-SPECIFIC APPLICABLE OR RELEVANT AND APPROPRIATE REQUIREMENTS FOR RI SITES AT FORT DEVENS

Location Characteristic(s)	Operating Condition(s)	Requirement(s)	Citation(s)
Floodplains			
• Within "lowland and relatively flat areas adjoining inland and coastal waters and other flood prone areas such as offshore islands, including at a minimum, that area subject to a one percent or greater chance of flooding in any given year." [Executive Order 11988 § 6(c) and 40 C.F.R. § 6, Appendix A § 4(d) (1992)]	• Federal agency action which involves: - acquiring, managing, and disposing of lands and facilities - providing federally undertaken, financed, or assisted construction and improvements. - conducting federal activities and programs affecting land use.	• Federal agencies shall take action to reduce the risk of flood loss, minimize the impact of floods on human safety, health and welfare, and restore and preserve the natural and beneficial values of floodplains. • Federal agencies shall evaluate potential effects of actions in floodplains and ensure consideration of flood hazards and floodplain management. • If action is taken in floodplains, federal agencies shall consider alternatives to avoid adverse effects, incompatible development, and minimize potential harm. - **Applicable**	• Executive Order 11988 • 40 C.F.R. § 6.302(b) (1992) • 40 C.F.R. § 6, Appendix
• Land subject to flooding as defined in Mass. Regs. Code[a] tit. 310, § 10.57(2) (1989)	• Activities within the area subject to flooding which involve removal, filling, dredging, or alteration of the area, as defined in Mass. Regs. Code tit. 310, § 10.04 (1989). • Activities within 100 feet of land subject to flooding which would alter the area.	• Actions in "bordering land subject to flooding" shall provide compensatory storage for flood storage volume lost as a result of the project, shall not restrict flows so as to cause an increase in flood stage or velocity, and shall not impair its capacity to provide important wildlife habitat functions or alter vernal pool habitat. - **Applicable** • Actions in "isolated land subject to flooding" shall not result in flood damage because of lateral displacement of water that would otherwise be confined within the area, adverse effects on water supply or groundwater supply, adverse effects on the capacity of the area to prevent groundwater pollution, or adverse effects on vernal pool habitat. - **Applicable**	• Mass. Gen. L.[b]ch. 131, § 40 (1990) • Mass. Regs. Code tit. 310, § § 10.00-10.60 (1989)
Wetlands			
• Presence of wetlands as defined in Executive Order 11990, § 7(c) and 40 C.F.R. § 6, Appendix A, § 4(j) (1992)	• Federal agency action which involves: - acquiring, managing, and disposing of lands and facilities. - providing federally undertaken, finances, or assisted construction and improvements - conducting federal activities and programs affecting land use	• Whenever possible, federal agency actions must avoid or minimize adverse impacts on wetlands and act to preserve and enhance their natural and beneficial values. Agencies should particularly avoid new construction in wetlands areas unless there are no practicable alternatives. • Federal agencies shall incorporate wetlands protection considerations into planning, regulating, and decision-making processes. - **Applicable**	• Executive Order 11990 • 40 C.F.R. § 6.302(a) (1992) • 40 C.F.R. § 6, Appendix A (1992)

Table 2-4

LOCATION-SPECIFIC APPLICABLE OR RELEVANT AND APPROPRIATE REQUIREMENTS FOR RI SITES AT FORT DEVENS

Location Characteristic(s)	Operating Condition(s)	Requirement(s)	Citation(s)
• Presence of wetlands as defined in 40 C.F.R. § 230.3(t) (1992) and 33 C.F.R. § 328.3(b)*	• Action involving discharge of dredge or fill material into wetlands	• Action must be taken to avoid degradation or destruction of wetlands to the extent possible. Discharges for which there are practicable alternatives with less adverse impacts or those which would cause or contribute to significant degradation are prohibited. • If adverse impacts are unavoidable, action must be taken to enhance, restore, or create alternative wetlands. - **Applicable**	• Clean Water Act § 404 [33 U.S.C. § 1344 (1991)] • 40 C.F.R. § 230 (1992) • 33 C.F.R. § § 320-330*
• Presence of wetlands as defined in Mass. Gen. L. ch. 130, § 105 (1990) or Mass. Gen. L. ch. 131, § 40 (1990), or regulations pursuant to those statutes	• Landfills, land treatment unit, surface impoundment, or waste pile subject to regulation under Mass. Regs. Code tit. 310, § 30.800 (1989) • Hazardous waste subject to regulation under Mass. Regs. Code tit. 310, § 30.000 (1989)	• Active portions of designated facilities cannot be constructed in, or expanded into, wetlands. - **Applicable**	• Mass. Regs. Code tit. 310, § 30.705(6) (1989)
• Presence of any bank, freshwater wetland, coastal wetland, beach, dune, flat, marsh, meadow, or swamp bordering on the ocean or on any estuary, creek, river, stream, pond, or lake or any land under these waters or land subject to tidal action, coastal storm flow, or flooding	• Activities within a protected area which involve removal, filling, dredging, or alteration of the area • Activities within 100 feet of a protected area which would alter the area.	• Removal, filling, dredging, or alteration of protected area is prohibited except under the conditions and criteria delineated in Mass. Regs. Code tit. 310, § § 10.00-10.60(1989). - **Applicable**	• Mass. Gen. L. ch. 131, § 40 (1990) • Mass. Regs. Code tit. 310, § § 10.00-10.60 (1989)
Wilderness areas, wildlife resources, wildlife refuges, or scenic rivers			
• Within wildlife refuge as designated in 16 U.S.C. § 668(dd)* -or- within range in which action could impact such an area	• Action which will impact wildlife refuges	• A refuge's administering agency and its appropriate regulations must be consulted to determine prohibited activities and possible exemptions • The effects of actions on the values of the wildlife refuge must be considered. - **Applicable**	• National Wildlife Refuge System Administration Act of 1966 [16 U.S.C. § § 668(dd)-668(ee)*
• Within area affecting stream or river -and- presence of fish or wildlife resources	• Action which results in the control or structural modification of a natural stream or body of water	• The effects of water-related projects on fish and wildlife resources must be considered. • Action must be taken to prevent, mitigate, or compensate for project-related damages or losses to fish and wildlife resources. • Off-site actions which alter a resource require consultation with the FWS^{c}, NMFS^{d}, and/or the appropriate state agency. • Consultation with the responsible agency is also strongly recommended for on-site actions. - **Applicable**	• Fish and Wildlife Coordination Act (16 U.S.C. § 661*) • 40 C.F.R. § 6.302(g) (1992)

Table 2-4

LOCATION-SPECIFIC APPLICABLE OR RELEVANT AND APPROPRIATE REQUIREMENTS FOR RI SITES AT FORT DEVENS

Location Characteristic(s)	Operating Condition(s)	Requirement(s)	Citation(s)
• Location encompassing aquatic ecosystem with dependent fish, wildlife, other aquatic life, or habitat	• Action involving the discharge of dredge or fill material into aquatic ecosystem	• Degradation or destruction of aquatic ecosystems must be avoided to the extent possible. Discharges which cause or contribute to significant degradation of the water of such ecosystem are prohibited. - **Applicable**	• Clean Water Act § 404 [33 U.S.C. § 1344 (1991)] • 40 C.F.R. § 230 (1992) • 33 C.F.R. § § 320-330*
• Presence of areas such as wetlands, etc., as listed in Mass. Regs. Code tit. 310, § 10.02(1) (1989), which due to their plant community composition and structure, hydraulic regime, or other characteristics, provide important food, shelter, migratory or overwintering areas, or breeding areas for wildlife	• Activities within a protected area which involve removal, filling, dredging, or alteration of the area • Activities within 100 feet of a protected area which would alter the area	• Actions which would have adverse effects on specific habitat characteristics and the important functions they serve are prohibited or regulated if they exceed certain threshold levels delineated in the regulations. - **Applicable**	• Mass. Gen. L. ch. 131, § 40 (1990) • Mass. Regs. Code tit. 310, § § 10.00-10.60 (1989)
<u>**Endangered, threatened or rare species**</u>			
• Presence of endangered or threatened species or critical habitat (see above citation) of same within an aquatic ecosystem as defined in 40 C.F.R. § 230.3(c) (1992)	• Action involving discharge of dredge or fill material into aquatic ecosystem.	• Dredge or fill material shall not be discharged into an aquatic ecosystem if it would jeopardize such species or would likely result in the destruction or adverse modification of a critical habitat of the species. - **Applicable**	• Clean Water Act § 404 [33 U.S.C. § 1344 (1991)] • 40 C.F.R. § 230.10(b) (1992)
• Presence of endangered or threatened species -or- critical habitat of such species as designated in 50 C.F.R. § 17 (1989), 50 C.F.R. § 226 (1989), or 50 C.F.R. § 227 (1989)	• Action which is likely to jeopardize species or destroy or adversely modify critical habitat	• Actions which jeopardize species/habitat must be avoided or appropriate mitigation measures taken. • Off-site actions which affect species/habitat require consultation with DOI, FWS, NMFS, and/or state agencies, as appropriate, to ensure that proposed actions do not jeopardize the continued existence of the species or adversely modify or destroy critical habitat. • Consultation with the responsible agency is also strongly recommended for on-site actions. - **Applicable**	• Endangered Species Act of 1973 (16 U.S.C. § § 1531-1543*) • 50 C.F.R. § 402 (1989) • 40 C.F.R. § 6.302(h) (1992) • Fish and Wildlife Coordination Act (16 U.S.C. § 661*)
• Presence of endangered, threatened, or rare species or significant habitats of state-listed species as designated pursuant to Mass. Gen. L. ch. 131A (1991)	• Action likely to alter significant habitat	• Actions which alter significant habitat are prohibited if the alteration will likely reduce the viability of a significant habitat. - **Applicable**	• Mass. Gen. L. ch. 131A (1991) • Mass. Regs. Code tit. 321, § § 10.00-10.61 (1992)
• Presence of a protected resources area, as designated in Mass. Regs. Code tit. 310, § 10.02(1) (1989), which is part of the habitat of a state-listed species	• Activities within a protected area which involve removal, filling, dredging, or alteration of the area • Activities within 100 feet of a protected area which would alter the area	• Short or long term adverse effects on the habitat of the local population of the listed species are prohibited.	• Mass. Gen. L. ch. 131, § 40 (1990) • Mass. Regs. Code tit. 310, 10.00-10.60(1989)

Table 2-4

LOCATION-SPECIFIC APPLICABLE OR RELEVANT AND APPROPRIATE REQUIREMENTS FOR RI SITES AT FORT DEVENS

Location Characteristic(s)	Operating Condition(s)	Requirement(s)	Citation(s)
Archaeological and historic resources			
• Presence of archaeological or historic resources	• Action involving dam construction or other alteration of terrain which might cause irreparable loss or destruction of significant scientific, prehistoric, historic, or archaeological data.	• The Secretary of the Interior must be advised of the presence of such data. • A survey must be conducted of affected areas for resources and data. Steps must be taken to recover, protect, and preserve data therefrom or DOI formally requested to do so.	• Archaeological and Historic Preservation Act [16 U.S.C. § § 469(a)-469(c)*] • 40 C.F.R. § 6.301 (1992) • 32 C.F.R. § 650.181*
• Presence of federally owned, administered, or controlled prehistoric or historic resources -or- the likelihood of undiscovered resources		• Cultural resources included on, or eligible for inclusion on, the National Register of Historic Places (36 C.F.R. § 60*) or National Historic Landmark Program (36 C.F.R. § 65*) must be identified. • A determination must be made as to whether proposed action(s) will affect such resources and, i so, alternatives to the action(s) must be examined and considered. • When alteration or destruction of the resource is unavoidable, steps must be taken to minimize or mitigate the impacts and to preserve records and data of the resource. • When all or part of a remedial action is off site, the consultation requirements of 16 U.S.C. § 470(f)* must be completed. • Consultation is also strongly recommended for on-site actions.	• National Historic Preservation Act [16 U.S.C. § § 470(a)-470(w)* • Executive Order 11593 • 40 C.F.R. § 6.301 (1992) • 36 C.F.R. § 800* • 32 C.F.R. § 650.181*
• Presence of properties included on the State Register of Historic Places	• Action(s), as listed in 950 CMR 71.05, which impact state listed properties	• All prudent means to eliminate, minimize, or mitigate adverse effects must be adopted. - **Relevant and appropriate**	• MGL c. 9, ss. 26-27C • 950 CMR 71.00 *et seq.*

* Version of cited law or regulation used in the preparation of this document was that in effect in June, 1993.

[a] Mass. Regs. Code = Code of Massachusetts Regulations.
[b] Mass. Gen. L. = Massachusetts General Laws.
[c] FWS = U.S. Fish and Wildlife Service.
[d] NMFS = National Marine Fisheries Service.
[e] DOI = Department of the Interior.

Source: Oak Ridge National Laboratory, 1994.

3. IDENTIFICATION AND SCREENING OF REMEDIAL ACTION TECHNOLOGIES AND MONITORING REQUIREMENTS

The purpose of this section is to identify and screen potential remedial action technologies that may be applicable to remediation of soil and groundwater at Fort Devens and to identify monitoring requirements. Each of the technologies identified in this section was evaluated with respect to effectiveness and implementability to determine whether they would be retained for further evaluation. In Section 4, those remedial technologies that are retained are combined to form remedial action alternatives. Tables 3-1 and 3-2 summarize these technologies.

3.1 GENERAL RESPONSE ACTIONS

The following general response actions have been identified for soil: no action, institutional action, containment, excavation, ex situ treatment, in situ treatment, and disposal. General response actions identified for groundwater include: no action, institutional action, containment, collection, ex situ treatment, in situ treatment, and disposal. In the following sections, technologies corresponding to each general response action are identified and screened.

The contamination in the soils at the DRMO Yard includes PCBs, DDT, DDD, DDE, lead, and cadmium. Groundwater contamination at UST-13 includes petroleum hydrocarbons, chlorinated benzenes, TCE, 1,2-DCE, DDT, and PCBs. Although groundwater contamination levels exceeding ARARs or TBCs are few and scattered in the POL Storage Area/DRMO Yard, they do occur. POL-3, downgradient of the DRMO Yard, showed low levels of TCE (up to 19 μg/L) and both 43MA93-04X and 43MA93-10X showed elevated TPHC, while 43MA93-10X also showed 2-methylnaphthalene (30 μg/L). For these reasons, the POL Storage Area/DRMO Yard will be considered a separate operable unit for groundwater remediation. Therefore, the remedial action technologies presented in Sections 3.2 and 3.3 are screened only in reference to the soil contamination at the DRMO Yard, the groundwater contamination in the UST 13 area, and the groundwater in the POL Storage Area/DRMO Yard.

3.2 SOILS

3.2.1 No Further Action

The No Further Action alternative does not include any remedial action regarding soil contamination. No Further Action will be retained and developed into a remedial alternative as required by the NCP.

3.2.2 Institutional Actions

Institutional actions do not include the use of remedial technologies, but involve actions taken to reduce the potential for exposure to the contaminated soils, such as fencing, zoning, and deed restrictions. Institutional actions will be retained for further evaluation.

3.2.3 Containment

Containment, or capping, involves the placement of an impermeable material over the contaminated area. This process prevents direct exposure to the soil itself, mobilization of soil particles by surface flow, infiltration and subsequent leaching of standing water, and the wind-induced mobilization of soil particles in air. Capping may be preferable when other remedial actions (e.g., excavation, treatment, and disposal) are cost-prohibitive, particularly when quantities are large. However, drawbacks of containment are the finite and uncertain design life and the need for long-term maintenance. Nevertheless, these alternatives may be less costly than excavation and treatment. Standard design practices specify permeabilities of at most 10^{-7} centimeters per second (cm/sec) for the liner. Two types of caps exist, single- and multi-layered. Because of their significant differences, they are discussed separately.

3.2.3.1 Single-Layered Caps

Several different single-layered techniques exist for the containment of contaminated soils. All begin with clearing, grubbing, and grading the site. Then, one of several low-permeable materials is applied. Examples include the spray application of a layer of asphalt; base course and concrete slab; and the placement of a base course and an asphalt pavement. All reduce infiltration and limit air-mobilization of particulates from the soil surface. They require little material handling and a small labor-force, and are easy to implement. However, they are not very reliable. Asphalt is susceptible to cracking from settlement and shrinkage. It is photosensitive and tends to weather rapidly. Concrete is more durable and resistant to chemical and mechanical damage. However, it is susceptible to cracking from settlement, shrinkage, and frost heave. In general, single-layer caps are not reliable enough to be acceptable unless frequent inspection and maintenance is performed. Because of these limitations in effectiveness, they will not be retained for further discussion.

3.2.3.2 Multi-Layered Caps

Multi-layered caps are more common and are required for RCRA land disposal facilities. After clearing, grubbing, and grading, the site is covered with an impermeable layer to minimize infiltration and eliminate particulate emissions from the soil surface. Options include a 24-inch-thick layer of compacted, low-permeability (10^{-7} cm/s) clay; a synthetic, impermeable membrane; or a combination of the two (membrane over clay). If the membrane is used, it must be overlain by a minimum 12-inch-thick layer of permeable sand to facilitate drainage. The final layer is topsoil to control moisture, protect the integrity of the impermeable layer and promote revegetation. These technologies are effective, and will be durable for extended periods assuming proper design, installation, and maintenance. Both clay and synthetic liners are less susceptible to cracking from settlement and frost heave.

Clay tends to be self-repairing, although maintenance may be required to prevent growth of deep-rooted trees that could penetrate the seal. Synthetic membranes are less susceptible to this problem, but are not self-repairing. In either method, a layer of gravel may need to be added over the impermeable layer to prevent burrowing animals from compromising the cap. These technologies can be very effective in reducing infiltration of water through contaminated soils. They are also readily implementable. Thus, they will be retained for further consideration.

3.2.4 Excavation

Excavation, combined with confirmatory sampling, ensures the permanent removal of contamination from the site. Once excavated, the soil can be treated to remove the contaminants and then backfilled, or can be hauled off site to a facility that will accept the waste (see sections below). In either case, however, the volume of soil, if large, may make this option cost-prohibitive, particularly if the contamination is very deep. Furthermore, excavation of soils increases the risks of exposure through airborne contaminants. Nevertheless, excavation enables a variety of ex situ treatment processes to be used. It is thus effective towards this goal, and is readily implementable. Thus, excavation will be retained for further consideration.

3.2.5 Ex Situ Treatment

A variety of treatment processes exist for soil once it has been excavated. A description of some potentially applicable techniques appear below.

3.2.5.1 Thermal Oxidation/Incineration

Thermal oxidation or incineration is a method in which the soil is subjected to a high-temperature under controlled conditions to fully oxidize organic contaminants. Products include carbon dioxide, water vapor, sulfur dioxide, nitrogen oxides, and ash. Incineration methods can be used on or off site to destroy organic contaminants in liquid, gaseous, and solid waste streams.

Several types of incinerators are technically feasible and have been used to treat hazardous waste. In general, multiple hearth, fluidized bed, infrared heating, and rotary kiln incinerators are most applicable for the incineration of solids. Each of these systems would destroy all organic contaminants present.

There are several drawbacks to this technology, however. It is a large unit process that may not be appropriate for small volumes of soil. In addition, there is an increased risk of exposure, not only due to the excavation of soil, but also from the actual incineration, incomplete combustion, process upsets, and additional waste streams from incineration. Furthermore, inorganic contaminants are not destroyed by incineration.

There are many vendors for this technology, making it implementable. Implementation would require, however, obtaining necessary permits, including those for air emissions. Also, some public opposition may be expected. However due to its effectiveness in destroying organic contaminants, including PCBs, incineration will be retained as a possible remedial technology appropriate for this site.

3.2.5.2 Chemical Treatment

Chemical treatment techniques include those which destroy, degrade, or reduce the toxicity of contaminants. Glycolate dechlorination is a chemical treatment that has potential effectiveness in remediating PCB-contaminated soil. The technology uses chemical reagents to remove chlorine atoms from PCBs, greatly reducing their toxicity. Reagents include APEG, a combination of alkaline (A) earth metal hydroxides and polyethylene glycol (PEG), and a proprietary new reagent developed by the EPA known as Base-Catalyzed Dechlorination (BCD) process. Regardless of the reagent used, this process mixes the reagent with the soil, sometimes with a non-toxic or low-toxicity cosolvent. The soil is batch-treated at high temperatures (150°C to 350°C) for several hours. When treatment is complete, the soil is removed and separated from the reagent/cosolvent liquid, which is recycled.

The effectiveness of this technology is site-specific, and must be determined through treatability studies. There are several vendors of this technology and no institutional obstacles. It is not effective in treating other organic contaminants or metals present at the site, but it will be retained as a treatment technique for PCBs.

3.2.5.3 Physical Treatment

Physical treatments involve physical manipulation of the soil in order to immobilize or remove contaminants. Potentially applicable remedial technologies for contaminated soils include soil washing, solvent extraction, solidification/stabilization, volatilization/thermal desorption, and asphalt batching.

Soil washing is a volume reduction technology that segregates the fine solid fractions from the coarser soils through an aqueous washing process and washing water treatment system. This technology is based on the observation that the vast majority of contaminants are found adsorbed to the fine soil particles due to their greater specific surface area. The coarser clean soil particles could be backfilled on site while the fine fraction would require further treatment or disposal. The volume of surficial contaminated soil at the DRMO Yard is not large compared to many sites. Thus, a volume reduction step would not greatly facilitate the remediation. Furthermore, the fine soils must be treated further. Such treatment would be difficult because most technologies other than incineration and solidification work best on coarser soils. Therefore, soil washing will not be retained for further evaluation.

Solvent extraction uses a treatment vessel in which soil is homogeneously mixed, flooded with a solvent, and again mixed thoroughly to allow the waste to come in contact with the solution. Liquid or supercritical phase solvents may be used. Once mixing is complete, the solvent is drawn off by gravity, vacuum filtration, or some other dewatering process. The solids are then rinsed with a neutralizing agent (if needed), dried, and placed back on site or otherwise treated/disposed of. Solvents and rinse waters are processed through an on-site treatment system and recycled for further use. Supercritical solvents may be recovered by simply reducing the pressure and removing the fluid as a gas. There are not many vendors of this technology. However, it is otherwise implementable. This process has shown potential effectiveness in the removal of metals as well as PCBs. Therefore, it will be retained as a viable technology.

Solidification/stabilization treatment systems, sometimes referred to as fixation systems, are meant to improve handling and physical characteristics of the waste, reduce the surface area across which contaminants can migrate, and/or reduce the solubility of hazardous constituents in the waste. Solidification involves techniques that seal the wastes into a relatively impermeable stable block. Stabilization involves techniques that would either neutralize or detoxify the wastes, so that the contaminants are maintained in the least soluble or toxic form.

Solidification/stabilization methods for chemical soil consolidation can immobilize contaminants. Most of the techniques involve a thorough mixing of the solidifying agent and the waste. Solidification of wastes produces a monolithic block with high structural integrity. The contaminants do not necessarily interact chemically with the solidification reagents but are mechanically locked within the solidified matrix. Stabilization methods usually involve the addition of materials which limit the solubility or mobility of waste constituents even though the physical handling characteristics of the waste may not be improved. Remedial actions involving combinations of solidification and stabilization techniques are often used and are readily implementable.

Solidification processes available as remedial action technologies for contaminated soils include the following:

- Cement-based processes;
- Pozzolanic processes;
- Thermoplastic techniques;
- Organic polymer techniques;
- Surface encapsulation techniques;
- Self-cement techniques; and
- Vitrification techniques.

Solidification is considered by EPA to be appropriate for large volumes of waste material containing toxic heavy metals. Organic contaminants do not bond chemically to the material, but are physically bound in the matrix. Solidification will be retained for further consideration.

Volatilization can be accomplished through thermal treatment or mechanical aeration. An example of this physical treatment is thermal desorption. In this process solids with organic contamination are heated, volatilizing water and organic contaminants and producing a dry solid containing trace amounts of the organic residue. An inert carrier gas is used to transport the volatilized water and organics to an off-gas handling system, a three stage cooling and condensing train which may condense organics of low, medium, and high volatility in a step wise fashion. The system is designed to treat organic wastes with boiling points up to 1,000°F, less than 10 percent total organics, and less than 60 percent moisture. This technology is effective for PCBs, is implementable, and is retained for further consideration. It would have to be combined with a metals-treatment technology such as solidification or solvent extraction.

Asphalt batching, also referred to as hot asphalt incorporation, involves the incorporation of organic-contaminated soils into hot asphalt mixes as a partial substitute for stone aggregate. Soil treatment by this method is achieved by volatilization, thermal destruction, and dilution. In addition, the soil is solidified in the asphalt/aggregate mixture, immobilizing the soil contaminants. The hot mix process involves sorting the soil aggregate, then heating and mixing the soil with liquefied asphalt. As the aggregate is heated, temperatures reach 260°C to 430°C for approximately five minutes. The mixture is stored, transported, and applied while still warm (approximately 150°C).

The hot mix technique requires the presence of an asphalt plant near the area of contamination. This facility must have appropriate environmental permits, particularly for air emissions. Past experience with asphalt batching have shown that plants may need to be retrofitted to accept the contaminated soils (Czarnecki 1989). Few data are available on removal efficiencies in practice and long-term integrity of the asphalt product. The cost of treating organically contaminated soil by incorporation into hot asphalt is high; therefore, this remedial technology will not be retained for further evaluation.

3.2.5.4 Biological Treatment

Biological treatment processes use indigenous or selectively cultured microorganisms to degrade organic compounds. Generally aerobic degradation is preferred, with the microorganisms breaking down the contaminants to water, carbon dioxide, and (if chlorinated) hydrogen chloride. Anaerobic processes only partially degrade organic contaminants, ideally resulting in a reduction of toxicity or making the end product more amenable to further treatment (e.g., aerobic treatment). Aromatic molecules such as the BTEX compounds are readily biotransformed. Even some of the chlorinated benzenes may be degraded. However, larger chlorinated molecules, such as PCBs and DDT, are recalcitrant to biological activity. Some progress has been reported in using anaerobic, followed by aerobic biodegradation to transform PCBs. However, biotreatment has not been routinely applied to PCB wastes, and is thus not considered effective. Therefore, biotreatment will not be retained for further consideration.

3.2.6 In Situ Treatment

Several methods are currently being developed which involve manipulation of the subsurface in order to immobilize, remove, or transform waste constituents. In situ techniques eliminate the need to excavate any soil. This approach can reduce remedial costs, and also eliminate the possibility of additional exposure. Therefore, the following physical treatments are evaluated:

- Bioventing,
- Vapor Extraction,
- Soil Flushing,
- Vitrification,
- Steam Stripping,
- Radio Frequency Heating,
- Solution Mining, and
- Stabilization and Solidification.

3.2.6.1 Bioventing

In situ bioventing is applied to contaminated soils in the unsaturated zone. This technology involves optimizing environmental conditions within the contaminated soils to promote the growth of microorganisms. Inorganic nutrients are intermittently delivered to the subsurface as aqueous solution through injection wells or an infiltration system. To increase the population of the degrading bacteria, groundwater from the saturated zone may be removed, treated in an above-ground bioreactor (generating increased numbers of microorganisms) and returned, with the delivered nutrients and oxygen, to the contaminated zone. Between periodic nutrient additions, air is drawn through the contaminated zone with a vapor extraction system. This supplies the necessary oxygen. Because PCBs and DDT are not readily biodegradable, in situ bioventing will not be retained for further evaluation.

3.2.6.2 Vapor Extraction

Vapor extraction is an in situ technique used to remove volatile and semivolatile organics from the vadose zone of soils. The basic components of the system include production wells, monitoring wells, and high-vacuum pumps. The system operates by applying a vacuum through the production wells. The vacuum system includes air flow through the soils, stripping and volatilizing the organics from the soil matrix into the air stream. The contaminated air stream is then typically treated by utilizing an activated carbon bed. However, the soil contaminants present are not volatile. Thus vapor extraction will not be retained for further evaluation.

3.2.6.3 Soil Flushing

Soil flushing is an extraction process in which organic and inorganic contaminants can be washed from contaminated soils. An aqueous solution is injected into the area of contamination, and the contaminant elutriate is pumped to the surface for removal, recirculation, on-site treatment, or reinjection. During elution, sorbed contaminants are mobilized into solution because of solubility, formation of an emulsion, or chemical reaction with the flushing solution. An in situ soil flushing system includes extraction wells installed in the area of contamination, injection wells installed upgradient of the contaminated soils area, and a wastewater treatment system.

This technology will not be retained for further evaluation. At the DRMO Yard, PCBs sorb strongly to soil particles and it would be difficult, if not impossible, to make them soluble. Although the metals may be mobilized with this technology, most contamination is at the surface and spread over a wide area. This would make it difficult to apply this technology. In addition, it would also be very difficult to select a flushing solution that would capture all of the different contaminants, due to their different chemistries.

3.2.6.4 Vitrification

In situ vitrification is a technology that was initially developed to stabilize transuranic-contaminated wastes, and it has been found to be applicable to other hazardous waste. The technology is based upon electric meter technology, and the principle of operation is joule heating, which occurs when an electrical current is passed through a molten mass. Contaminated soil is converted into durable glass, and wastes are pyrolyzed or crystallized.

In the process, a voltage is applied across electrodes placed in the ground. Under the high voltage, the soil volume between the electrode is heated to temperatures in excess of 3,000°F, thereby melting the soils. The molten mass of soil is then cooled to form a glassy, crystalline end product that is extremely stable. It is projected that materials will remain totally isolated for greater than 10,000 years. Although this technology is promising, and would almost certainly be successful in stabilizing the contamination, it is not an appropriate method for the small-scale contamination at the DRMO Yard. It also has not been fully developed, limiting its implementability. Therefore it will not be considered further.

3.2.6.5 Steam Stripping

In situ steam stripping is a technology in which steam is forced into areas of contamination to volatilize the contaminants. There are two types of technology available. Several vendors offer systems that inject steam through wells to deep organic contamination. The vaporized contaminants are then collected in a vapor extraction well. This approach is applicable only for contaminants located deep in the ground, or at sites with a cap. Application to shallow contaminated soil would cause contaminant vapors to be released to the atmosphere. Thus this process would not be applicable to the DRMO soils.

The second process uses twin large bore augers to penetrate and mix the soil, while simultaneously injecting steam. To capture the volatilized contaminants, a shroud is placed over the area being treated (approximately 30 square feet are treated at once). The shroud captures contaminants for condensation. Some success has been reported for semivolatile compounds. However, it is unlikely to be at all effective on PCBs or metals present at the DRMO Yard. Therefore, it will not be retained for further discussion.

3.2.6.6 Radio Frequency Heating

Radio frequency (RF) heating has been proposed as a method to remove organic contaminants in the subsurface through vaporization. In situ RF heating is applicable to vadose zone contamination. Vadose zone contamination in the DRMO Yard soils consists primarily of PCBs, DDT, and metals, none of which can be adequately handled by this technology. Therefore, in situ RF heating is not effective and will not be evaluated further.

3.2.6.7 Solution Mining

Solution mining is similar in principle to soil flushing. This technology involves flooding contaminated land areas with a solvent and then collecting the elutriate with a series of shallow well points. The process requires that the contaminants be mobilized into the solvent for recovery, either by solution or chemical reaction. Wastewater treatment of the recovered elutriate would be required. Potential problems associated with in situ solution mining include the difficulty of achieving adequate contact time with buried wastes and the increased risk of solvent or elutriate contributing to or spreading contamination. The degree of contact between solvent and contaminants can be difficult to determine. At the DRMO Yard, the contaminants are too diverse to allow this technology to be effective. A solvent capable of recovering the metals, PCBs, and DDT together would be difficult or impossible to develop. Thus this technology would be ineffective and is not retained for further evaluation.

3.2.6.8 Stabilization and Solidification

In situ stabilization consists of applying or injecting substances into a contaminated area with chemicals that detoxify pollutants. As with solution mining, a localized increase in hydraulic head due to injection could increase the vertical gradients, particularly near the injection points. In order to ensure complete contact with the subsurface contaminants, either very large quantities of stabilization chemicals would have to be injected, or some provision for controlling groundwater flow by pumping or diversion would be necessary. Variations in soil permeability may prevent complete contact with some of the contaminants. Because some of the contaminants present, such as PCBs and DDT, are not subject to detoxification agents in situ, in situ stabilization will not be retained for further consideration.

In situ solidification is a process in which the contaminants are immobilized. Several vendors market systems that solidify soils in place. Generally, these systems utilize large bore augers that penetrate and mix the soil. Meanwhile, solidification agents such as portland cement, silicates, or others (sometimes proprietary agents) are introduced through the auger to the soil. This technology can adequately reduce the mobility of contaminants, especially metals, providing sufficient in situ mixing is realized. Metals are best treated by this technology because they actually bond with the solidification agents. Organic contaminants may be less effectively treated by solidification. Unlike metals, they do not react with the added pozzolanic materials to form immobile complexes; they would simply be entrapped in the matrix. The soil contamination at the DRMO is located in both the asphalt pad and in native soils. It would be difficult to adequately mix these media in place with the solidification agents. This would be a significant obstacle for the implementation of this alternative. Thus, in situ solidification is not recommended and will not be evaluated further.

3.2.7 Disposal

3.2.7.1 Off-Site Disposal

Off-site disposal of contaminated soil/waste involves the hauling of excavated soil/ waste to a commercial sanitary or secure landfill for disposal. This technology effectively eliminates contaminant exposure routes. Several factors influence the implementability of off-site disposal in secure or sanitary landfills. The primary factors are whether the excavated soil is classified as hazardous by RCRA or is considered a TSCA-regulated waste. Some of the soils at the DRMO Yard would be regulated under TSCA due to the presence of PCBs. Those soils that are not hazardous or TSCA-regulated can be disposed of in a sanitary landfill. Thus, this technology is both effective and implementable and will be considered further.

3.2.7.2 On-Site Disposal

Excavated soil could be disposed of on-site either in a constructed landfill (with or without prior treatment) or directly on the site (after treatment). Untreated soil would have to be disposed of in a landfill constructed in accordance with Massachusetts Landfill regulations. Meeting these regulations would be an obstacle to implementation, but could still be possible. Treated soils may be disposed of directly on site as backfill. A special case would be soils treated by solidification. Although these soils would not be required to be disposed of in a landfill, it may be desired to backfill them in a designated area (because of their monolithic morphology) and under a cap to minimize weathering. On-site disposal will be retained for further evaluation.

3.2.8 Summary

Table 3-1 summarizes the remedial technologies for soils at the DRMO Yard operable unit that are screened in Section 3.2.

3.3 GROUNDWATER REMEDIAL TECHNOLOGIES AND MONITORING (AOCs 32 and 43A)

3.3.1 No Further Action

No Further Action provides no remedial actions for the present groundwater contamination. This option will be retained. Groundwater monitoring to observe potential change in water quality will also be retained under this option for both operable units.

3.3.2 Institutional Actions

Institutional controls over the groundwater contamination plumes can include zoning and deed restrictions, and continued monitoring of existing groundwater wells in the vicinity. Industrial and/or commercial zoning would restrict development of the property from residential usage. Deed restrictions would be required to ensure that no drinking water wells are installed which could potentially be impacted by the contaminated groundwater and that no construction would ensue which could expose the contamination. This option is effective in controlling the exposure to the contaminants. A waiver from attaining ARARs would be required. Continued maintenance of the use restrictions increase the difficulty of implementation. However, such action will be retained for further evaluation for both operable units.

3.3.3 Intrinsic Remediation (With Long-Term Monitoring)

Intrinsic remediation relies on natural attenuation to remediate contaminants in the subsurface. In many cases natural attenuation, by biotransformation, sorption, dispersion, diffusion, and other natural processes can reduce contaminant concentrations to acceptable levels before potential receptors are reached. Where ARARS are exceeded in the groundwater, the intrinsic remediation can only be applied in conjunction with institutional control, since drinking water wells cannot be permitted where ARARs are exceeded.

The use of intrinsic remediation requires the acquisition of sufficient data to demonstrate that the mechanisms of intrinsic remediation are reducing or will reduce contaminant concentrations to acceptable levels within the controlled area. It requires the use of groundwater models with conservative input parameters and sufficient sensitivity analyses to satisfy all plausible contaminant migration scenarios. Where possible, both historical monitoring data and modeling should be used to provide projections that collectively and consistently support the conclusion that the dissolved contaminant plume is naturally reduced to acceptable levels within the controlled area.

Currently, the POL Storage Area shows no downgradient wells exceeding ARARs or TBCs (since 43M93-05X is registering contaminants from elsewhere). Both 43MA93-04X and 43MA93-10X wells lie within the spill area associated with former leaking USTs, and show elevated TPHC. 43MA93-10X also showed elevated 2-methylnaphthalene exceeding ARARs. No downgradient monitoring wells have sampled water quality in the overburden aquifer except at and just below the water table. Additional investigation would be required to establish if intrinsic remediation is effectively working. The persistent low levels of TCE in POL-3 may possibly be indicative of the presence of a TCE dense non-aqueous phase liquid (DNAPL) within the underlying bedrock, although higher concentrations of TCE would be expected if the DNAPL exists in the overburden aquifer. Again, this possibility cannot be explored without additional investigation.

The presence of TCE in at least one bedrock well around UST 13 (32M-92-06X) at levels well in excess of those found in POL-3 (up to 200 μg/L) raises the possibility that the hydraulic gradients or fractures within the bedrock allow migration from the location of 32M-92-06X to the vicinity of POL-3, although this seems highly unlikely. To evaluate this question and the question of the effectiveness of intrinsic remediation at UST 13, additional investigation would again be required.

Intrinsic remediation will be retained as an alternative for both groundwater operable units.

3.3.4 Containment

Containment involves the prevention of contaminant migration by installing impermeable physical barriers or inducing hydraulic barriers by extracting and reinjecting to the contaminated groundwater. There are three process options involved in impermeable barriers; sheet piling, slurry walls, and grout curtains. Metal sheet piles may be inserted vertically into the overburden downgradient of the contamination plume, creating a physical barrier prohibiting migration of the contamination. The slurry wall is constructed by excavating a trench to the depth of bedrock, while simultaneously filling the trench with a bentonite slurry. A grout curtain is formed by drilling boreholes at a predetermined spacing and injecting grout under pressure to form a physical barrier against contaminant migration. Hydraulic containment can be achieved by extracting water in or downgradient of the plume at a rate sufficient just to reverse the flow gradient so that groundwater no longer migrates from the source area.

The groundwater at the UST 13 site is present in the bedrock. It is not possible to place physical containment barriers in this medium; thus physical barriers are not implementable. It is theoretically possible to implement a hydraulic containment option. However, the aquifer yields little or no water due to its low permeability, suggesting that hydraulic containment would not be implementable. Furthermore, the objective of hydraulic containment is to reverse the pattern of migration. As stated in Section 1.2.1.3, there is no apparent contaminant migration and the contaminant source (in soils) was removed with the tank. Therefore, this alternative would not be any more effective at reducing contaminant migration than the No Further Action alternative; it will not be retained.

The groundwater at the POL Storage Area/DRMO Yard shows only intermittent and low level contamination at or close to the water table, or where lower permeability till or bedrock are close to the surface. If subsequent investigation shows higher concentrations of contaminants in the bedrock then physical barriers are not likely to implementable. If higher levels of contamination are found in the deeper parts of the overburden aquifer (up to 50 feet below ground surface in boreholes 43BA93-03X, B-04S, B 43BA93-06X, and over 60 feet below surface in B-59S), costs are prohibitive. This is particularly so because to achieve closure, the barrier would have to extend around the site or be tied into lower hydraulic conductivity bedrock outcrops to east and northwest (Shepley's Hill). The installation of a containment barrier or barriers cannot be justified for this site and will not be retained for further evaluation.

Capping was discussed in Section 3.2.3 as a containment alternative for soils. It can also be used to minimize the production of leachate and the migration of groundwater, by preventing the infiltration of rainwater. It will be retained for further evaluation at UST 13.

3.3.5 Collection

The general response action of collection is represented by the technologies of groundwater extraction and subsurface collection trenches. Extraction involves the use of recovery wells to pump contaminated groundwater from the subsurface. In cases where adsorbed contaminants partition slowly to the groundwater, a pulsed pumping mode may reduce the volume of groundwater which is needed to flush the contaminated plume. Subsurface collection trenches are constructed by excavating to bedrock downgradient of the contaminated plume and installing a conduit to collect groundwater by gravity flow. Subsurface collection trenches are not implementable at the UST 13 site. As discussed in Section 3.3.3, the groundwater contamination is present in the bedrock. It is not feasible to install trenches in bedrock. It would be very difficult to collect groundwater from the bedrock due to its very low effective porosity so collection trenches will not be retained. Collection wells are also not likely to be effective in recovering a significant volume of contaminated groundwater. However, in the interest of developing remedial alternatives for this operable unit, collection via recovery wells will be retained for this operable unit.

If groundwater at the POL Storage Area/DRMO Yard requires remediation, then wells in the overburden aquifer are the most feasible method of intercepting and collecting the groundwater. Collection via recovery wells will be retained for this operable unit.

3.3.6 Ex Situ Treatment

Ex situ treatment involves either biological or physical/chemical technologies applied once the contaminated groundwater has been brought to the surface through collection.

3.3.6.1 Physical/Chemical Treatment

Many ex situ physical and chemical treatment technologies are utilized to treat inorganic and organic contaminants resistant to biodegradation.

Gravity separation is a technology used to treat two-phased aqueous wastes. It may be used to separate free gasoline or fuel oil from a fuel-contaminated aquifer, or to separate PCB oils from contaminated groundwater. The treatment tank must be designed with appropriate residence time to allow complete separation between the oil and water phases. This technology is effective and implementable. Some oil-phase material may remain at the UST 13 site. Thus this technology will be retained at UST 13 operable unit for further consideration as a pre-treatment step. For the POL Storage Area/DRMO Yard where no separate phase has been found or is expected, this technology will not be retained.

Flotation is used to remove oils and other suspended substances with densities less than that of water. Dissolved air flotation may also remove substances slightly heavier than water through adsorption to bubbles. Flocculants are frequently employed to enhance the efficiency of flotation units. Skimming is often incorporated into the flotation process. This technology is generally effective and implementable. As some emulsified organics may be present in the UST 13 groundwater, flotation will be retained for further consideration at this operable unit. At the POL Storage Area/DRMO Yard, the technology is not applicable and will not be retained..

The technologies of precipitation, coagulation, and flocculation are utilized to remove heavy metals, colloidal solids, and dissolved solids which could not be removed by sedimentation alone (see below). Precipitation is a chemical process where certain anions are added to the contaminated water to bond with soluble metallic ions, converting them to an insoluble form for precipitation out of the solution. Coagulation is a physical/electrochemical process in which suspended colloidal particles are destabilized. These particles generally possess a net negative charge on their surfaces. Coagulants neutralize this charge. Attractive forces between particles then become sufficient to allow for the creation of larger particles. Flocculation usually is done after precipitation or coagulation. The most common technique is orthokinetic flocculation, in which the water is mixed in a vessel to induce velocity gradients between particles of different sizes. These gradients increase the likelihood of collision between particles. Thus, larger particles result, which can be removed more easily by sedimentation or filtration (described below). Flocculation may be enhanced by the addition of organic polymers. The process is dependent upon chemical interactions, temperature, pH, solubility variances, and mixing effects. These technologies are effective and implementable. Although metals in the UST area groundwater operable unit are not being remediated, these technologies, in conjunction with a removal technique, can be successful in removing metals from an aqueous solution, if such removal is required prior to treatment for organics, through air stripping, for example. They will thus be retained for further consideration as a pre-treatment step. For the POL Storage Area/DRMO Yard groundwater operable unit, this technology could only be selected at a design stage after further site characterization identifies the need for remediation. It will not be retained at this stage.

Sedimentation removes suspended particles from contaminated water by allowing them to physically settle out if their densities are greater than water. Residence time in the sedimentation chamber must be adjusted to achieve maximum settling. The settled solids form a sludge at the bottom of the chamber, which is pumped out when necessary. This technique is effective when combined with coagulation and flocculation, and will be retained for further consideration as a pre-treatment step at the UST 13 operable unit. For the POL Storage Area/DRMO Yard groundwater operable unit, this technology could only be selected at a design stage after further site characterization identifies the need for remediation. It will not be retained at this operable unit at this stage.

Filtration is an excellent method for supplemental removal of residual suspended solids from contaminated groundwater. When water percolates from the surface into groundwater aquifers, natural filtration occurs and may remove a large portion of the suspended solids. The media and media size used are dependent upon the size of suspended particles remaining in the water to be treated. Silica sand, anthracite coal, and garnet sand are incorporated in uniform or mixed media filter processes. Filtration may be employed prior to other technologies to reduce potential for clogging, or as a polishing unit to remove residual floc from the effluent. This technology is effective in removing suspended materials that may otherwise interfere with other downstream processes. This technology is readily implementable. Thus, filtration will be retained for further consideration as a pre-treatment step for the UST 13 operable unit. For the POL Storage Area/DRMO Yard groundwater operable unit, this technology could only be selected at a design stage after further site characterization identifies the need for remediation. It will not be retained at this operable unit at this stage.

Neutralization is a technology implemented to raise or lower the pH of a wastewater stream to neutral levels. Acidic waters may be neutralized with lime, soda ash, caustic soda, or anhydrous ammonia, while alkaline waters may be neutralized with hydrochloric acid, carbon dioxide, sulfur dioxide, and sulfuric acid. The pH of the groundwater at Fort Devens does not warrant neutralization. However, although metals in the UST area groundwater are not being remediated, this technology may be needed as part of an overall treatment train. For instance, pH may need to be adjusted during precipitation to remove metals prior to treatment for organics, through air stripping, for example. Therefore, this treatment method will be retained for future consideration at the UST 13 operable unit. For the POL Storage Area/DRMO Yard groundwater operable unit, this technology could only be selected at a design stage after further site characterization identifies the need for remediation. It will not be retained at this operable unit at this stage.

Activated carbon adsorption is a technology that removes organics from contaminated water by adsorbing the organic compounds onto the extensive surface area of activated carbon. Activated carbon is utilized by adding powdered carbon directly into contaminated water, or by a more common method of allowing the water to flow through a column of fixed granulated carbon. When the activated carbon has been utilized to its maximum adsorptive capacity it is removed for disposal or regeneration. Activated carbon adsorption is effective on organics exhibiting low solubility and high molecular weight, and is reliable over a broad range of concentrations. The technology can be readily implemented on site and can remove dissolved organics from aqueous wastes to levels below 1 part per billion. Therefore, activated carbon will be retained for further consideration for the UST 13 operable unit. For the POL Storage Area/DRMO Yard groundwater operable unit, this technology could only be selected at a design stage after further site characterization identifies the need for remediation. It will not be retained at this operable unit at this stage.

Air and steam stripping technologies involve mass transfer processes in which volatile organic contaminants in water are transferred to gas. The contact between contaminated aqueous solutions and air is maximized, thus transferring volatile organics to the air or steam. Air stripping is effective for dilute waste streams containing highly volatile organics, while steam stripping is more effective for more concentrated waste streams containing less volatile organics. In the steam stripping process, steam is introduced into the bottom of a tower, and heats and volatilizes the organics before exiting the top of the tower. In air stripping, air is forced from the bottom to the top. In either case, it is likely that the off-gas stream will need further treatment by some other process. This technology has proven successful for the removal of organics and is therefore retained for further consideration for the UST 13 operable unit. For the POL Storage Area/DRMO Yard groundwater operable unit, this technology could only be selected at a design stage after further site characterization identifies the need for remediation. It will not be retained at this operable unit at this stage.

Ultraviolet (UV) light chemical oxidation technology provides for the destruction of organic contaminants in groundwater by simultaneously applying UV radiation and chemical oxidants. Hydrogen peroxide or ozone is used as a reagent to reduce or destroy the contaminants while the UV light catalyzes the chemical oxidation of the organics. The process entails passing contaminated groundwater through an oxidation chamber with UV lamps. The organic contaminants absorb the UV light, and the energy activates the contaminant to be easily oxidized by the reagent. This technology is not very effective on highly saturated hydrocarbons, as would be found at the UST 13 operable unit. Thus, this technology will not be retained. For the POL Storage Area/DRMO Yard groundwater operable unit, this technology could only be selected at a design stage after further site characterization identifies the need for remediation. It will not be retained at this operable unit at this stage.

Ion exchange technology is employed to remove toxic ions such as heavy metals from the waste stream, and replace them with non-toxic ions. The contaminated groundwater is first passed over an appropriate solid resin material with non-toxic ions to exchange. A second aqueous solution is used to remove the toxic ions from the resin. Liquid ion exchange involves the exchange of inorganic ions in contaminated groundwater to an immiscible organic stream containing reagents. No dissolved inorganic contaminants are present in the UST 13 groundwater. Thus this technology would be ineffective and is not retained. For the POL Storage Area/DRMO Yard groundwater operable unit, this technology would be inappropriate and will not be retained for further consideration.

Chemical oxidation utilizes an oxidizer such as hydrogen peroxide or chlorine to treat dilute contaminated water containing oxidizable organics. This technology has been successful in treating aldehyde, cyanide, mercaptans, phenols, benzidine, unsaturated acids, and pesticides. The contamination present at UST 13 is not treatable by this technology; therefore, it will not be retained for further consideration. For the POL Storage Area/DRMO Yard groundwater operable unit, this technology would be inappropriate and will not be retained for further consideration.

Chemical reduction involves the addition of a reducing agent which lowers the oxidation state of a substance to reduce toxicity, solubility, or to transform it into a form which can be easily handled. This technology is primarily applicable to metals, and therefore will not be retained for further consideration at UST 13. For the POL Storage Area/DRMO Yard groundwater operable unit, this technology would be inappropriate and will not be retained for further consideration.

Wet-air oxidation is a technology in which elevated temperatures and high pressures are applied to contaminated water to completely oxidize the organic contaminants. A disadvantage is the high strength recycle liquor produced. Wet-air oxidation is primarily applicable on extremely contaminated waters, thus it will not be retained for further consideration at UST 13. For the POL Storage Area/DRMO Yard groundwater operable unit, this technology would be inappropriate and will not be retained for further consideration.

Reverse osmosis and ultrafiltration are two technologies using membranes to segregate clean water from a contaminated concentrated aqueous stream. In reverse osmosis, fresh water is forced through a semipermeable membrane in the direction opposite to that occurring in natural osmosis. This technology is implemented after pretreatment to prevent plugging of the membrane. Reverse osmosis is primarily used to remove dissolved salts. Ultrafiltration technology removes suspended solids and dissolved particles from contaminated water on the basis of their molecular size as it passes through semipermeable polymeric membranes. Ultrafiltration may be applied to homogeneous solutions and colloidal suspensions. Both of these technologies generate a clean water stream, and a concentrate stream containing the contaminants. Thus these technologies principally serve to reduce the volume of liquid needing further treatment. At the UST 13 site, however, the volume of water needing treatment is relatively small. It is unlikely that groundwater can be extracted at any appreciable rate. Thus, it would not be appropriate to use a technology that simply reduces the volume of water requiring treatment, and these two technologies will not be retained.

At the POL Storage Area/DRMO Yard groundwater operable unit, the applicability of reverse osmosis and ultrafiltration can only be determined after further site characterization has identified the need for remediation and the nature of the contaminants. It will not be retained for this operable unit at this stage.

3.3.6.2 Biological Treatment

Two basic ex situ biological treatment technologies are fixed-film processes and activated sludge processes. These aerobic processes biologically convert contaminants to carbon dioxide and water.

The technology of fixed film treatment operates by allowing contaminated groundwater to contact a film of microorganisms attached to a solid material surface. One example is a trickling filter, in which water flows via gravity over a bed of rocks to which microorganisms are attached. This is used for drinking water treatment to remove organic compounds. Another technology for the treatment of hazardous organics is the fluidized bed. In the fluidized bed, water flows under pressure through a bed of treatment media at a rate high enough that the media is fluidized. The surface of the media is covered with a film of microorganisms which degrade the organics. Oxygen and nutrients may be pumped in as well to enhance treatment. The fluidized bed provides more complete mixing than the trickling filter, thereby accelerating the degradation process.

In activated sludge bioreactors, the microbial population are free floating within the reactor. In general, solids are separated out of the effluent, and a portion of the sludge is recycled back into the reactor to maintain the population. Three basic types of activated sludge reactors exist, batch reactors, completely stirred tank reactors, and plug flow reactors. Batch reactors are simple tanks in which wastewater is completely mixed and organics are allowed to biodegrade with no inflow or outflow. Stirred tank reactors are batch reactors with a constant inflow and outflow. Plug flow reactors are not mixed at all; wastewater simply flows in one end and out the other and organics are degraded along the way. The advantage of a plug flow reactor over the stirred reactor is that as the waste flows in, the concentration of contaminants is relatively high, which promotes fast degradation. The concentration decreases along the length, attaining its minimum at the outflow. In the completely stirred reactor, the concentration of contaminants must be maintained at the relatively low, desired outflow concentration. Therefore, degradation is slow and the volume of the reactor must be large. Nevertheless, they are often preferred because they are easier to operate.

Bioreactors have achieved some success with some of the contaminants of concern, such as petroleum hydrocarbon and chlorinated aliphatics (DDT and PCBs are difficult to degrade). Therefore, bioreactors will be retained for further consideration at the UST 13 operable unit.

At the POL Storage Area/DRMO Yard groundwater operable unit, these technologies could only be selected at a design stage after further site characterization identified the need for remediation. It will not be retained for this operable unit at this stage.

3.3.7 In Situ Treatment

Biological and physical/chemical in situ treatment technologies provide for the decontamination of groundwater without requiring its extraction and the construction of ex situ treatment units.

3.3.7.1 Permeable Treatment Beds

Permeable treatment beds are used to provide in situ treatment of the groundwater by constructing a trench to intercept groundwater flow, filling the trench with appropriate treatment materials, and capping the trench. The materials considered to be feasible in permeable beds are limestone, activated carbon, glauconitic greensands, and synthetic ion exchange resins. Although the relative cost of this technology is low to moderate compared with other technologies, permeable treatment beds will not be retained at the UST 13 site because trenching over 10 feet to the groundwater partly through hard igneous bedrock is not feasible.

Depth to groundwater and to top of bedrock downgradient of the POL Storage Area/DRMO Yard groundwater operable unit make the use of permeable treatment beds infeasible for this area. The use of "barrier and gateway" permeable treatment walls might be appropriate if subsequent investigation shows high levels of chlorinated solvents in the groundwater, but this could only be selected after further site characterization identifies the need for remediation. Permeable treatment beds will not be retained for further consideration at this operable unit at this stage.

3.3.7.2 Air Sparging

Air sparging is essentially an air stripping process conducted underground that involves the injection of pressurized air below the water table to create a transient air-filled porosity within the soil by displacing water. This process enhances biodegradation by increasing oxygen transfer to the ground water while promoting the physical removal of VOCs by direct volatilization. The technology is applicable to contaminated aquifer solids and vadose zone materials.

Certain limitations to the utility and applicability of air sparging exist. One such limitation is that air sparging systems cause water and contaminants to move away from the point of injection which can potentially accelerate and aggravate the spread of contamination. Changes in lithology can affect both the direction and velocity of air flow. This technology also increases the vapor pressure in the vadose zone; therefore, if the system is not designed properly, exhausted vapors could be drawn into receptors such as basements. Air sparging can be best controlled at depths from 4 to 30 feet at a site with relatively homogenous soil. If significant stratification is present, sparged air has the potential to be trapped below an impervious layer and contamination could be spread laterally.

As a result of these limitations and since the theory behind air sparging has not been developed to the extent that it can predict success or the time required to achieve it, treatability studies are required to assess site conditions, potential problems, obstacles, and actual timeframes. Because treatability studies are required for this technology, costs are moderate to high compared to other treatment options. Therefore, this technology will not be retained for further evaluation for either the UST 13 operable unit or the POL Storage Area/DRMO Yard operable unit.

3.3.7.3 Biological Treatment

In situ biological treatment uses biological cultures combined with aeration, additives such as acidic or caustic solutions for the adjustment of pH, and nutrient supplements such as nitrogen and phosphorus for nutrient-deficient environments to facilitate in-place groundwater treatment of organic contaminants. The cost associated with this treatment is moderate relative to other technologies. Although some of the contaminants of concern at the UST 13 site (i.e., DDT and PCBs) are not readily degradable and the chlorinated aliphatics may yield toxic degradation by-products (e.g., vinyl chloride), recent advances have been made in the biotreatment of these compounds. Therefore, this treatment option will be retained for further evaluation at this operable unit. In situ biological treatment can only be evaluated for the POL Storage Area/DRMO Yard groundwater operable unit at a design stage after further characterization identifies the need for remediation. It will not be retained for this operable unit at this stage.

3.3.8 Disposal

Upon extraction of the contaminated groundwater at either operable unit, or upon completion of a treatment technique discussed above, the water must be disposed of either by discharging into surface water, reinjection into the groundwater, or by transporting it to a wastewater treatment plant.

3.3.8.1 Off-Site Disposal

The wastewater treatment plants in the vicinity are the Ayer publicly-owned treatment works (POTW) and the Fort Devens wastewater treatment plant. The Fort Devens wastewater treatment plant is designed for primary treatment only, and its treatment techniques may not be applicable. The Town of Ayer POTW has a capacity of 1.79 million gallons per day, utilizes activated sludge technology, and discharges treated wastewater into the Nashua River. Water would have to be transported to the facility via truck or a new dedicated pipeline. This technology will be retained for further screening, given that the water meets pretreatment requirements before it is piped to one of these facilities.

3.3.8.2 On-Site Disposal

Discharge into a surface water body of treated groundwater would require an NPDES permit and would require satisfaction of all Massachusetts discharge limits. The surface water bodies in closest proximity to the remediation would be Plow Shop Pond or Willow Brook. This option is retained for further screening in conjunction with treatment technologies.

Reinjection of the treated groundwater back into the aquifer can be used to dispose of the groundwater. Although it is not possible to reinject water into the bedrock aquifer at the UST 13 site, as discussed in Section 3.3.6, treated water could be injected into the vadose zone/overburden above the bedrock. This reinjection, however, may locally increase the downward vertical gradient and subsequently cause downward movement of contamination. In addition, reinjection may clog the well screens with grit and precipitated matter. Furthermore, to reinject, all constituents in the effluent must be at or below background levels. This technology, therefore, will not be retained for further evaluation at this operable unit. Reinjection of treated groundwater at the POL Storage Area/DRMO Yard groundwater operable unit might be technically feasible, but uncertainties about the effect of reinjecting water of different pH, eH, and oxygen content would require pilot studies to ensure that this type of disposal would, in fact, be feasible. It will not be retained for further evaluation at this stage, since active remediation has not yet been shown to be necessary at this operable unit.

3.4 SUMMARY

Table 3-2 summarizes the remedial technologies screened for the groundwater at the UST 13 and POL Storage Area/DRMO Yard operable units and the results of the screening of the response action. All the remedial technologies except No Further Action, Institutional Action, and Intrinsic Remediation are rejected at this time for the POL Storage Area/DRMO Yard groundwater operable unit, because the proposed remedies can only be evaluated at a later stage, if after further characterization, the need for active remediation is identified.

Table 3-1

SUMMARY OF REMEDIAL TECHNOLOGIES FOR SOILS

General Response Action	Remedial Technology	Screening Result
No Further Action		Evaluate
Institutional Actions		Evaluate
Containment	Single layer caps	
	- Sprayed asphalt	Reject
	- Concrete slab	Reject
	- Asphalt pavement	Reject
	Multilayer caps	
	- Clay	Evaluate
	- Synthetic membrane	Evaluate
	- Combination	Evaluate
Excavation		Evaluate
Ex Situ Treatment	Thermal Oxidation/ Incineration	Evaluate
	Chemical Treatment	
	- Glycolate dechlorination	Reject
	Physical Treatment	
	- Soil washing	Reject
	- Solvent extraction	Evaluate
	- Solidification/Stabilization	Evaluate
	- Volatilization/Thermal Desorption	Evaluate
	- Asphalt batching	Reject
	Biological Treatment	Reject
In Situ Treatment	Biological Treatment	Reject
	Physical Treatment	
	- Bioventing	Reject
	- Vapor extraction	Reject
	- Soil flushing	Reject
	- Vitrification	Reject
	- Steam stripping	Reject
	- Radio frequency heating	Reject
	- Solution mining	Reject
	- Stabilization	Reject

Table 3-1

SUMMARY OF REMEDIAL TECHNOLOGIES FOR SOILS

General Response Action	Remedial Technology	Screening Result
In Situ Treatment (cont.)	- Solidification	Reject
Disposal	Off-site Disposal	Evaluate
	On-site Disposal	Evaluate

Table 3-2

SUMMARY OF REMEDIAL TECHNOLOGIES FOR GROUNDWATER AT UST 13 AND POL STORAGE AREA/DRMO YARD OPERABLE UNITS

General Response Action	Remedial Technology	UST 13 Screening Result	POL/DRMO Screening Result
No Further Action		Evaluate	Evaluate
Institutional Actions		Evaluate	Evaluate
Intrinsic Remediation (with long-term monitoring)		Evaluate	Evaluate
Containment	Physical Barrier		
	- Sheet piling	Reject	Reject
	- Slurry wall	Reject	Reject
	- Grout curtain	Reject	Reject
	Hydraulic Barrier	Reject	Reject
	Capping	Evaluate	Reject
Collection	Recovery Wells	Evaluate	Evaluate
	Collection Trenches	Reject	Reject
Ex Situ Treatment	Biological Treatment		
	- Fixed film	Evaluate	Reject
	- Activated sludge	Evaluate	Reject
	Physical/Chemical Treatment		
	- Gravity separation	Evaluate	Reject
	- Flotation	Evaluate	Reject
	- Precipitation/Coagulation/ Flocculation	Evaluate	Reject
	- Sedimentation	Evaluate	Reject
	- Filtration	Evaluate	Reject
	- Neutralization	Evaluate	Reject
	- Activated carbon adsorption	Evaluate	Reject
	- Air/Steam stripping	Evaluate	Reject
	- UV oxidation	Reject	Reject
	- Ion exchange	Reject	Reject
	- Chemical oxidation	Reject	Reject
	- Chemical reduction	Reject	Reject
	- Wet air oxidation	Reject	Reject
	- Reverse osmosis	Reject	Reject

Table 3-2

SUMMARY OF REMEDIAL TECHNOLOGIES FOR GROUNDWATER AT UST 13 AND POL STORAGE AREA/DRMO YARD OPERABLE UNITS

General Response Action	Remedial Technology	UST 13 Screening Result	POL/DRMO Screening Result
	- Ultrafiltration	Reject	Reject
In Situ Treatment	- Permeable Treatment Beds	Reject	Reject
	- Air Sparging	Reject	Reject
	- Biological Treatment	Evaluate	Reject
Disposal	Surface Water Discharge	Evaluate	Reject
	Reinjection	Reject	Reject
	POTW	Evaluate	Reject

4. DEVELOPMENT AND SCREENING OF REMEDIAL ALTERNATIVES AND MONITORING

The remedial technologies that were identified and retained in Section 3 are developed into remedial alternatives in this section. The retained technologies are assembled, as appropriate, into comprehensive alternatives that address the entire operable unit. Although more combinations of technologies exist than those identified as alternatives, only those technologies that are compatible with each other and potentially feasible for the specific operable unit were combined into the alternatives presented below. Also, some of the technologies that were retained in Section 3 were not included in any alternative, because other technologies were considered more appropriate.

The developed alternatives are then screened to select those that will be examined in detail in Section 5. Screening is performed on the bases of effectiveness, implementability, and relative costs.

4.1 DRMO YARD SOILS OPERABLE UNIT

Seven alternatives have been developed for the DRMO Yard soils operable unit. These are:

A1: No Further Action;
A2: Institutional Actions;
A3: Containment via Capping;
A4: Excavation, Solidification, and On-Site Disposal;
A5: Excavation, Solvent Extraction, Thermal Desorption, and Backfilling;
A6: Excavation and Off-Site Disposal; and
A7: Excavation and Off-Site Incineration.

Each of these alternatives is described and screened below.

4.1.1 Alternative A1: No Further Action

4.1.1.1 Description

This alternative involves no remedial action; no treatment or containment will be performed, and the contamination will remain in its present state. The selection of this alternative does not satisfy the remedial action objectives for the DRMO Yard operable unit. This alternative would leave contaminated soil in place; it would also take no action in eliminating the exposure pathways of these contaminants. The No Further Action alternative is included as a requirement of the NCP (40 CFR 300) and to provide a basis of comparison for the remaining alternatives.

4.1.1.2 Evaluation

Effectiveness

The No Further Action alternative is ineffective and does not meet the remedial action objectives for this operable unit. The human health risks would remain as described in the risk assessment. The soil contamination could conceivably impact drinking water sources in the future. The soil would continue to pose a theoretical hazard to construction workers in the future if the site were to be developed.

Implementability

The no-action alternative would be difficult to implement as the current situation exceeds cleanup goals, including PCB ARARs, and a waiver from meeting ARARs would have to be obtained. This waiver would be difficult to obtain.

Relative Cost

As this alternative involves no remedial action, institutional action, containment, disposal, or monitoring, no capital or operation and maintenance (O&M) costs are associated with it. Although not easily quantified, the cost of future liability from contaminants remaining on site may be significant.

4.1.2 Alternative A2: Institutional Actions

4.1.2.1 Description

Institutional actions are minimal actions taken to reduce exposure to contaminated media. This alternative would involve no actual remediation. Examples of the actions that could be taken include the installation of a fence surrounding the perimeter of the operable unit, and the prohibition of future development of the land, possibly through deed restrictions. This alternative does not remove the source of contamination, and if these institutional controls were violated in some way, the protection of human health would be compromised.

4.1.2.2 Evaluation

Effectiveness

This alternative would not be effective in reducing the level of contamination at the DRMO Yard operable unit. It would have no more of a remedial effect than Alternative A1, No Further Action. However, it does have the potential, if executed properly, to reduce exposure to the contaminants of concern. The effectiveness of the institutional actions would depend on the type of control implemented. As most of the contamination is surface contamination, access controls would have to be monitored regularly to ensure effectiveness.

Implementability

Implementation of this alternative would depend on legal authority and requirements. It may be difficult to implement Alternative A2 as PCB ARARs would still be exceeded, and it may be difficult to obtain a waiver of this requirement.

Relative Cost

Institutional actions are very inexpensive relative to treatment, containment, excavation, and disposal.

4.1.3 Alternative A3: Containment via Capping

4.1.3.1 Description

This alternative would reduce the risks of direct exposure to the DRMO Yard contaminants through capping. A multiple layer cap consisting of clay and topsoil would be used.

The first step of this alternative would be to grade the areas that are to be capped. In some cases, it may be appropriate to excavate certain isolated hotspots that are far from the main areas of contamination and consolidate these with other contaminated wastes. Once graded, a layer of clay (maximum permeability of 10^{-7} cm/sec) approximately two feet thick would be applied to the area and compacted. Loam (topsoil) would be placed over the clay to allow vegetative growth to help maintain the integrity of the cap. (The clay cap could be replaced by a low permeable plastic liner, overlain by a 12-inch high-permeable sand drainage layer. However, for simplicity, only the clay alternative is fully developed.) The site would require long term monitoring of the integrity of the cap, and future use of the site would be precluded. Cap maintenance would be required from time to time to repair areas that may become eroded or otherwise damaged with age.

4.1.3.2 Evaluation

Effectiveness

A properly installed and maintained multiple-layered cap would effectively prevent exposure to contaminated soil via dermal adsorption, ingestion, or inhalation because the contaminated material would be physically isolated. It would also prevent erosion and the contamination of groundwater and surface water. Contaminants at concentrations above cleanup goals would remain at the site. This alternative would not meet the preference for treatment of contaminants.

Implementability

The technology needed for capping this operable unit is reliable and well-established and thus is readily implementable. A storm water management and erosion control plan may be required to minimize erosion during cap construction. This alternative would require that the site not be used for development in the future.

Relative Cost

Capping costs are dependent on the size of the area to be capped as well as the cap design. Although the area to be capped at the DRMO area is relatively small, the proposed design of the cap is multilayer. Therefore, costs are expected to be moderate relative to treatment, disposal, and institutional actions.

4.1.4 Alternative A4: Excavation, Solidification, and On-Site Disposal

4.1.4.1 Description

This alternative would require the excavation of those contaminated areas at the DRMO Yard exceeding cleanup goals. The soils to be excavated are primarily surface soils from various parts of the northern section of the yard. The excavated soils would be consolidated and stockpiled. On-site solidification involves mixing the excavated soils with cement, fly ash and lime, or other reagents that will both transform the soil into solid monoliths, reducing potential exposure risks, and reduce the leachability of metals. Organic contaminants, such as PCBs and DDT, would be physically bound up in the solidified material, making them inaccessible to direct contact. Inorganic contaminants react with the solidification reagents and become chemically bound up in the solidified matrix. This significantly reduces their leachability.

Solidification may be carried out in a number of similar ways, including mixing in a pug mill followed by curing in forms, or simple bulk mixing with earth moving equipment on a specially constructed mixing pad. The correct mixture of soil, reagents such as cement, and water that would produce the strongest monolith, reduce leachability, and keep volume increase to a minimum, would be determined with a treatability study. Once mixed, the mixture would have to cure for up to a month to achieve full strength.

Once the material was fully cured, it would be placed in a disposal cell on site. This cell would require some excavation, primarily for grading reasons, but for the most part could be above ground, especially considering the limited amount of soil requiring solidification. The location of the disposal cell would have to be determined in consultation with installation authorities, but would likely be near the north end of the yard, from where most of the contaminated soil had been removed. The disposed monoliths would be covered with a layer of topsoil and seeded.

4.1.4.2 Evaluation

Effectiveness

This alternative would be effective in reducing direct contact exposure routes to the contaminants. The leachability of lead and cadmium would be drastically reduced, thereby preventing exposure to either surface water or groundwater. Organic contaminants would be essentially contained rather than destroyed. However, the organics would also be far less susceptible to erosion (to surface water) or leaching (to groundwater). Solidification is widely used to treat metals contamination. Although it is generally less effective for organics, it is used successfully on larger molecular weight, less mobile organics, such as PCBs and DDT.

Implementability

The implementability of the alternative depends on the extent that the installation is willing to have solidified material remain at the DRMO Yard site. Leaving the solidified material there would limit the usefulness of that portion of the site. This would preclude some future uses. Potentially, the MDEP could impose ongoing future monitoring requirements at the disposal site. There would be no legal barriers to implementability, as the soil is not a RCRA hazardous waste. As the solidification process is exothermic, the process would have to ensure that no significant fugitive organic emissions are released during the treatment process.

Relative Cost

The excavation, solidification, and on-site disposal costs associated with this alterative are moderate compared with the costs of institutional controls, containment, and other treatment methods.

4.1.5 Alternative A5: Excavation, Solvent Extraction, Thermal Desorption, and Backfilling

4.1.5.1 Description

This alternative would provide a complete on-site treatment of the DRMO Yard soils contaminated above cleanup goals, allowing them to be backfilled on-site. Because the nature of the contaminants varies throughout this operable unit's soils, two treatment technologies would be employed to provide complete treatment. These treatments would be conducted in series, although, if soils can be segregated during excavation into organic-only and inorganic-only contaminated soils, then these soils need only to be treated in the single appropriate treatment step.

The first treatment would be solvent extraction to remove metals from the soil. Solvent extraction uses a solvent to leach contaminants from the solid matrix. The solvent would then be treated to transfer the leached metals from solution into a concentrated sludge. The sludge, which would be a much smaller volume than the contaminated soil, would then be disposed of off-site, possibly after first being treated by solidification at the disposal site. The solvent would then be reused. As it would be difficult to select a solvent that could recover both metals and organic contaminants, the process would be directed only at metals removal. Thus a solvent such as an acid or an aqueous chelator solution would be used. To regenerate an aqueous or chelating aqueous solvent, treatment technologies such as precipitation (possibly simply through neutralization), ion exchange, or evaporation may be used. This process would require the mobilization of tanks, clarifiers, and other process units on site. The system would have to be configured from the results of treatability studies that pick the best solvent, solvent regeneration system, and solvent/soil separation systems.

The second treatment would be aimed at removing organic contaminants. Thermal desorption removes volatile and semi-volatile contaminants from soil as vapors through heating. The thermal desorption unit would be a mobile unit owned and operated by one of several vendors in this field. Because of the small volume of soil to be treated, the unit could probably be one of the vendors' pilot units. The actual treatment process is straightforward. Contaminated materials are fed into a thermal processor or materials drier, where they are heated to 500°F to 1,000°F while being mixed to allow moisture and volatile contaminants to escape. The soil can be heated either by direct firing with the hot gases from a combustion process, or indirect firing, where the heat is conducted through the walls of a screw or drum. The indirect firing method results in a smaller volume of offgas requiring treatment. The treated soil would be stockpiled, tested for treatment verification, then backfilled on site.

The offgas from the process would be directed to an offgas treatment system, including a cyclone/baghouse (fabric filter) system, to remove entrained particulate material, a condenser to remove the condensible organic compounds, and then an additional organic vapor treatment unit such as activated carbon or an afterburner. Condensate from the condenser would be composed of water and condensed organics. The two-phase condensate would be separated in an oil/water separator. The separated oil would be stored for future transport and processing off site. The water, with a relatively low concentration of soluble organics, would typically be treated using a carbon adsorption system. The treated water would be sprayed on the treated soil to cool it and suppress gas generation. The spent carbon from the carbon adsorption system would require periodic replacement and/or regeneration. A likely disposal option for the spent carbon would be regeneration in which the organic contaminants are destroyed by incineration.

4.1.5.2 Evaluation

Effectiveness

This alternative would use two separate sequential treatment technologies to remove contaminants from the DRMO Yard soils. Successful treatment of the soils would remove all routes of exposure and would meet all RAOs for the operable unit. The effectiveness of solvent extraction is difficult to predict prior to conducting treatability studies. A solvent that could effectively remove metals (lead and cadmium are the principal metal of concern) could probably be selected. However, it can be difficult to select a solvent that is effective in removing the metals, yet can be easily regenerated. Acid solvents require a great deal of neutralization chemicals to precipitate the dissolved metals. This would also remove the acidity from the solvent, such that it cannot be reused. In addition, it is very difficult to remove chelated metals from solution, although once removed, the solvent could be reused.

The second technology, thermal desorption, is an increasingly commonly used treatment technology that would be effective in removing organic contaminants, including low volatility chemicals such as PCBs and DDT. Although this technology does not itself destroy the contaminants, once separated, the chemicals are destroyed in subsequent steps, such as when the carbon is regenerated, or the condensate is treated off site. (Glycolate dechlorination was retained in Section 3 as a potential treatment for PCBs. However, since it is not effective for DDT, DDD, and DDE, it was dismissed in favor of thermal desorption in the development of alternatives.)

Implementability

Residuals from both of these technologies would require off-site treatment and/or disposal. The metals in the sludge generated from the solvent regeneration would likely be hazardous by the toxicity characteristic, and thus would have to be treated prior to disposal. This treatment would be conducted at the disposal facility. Condensed oil from the desorption unit would have to be destroyed, probably by incineration, at an off-site facility. Because this oil would contain PCBs, it would have to be treated in a TSCA-regulated facility. As such facilities are available, this would not be an obstacle to implementation.

Even if the solvent extraction treatment step is effective, residual arsenic below the cleanup goal remaining in the soil after treatment could pose a problem during thermal desorption. This metal, and the compounds in which it is frequently found, is fairly volatile, and difficult to remove from an offgas. Meeting off-gas requirements for this metal could be an obstacle to implementation. This alternative would also be required to meet a number of other requirements during operation, including surface water discharge requirements applicable for any spent solvent or recovered water discharges, and possible RCRA and TSCA requirements from handling characteristic-hazardous wastes and PCBs.

Though not specific obstacles to implementation, this alternative would require a great deal of treatability testing, on-site mobilization, and regulatory interface. This may not be appropriate for the relatively small amount of contaminants present at this operable unit.

Relative Cost

The excavation, solvent extraction, thermal desorption, and backfilling costs associated with this alternative are high compared with the costs of institutional controls, containment, disposal, and other treatment methods.

4.1.6 Alternative A6: Excavation and Off-Site Disposal

4.1.6.1 Description

This alternative is very straightforward. Contaminated soils would be excavated as discussed for previous alternatives. The soils would then be disposed of off site in a non-hazardous industrial landfill. Because of the absence of RCRA hazardous wastes (listed or characteristic), and the relatively low concentrations of PCBs (less than 50 mg/kg), the soil does not need to go to a RCRA- or TSCA-regulated landfill. Because the soils are mostly surficial, backfilling may not be required (i.e., regrading may be sufficient to return the site to an acceptable grade). Regrading may be sufficient for handling any of the deeper areas of excavation, and for smoothing out, in general, the excavated area.

4.1.6.2 Evaluation

Effectiveness

This technology would remove all routes of exposure, and meet RAOs for the operable unit. It would not satisfy the preference for treatment at the site. However, for the relatively small volume of contaminated soil and the variety of contaminants, treatment may not be appropriate.

Implementability

Because of the non-hazardous nature of the soil, there should be no obstacles to implementing this alternative.

Relative Cost

Excavation and off-site disposal costs are expected to be low to moderate relative to treatment, containment, and institutional actions.

4.1.7 Alternative A7: Excavation and Off-Site Incineration

4.1.7.1 Description

This alternative would be similar to Alternative A6, except that the soils would be sent to an off-site incinerator rather than a landfill. The incinerator would thermally destroy the organic contaminants in the soil, while the metals would remain in the ash. The incineration facility would then dispose of the ash in accordance with applicable regulations.

4.1.7.2 Evaluation

Effectiveness

This alternative would remove all routes of exposure and meet all RAOs for the operable unit. It would also satisfy the preference for treatment for the organic contaminants.

Implementability

There are no obstacles to implementation expected with this alternative.

Relative Cost

Excavation and off-site incineration costs are expected to be very high relative to institutional controls, containment, disposal, and other treatment methods.

4.1.8 Selection of DRMO Yard Alternatives for Detailed Analysis

The following alternatives are retained for further consideration in the detailed analysis:

A1: No Further Action;
A2: Institutional Actions;
A3: Containment with Capping;
A4: Excavation, Solidification, and On-Site Disposal; and
A6: Excavation and Off-Site Disposal.

The other two alternatives were eliminated because they were both significantly more complex and thus would be more expensive, without providing additional levels of protection to human health and the environment. Alternative A5 called for two treatments that would require significant development to work well enough to allow the treated soils to be backfilled. The effort involved is not warranted in light of the small volume of soil to be treated. Alternative A7 calls for off-site incineration, which is not warranted for the levels of organic contaminants present in the soils at this operable unit. Table 4-1 provides a summary of this screening. Alternatives A1, A2, A3, A4, and A6 are analyzed in greater detail in Section 5.

4.2 UST 13 GROUNDWATER OPERABLE UNIT ALTERNATIVES

Six alternatives were developed for the UST 13 groundwater operable unit:

B1: No Further Action;
B2: Institutional Actions;
B3: Intrinsic Remediation (with long-term monitoring);
B4: Containment via Capping;
B5: Groundwater Extraction with On-Site Treatment via Carbon Adsorption; and
B6: In Situ Groundwater Bioremediation.

Each of these alternatives is described and evaluated below.

4.2.1 Alternative B1: No Further Action

4.2.1.1 Description

This alternative would involve no remedial action; no treatment or containment would be performed, and the contamination would remain in its present state. The selection of this alternative would not satisfy the remedial action objectives for the UST 13 operable unit. This alternative would leave contaminated groundwater in place; it would also take no action in eliminating the exposure pathways of these contaminants. Monitoring of the groundwater would continue annually and the site would be reevaluated after 5 years. This will ensure that changes at the site do not affect the conclusions concerning the risks of the No Further Action alternative.

4.2.1.2 Evaluation

Effectiveness

The no-action alternative is ineffective and does not meet the remedial action objectives for this operable unit. The human health risks would remain as described in the risk assessment. However, because the contamination is in a very small area (less than 0.25 acres), with very slow groundwater movement (and groundwater from the site ultimately flows under Shepley's Hill Landfill), it is highly unlikely that it could impact human health or the environment. Groundwater would continue to exceed cleanup goals, but will be monitored for deterioration.

Implementability

The No Further Action alternative would be difficult to implement as the current situation exceeds groundwater ARARs and a waiver from meeting the ARARs would have to be obtained. This waiver may be difficult to obtain.

Relative Cost

As this alternative involves no remedial action, institutional action, containment, collection, treatment, or disposal costs, only monitoring costs are associated with it. Although not easily quantified, the costs of future liability from contaminants remaining within the bedrock on site are not likely to be significant.

4.2.2 Alternative B2: Institutional Actions

4.2.2.1 Description

Institutional actions are minimal actions taken to reduce exposure to contaminated media. This alternative would involve no actual remediation. Examples of the actions that could be taken include prohibition of drinking water well installation, the installation of a fence surrounding the perimeter of the operable unit, and the prohibition of future development of the land, possibly through deed restrictions. It would also include continued monitoring of the wells every 5 years for up to 30 years to detect the movement of contaminants, if any. This alternative fails to remove the contamination, and if these institutional controls were violated in some way (e.g., if a drinking water well were installed at the site), the protection of human health would be compromised. However, the aquifer yield at this site is so low that a drinking water well would probably not provide sufficient water even for domestic supply.

4.2.2.2 Evaluation

Effectiveness

This alternative would not be effective in reducing the level of contamination at the UST 13 operable unit. It would have no more of a remedial effect than Alternative B1, No Further Action. However, it does have the potential, if executed properly, to minimize exposure to the contaminants of concern. The effectiveness of the institutional actions would be directly dependent on the type of control implemented.

Implementability

Implementation of this alternative would depend on legal authority and requirements. It may be difficult to implement Alternative B2 as groundwater ARARs would still be exceeded, and it may be difficult to obtain a waiver of this requirement.

Relative Cost

Institutional actions are inexpensive relative to treatment, containment, collection, and disposal.

4.2.3 Alternative B3: Intrinsic Remediation

4.2.3.1 Description

Intrinsic remediation is an approach that relies on natural attenuation to remediate contaminants in the subsurface. Because it relies upon slow natural processes, and involves long-term monitoring to observe the gradual natural restoration of the site to pre-contaminant conditions, it necessarily involves institutional action. During the period of restoration, access to the site for some uses, such as water supply, is necessarily restricted, since the groundwater contaminant levels exceed ARARs.

What differentiates intrinsic remediation from institutional action is the degree of characterization of the site, the modeling of groundwater flow and contaminant migration, and the long-term monitoring effort to ensure that natural attenuation is working as expected.

Because of these needs, the UST 13 area would require the installation of additional wells (three are costed), integration of the field data into a groundwater flow and contaminant transport model, and the performance of long-term monitoring.

4.2.3.2 Evaluation

The detailed characterization of the site, with eight wells within a two-acre area around the former tank (UST 13) location, will be combined with borehole and geophysical (seismic) data to refine the shape of the top of bedrock. The water levels in the wells will define the relationship between the water table and top of bedrock, and hence the relationship between the "overburden" and "bedrock" aquifers with differing hydraulic conductivities and anisotropies.

A groundwater model will incorporate climatic, geologic, hydrologic and contaminant distribution data, to test various assumptions about groundwater flow, and to explore the sensitivity of the model to changing assumptions. Once the flow model has been calibrated to reproduce the main features of the site and to fit satisfactorily with the field data, transport modeling of contaminants can be performed.

Continued monitoring of the site on a yearly basis will confirm or disprove the projected rates of contaminant movement. If the monitoring proves that contaminants are not leaving the site at levels above ARARs, then the remedy will be protective of human health and the environment.

If monitoring demonstrates that the model is underestimating rates and levels of movement of contaminants, then the remedy may have to be reviewed and perhaps amended.

Implementability

The materials, techniques, and labor necessary to implement this alternative are all readily available, and aspects of the proposed program have already been implemented. Many vendors are available to provide competitive bids on all aspects of the program: well installation, data collection, modeling, and data assessment.

After well installation, O&M would be minimal, and continuing costs of sampling and analysis relatively predicable. Investigation-derived waste would have to be properly stored and handled, but no hazardous waste generation is expected.

If successfully implemented, this remedial alternative would be protective of human health and the environment, and would minimally disrupt site activities.

Relative Cost

The well installation, continued sampling, and monitoring would be more expensive than institutional controls alone. It would have to be implemented with restrictions on specific activities up to the time of its completion.

4.2.4 Alternative B4: Containment Via Capping

4.2.4.1 Description

This alternative would construct a cap over the area of contaminated groundwater. Soils contaminated by the UST leak have already been removed. Thus the principle objective of the cap would be to reduce infiltration of precipitation into the overburden above the bedrock aquifer, and hence reduce recharge to the aquifer. This would reduce the plume migration rate within the aquifer. The cap would be as described for Alternative A3. Its principal component would be a layer of 10^{-7} cm/sec permeability clay to eliminate water infiltration.

4.2.4.2 Evaluation

Effectiveness

Although capping would reduce the infiltration of precipitation and snow melt, the proposed cap would sit approximately 12 feet above the water table, allowing the water to seep in from the adjacent uncapped areas and reach the aquifer. Augmenting the cap with vertical barriers would not be effective in stopping the infiltration from these adjacent uncapped areas, since the aquifer exists mainly in bedrock and vertical barriers cannot be installed in bedrock except with great difficulty and expense. Under present conditions, the migration of the plume is being restrained by the low hydraulic conductivity and low gradient of the bedrock aquifer. Furthermore, the area affected is small, less than 0.25 acres, and this aquifer is not used as a potable water supply.

Implementability

The technology required to cap and grade the UST 13 area is reliable and well established. No specialized techniques, material, or labor would be required. Long-term maintenance and groundwater monitoring would be required to ensure that the integrity of the cap is maintained. In order to minimize erosion, erosion controls may be necessary. Future residential use of the area would likely be precluded and would be reviewed by the appropriate boards or agencies. However, a waiver may be required because groundwater ARARs would still be exceeded, and this waiver may be difficult to obtain.

Relative Cost

Capping costs are dependent on the size of the area to be capped as well as cap design. Although the size of the UST area is small, the design of the cap is multilayer. In addition, long-term maintenance and groundwater monitoring would increase costs, making expected capping O&M costs moderate relative to institutional action, collection, treatment, and disposal.

4.2.5 Alternative B5: Groundwater Extraction with On-Site Treatment via Carbon Adsorption

4.2.5.1 Description

Under this alternative, groundwater would be extracted by an extraction system composed of pumping wells. The groundwater would then be passed through a liquid-phase carbon adsorption system in order to remove organic contamination. The treated groundwater would then be transported to the town of Ayer POTW or commercial aqueous waste treatment facility.

4.2.5.2 Evaluation

Effectiveness

Any groundwater that could be recovered would be treated effectively by carbon adsorption, a well-demonstrated technology that can remove organics from aqueous wastes to levels below 1 part per billion (ppb). Carbon adsorption, was selected over air stripping (which was also retained in Section 3) because it is more effective on a wider range of organics. Also, air stripping would require treatment of offgas and use of pre-treatment technologies (separation, precipitation, etc.) to remove metals prior to air-stripping.

The UST 13 area aquifer exists mostly in the underlying bedrock and the hydraulic conductivity of the bedrock in this area is relatively low (3.5×10^{-4} cm/sec) and the area involved is small. Therefore, it is expected that very little water could be extracted. It is estimated that less than 1 gallon per minute (gpm) would be extracted. The migration of the plume would be halted, but it is currently being restrained by the low hydraulic conductivity and low gradient of the bedrock aquifer. Furthermore, this aquifer is not used as a potable water supply so no exposure currently occurs.

Implementability

The techniques, materials, and labor necessary to implement this alternative are readily available. Many vendors are available to provide competitive bids for the construction and operation of a groundwater extraction system. Impacts on surrounding land use from the installation of extraction wells would be minimal. A carbon adsorption system would be relatively simple to construct and operate. The necessary materials and equipment are available from several vendors. O&M requirements would be minimal, involving monitoring of the effluent for breakthrough. The treated water would be transported to the POTW via truck, rather than a new dedicated pipeline, as transporting it is more feasible, based on the low volume expected. (Transport to a POTW was considered easier to implement than discharge to surface water, which would have required a NPDES permit and SPDES permit for all compounds.) Implementation of this alternative would satisfy the statutory preference for using treatment as a principal element in remediation.

Relative Cost

The extraction, carbon adsorption, and disposal costs associated with this alternative are expected to be moderate to high compared with the costs of institutional controls, containment, and other treatment and disposal technologies. The spent carbon can be regenerated, but for strongly adsorbed contaminants, the cost of such regeneration can be higher than simple replacement with new carbon.

4.2.6 Alternative B6: In Situ Groundwater Bioremediation

4.2.6.1 Description

Under this alternative, remediation of groundwater would be accomplished in situ via bioremediation using injection and extraction wells. In addition to bioremediation units, an in-line mixing tank and groundwater extraction pump would be needed. Nutrients and an oxygen source would be added to the groundwater through the in-line mixing tank. Air would be delivered to contaminated groundwater through injection wells. Treatability studies or field pilot tests would be required.

4.2.6.2 Evaluation

Effectiveness

Under suitable conditions with proper design, in situ bioremediation can reduce organics to nondetectable levels, converting contaminants to innocuous compounds. However, at the UST 13 area, the aquifer exists mostly in the underlying bedrock, the hydraulic conductivity of which is relatively low (3.5×10^{-4} cm/sec). Due to this low hydraulic conductivity, injected oxygen and nutrients may not be adequately delivered to the aquifer, making this method of remediation ineffective. (Ex situ bioremediation was dismissed in favor of in situ because there would be ever more difficulty extracting the volume of water required for ex situ treatment.) In addition, this low hydraulic conductivity, as well as the low gradient of the bedrock aquifer, is keeping the plume from migrating from the area. Furthermore, metals that exist in the groundwater may inhibit biological activity, and this aquifer is not used as a potable water supply.

Implementability

The techniques, materials, and labor necessary to implement in situ bioremediation of groundwater are readily available. However, long periods of time may be required to meet cleanup goals. In addition to the potentially long time frame associated with remediation, treatability studies or field pilot testing necessary prior to full-scale remediation may require as long as six months to one year to complete. In situ bioremediation must be properly controlled to ensure that contaminants or injected materials do not migrate from the point of injection, spreading contamination. It is important that the effectiveness of the system is closely monitored after initial full-scale startup. Periodic modifications will likely be necessary in order to adjust injection and/or extraction flow rates, as well as oxygen and nutrient supplies. As an in situ process, bioremediation would cause minimal land disturbance.

Relative Cost

In situ bioremediation costs are expected to be moderate compared with the costs of institutional controls, containment, collection, disposal, and other treatment technologies.

4.2.7 Selection of UST 13 Alternatives for Detailed Analysis

The following UST 13 alternatives will be retained for analysis in the detailed analysis of alternatives:

B1: No Further Action;
B2: Institutional Actions; and
B3: Intrinsic Remediation (With Long-Term Monitoring).

The other three alternatives addressed control and/or treatment of the groundwater plume. As previously indicated (see Section 1.2.1.3), this small plume is already controlled to a great extent by the low permeability and low hydraulic gradient of the bedrock aquifer. The low permeability also renders extraction and treatment approaches infeasible.

It is clear that adopting Alternative B2, Institutional Actions, will be more protective of human health and the environment than Alternative B1. Groundwater ARARs would still be exceeded in the very limited area of actual contamination. However, it is not technically practical to remediate this plume. This would be a basis of an ARAR waiver. The lack of plume migration ensures that no risk will be present in the future outside this site. Alternative B3, Intrinsic Remediation, will provide a similar degree of protection for human health and the environment, but will do so with more certainty and better data. The increased number of monitoring points ensures that it is less likely that any contaminants can leave the site undetected, and the use of a model allows for verifiable predictions and model recalibrations to evaluate continued effectiveness over time. Table 4-1 provides a summary of this screening. Alternatives B1, B2, and B3 are analyzed in greater detail in Section 5.

4.3 POL STORAGE AREA/DRMO YARD GROUNDWATER OPERABLE UNIT ALTERNATIVES

Three alternatives were developed for the POL Storage Area/DRMO Yard groundwater operable unit:

C1: No Further Action;
C2: Institutional Action; and
C3: Intrinsic Remediation (With Long-Term Monitoring).

Each of these alternatives is described and evaluated below.

4.3.1 Alternative C1: No Further Action

4.3.1.1 Description

This alternative would involve no remedial action; no treatment or containment would be performed, and the contamination would remain in its present state. The selection of this alternative would not satisfy the remedial action objectives for the POL Storage Area/DRMO Yard groundwater operable unit. This alternative would leave contaminated groundwater in place; it would also take no action in eliminating the exposure pathways of these contaminants. Monitoring of the groundwater would continue annually and the site would be reevaluated after 5 years. This will ensure that changes at the site do not affect the conclusions concerning the risks of the No Further Action alternative.

4.3.1.2 Evaluation

Effectiveness

The no-action alternative is ineffective and does not meet the remedial action objectives for this operable unit. The human health risks would remain as described in the risk assessment. However, because the observed contamination is in only three wells in a small area approximately 2 acres, and MCLs are only slightly exceeded, it is highly unlikely that it could impact human health or the environment. Groundwater could continue to exceed cleanup goals, but will be monitored for deterioration.

Implementability

The No Further Action alternative would be difficult to implement as the current situation exceeds groundwater ARARs and a waiver from meeting the ARARs would have to be obtained. This waiver may be difficult to obtain.

Relative Cost

As this alternative involves no remedial action, institutional action, containment, collection, treatment, or disposal costs, only monitoring costs are associated with it. Although not easily quantified, the costs of future liability from the low level of contaminants remaining in the groundwater on site are not likely to be significant.

4.3.2 Alternative C2: Institutional Actions

4.3.2.1 Description

Institutional actions are minimal actions taken to reduce exposure to contaminated media. This alternative would involve no actual remediation. Examples of the actions that could be taken include prohibition of drinking water well installation, possibly through deed restrictions. It would also include continued monitoring of the wells every 5 years for up to 30 years to detect the movement of contaminants, if any. This alternative fails to remove the contamination, and if these institutional controls were violated in some way (e.g., if a drinking water well were installed at the site), the protection of human health would be compromised. However, the aquifer yield at this site is low so a drinking water well would probably not provide sufficient water for industrial supply, and the site will be zoned industrial.

4.3.2.2 Evaluation

Effectiveness

This alternative would not be effective in reducing the level of contamination at the POL Storage Area/DRMO Yard groundwater operable unit. It would have no more of a remedial effect than Alternative B1, No Further Action. However, it does have the potential, if executed properly, to minimize exposure to the contaminants of concern. The effectiveness of the institutional actions would be directly dependent on the type of control implemented.

Implementability

Implementation of this alternative would depend on legal authority and requirements. It may be difficult to implement Alternative B2 as groundwater ARARs could still be exceeded, and it may be difficult to obtain a waiver of this requirement.

Relative Cost

Institutional actions are inexpensive relative to treatment, containment, collection, and disposal.

4.3.3 Alternative C3: Intrinsic Remediation (With Long-Term Monitoring)

4.3.3.1 Description

Intrinsic remediation is an approach that relies on natural attenuation to remediate contaminants in the subsurface. Because it relies upon slow natural processes, and involves long-term monitoring to observe the gradual natural restoration of the site to pre-contaminant conditions, it necessarily involves institutional action. During the period of restoration the access to the site for some uses, such as water supply wells, is necessarily restricted, since the groundwater contaminant levels exceed ARARs.

What differentiates intrinsic remediation from institutional action alone, is the degree of characterization of the site, the modeling of groundwater flow and contaminant migration, and the long-term monitoring effort to ensure that natural attenuation is working as expected.

The concerns expressed by the regulatory agencies about possible Dense Non-Aqueous Phase Liquid (DNAPL) in the form of TCE liquid in the bedrock, and possible migration of benzene, toluene, ethylbenzene, and xylenes (BTEX) in the lower part of the overburden aquifer downgradient of the POL Storage Area, will be addressed by this alternative.

To implement intrinsic remediation, additional site characterization will be required and for costing purposes, the Army is proposing five new wells. Four of these wells would be monitoring the overburden aquifer downgradient of "plumes" of hydrocarbon contamination in the soil, identified by field screening techniques, and one will be a bedrock well adjacent to POL-3 which has shown persistent TCE contamination. Data collected from these new wells and the existing wells on and around the site will be integrated into a groundwater flow model. Once this has been established, it will be used as input to a model to simulate contaminant transport. As long as it appears that there is a potential public health threat from the contaminants in the groundwater, institutional restrictions on groundwater use would be maintained, and monitoring would continue.

4.3.3.2 Evaluation

The detailed investigation of the site and its setting, by over 20 wells and over 60 boreholes will allow for the development of a well defined and characterized groundwater model. These data combined with results of seismic surveys will be used to define the shape of top-of-bedrock in greater detail than at present, and show the relationship of the water table to the top of bedrock. This in turn will show how the different hydraulic conductivities and isotropy/anisotropy affect the flows of water within and between the "overburden" and "bedrock" aquifers. The groundwater flow model will, in turn, be used for a contaminant transport model, which will incorporate contaminant distribution and groundwater flow to predict migration, and to test the sensitivity of the model to variations in different parameters included in the model.

Continued long-term monitoring of the site, initially on a yearly basis, will confirm or disprove the project rates of contaminant movement and/or decay. If the monitoring proves that the contaminants are not leaving the institutional control area at levels above ARARs, then the remedy will have been shown to be protective of human health and the environment.

Implementability

The materials, techniques, and labor necessary to implement this alternative are all readily available, and aspects of this program have already been implemented. Many vendors are available to provide competitive bids on the different components of the program, including well installation, data collection, modeling, and data assessment.

After new wells are installed, O&M would be minimal and continued costs of sampling and analysis relatively predictable. Investigation-derived waste would have to be properly stored and handled, but no hazardous waste generation is expected.

If successfully implemented, this remedial alternative would be protective of human health and the environment, and would minimally disrupt site activities.

Relative Cost

The well installation, expanded sampling, and modeling would be more expensive than institutional controls alone, and would have to be implemented in conjunction with institutional controls until such time as the long-term monitoring shows that there is no continuing exceedance of risk-based standards.

4.3.4 Selection of POL Storage Area/DRMO Yard Groundwater

Alternatives for Detailed Analysis

All three alternatives, C1: No Further Action; C2: Institutional Actions, and C3: Intrinsic Remediation, will be retained for detailed analysis of alternatives.

Table 4-1

RESULTS OF SCREENING OF ALTERNATIVES

DRMO SOILS OPERABLE UNIT

Alternative	Retained	Comment
A1: No Further Action	Yes	
A2: Institutional Actions	Yes	
A3: Containment via Capping	Yes	
A4: Excavation, Solidification, On-site Disposal	Yes	
A5: Excavation, Solvent Extraction, Thermal Desorption, Backfilling	No	Does not provide significantly greater level of treatment than A4, but would be much more complex and expensive.
A6: Excavation and Off-Site Disposal	Yes	
A7: Excavation and Off-Site Incineration	No	Does not provide a significantly greater level of environmental protection than A4 or A6 to justify higher costs.

UST 13 GROUNDWATER OPERABLE UNIT

Alternative	Retained	Comment
B1: No Further Action	Yes	
B2: Institutional Actions	Yes	
B3: Intrinsic Remediation	Yes	Requires further site characterization.
B4: Containment via Capping	No	Would not eliminate infiltration; would only reduce it. Also, plume is currently contained by the low hydraulic conductivity and low gradient of the bedrock.
B5: Groundwater Extraction with On-Site Treatment via Carbon Adsorption	No	Would extract a volume of groundwater too small to be effective due to the low permeability of the bedrock.
B6: In Situ Groundwater Bioremediation	No	Not likely to deliver adequate oxygen and nutrients to groundwater due to the low permeability of the bedrock. Also, metals may hinder remediation.

POL STORAGE AREA/DRMO YARD GROUNDWATER OPERABLE UNIT

Alternative	Retained	Comment
C1: No Further Action	Yes	
C2: Institutional Actions	Yes	
C3: Intrinsic Remediation (with long-term monitoring)	Yes	Requires further site characterization.

5. DETAILED ANALYSIS OF REMEDIAL ALTERNATIVES AND MONITORING

In this section, the remedial technologies that were identified and retained in Section 4 are presented as detailed remedial alternatives. To gauge the overall feasibility and acceptability, the relevant information for the selection of a remedy is provided in a detailed analysis with respect to the nine EPA criteria encompassing the statutory requirements of CERCLA. The nine criteria by which the alternatives will be assessed include, in three groups:

- Overall protection of human health and the environment;
- Compliance with applicable or relevant and appropriate requirements;

- Reduction of toxicity, mobility, or volume through treatment;
- Long-term effectiveness and permanence;
- Short-term effectiveness;
- Implementability;
- Cost;

- State acceptance; and
- Community acceptance.

The first two items are considered threshold criteria. An alternative must satisfy both of these in order to be eligible for selection. Overall protection describes how the alternative, as a whole, achieves and maintains protection of human health and the environment. The compliance criterion assesses whether an alternative complies with ARARs, or, if a waiver is required, how it is justified.

The next five are known as balancing criteria. They are technical criteria used to evaluate effectiveness and implementability. Performance of specific treatment technologies is evaluated in the reduction of toxicity, mobility, or volume (TMV) criterion. The extent to which TMV issues are met in each alternative is evaluated and predicted. Long-term effectiveness evaluates whether an alternative will preserve human health and the environment after RAOs have been met. The magnitude of residual risk and adequacy of controls are also considered under this criterion. Short-term effectiveness of an alternative considers both the time required until RAOs are met as well as an evaluation of the impacts on human health and the environment during the remediation stage. The implementability criterion is concerned with the technical and administrative feasibility of an alternative. Post remediation monitoring and additional action are also considered under this criterion. Finally, the major cost components of each alternative are estimated and evaluated.

The assessment of state and community acceptance criteria will be addressed in the Record of Decision (ROD) following public comment on the RI/FS report and proposed plan.

Following the individual analyses of criteria for each alternative, the alternatives are compared and contrasted based on each set of criteria. A summary of the criteria assessment of the DRMO Yard Soils Operable Unit alternatives subjected to the detailed screening in this section is presented in Table 5-1. For ease of referencing, the costs reported in the text and in Table 5-1 for the DRMO Operable Unit have been rounded to three significant digits. A breakdown of the costs associated with the various DRMO Operable Unit alternatives are reported in Tables 5-2 through 5-7. Detailed costs for the UST 13 groundwater Operable Unit alternatives are provided in Tables 5-8 through 5-10.

Detailed costs of the POL Storage Area/DRMO Yard groundwater operable unit alternatives are provided in Tables 5-11 through 5-13.

5.1 DRMO SOILS OPERABLE UNIT (AOC 32)

Five alternatives for remediation of DRMO Yard soils were retained from the initial alternative screening (Section 4). These are described in detail in this section and analyzed with respect to the criteria presented by the EPA. The five alternatives discussed below are:

Alternative A1:	No Further Action
Alternative A2:	Institutional Actions
Alternative A3:	Containment via Capping
Alternative A4:	Excavation, Solidification, and On-Site Disposal
Alternative A6:	Excavation and Off-Site Disposal

Figure 2-2 shows the detections at AOC 32 that exceed cleanup goals. Figure 2-3 shows the DRMO Yard areas requiring remediation based on the detections above cleanup goals.

5.1.1 Alternative A1: No Further Action

5.1.1.1 Detailed Description

The "No Further Action" alternative is developed and evaluated to establish a baseline for comparison with other remedial alternatives. Under this alternative, no remedial action of any type would be undertaken. The soils at the east DRMO Yard would not be removed or treated in any way. It is assumed that the contamination would remain in its present state and pose the same risks as currently exist including the potential for continued contamination of groundwater.

Groundwater monitoring would be performed annually for 5 years under this alternative. After 5 years the need for continued monitoring will be reviewed.

5.1.1.2 Criteria Analysis

Overall Protection of Human Health and the Environment

The "No Further Action" alternative would neither contain, treat, nor destroy the contaminants in the soils at the DRMO Yard. No measures, either remedial or institutional, would be taken to protect human health or the environment. Monitoring, however, would be performed in order to detect contaminant migration. This would influence a decision to take additional action, if necessary.

Compliance with ARARs

Maximum detections of PCBs currently exceed the cleanup goal based on TSCA, which is considered a chemical-specific ARAR. Therefore, a waiver would have to be granted to pursue this alternative. However, such a waiver would be difficult to obtain because there would be no reduction of human health risk under this alternative. No location-specific ARARs would be triggered (see Table 2-4). No action-specific ARARs would be triggered. Table 5-14 lists all ARARs and TBCs for the DRMO Yard soils remedial alternatives.

Reduction of Toxicity, Mobility, or Volume through Treatment

The "No Further Action" alternative would have no effect on the toxicity, mobility, or volume of contamination. Monitoring, however, would detect any contaminant migration over time.

Long-term Effectiveness and Permanence

Because the "No Further Action" alternative will not meet the RAOs, the residual risk is equivalent to the existing risks. The potential for human or ecological exposure to contaminants in surface soils would endure, as would the potential for the contamination of other media. This alternative does not satisfy the preference for treatment and permanence, but groundwater monitoring will assess long-term contaminant migration and human health risks, allowing appropriate action to be taken if conditions change.

Short-term Effectiveness

The "No Further Action" alternative will have no impact on existing site conditions. Personal protection equipment (PPE) and field instruments will be used to control potential exposures to field personnel during monitoring.

Implementability

The "No Further Action" alternative does not present any technical implementability obstacles. Monitoring and/or future remedial action would be easily applied. However, the failure to comply with ARARs poses a potentially difficult administrative obstacle.

Costs

There are no capital costs associated with this alternative. O&M costs, as presented in Table 5-2, are associated with the groundwater sampling events, to be conducted for 5 years. It is assumed that existing wells would be sampled, and there would be no new wells installed. The approximate present worth of the "No Further Action" alternative is $80,380, assuming no further monitoring is required after 5 years.

5.1.2 Alternative A2: Institutional Actions

5.1.2.1 Detailed Description

No remediation would occur under this alternative; activity would be limited to minimal measures intended to reduce exposure to contaminated media. Deed restrictions would limit land use and development. The land is currently slated for industrial land use by the Massachusetts Land Bank, which will control development after the Army releases the property, thus no further zoning alterations would be required.

There is currently a 6 foot high chain-linked fence with a barbed wire top surrounding the east DRMO and tire yards. However, the contamination is found in drainage ditches along the perimeter of the east yard. It would therefore be necessary to move the eastern and western portions of the fence to the outside of the drainage ditches to ensure that the contaminated zone is fully enclosed. The western fence would be moved to the edge of Cook Street, approximately 15 feet to the west. The eastern fence would be moved 15 feet to the east. Personnel constructing the fence will be outfitted in level C PPE to prevent dermal exposure to and ingestion and inhalation of contaminated soil. Level C PPE includes, but is not limited to, a full-face air-purifying respirator with dual cartridges for filtering organic vapors and particulates; chemical resistant clothing; leather safety boots with chemical resistant overboots as necessary; a hard hat; and chemical resistant gloves.

The new fencing would isolate the contaminated soils and reduce exposure to authorized future site workers. Site workers would be trained in safety precautions to minimize exposure to the surface soils, and work shifts would be organized to minimize frequency and duration of exposure. Level C PPE would be considered when future site activities are conducted within the contaminated area (i.e., inside the fence).

Groundwater monitoring would also be performed under this alternative. Every 5 years for a period of 30 years, the site conditions will be reviewed to determine the extent of contaminant migration. A groundwater sampling event will be performed during each of these reviews. In addition, exposure scenarios will be revisited based on site use at the time of each review. If warranted, additional action will be considered at these times.

5.1.2.2 Criteria Analysis

Overall Protection of Human Health and the Environment

Institutional actions would not treat or destroy any of the contaminants; however, they would isolate the contamination in a restricted area. Future site work within the restricted area would require PPE. Therefore, if executed properly, this alternative would reduce human exposure to the contaminants to acceptable risk levels, meeting the first RAO. Proper execution includes ensuring worker safety both during and after the construction phase, as well as periodic maintenance of the fence. Risks to the environment would be unaffected; however, ecological risks were found to be minimal. The other two RAOs would not be met under this alternative. Groundwater monitoring would also aid in the protection of human health and the environment in that it would be used to evaluate potential contaminant migration. This would influence a decision to take additional action, if necessary.

Compliance with ARARs

The surface soils would still fail the TSCA level for PCBs under this alternative, which is a chemical-specific ARAR (see Table 2-1). A waiver application should be performance based, i.e., if properly executed, the human health risks may be reduced to a level nearly equivalent with Alternatives A3, A4, and A6. Future use of the site would necessarily be limited. No location-specific ARARs would be triggered (see Table 5-14). No action-specific ARARs would be triggered.

Reduction of Toxicity, Mobility, or Volume through Treatment

Provisions under this alternative would have no effect on toxicity, mobility, or volume of contamination. Monitoring, however, would detect contaminant migration over time.

Long-term Effectiveness and Permanence

This alternative is intended to reduce potential exposure routes, and residual risks would be minimal if implemented properly. However, because this alternative does not include any treatment of surface soils, long-term effectiveness depends on adequate maintenance. Fencing and monitoring wells are susceptible to damage over time. If the controls (i.e., fencing and development restrictions) or wells are not maintained, then the residual risk could become equivalent with current risks. Therefore, this alternative does not satisfy the preference for treatment and permanence.

Short-term Effectiveness

There would be no short-term effects on the community or the environment under this alternative. Exposure to the workers installing the controls or performing sampling activities would be controlled through respiratory and dermal protection. Minimal time, probably less than 1 week, would be required to complete the field activities, meeting the first RAO. Groundwater sampling could be performed in a few days per sampling event.

Implementability

Institutional actions do not present any technical implementability obstacles. Monitoring and/or future remedial action would be easily applied. However, the failure to comply with ARARs poses a potentially difficult administrative obstacle. Because human exposure, and therefore, human health risks would be reduced, a waiver to ARARs could potentially be obtained.

Costs

Capital costs associated with this alternative involve fenceline changes, mobilization/demobilization, and health and safety costs. Approximately 840 feet of fence along the eastern and western edges of the east yard would have to be moved to widen the area of enclosure. An additional 60 feet of fence would have to be added to the existing line. The costs associated with this alternative are presented in Table 5-3 and include semiannual inspection and maintenance of the fenceline, as well as site evaluation and groundwater sampling every 5 years. It is assumed that existing wells will be sampled, and no new wells will be installed. The estimated capital costs are $17,950. The present worth of O&M and monitoring costs combined, assuming these activities continue every 5 years for 30 years, is approximately $64,880. The approximate total present worth of Alternative A2 is $103,690.

5.1.3 Alternative A3: Containment via Capping

5.1.3.1 Detailed Description

Under this alternative, direct contact with the contaminated soils and asphalt around the east DRMO Yard would be eliminated through the installation of an impermeable cap. The cap would also reduce surface water infiltration through the contaminated soil and would serve to minimize the generation of contaminated groundwater.

The first element of this alternative would be the excavation and consolidation of the contaminated soils to minimize the area requiring capping. Excavation would be performed using conventional earth-moving equipment, such as backhoes, bulldozers, dump trucks, etc. Currently, the contaminated soils are found in four areas: the area in the southern portion of the tire storage area, adjacent to the northern border of the east DRMO Yard; the area in the center of the east DRMO Yard; the drainage swale along the western edge of the yard; and, the drainage swale along the eastern edge of the yard. Clearing and grubbing of these areas would not be required since the areas are not vegetated. Capping these areas directly is inadvisable because the cap would consist of four long, thin sections. This would not only complicate the installation of the cap, but would also reduce the cap's ability to prevent leachate generation and groundwater contamination.

Therefore, it is proposed that the soils in the eastern and western drainage swales be excavated and placed on and in between the other two areas of contamination. On the eastern swale, only the southern half (south of the contaminated area in the center of the yard) would need to be excavated. The width of contamination is assumed to be 15 feet. On the western swale, it would be necessary to excavate the entire length. Consolidation of the southern portion would be to minimize the area requiring capping, as discussed above. The northern half would also need to be excavated due to of its proximity to Cook Street. Excavation would make room for a new drainage swale that would be required beyond the edge of the impermeable cap. This new swale would be needed to help drain the cap area. The swale cannot be underlain with impermeable material and must be no steeper than a 3:1 slope. Moving the contaminated soils approximately 15 feet from the road would provide enough space for the new swale. These excavated soils would require toxicity characteristic leaching procedure (TCLP) testing in order to determine if RCRA action-specific ARARs would apply. Figure 5-1 presents a depiction of the excavated areas. These excavated areas will be backfilled from either on-site or off-site stockpiles.

Based on these assumptions and a depth of contamination of 1 foot, approximately 9,675 cubic feet (360 cubic yards) of soil would have to be excavated along the edges of the east DRMO Yard. The area of the cap would be approximately 49,400 square feet (see Figure 5-1). Therefore, the excavated soils would rise to an average of 0.20 feet, or about 2.4 inches. It is more likely that these soils would be piled higher in the center of the capped area to help achieve the required slope off of the top of the cap.

During the soils excavation, verification sampling would be required to ensure achievement of cleanup goals. This sampling would consist of collecting soil samples from the bottom and edges of excavation areas for laboratory analysis for the contaminants with site-specific cleanup goals (PCBs, pesticides, lead, and cadmium). Actual sampling procedures and protocols would be outlined as part of the remedial design process. When verification sampling indicates that soil remaining at the bottom and edges of excavation pits meets cleanup goals, the excavation for that area would be considered complete, and it would be cleared for backfilling. If the results are not acceptable, then additional soil would be excavated. The excavation would then be resampled and this cycle repeated until sampling and analytical testing indicate that the cleanup goals were met.

The cap would be multilayered. Following Massachusetts landfill cover requirements, the cap would consist of 18 inches of clay with a permeability of 10^{-7} cm/sec, covered by 6 inches of a drainage layer soil with a minimum permeability of 10^{-3} cm/sec, 6 inches of loam subsoil, and a final 6 inch layer of topsoil seeded with vegetative cover. (The low permeability clay could be substituted with a 40 mil high density polyethylene (HDPE) synthetic liner (Murphy 1994). However, only the clay alterative is developed and costed.) The cover would be vegetated to stabilize the soil capping material and prevent erosion. The slight northerly slope of the swales on the eastern and western sides of the east DRMO Yard would be maintained to allow for continued drainage to the storm water line. The asphalt that currently covers almost all of the contaminated area does not allow for very much infiltration. Therefore it is not expected that the impermeable cap will greatly increase the expected runoff. Currently, flow to the catch basin to the north is slight, only observed during very heavy rain events. For these reasons, it is not anticipated that additional storm water control measures, such as deeper swales or retention ponds, will be necessary. However, minimal controls such as rip-rap may be employed to facilitate flow to the catch basin. The effects of runoff and the need for a drainage study on the area will be further analyzed and evaluated during the design phase.

The southern portion of the east DRMO Yard could be used as a decontamination pad for the excavation and capping equipment. Wastewater generated from decontamination procedures could be contained, and treated and disposed of, if necessary. The 6-foot high chain-linked, barbed wire fence surrounding the east DRMO and tire yards would be removed during capping activities, then re-installed around the cap. The fence would serve as additional protection against human and wildlife exposure as well as against cap deterioration caused by "trespassing" wildlife.

To ensure worker safety during the construction process, site work would be conducted in Level C PPE to provide for protection against inhalation, ingestion, and dermal exposure. Dust control measures may be required during soils excavation and before placement of the cap. Soils around the perimeter of the cap area will be sampled to verify that the cover is sufficient. Finally, annual operating and maintenance activities will be conducted for 30 years. This would include cap inspection and maintenance, and, in order to evaluate contaminant migration, groundwater monitoring. Cap maintenance activities would include repair of holes (made by burrowing animals, for example) and any necessary revegetation to reduce the possibility of erosion. These maintenance activities would also be performed in dermal and respiratory protection.

5.1.3.2 Criteria Analysis

Overall Protection of Human Health and the Environment

Under this alternative, contaminants would not be treated or destroyed. However, they would be isolated from the surface by an impermeable cover. This would satisfy all three RAOs. Dermal, ingestion, and inhalation exposure routes would be eliminated, for both human and ecological receptors; however, the ecological risk assessment concluded that only minimal risks exist with the current situation. Contaminant migration to surface water and groundwater media would be significantly reduced, if not eliminated. The fence around the cap would provide additional protection against exposure. Groundwater monitoring would also aid in the protection of human health and the environment in that it would be used to evaluate potential contaminant migration. This would influence a decision to take additional action, if necessary.

Compliance with ARARs

This alternative could bring the site into compliance if the contaminated soils were subsequently considered as subsurface soils. The maximum PCB detection, 9.3 μg/g would be below the TSCA level for subsurface soils of 10 μg/g. If the contamination were still considered surficial, then a waiver application would be required. The likely rationale would be that this alternative provides equivalent or nearly equivalent performance, with respect to human health risks, as Alternatives A4 and A6. Lead and cadmium concentrations do not exceed any chemical-specific ARARs; however, if the excavated soils were found to exhibit the hazardous characteristic of toxicity due to lead and/or cadmium (or any other contaminant), then moving, consolidating, and capping these soils would violate RCRA action-specific ARARs. However, the Extraction Procedure (EP) toxicity test was applied to the sample with the highest level of lead and cadmium found during the SI, and this showed only low levels of solubility for these metals. No location-specific ARARs would be violated by this alternative(see Table 5-14).

Reduction of Toxicity, Mobility, or Volume through Treatment

This alternative is not technically a treatment technique, and the toxicity and volume of contamination would not be affected. However, the potential for contaminant mobility, both in surface water and groundwater, would be significantly reduced, if not eliminated. If the cap is breached significantly, or if the cover erodes, migration of contaminants could occur. However, regular cap maintenance should prevent this situation (see section on long-term effectiveness) and monitoring would detect it.

Long-term Effectiveness and Permanence

As long as the cap and fence are properly maintained, this alternative should be effective over the long term, both in reducing the mobility of, and in preventing direct contact with the contamination. Regular inspection and maintenance of the fence, cap, and monitoring wells would be required. This would ensure that the vegetation is intact (to prevent erosion of cap materials), to evaluate whether other causes, such as burrowing animals, have compromised the cap's integrity, and to ensure the fence is secure. Future site usage would be necessarily limited to further ensure the cap's integrity. This alternative is not considered permanent because it does not treat the contamination. However, if the cap and fence are maintained properly, residual risk would be minimal, and management/ maintenance controls should be adequate to maintain the risk at minimal levels.

Short-term Effectiveness

This alternative would create temporary increases in dust production, while the soil excavation is taking place and potential dust and runoff problems for the brief period before the excavated soil is covered with the cap. If excessive dust production was determined, through continuous air monitoring activities, to pose a hazard to the community or ecological receptors, dust and rainwater control measures (such as using a temporary impermeable plastic cover) may be required. Site workers involved with excavation activities would be required to use Level C PPE to prevent inhalation, ingestion, and dermal exposure. Groundwater sampling activities would also require that respiratory and dermal protection be worn to reduce risk of exposure. Excavation could probably be accomplished in approximately 1 week. Capping activities, which could take several months, would not pose the same degree of dust generation problems as soil excavation. However, it is likely that site workers would remain in Level C PPE during this phase. Removing and re-installing the fence would take a few days and would also be performed with dermal and respiratory protection. Groundwater sampling could be performed in a few days per sampling event. This alternative would not pose additional risks to the environment.

Implementability

This alternative would be relatively easy to implement, assuming the soils do not fail TCLP tests. Remedial contractors are available to provide the necessary services, and cap installation could be accomplished in a matter of months. Groundwater monitoring should effectively evaluate if contaminant mobility has been reduced. However, additional remedial actions would be costly, due to materials handling relating to the cover material. If, after capping, it was determined that the site was not in compliance with TSCA, there could be some administrative difficulties. However, because human exposure, and therefore, human health risks would be dramatically reduced, a waiver to ARARs could likely be obtained. Future site use would also be limited. In the event the excavated soils fail TCLP tests, these soils would have to be transported to a RCRA-certified landfill. Only the soils that remain in place would be able to be capped, in this case.

Costs

The costs associated with Alternative A3 are presented in Table 5-4. Capital costs including mobilization/demobilization, site services, health and safety, excavation, consolidation, backfill, construction of the cover, verification and TCLP sampling and analysis, and fenceline changes are estimated at $470,320. Annual O&M costs, including maintenance and groundwater monitoring, are estimated at $26,650. The approximate present worth of O&M activities, assuming annual monitoring over 30 years, is $366,200. This assumes that only existing wells will be sampled. The approximate total present worth of Alternative A3 is $836,520.

5.1.4 Alternative A4: Excavation, Solidification, and On-site Disposal

5.1.4.1 Detailed Description

This alternative includes the excavation, on-site treatment via solidification, and on-site disposal of contaminated soils. A treatability study would be required to determine whether solidification is likely to be successful and to determine the optimal solidification technique (USEPA 1989a). First, the waste and contaminants would be screened to select the most appropriate method of solidification. A cement-based technique would probably be chosen because it has been demonstrated to work on waste containing lead, cadmium, PCBs, and pesticides. Second, the waste is further characterized to identify potential inhibitors to the solidification process, such as oxidizing salts or low pH. Third, bench-scale testing is performed. Different mixtures are tested, and the optimum waste-to-binder ratio is based primarily on leachability and durability tests. In particular, TCLP testing may be necessary to determine if a waiver would be required to dispose of the solidified material on site. In addition, the treatability study must examine the solidification of asphalt. Asphalt would probably not inhibit the solidification capacity of the cement; in fact, because asphalt has some binding capacity of its own, it may enhance the encapsulation. The study should examine both the handling of the asphalt separately from the soils, and the mixing of the two together. The optimal size of the pieces of asphalt would also be a parameter for study. The decision regarding the asphalt will be made in the remedial design, based on performance in bench-scale testing. If possible, pilot scale testing could be performed to determine if bulk-mixing would sufficiently mix the waste and binding agent, or if the use of a pug mill would be required (see description of mixing techniques, below). Finally, site conditions are evaluated to account for site-specific concerns such as stockpiling and waste transport, drainage, and access routes.

The treatment process itself includes the following tasks: excavation of the waste, transport to a temporary storage area, waste/binder mixing, material curing, and transport to a final disposal location. Each of these processes is discussed briefly below.

Based on interpretation of soil sampling data collected during the RI, approximately 35,100 cubic feet (1,300 cubic yards) would be subject to excavation. This volume corresponds to the estimated areas and depths of contaminated soils as presented in Figure 5-2. Since the contaminated material is not in a vegetated area, clearing and grubbing would not be required. Excavation of contaminated soils would be conducted using conventional earth-moving equipment such as backhoes, bulldozers, dump trucks, etc. During excavation (and mixing, see below), dust generation would have to be controlled to acceptable levels. The specific means and methods of excavation and dust control would be determined during the remedial design. Level C PPE would be required for site workers to prevent inhalation, ingestion, and dermal exposure routes. The contaminated asphalt in the center portion of the east yard would be excavated using earth moving equipment and would have to be broken into pieces small enough for handling. This could probably be accomplished with the backhoes and bulldozers as well. Based on the results of the treatability study (see above), the asphalt may have to be broken into smaller pieces and/or piled separately from the soils.

During excavation of the soils, verification sampling, as previously detailed in Section 5.1.3.1, would be performed. The excavated soils and asphalt would then be transported to the on-site staging area to await treatment. The southern portion of the east DRMO Yard could be used for this purpose. It would first have to be covered with a plastic liner, and, after emplacement of the soil and asphalt, covered with an impermeable plastic cover to prevent direct contact, wind erosion, and stormwater runoff. This portion of the yard could also be used as a decontamination pad for the excavation equipment. Waste water generated from decontamination procedures would be contained, and treated and disposed of, if necessary. The southern half of the yard is 72,900 square feet, easily large enough to handle both decontamination and temporary storage. The proximity of the contaminated soils to the temporary storage areas will significantly reduce transport costs.

The contaminated material would then be mixed with the solidification agent, most likely portland cement, and water. The exact mixture of waste, cement, and water which would produce the strongest monolith, reduce leachability, and keep volume to a minimum, would be determined in the treatability study mentioned above. The optimal solidification of the asphalt would also be determined in the treatability study.

Two general methods exist for the mixing of the waste and the binding agent. The simpler method is known as "bulk mixing." The binding agent is delivered to the stockpile area and mixed with the waste directly. Conventional earth moving equipment, such as backhoes, are used to mix the materials. No quality assurance/quality control (QA/QC) program has been established to determine when the mixing is complete, so this is generally left to the operator. Complete mixing is difficult using this method. The second method involves the use of more specialized mixing equipment, of which "pug mills" are the most common. Pug mills consist of two screws, one of which delivers the waste, the other, the binding agent. The two streams are then mixed, and fed to the pug mill. Bulk mixing is less expensive than the use of a pug mill, and it does not require the use of specialized equipment. If a pug mill were used, it would either have to be mobilized on site, or the waste would have to be transported off site. The method of mixing will be determined during the remedial design, based on results of the treatability study (see above). However, because the volume of waste is relatively small, the soil contaminants (PCBs, pesticides, lead, and cadmium) do not have a strong tendency to leach, and there is sufficient area to mix in bulk, it is unlikely that the advantages of pug milling could justify the increased cost.

Regardless of the mixing technique, the waste/binder mixture would have to be placed in forms and allowed to cure for up to a month (the curing period will also be examined in the treatability study) to achieve full strength. However, for handling purposes, it is generally preferred to dispose of the cured concrete before it is fully set. Final disposal (see below) of the material would be considered when configuring the forms. During the curing period, any water passing over or through the forms would have to be collected for treatment and/or disposal. After the curing period, TCLP tests would be conducted prior to final disposal, to determine if RCRA action-specific ARARs would apply. TCLP testing would have to include PCBs as an analytical parameter. However, because no regulatory level exists for PCB TCLP analysis, an action level would have to be negotiated.

Finally, the monoliths would be disposed of on site. The probable location for disposal would be the northern DRMO yard and southern tire recycling area, from which much of the excavated soils would come. If other remedial actions on Fort Devens require soils disposal, then a central disposal area would be considered, to determine if site-wide cost savings could be achieved. Because of the addition of cement and water, the total volume of material after treatment will likely be greater than before treatment. This final volume depends on pretreatment porosity of the waste, and on the extent of compaction possible after treatment. It is therefore probable that the final grade would be higher than it was initially. Some further excavation may be required, based on the shape of the forms. After the semi-cured monoliths are placed in the ground, they would be covered with approximately six inches of topsoil. The topsoil would then be seeded to promote vegetation, thereby preventing erosion and subsequent exposure of the solid masses. In addition, at some point during the design phase, a means to control precipitation infiltration must be addressed. Otherwise, problems with frequent saturation of the overlying topsoil will likely result.

A groundwater monitoring program would be established to evaluate potential contaminant migration. Wells will be sampled on an annual basis for a period of 30 years.

5.1.4.2 Criteria Analysis

Overall Protection of Human Health and the Environment

Under this alternative, the contaminants would be treated and contained, but not removed from the site. Nevertheless, it would satisfy all three RAOs. Solidification is primarily intended to handle inorganic contaminants in soil. Metals such as lead and cadmium react chemically with the cement and become chemically bound up in the monolithic matrix. Organic constituents, on the other hand, do not react with the cement. Rather, they are physically bound in the matrix. This does not completely prevent their leaching out with infiltrating water. However, the matrix has a low permeability, and the physical binding of large organics like PCBs and pesticides results in a drastic reduction in the risk of exposure. Groundwater monitoring would also aid in the protection of human health and the environment in that it would detect and evaluate potential contaminant migration. This would influence a decision to take additional action, if necessary.

Compliance with ARARs

Currently, the soils exceed the TSCA chemical-specific ARAR for PCBs. After treatment, the PCBs will be essentially contained within the blocks, thus removing the exposure route. Therefore, it may be considered that this alternative complies with cleanup goals based on regulatory and calculated risk levels. If the treated soil is still considered to be in violation of the TSCA ARAR, a waiver application would be based on this alternative providing an equivalent level of protection as Alternative A6. No location-specific ARARs will be violated by this alternative (see Table 5-14).

The concentrations of lead and cadmium do not exceed any chemical specific ARARs. However, if any soils were found to exhibit the hazard characteristic of toxicity due to lead and/or cadmium (or any other contaminant), then disposal of the solidified soil on site would violate RCRA action-specific ARARs. However, no soils are expected to exceed the TCLP criteria after solidification, especially as the EP toxicity characteristic did not identify soluble toxic metals in soil during the SI.

Reduction of Toxicity, Mobility, or Volume through Treatment

Because both lead and cadmium will be chemically bound to the cement, there would be a reduction in lead- and cadmium-related toxicity. Furthermore, its mobility would be practically eliminated. PCBs and pesticides would only be encapsulated physically, so their toxicity would not be changed. However, their mobility would be significantly reduced. Although there is some chance that the PCBs and pesticides could be mobilized to some degree over the long-term, this possibility is not considered likely and would be verified through groundwater monitoring. Therefore, this alternative satisfies the statutory preference for the permanent reduction of mobility through treatment. The total volume of contaminated material will likely increase to some extent due to the addition of cement.

Long-term Effectiveness and Permanence

The lead and cadmium would be virtually immobilized within the cement matrix. Since they would be chemically bound to the cement, they could be considered to be permanently removed, thus eliminating exposure routes and human health risks. However, there is the possibility that organic constituents could leach out of the matrix based on monitoring results, over the long-term. It would be difficult to control residual risks associated with this possibility. However, if care is taken during the treatability study, then this residual risk should be very low, especially considering that PCBs and pesticides are of low mobility to begin with. Therefore, this alternative could be considered effective over the long-term, and even permanent, with respect to PCBs and pesticides. Monitoring wells would require proper inspection and maintenance under this alternative.

Short-term Effectiveness

There would be some short term increase in exposure, particularly to the workers involved. Therefore, all work would be carried out in Level C PPE. In addition, continuous air monitoring activities would be required during excavation. As with other excavation alternatives, dust control would be required to protect on-site workers and the community. Because of the requirement to perform verification sampling, there would be a significant interim period during which contaminated soils would be staged in the temporary area. This could expose the community and the environment to additional short-term risks. Therefore, during the storage phase, it would be required that some measures be taken to reduce exposure to the soils, such as daily covering with an impermeable plastic liner to prevent direct contact, wind erosion, and runoff from precipitation. Site workers involved in groundwater sampling would also use respiratory and dermal protection to prevent exposure. It is estimated that this alternative would take between 3 and 5 months to complete. However, the time could be decreased if verification sampling can be accelerated (using field analysis, for example). Groundwater sampling could be performed in a few days per sampling event.

Implementability

Contractors to provide the described treatment services are readily available, and the treatment technique is considered reliable for both lead and cadmium as well as PCBs and pesticides. It should not be difficult to obtain regulatory approval. However, it will be very difficult to monitor the effectiveness. The groundwater monitoring program will be used to assess subsequent contaminant migration. The contaminants are not particularly mobile in the aqueous phase to begin with, and these contaminants are not considered a groundwater problem. Therefore, it is unlikely that groundwater sampling would reveal leaching from the solidified mass. Additional remedial action on the monoliths themselves would be difficult, particularly if they become completely solidified into concrete. However, the area could be covered with an impermeable cap if leaching were deemed to be a problem. Finally, this alternative would require more time to complete than other alternatives, and future use of the site would be limited because the contaminated material would remain, and because the presence of the monoliths could obstruct future excavation and development.

Costs

The cost of Alternative A4 would be more accurately predicted after the treatability study is complete. The breakdown of estimated costs for this alternative for the contaminated soils and asphalt at the DRMO Yard is presented in Table 5-5. Capital costs include mobilization/demobilization, site services, health and safety, a treatability study, soils excavation and handling, solidification, verification, TCLP sampling, backfilling, grading, and restoration, totaling an estimated $490,870. The total approximate present value of O&M costs, associated with monitoring, is $287,270. This assumes only existing wells will be sampled annually for 30 years. The approximate total present worth for Alternative A4 is $778,140.

5.1.5 Alternative A6: Excavation and Off-Site Disposal

5.1.5.1 Detailed Description

Under this alternative, all soil identified above as being contaminated would be excavated and disposed of off site. The excavation would be exactly as described in Alternative A4. Level C PPE would be required for site workers to prevent inhalation, ingestion, or dermal exposure routes. Dust control measures would be employed as well. However, it would not be required to stage the soils in a temporary area. Rather, they would be transported immediately to an off-site non-hazardous landfill. Because only low levels of PCBs (less than 50 ppm) were detected the soil should not have to go to a TSCA-regulated landfill. However, it is possible that the soils could fail TCLP tests for lead based on the detected concentrations of this metal in the soil. In this case, the soils would be classified as RCRA hazardous wastes and would require disposal at an off-site RCRA-regulated landfill. Soils are not expected to fail TCLP tests for cadmium, based on sampling results. As discussed above, a total of 1,300 cubic yards of soil will be excavated (see Figure 5-2). Verification sampling, as discussed in Section 5.1.3.1, of the soil would be performed to ensure that all of the contamination had been removed. Finally, the excavated areas would be regraded or backfilled to grade with clean soils and revegetated for stabilization. The southern portion of the east DRMO Yard could be used as a decontamination pad for the excavation equipment. Waste water generated from decontamination procedures would be contained, and treated and disposed of, if necessary. Because the source of contamination would be removed from the site, no long-term monitoring would be required. However, a review of site conditions, including groundwater sampling, would be conducted in 5 years to ensure no contaminant migration from unidentified sources. Appropriate action would be considered at that time.

5.1.5.2 Criteria Analysis

Overall Protection of Human Health and the Environment

This alternative would not treat or destroy the contaminants, but it would completely remove them from the site. All three RAOs would be achieved, permanently. Therefore, this alternative would provide for the complete protection of human health and the environment.

To verify this, groundwater would be sampled from this location 5 years after excavation and disposal.

Compliance with ARARs

Chemical-specific ARARs at the site would be met with the soils removal. However, RCRA action-specific ARARs could apply, if the soils fail the TCLP criteria for lead, cadmium, or any other contaminant. This is not expected, based on the EP toxicity test run on the sample with the highest lead and cadmium found during the SI, which showed low levels of solubility for these metals. No location-specific ARAR will be violated by this alternative (see Table 5-14).

Reduction of Toxicity, Mobility, or Volume through Treatment

Because this alternative does not include treatment, the volume and toxicity of the waste would be unchanged. Contaminant mobility would be controlled in a certified landfill. However, this alternative does not satisfy the EPA preference for on-site treatment over off-site disposal. Monitoring would detect any residual contaminant migration over time.

Long-term Effectiveness and Permanence

Assuming the contaminated soils are removed completely from the DRMO Yard, there would be essentially no residual risk associated with this alternative. Therefore, there would be no long-term management or monitoring needs. Monitoring would only be performed once, 5 years after implementation of this alternative, in order to verify its effectiveness in removing all the contamination. Because the waste would be completely removed from the site, this alternative would be considered permanent.

Short-term Effectiveness

As with other excavation alternatives, there would be a short-term increase in human health risk, mostly to site workers, due to direct contact and dust creation. Therefore, all excavation and removal activities would be performed in Level C PPE. Groundwater sampling would also be performed in level C PPE to prevent dermal exposure and ingestion and inhalation of contaminants. In addition, air monitoring activities would be required during excavation. There could be some increase in risk to the community due to dust creation and possible runoff during storms. Therefore, dust control activities would have to be performed, which may involve covering the excavation with a temporary water-proof cover after each day's work. No more than 2 months would be required to achieve RAOs. Groundwater sampling, scheduled to be performed approximately 5 years after implementation of this alternative, would only take a few days.

Implementability

Alternative A6 is easily implementable, assuming the soils do not fail TCLP criteria. If they did fail, a waiver to dispose of the material in a sanitary landfill would be difficult to obtain, and the soil would have to be transported to a RCRA-certified landfill. There are no technical difficulties associated with this alternative, and many contractors would be able to perform the work. Additional remedial action on the DRMO Yard would not be impeded in any way.

Costs

The estimated costs associated with Alternative A6 are listed in Table 5-6. Capital costs are estimated at $543,696 and include mobilization/demobilization, site services, health and safety, excavation, soil handling and loading, verification and TCLP sampling, transport, backfilling, restoration, and disposal. The present worth of monitoring activities, including the one sample event in 5 years, is approximately $19,850. The approximate total present worth of Alternative A6 is $563,550.

5.1.6 Comparative Analysis of Alternatives

Table 5-1 summarizes the detailed analysis of alternatives presented above: Alternative A1, No Further Action; Alternative A2, Institutional Actions; Alternative A3, Containment via Capping; Alternative A4, Excavation, Solidification, and On-Site Disposal; and Alternative A6, Excavation and Off-Site Disposal. These remedial alternatives are compared to the EPA criteria of overall protection of human health and the environment; compliance with ARARs; reduction of toxicity, mobility, or volume; long and short term effectiveness; implementability; and cost.

Overall Protection of Human Health and the Environment

Alternative A1 would not provide any additional protection than that which already exists in the current zoning, fencing, and land use plans for the site. Alternatives A2, A3, and A4 would minimize the exposure routes to human and environmental receptors, thus reducing risks to acceptable levels. Alternative A6 would remove contaminated soils to an off-site landfill, eliminating contamination at the site. All alternatives would involve some duration of monitoring in order to detect potential contaminant migration.

Compliance with ARARs

The PCB chemical-specific ARAR would be exceeded in all alternatives except for Alternative A6 and possibly Alternative A4. However, minimizing the exposure routes via Alternatives A2 and A3 would minimize risks for the TSCA ARAR for PCBs, the RCRA action levels for pesticides and cadmium, and the human health risk assessment calculated cleanup goals for lead. Also, Alternatives A1, A2, and A3 would eliminate the possibility that the RCRA action-specific ARAR would apply. No location-specific ARAR would be violated by this alternative (see Table 5-14).

Reduction of Toxicity, Mobility, or Volume through Treatment

Alternatives A1 and A2 do not involve treatment, and would not reduce toxicity, mobility, or volume of contamination. Alternatives A3 and A6 would not provide for a reduction in toxicity or volume, but they would reduce the mobility of contamination. Of these two, Alternative A6 would be more effective in this reduction. Neither satisfies the preference for on-site treatment. Alternative A4 would reduce the toxicity of lead and cadmium contamination, but not of PCBs or pesticides. It would drastically reduce the mobility of these contaminants, but would likely increase the volume. Alternative A4 is the only option that would satisfy the regulatory preference for on-site treatment. Monitoring, under all alternatives, would serve to verify reduction in contaminant migration.

Long-term Effectiveness and Permanence

Alternatives A1, A2, A3, and A4 all require continued institutional controls. Alternatives A1 and A2 require continued control of access to the DRMO Yard, and thus are not considered effective in the long-term. Alternative A3 requires maintenance of the integrity of the cap along with fence maintenance, and Alternative A4 requires protection of the buried monoliths. Of these alternatives, A4 would be more effective in the long-term. In Alternative A6, the burden of responsibility shifts to the off-site landfill operator to ensure the landfill integrity is upheld. However, the site risks would be eliminated in the long-term. All alternatives would require monitoring well inspection and maintenance.

Short-term Effectiveness

On a short term basis, only Alternative A1 would cause no disturbance of surface soils which may endanger human health. Alternative A2 would cause brief disturbance to the surface soils while fencing was installed. Alternatives A3, A4, and A6 would involve extensive short term earth moving and remedial activities, which would require Level C PPE to prevent worker exposure and dust control and runoff control activities to prevent community exposure. In addition, these three alternatives would require air monitoring during excavation activities. Under all alternatives, groundwater sampling would be performed in dermal and respiratory protection in order to minimize exposure risks.

Implementability

None of the alternatives face any technical obstacles to implementation. However, Alternatives A1, A2, and A3 would require waivers from the PCB ARAR. On the other hand, alternatives A4 and A6 would create the possibility that the RCRA action-specific ARARs for lead and cadmium would apply. Alternative A4 would require the longest time to implement, at approximately 4 to 5 months. All of the alternatives except for A6 would require future site use restrictions.

Costs

Table 5-7 presents a summary of the costs of the five alternatives at the DRMO Yard. Alternative A1 requires annual monitoring costs, totaling approximately $80,380. Alternative A2 requires minimal work, and an estimated $103,690 to implement. Alternative A3 would require consolidation and capping of the soil which could be implemented relatively easily at an estimated cost of $836,520. Alternative A4 would require slightly more time for solidification and burial, at an estimated cost of $778,140. Alternative A6 would be easily implementable and could be accomplished quickly for an estimated cost of $563,550.

5.2 UST 13 GROUNDWATER OPERABLE UNIT (AOC 32)

Three alternatives for remediation of UST 13 groundwater were retained from the initial screening (Section 4). These are described in detail in this section and analyzed with respect to the criteria presented by the EPA. The three alternatives discussed below are:

Alternative B1: No Further Action
Alternative B2: Institutional Actions
Alternative B3: Intrinsic Remediation (with long-term monitoring).

5.2.1 Alternative B1: No Further Action

5.2.1.1 Detailed Description

The "No Further Action" alternative is developed and evaluated to establish a baseline for comparison with other remedial alternatives. Under this alternative, no remedial action of any type would be undertaken. Neither the soils or groundwater in the vicinity of the former UST would be removed, contained, or treated in any way. It is assumed that the contamination would remain in its present state and pose the same risks as currently exist.

Groundwater monitoring would be performed annually for 5 years under this alternative. After 5 years the need for continued monitoring will be reviewed.

5.2.1.2 Criteria Analysis

Overall Protection of Human Health and the Environment

The "No Further Action" alternative would neither contain, treat, nor destroy the contaminants in the groundwater near UST 13. No measures, either remedial or institutional, would be taken to protect human health or the environment, and RAOs would not be met. Monitoring, however, would be performed in order to detect contaminant migration. This would influence a decision to take additional action, if necessary.

Compliance with ARARs

The groundwater would still exceed SDWA based ARARs for chlorobenzenes. Therefore, a waiver would have to be granted to pursue this alternative. If future site use is planned to be restricted to industrial use, the threat of exposure to this contamination may be deemed acceptable by regulators. Future site use would be necessarily limited. Table 5-15 sets out the Federal and State ARARs as they apply to groundwater in the area of the POL Storage Area/DRMO Yard (AOCs 32 and 43A).

Reduction of Toxicity, Mobility, or Volume through Treatment

The "No Further Action" alternative would have no effect on the toxicity, mobility, or volume of contamination. However, as discussed in Section 1, the contaminants are practically immobile and the volume is relatively small. Monitoring would detect any contaminant migration over time.

Long-term Effectiveness and Permanence

Because the "No Further Action" alternative will not meet the RAOs, the residual risk is equivalent to the existing risks. The potential for human or ecological exposure to contaminants in groundwater would endure, as would the potential for the contamination of other media. This alternative does not satisfy the preference for treatment and permanence. However, based on the small area involved, the very slow migration of contamination, and the lack of drinking water wells, the exposure is deemed to be minimal. Groundwater monitoring will assess long-term contamination migration and human health risks, allowing appropriate actions to be taken if conditions change.

Short-term Effectiveness

The "No Further Action" alternative will have no impact on existing site conditions. Groundwater sampling would be performed wearing PPE to prevent dermal exposure to and ingestion and inhalation of contaminants.

Implementability

The "No Further Action" alternative does not present any technical implementability obstacles. Monitoring and/or future remedial action would be easily applied. However, the failure to comply with ARARs poses a potentially difficult administrative obstacle.

Costs

There are no capital costs associated with this alternative. O&M costs, as presented in Table 5-8, are associated with the groundwater sampling events, to be conducted for 5 years. It is assumed that existing wells would be sampled and no new wells installed. The approximate total present worth of the "No Further Action" alternative is $75,820, assuming no further monitoring is required after 5 years.

5.2.2 Alternative B2: Institutional Actions

5.2.2.1 Detailed Description

No remediation would occur under this alternative; activity would be limited to minimal measures intended to reduce exposure to contaminated media. Deed restrictions would limit land use and development. The land would be limited to restricted development, including a ban on drinking well installation, through deed restrictions. The land is currently slated for industrial land use by the Massachusetts Land Bank, which will control development upon Army release of the property, thus no further zoning alterations would be required. Because there is no surficial contamination, fencing would not further reduce risks to human health or the environment.

Groundwater monitoring would also be performed under this alternative. Every 5 years for a period of 30 years, the site conditions would be reviewed to determine the extent of contaminant migration. A groundwater sampling event will be performed for each of these reviews. In addition, exposure scenarios will be revisited based on site use at the time of each review. If warranted, additional action will be considered at these times.

5.2.2.2 Criteria Analysis

Overall Protection of Human Health and the Environment

Institutional actions would not treat or destroy any of the contaminants; however, they would isolate the contamination in an area restricted to development. Therefore, if executed properly, institutional actions under this alternative would reduce human exposure to the contaminants to acceptable risk levels. Risks to the environment would be unaffected; however, ecological risks were found to be minimal. Groundwater monitoring would also aid in the protection of human health and the environment in that it would be used to evaluate potential contaminant migration. This would influence a decision to take additional action, if necessary.

Compliance with ARARs

The groundwater would still exceed SDWA based ARARs for chlorobenzenes. Therefore, a waiver would have to be granted to pursue this alternative. If future site use is planned to be restricted to rail, industrial, or trade-related uses, the threat of exposure to this contamination may be deemed acceptable by regulators.

Reduction of Toxicity, Mobility, or Volume through Treatment

Provisions under this alternative would have no effect on toxicity, mobility, or volume of contamination. However, as discussed in Section 1, the contaminants are practically immobile and their volume is relatively small. Monitoring would serve to detect contaminant migration over time.

Long-term Effectiveness and Permanence

Because Institutional Actions will not meet the RAOs, the residual risk is equivalent to the existing risks. The potential for human or ecological exposure to contaminants in groundwater would endure, as would the potential for the contamination of other media. This alternative does not satisfy the preference for treatment and permanence. However, based on the very slow migration of contamination and the lack of drinking water wells, this exposure is deemed to be minimal. A review of site conditions every 5 years, including a groundwater sampling event, would be required to assess long-term risks. Appropriate action would be taken at these times based on the review.

Short-term Effectiveness

The Institutional Actions alternative will have no impact on existing site conditions. Personnel performing groundwater sampling activities would use PPE to prevent dermal exposure to and inhalation of contaminants. This sampling could be done in a few days per sampling event.

Implementability

Institutional Actions do not present any technical implementability obstacles. Monitoring and/or future remedial action would be easily applied. However, the failure to comply with ARARs poses a potentially difficult administrative obstacle.

Costs

There are no capital costs associated with this alternative. O&M costs, as presented in Table 5-9, are associated with the groundwater sampling events every 5 years for 30 years. It is assumed that only existing wells would be sampled and no new wells would be installed. The approximate total present worth of Alternative B2 is $81,950.

5.2.3 Alternative B3: Intrinsic Remediation

5.2.3.1 Detailed Description

The principal component of this alternative is the assumed natural attenuation and bioremediation taking place at this site, which is proposed to reduce contaminant levels to below ARARs before contaminants in the groundwater can leave the controlled area.

The key components of this alternative are:

- institutional control to prevent intrusion into or installation of wells into the known area of contamination in the bedrock;
- intrinsic remediation by naturally occurring microorganisms in the groundwater within the bedrock;

- installation of additional groundwater monitoring wells (for costing purposes, three shallow bedrock wells are proposed);
- collection of additional field data and incorporation of the data into groundwater flow and contaminant transport models;
- long-term monitoring and reports of groundwater quality;
- reviews of field data, modeling predictions and compliance with ARARs, at 5-year intervals; and
- review of the need for continued monitoring or of the need for additional action, at 5-year intervals.

5.2.3.2 Criteria Analysis

Overall Protection of Human Health and the Environment

The intrinsic remediation alternative will not directly treat, contain, destroy, or reduce the mobility of contaminants at the UST 13 groundwater area. The institutional restrictions will, if properly executed, prevent exposure to contaminants and reduce potential risks to human health to below acceptable levels. It will also provide good data on contaminant migration and the potential for human health risks to occur outside the controlled area.

Compliance with ARARs

Groundwater would not comply with ARARs for a long time. Prediction of the estimated time to achieve ARARs would depend on calibration and verification of the groundwater models, which would require a number of years of continued monitoring. There will be a certain degree of uncertainty in modeling the fractured bedrock aquifer at this site.

Reduction of Toxicity, Mobility, or Volume Through Treatment

This alternative does not offer any direct reduction of toxicity, mobility, or volume through treatment. The naturally occurring bioremediation is expected to reduce the compounds present in the bedrock beneath the site to protoplasm, carbon dioxide, water, and chlorides, by reductive dechlorination and metabolism of non-chlorinated constituents. This "remedy" proposes more intensive site characterization and monitoring to ensure that the expected results are, or are not, achieved.

Long-Term Effectiveness and Permanence

If performed as proposed and found to be effective, intrinsic remediation will be a permanent and effective long-term remediation of the site, which will restore groundwater to contaminant levels that represent an acceptable risk to human health and the environment.

Short-Term Effectiveness

The proposed "remedy" will have little impact on site conditions in the short term. Groundwater quality may, or may not, have improved by the time the additional field investigation is completed and the existing wells are resampled.

Implementability

The intrinsic remediation alternative is readily implementable, both for additional well installation, sampling, and modeling. Since the ultimate objective is compliance with ARARs, no administrative obstacles appear to be likely.

Costs

Capital costs are involved for installation of additional wells and the creation of a site-specific calibrated flow and contaminant transport model. O&M costs will consist of sampling, analysis, and data interpretation, including possibly model adjustment, will occur yearly. Costs are presented in Table 5-10. The approximate total present worth of the "intrinsic remediation" alternative, assuming three additional shallow bedrock wells is $170,910. Costs are calculated annually for the first 5 years, when the entire remedial process will be reviewed and revised, extended, or canceled. Thereafter, costs are calculated for 5-year intervals until 30 years.

5.2.4 Comparative Analysis of Alternatives

Two of these alternatives, No Further Action and Institutional Actions, are essentially equivalent. Neither involves any remedial action. The only difference is that Alternative B1 would provide annual monitoring for 5 years, whereas B2 provides for seven monitoring events at 5 year intervals. Therefore, Alternative B2 would provide for monitoring of the long-term potential for human health risk. However, as discussed in Section 2, the current human health risks are minimal. Alternative B3, Intrinsic Remediation, provides for greater safeguards to human health and the environment in that the distribution of contaminants is more extensively characterized and monitored than in the preceding two alternatives. Models of groundwater flow and of contaminant transport are also created and calibrated to provide predictive capability, and then verified or modified as the result of long-term monitoring. Because this alternative ensures that the site ultimately complies with ARARs, it appears that there will be no administrative obstacles to implementing this alternative.

5.3 POL STORAGE AREA/DRMO YARD GROUNDWATER OPERABLE UNIT (AOC 32, 43A)

Three alternatives for remediation of the POL Storage Area/DRMO Yard groundwater were retained from the initial screening (Section 4). These are described in detail in this section and analyzed with respect to the criteria presented by the EPA. The three alternatives discussed below are:

Alternative C1: No Further Action
Alternative C2: Institutional Actions
Alternative C3: Intrinsic Remediation

5.3.1 Alternative C1: No Further Action

5.3.1.1 Detailed Description

The "No Further Action" alternative is developed and evaluated to establish a baseline for comparison with other remedial alternatives. Under this alternative, no remedial action of any type would be undertaken. Neither the soils or groundwater in the vicinity of the POL Storage Area/DRMO Yard would be removed, contained, or treated in any way. It is assumed that the contamination would remain in its present state and pose the same risks as currently exist.

Groundwater monitoring would be performed annually for 5 years under this alternative. After 5 years the need for continued monitoring will be reviewed.

5.3.1.2 Criteria Analysis

Overall Protection of Human Health and the Environment

The "No Further Action" alternative would neither contain, treat, nor destroy the contaminants in the groundwater under and downgradient of the POL Storage Area/DRMO Yard. No measures, either remedial or institutional, would be taken to protect human health or the environment, and RAOs would not be met. Monitoring, however, would be performed in order to detect contaminant migration. This would influence a decision to take additional action, if necessary.

Compliance with ARARs

The groundwater would still exceed ARARs for trichloroethene and 2-methylnaphthalene, and a TBC for petroleum hydrocarbons. Therefore, a waiver would have to be granted to pursue this alternative. If future site use is planned to be restricted to industrial use, the threat of exposure to this contamination may be deemed acceptable by regulators.

Reduction of Toxicity, Mobility, or Volume through Treatment

The "No Further Action" alternative would have no effect on the toxicity, mobility, or volume of contamination. However, as discussed in Section 1, the contaminants occur in only two isolated wells at relatively low levels. Monitoring would detect any contaminant migration over time.

Long-term Effectiveness and Permanence

Because the "No Further Action" alternative will not meet the RAOs, the residual risk is equivalent to the existing risks. The potential for human or ecological exposure to contaminants in groundwater would endure, as would the potential for the contamination of other media. This alternative does not satisfy the preference for treatment and permanence. However, based on the three wells affected and the lack of drinking water wells, the exposure is deemed to be minimal. Groundwater monitoring will assess long-term contamination migration and human health risks, allowing appropriate actions to be taken if conditions change.

Short-term Effectiveness

The "No Further Action" alternative will have no impact on existing site conditions. Sampling could be performed in a few days per sampling event and represents minimal risk to sampling personnel.

Implementability

The "No Further Action" alternative does not present any technical implementability obstacles. Monitoring and/or future remedial action would be easily applied. However, the failure to comply with ARARs poses a potentially difficult administrative obstacle.

Costs

There are no capital costs associated with this alternative. O&M costs, as presented in Table 5-11, are associated with the groundwater sampling events, to be conducted for 5 years. It is assumed that existing wells would be sampled and no new wells installed. The approximate total present worth of the "No Further Action" alternative is $84,840, assuming no further monitoring is required after 5 years.

5.3.2 Alternative C2: Institutional Actions

5.3.2.1 Detailed Description

No remediation would occur under this alternative; activity would be limited to minimal measures intended to reduce exposure to contaminated media. Deed restrictions would limit land use and development. The land would be limited to restricted development, including a ban on drinking well installation, through deed restrictions. The land is currently slated for rail, industrial, and trade-related uses by the Massachusetts Government Land Bank (November 1996 Devens Reuse Plan), which will control development upon Army release of the property, thus no further zoning alterations would be required. Because there is no surficial contamination, fencing would not further reduce risks to human health or the environment.

Groundwater monitoring would also be performed under this alternative. Every 5 years for a period of 30 years, the site conditions would be reviewed to determine the extent of contaminant migration. A groundwater sampling event will be performed for each of these reviews. In addition, exposure scenarios will be revisited based on site use at the time of each review. If warranted, additional action will be considered at these times.

5.3.2.2 Criteria Analysis

Overall Protection of Human Health and the Environment

Institutional actions would not treat or destroy any of the contaminants; however, they would isolate the contamination in an area restricted to development. Therefore, if executed properly, institutional actions under this alternative would reduce human exposure to the contaminants to acceptable risk levels. Risks to the environment would be unaffected; however, ecological risks were found to be minimal. Groundwater monitoring would also aid in the protection of human health and the environment in that it would be used to evaluate potential contaminant migration. This would influence a decision to take additional action, if necessary.

Compliance with ARARs

The groundwater would still exceed ARARs and TBCs. Therefore, a waiver would have to be granted to pursue this alternative. If future site use is planned to be restricted to industrial use, the threat of exposure to this contamination may be deemed acceptable by regulators.

Reduction of Toxicity, Mobility, or Volume through Treatment

Provisions under this alternative would have no effect on toxicity, mobility, or volume of contamination. However, as discussed in Section 1, the contaminants are scattered and at relatively low levels. Monitoring would serve to detect contaminant migration over time.

Long-term Effectiveness and Permanence

Because Institutional Actions will not meet the RAOs, the residual risk is equivalent to the existing risks. The potential for human or ecological exposure to contaminants in groundwater would endure, as would the potential for the contamination of other media. This alternative does not satisfy the preference for treatment and permanence. However, based on the lack of drinking water wells, this exposure is deemed to be minimal. A review of site conditions every 5 years, including a groundwater sampling event, would be required to assess long-term risks. Appropriate action would be taken at these times based on the review.

Short-term Effectiveness

The Institutional Actions alternative will have no impact on existing site conditions. Sampling could be done in a few days per sampling event and represents minimal risk to sampling personnel.

Implementability

Institutional Actions do not present any technical implementability obstacles. Monitoring and/or future remedial action would be easily applied. However, the failure to comply with ARARs poses a potentially difficult administrative obstacle.

Costs

There are no capital costs associated with this alternative. O&M costs, as presented in Table 5-12, are associated with the groundwater sampling events every 5 years for 30 years. It is assumed that only existing wells would be sampled and no new wells would be installed. The approximate total present worth of Alternative C2 is $69,460.

5.3.3 Alternative C3: Intrinsic Remediation

5.3.3.1 Detailed Description

The principal component of this alternative is the assumed natural attenuation and bioremediation taking place at this site, which is proposed to reduce contaminant levels to below ARARs before contaminants in the groundwater can leave the controlled area.

The key components of this alternative are:

- institutional control to prevent intrusion into or installation of wells into the known area of contamination in the bedrock;
- intrinsic remediation by naturally occurring microorganisms in the groundwater within the bedrock;
- installation of additional groundwater monitoring wells (for costing purposes, three shallow bedrock wells are proposed);
- collection of additional field data and incorporation of the data into groundwater flow and contaminant transport models;
- long-term monitoring and annual reports of groundwater quality;
- reviews of field data, modeling predictions and compliance with ARARs, at 5-year intervals; and

- review of the need for continued monitoring or of the need for additional action, at 5-year intervals.

5.3.3.2 Criteria Analysis

Overall Protection of Human Health and the Environment

The intrinsic remediation alternative will not treat, contain, destroy, or reduce the mobility of contaminants at the POL Storage Area/DRMO Yard groundwater operable unit. The institutional restrictions will, if properly executed, prevent exposure to contaminants and reduce potential risks to human health to below acceptable levels. It will also provide good data on contaminant migration and the potential for human health risks to occur outside the controlled area.

Compliance with ARARs

Groundwater would not immediately comply with ARARs. Prediction of the estimated time to achieve ARARs would depend on calibration and verification of the groundwater models, which would require a number of years of continued monitoring, by which time ARARs may no longer be exceeded.

Reduction of Toxicity, Mobility, or Volume Through Treatment

This alternative does not offer any direct reduction of toxicity, mobility, or volume through treatment. The naturally occurring bioremediation is expected to reduce the compounds present in the aquifer beneath the site to protoplasm, carbon dioxide, water, and chlorides, by reductive dechlorination and metabolism of non-chlorinated constituents. This "remedy" proposes more intensive site characterization and monitoring to determine if the expected results are, or are not, achieved.

Long-Term Effectiveness and Permanence

If performed or proposed and found to be effective, intrinsic remediation will be a permanent and effective long-term remediation of the site, which will restore groundwater to contaminant levels that represent an acceptable risk to human health and the environment.

Short-Term Effectiveness

The proposed "remedy" will have little impact on site conditions in the short term. Groundwater quality may, or may not, have improved by the time the additional field investigation is completed and the new and existing wells are resampled.

Implementability

The intrinsic remediation alternative is readily implementable, both for additional well installation, sampling, and modeling. Since the ultimate objective is compliance with ARARs, no administrative obstacles appear to be likely.

Costs

Capital costs are involved for installation of additional wells and the creation of a site-specific calibrated flow and contaminant transport model. O&M costs will consist of sampling, analysis, and data interpretation, including possibly model adjustment, to occur yearly. Costs are presented in Table 5-13. The approximate total present worth of the "intrinsic remediation" alternative, assuming one additional bedrock well and four deeper (50 to 60 feet) overburden wells, is $258,870. Costs are calculated annually for the first 5 years, when the entire remedial process will be reviewed and revised, extended, or canceled. Monitoring will continue at 5-year intervals until 30 years, and costs are calculated for these, assuming that the program is carried to its maximum duration.

5.3.4 Comparative Analysis of Alternatives

Two of these alternatives, No Further Action and Institutional Actions, are essentially equivalent. Neither involves any remedial action. The only difference is that Alternative C1 would provide annual monitoring for 5 years, whereas C2 provides for seven monitoring events at 5 year intervals and controls exposure to groundwater. Therefore, Alternative C2 would provide for monitoring of the long-term potential for human health risk. However, as discussed in Section 2, the current human health risks are minimal. Alternative B3, Intrinsic Remediation, provides for greater safeguards to human health and the environment in that the distribution of contaminants is more extensively characterized and monitored than in the preceding two alternatives. Models of groundwater flow and of contaminant transport are also created and calibrated to provide predictive capability, and then verified or modified as the result of long-term monitoring. Because this alternative ensures that the site ultimately complies with ARARs, it appears that there will be no administrative obstacles to implementing this alternative.

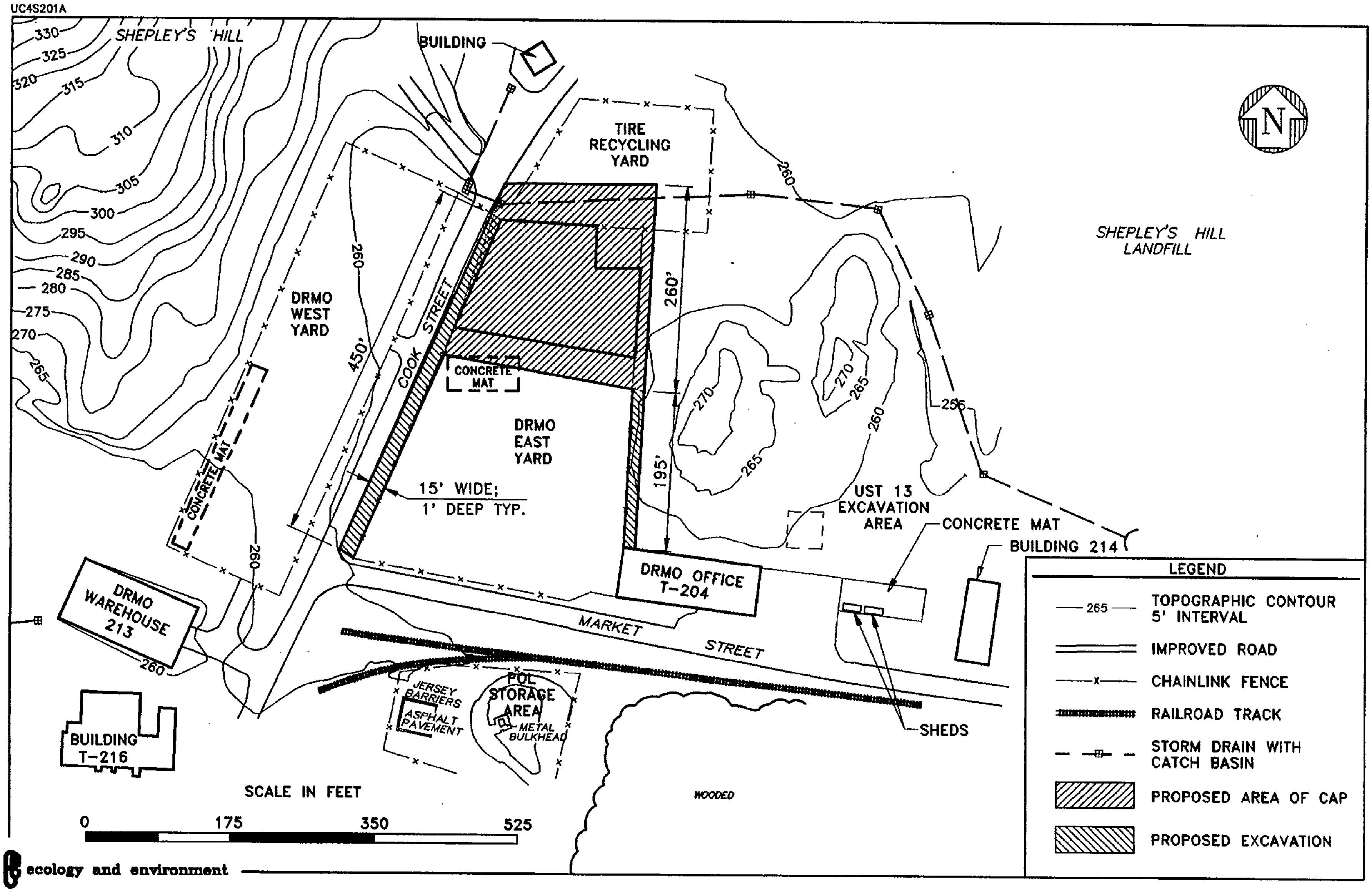

Figure 5-1 ALTERNATIVE A3: AREAS OF EXCAVATION AND CAP

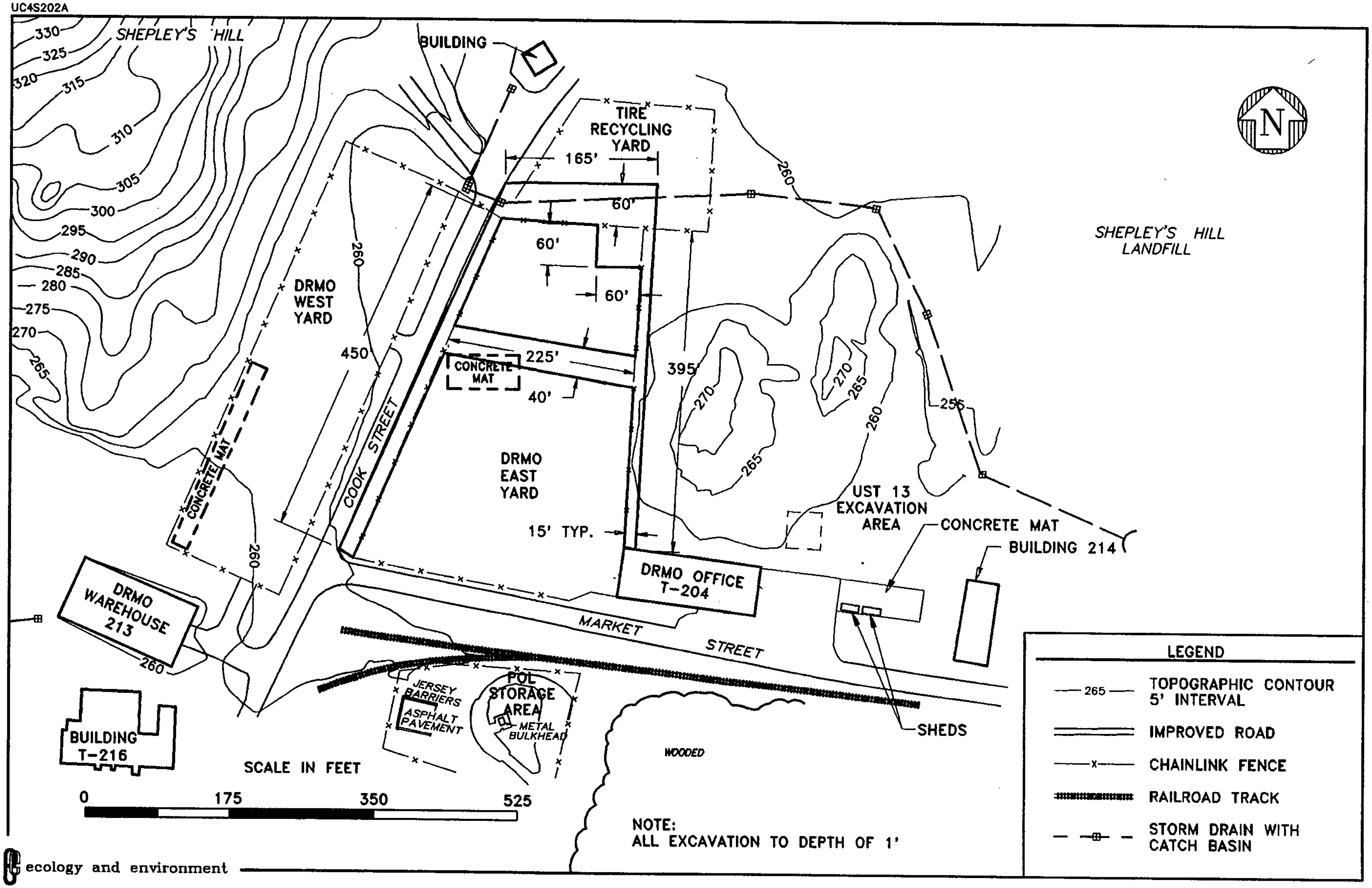

Figure 5-2 ALTERNATIVES A4 AND A6: AREAS OF EXCAVATION

Table 5-1

DETAILED ANALYSIS OF ALTERNATIVES FOR DRMO YARD SOILS OPERABLE UNIT

Alternatives	Overall Protection	Compliance with ARARs	Reduction of Toxicity, Mobility, or Volume	Long Term Effectiveness	Short Term Effectiveness	Implementability	Capital Costs	O&M Present Worth Costs	Total Cost
A1: No Further Action (with groundwater monitoring)	No additional protection to human health over the present state. There are no current ecological risks.	Surface soil ARAR (TSCA) for PCBs would be exceeded.	No reduction of toxicity, mobility, or volume is achieved in this alternative.	No additional protection in the long term would be provided. Existing zoning for restricted industrial use must be enforced. EPA's preference for permanent treatment would not be met under this alternative.	No additional protection would be provided in the short term.	An ARARs waiver would be required to implement this alternative.	$0	$80,380	**$80,380**
A2: Institutional Actions	If implemented properly, Alternative A2 would isolate and contain contaminants, eliminating exposure routes and providing for protection of human health. There are no current ecological risks.	The exceedance, as in Alternative A1, would remain, but elimination of exposure routes may reduce risks to levels deemed acceptable by Superfund policy.	The toxicological risks are reduced by elimination of exposure pathways, yet there is no reduction of toxicity, mobility, or volume.	If fencing and access restrictions are properly maintained, this alternative may provide protection but, because no treatment is employed, this alternative would not necessarily be effective over the long term. EPA's preference for permanent treatment would not be met under this alternative.	Site workers constructing the fence would wear dermal and respiratory protection to avoid dust and contaminant exposure, but the alternative could be initiated immediately.	This alternative is easily implemented in a few weeks and would require minimal coordination and start up time. However, a waiver of ARARs would be required to leave the TSCA-regulated PCB contamination in place.	$17,950	$85,740	**$103,690**

Table 5-1

DETAILED ANALYSIS OF ALTERNATIVES FOR DRMO YARD SOILS OPERABLE UNIT

Alternatives	Overall Protection	Compliance with ARARs	Reduction of Toxicity, Mobility, or Volume	Long Term Effectiveness	Short Term Effectiveness	Implementability	Capital Costs	O&M Present Worth Costs	Total Cost
A3: Containment Via Capping	Direct contact would be eliminated through the installation of an impermeable cap and a surrounding fence, eliminating exposure routes to humans. There are no current ecological risks.	The exceedance, as in the above alternatives, could still apply, but exposure routes would be eliminated. If the excavated soil to be capped is found to exhibit the toxicity characteristic due to lead, cadmium, or other contaminant, capping of these excavated soils would violate RCRA action-specific ARARs.	There is no reduction of toxicity or volume, yet mobility is reduced by prevention of surface water infiltration.	This alternative would require continuous maintenance and institutional actions to protect the capped area. Cap deterioration could potentially limit its long-term effectiveness. EPA's preference for permanent treatment would not be met under this alternative.	Human health risks may exist from dust and runoff over the short term, during earth moving and cap construction. Therefore dust control and runoff control activities would be required, as would dermal and respiratory protection for workers.	Contractors are available to perform this remedy. However, untreated TSCA-regulated PCB-contaminated soils would remain on site. Thus an ARARs waiver could be required. Also future use of the site would be restricted. These two issues limit the implementability of this alternative.	$470,320	$366,200	**$836,520**

Table 5-1

DETAILED ANALYSIS OF ALTERNATIVES FOR DRMO YARD SOILS OPERABLE UNIT

Alternatives	Overall Protection	Compliance with ARARs	Reduction of Toxicity, Mobility, or Volume	Long Term Effectiveness	Short Term Effectiveness	Implementability	Capital Costs	O&M Present Worth Costs	Total Cost
A4: Excavation, Solidification, and On-Site Disposal	Direct contact would be eliminated through immobilization and containment of the soils, eliminating exposure routes to humans. There are no current ecological risks.	As the TSCA-regulated PCB-contaminated soil would be treated, ARARs would be complied with. If the solidified soil was found to exhibit the toxicity characteristic due to lead, cadmium, or other contaminants, then disposal of this solidified soil on site would violate RCRA action-specific ARARs.	There is a reduction of toxicity for lead and cadmium, but not for PCBs or pesticides. The mobility of the contaminants will be drastically reduced. The volume of waste will most likely, however, be increased.	Treatment of the soil would provide a good measure of long-term effectiveness. As neither PCBs nor pesticides would be chemically bound in the solidified matrix, some organics may eventually leach out. EPA's preference for permanent treatment is therefore not met under this alternative. A treatability study would be performed to determine if solidification is likely to be successful and to determine the optimal solidification technique.	Human health risks to workers and the community may exist from dust and runoff during earth moving and solidification activities. Therefore dust control and runoff control activities would be required, as would dermal and respiratory protection for workers.	Contractors are available to perform this work. However, future use of the site would be restricted due to monolith storage. Also, it will be difficult to evaluate its effectiveness or to implement additional remedial action.	$490,870	$287,270	**$778,140**

Table 5-1

DETAILED ANALYSIS OF ALTERNATIVES FOR DRMO YARD SOILS OPERABLE UNIT

Alternatives	Overall Protection	Compliance with ARARs	Reduction of Toxicity, Mobility, or Volume	Long Term Effectiveness	Short Term Effectiveness	Implementability	Capital Costs	O&M Present Worth Costs	Total Cost
A6: Excavation and Off-Site Disposal	This alternative would remove contaminants from the site, resulting in protection of human health at the site. There are no current ecological risks.	By removing TSCA-regulated PCB-contaminated soil, the PCB cleanup ARAR would be satisfied. If any soils were found to exhibit the hazard characteristic of toxicity due to lead, cadmium, or any other contaminant, they would have to be treated and/or disposed of in a RCRA-regulated facility.	There is no reduction of toxicity or volume. Soil is transported to a landfill, where its mobility will be controlled by landfill authorities.	This alternative would provide long term effectiveness, as long as the landfill continued to be monitored and regulated. It is a permanent solution to the on-site problem, but does not satisfy EPA preference for permanent treatment.	Human health risks to site workers and the community may exist during earth moving activities from dust and runoff. Therefore, dust control and runoff control activities would be required, as would dermal and respiratory protection for workers.	This alternative is readily implementable, assuming the soils do not fail TCLP tests. If they did, they would require disposal in a RCRA-certified landfill, as a waiver to dispose of the soils in a sanitary landfill would be difficult to obtain.	$543,696	$19,850	**$563,550**

Table 5-2

DRMO YARD SOILS
ALTERNATIVE A1: NO FURTHER ACTION COSTS

Monitoring Costs
Interest rate (%): 6
Operation and Maintenance (years): 5

Description	Quantity/ Year	Units	Unit Cost	Annual Cost
Groundwater monitoring (5 existing wells)				
Sampling equipment (containers, coolers, bailers, etc.)	1	lump sum	$1,510	$1,510
Safety equipment (monitoring devices, clothing)	1	lump sum	$510	$510
Shipping (equipment, protective clothing, samples)	550	lb.	$1.50	$830
Sample collection-labor (two-man team)	1	lump sum	$400	$400
Travel expenses (air fares, per diem (meals), van rental, fuel)	1	lump sum	$1,250	$1,250
Sample analysis costs (VOCs, PCBs/pest., metals-filtered and unfiltered; includes duplicate, trip blank, and rinsate blank samples)	1	lump sum	$9,880	$9,880
Data validation	20	hr.	$470	$470
Summary Report and Site Evaluation	1	lump sum	$1,090	$1,090
Subtotal Monitoring				$15,940
10% legal, administrative, and engineering fees				$1,594
10% contingencies				$1,594
Total Monitoring Costs for 1 Year				$19,130
Total Monitoring Present Worth (Annual for 5 years)				$80,380
Total Present Worth - Alternative A1				**$80,380**

Note: Costs were rounded to the nearest $10.

Table 5-3

DRMO YARD SOILS
ALTERNATIVE A2: INSTITUTIONAL ACTIONS COSTS

Description	Quantity	Unit	Unit Cost	Cost
Summary of Capital Costs				
Mobilization	4	per person	$61.84	$250
Demobilization (3% of the capital costs)	1	lump sum	$500	$500
Health and safety (PPE)	1	lump sum	$3,550	$1,250
Fence Moving	840	linear foot	$14.55	$12,220
Addition of new fencing	60	linear foot	$12.35	$740
Subtotal Capital				$14,960
10% legal, administrative, and engineering fees				$1,496
10% contingencies				$1,496
Total Capital Costs				$17,950
Operation and Maintenance Costs				
Interest rate (%):	6			
Operation and Maintenance (years):	30			
Fence maintenance	50	linear foot	$12.60	$630
Subtotal O&M				$630
10% legal, administrative, and engineering fees				$63
10% contingencies				$63
Total Annual O&M Costs				$760
Total O&M Present Worth (every 6 months for 30 years)				$20,860
Total Capital Costs (above)				$17,950
Total Present Worth, Monitoring (see table below)				$64,880
Total Present Worth - Alternative A2				**$103,690**

Table 5-3 (continued)

DRMO YARD SOILS
ALTERNATIVE A2: INSTITUTIONAL ACTIONS COSTS

Monitoring Costs
Interest rate (%): 6
Operation and Maintenance (years): 30

Description	Quantity/Year	Units	Unit Cost	Annual Cost
Groundwater Monitoring (5 existing wells)				
Sampling equipment (containers, coolers, bailers, etc.)	1	lump sum	$1,510	$1,510
Safety equipment (monitoring devices, clothing)	1	lump sum	$510	$510
Shipping (equipment, protective clothing, samples)	550	lb.	$1.50	$830
Sample collection - labor (2-man team)	1	lump sum	$400	$400
Travel expenses (air fare, per diem [meals], van rental, fuel)	1	lump sum	$1,250	$1,250
Sample analysis costs (VOCs, PCBs/ pest, metals - filtered and unfiltered; includes duplicate, trip blank, and rinsate blank samples)	1	lump sum	$10,760	$10,760
Data Validation	40	hr.	$23.50	$940
Summary Report	1	lump sum	$1,190	$1,190
Site Evaluation every 5 years	1	lump sum	$4,750	$4,750
Subtotal Monitoring				$22,140
10% legal, administrative, and engineering fees				$2,214
10% contingencies				$2,214
Total Future Monitoring Costs				$26,570
Total Monitoring Present Worth (every 5 years for 30 years)				$64,880

Note: Costs were rounded to the nearest $10.

Table 5-4

DRMO YARD SOILS
ALTERNATIVE A3: CONTAINMENT VIA CAPPING COSTS

Description	Quantity	Unit	Unit Cost	Cost
Summary of Capital Costs				
Mobilization	6	per person	$61.84	$370
Demobilization (3% of the capital costs)	1	lump sum	$12,640	$12,640
Site services (utilities, survey, etc.)	1	lump sum	$19,240	$19,240
Health and safety (PPE)	1	lump sum	$36,920	$36,920
Excavation, Backfill and Consolidation (Ditches)	360	cubic yard	$9.38	$3,380
Temporary Cover	5,425	square yard	$0.07	$660
Cap:				
Regrading	5,425	square yard	$1.36	$7,380
18-inch clay layer	2,713	cubic yard	$16.10	$43,680
6-inch sand drainage layer	904	cubic yard	$9.79	$8,850
6-inch topsoil	904	cubic yard	$24.71	$22,340
Seeding	1.13	acre	$1,488.73	$1,680
Rip-Rap	904	cubic yard	$28.50	$25,760
Verification Sampling	1	lump sum	$3,810	$3,810
Verification Analysis	106	each	$792.16	$83,970
TCLP Sampling	1	lump sum	$3,810	$3,810
TCLP Analysis	106	each	$866.37	$91,840
Fence Moving	840	linear feet	$14.55	$12,220
Addition of New Fencing	60	linear feet	$12.35	$740
Subtotal Capital				$391,930
10% legal, administrative, and engineering fees				$39,193
10% contingencies				$39,193
Total Capital Costs				$470,320
Total O&M Present Worth (see table below)				$366,200
Total Present Worth - Alternative A3				**$836,520**

Table 5-4 (continued)

DRMO YARD SOILS
ALTERNATIVE A3: CONTAMINANT VIA CAPPING COSTS

Operation and Maintenance and Monitoring Costs
Interest rate (%): 6
Operation and Maintenance (years): 30

Description	Quantity/Year	Units	Unit Cost	Annual Cost
Groundwater Monitoring (5 existing wells)				
Sampling equipment (containers, coolers, bailers, etc.)	1	lump sum	$1,510	$1,510
Safety equipment (monitoring devices, clothing)	1	lump sum	$510	$510
Shipping (equipment, protective clothing, samples)	550	lb.	$1.50	$830
Sample collection - labor (2-man team)	1	lump sum	$400	$400
Travel expenses (air fare, per diem [meals], van rental, fuel)	1	lump sum	$1,250	$1,250
Sample analysis costs (VOCs, PCBs/ pest., metals - filtered and unfiltered; includes duplicate, trip blank, and rinsate blank samples)	1	lump sum	$10,760	$10,760
Data Validation	40	hr.	$23.50	$940
Summary Report	1	lump sum	$1,190	$1,190
Maintenance:				
Cap	1	lump sum	$4,190	$4,190
Fence	50	linear foot	$12.60	$630
Subtotal O&M				$22,210
10% legal, administrative, and engineering fees				$2,221
10% contingencies				$2,221
Total Annual O&M and Monitoring Costs				$26,650
Total O&M and Monitoring Present Worth (every year for 30 years)				$366,200

Note: Costs were rounded to the nearest $10.

Table 5-5

DRMO YARD SOILS
ALTERNATIVE A4: EXCAVATION, SOLIDIFICATION, AND ON-SITE DISPOSAL

Description	Quantity	Unit	Unit Cost	Cost
Summary of Capital Costs				
Mobilization	6	per person	$61.84	$370
Demobilization (3% of the capital costs)	1	lump sum	$14,030	$14,030
Site service (utilities, survey, etc.)	1	lump sum	$24,330	$24,330
Health and safety (PPE)	1	lump sum	$49,230	$49,230
Treatability Study	1	lump sum	$25,000	$25,000
Soil Excavation	1,300	cubic yard	$2.62	$3,410
Backfill	1,300	cubic yard	$1.51	$1,960
Soil Loading and Handling	1,300	cubic yard	$1.38	$1,790
Temporary Cover	3,940	square yard	$0.07	$280
Soil Treatment	1	lump sum	$72,240	$72,240
Verification sampling	1	lump sum	$3,810	$3,810
Verification analysis	106	each	$792.16	$83,970
TCLP sampling	1	lump sum	$3,810	$3,810
TCLP analysis	106	each	$866.37	$91,840
Additional soil excavation	325	cubic yard	$2.62	$850
Backfilling and Compaction of Treated Soil	1,625	cubic yard	$5.00	$8,130
Grading	3,940	square yard	$1.36	$5,360
6-inch Topsoil	660	cubic yard	$24.71	$16,310
Seeding	0.81	acre	$1,488.73	$1,210
Subtotal Capital				$409,060
10% legal, administrative, and engineering fees				$40,906
10% contingencies				$40,906
Total Capital Costs				$490,870
Total Monitoring Present Worth (see table below)				$287,270
Total Present Worth - Alternative A4				**$778,140**

Table 5-5 (continued)

DRMO YARD SOILS
ALTERNATIVE A4: EXCAVATION, SOLIDIFICATION, AND ON-SITE DISPOSAL

Monitoring Costs
Interest rate (%): 6
Operation and Maintenance (years): 30

Description	Quantity/Year	Units	Unit Cost	Annual Cost
Groundwater Monitoring (5 existing wells)				
Sampling equipment (containers, coolers, bailers, etc.)	1	lump sum	$1,510	$1,510
Safety equipment (monitoring devices, clothing)	1	lump sum	$510	$510
Shipping (equipment, protective clothing, samples)	550	lb.	$1.50	$830
Sample collection - labor (2-man team)	1	lump sum	$400	$400
Travel expenses (air fare, per diem [meals], van rental, fuel)	1	lump sum	$1,250	$1,250
Sample analysis costs (VOCs, PCBs/ pest., metals - filtered and unfiltered; includes duplicate, trip blank, and rinsate blank sample)	1	lump sum	$10,760	$10,760
Data Validation	40	hr.	$23.50	$940
Summary Report	1	lump sum	$1,190	$1,190
Subtotal Monitoring				$17,390
10% legal, administrative, and engineering fees				$1,739
10% contingencies				$1,739
Total Annual Monitoring Costs				$20,870
Total Monitoring Present Worth (every year for 30 years)				$287,270

Note: Costs were rounded to the nearest $10.

Table 5-6

DRMO YARD SOILS
ALTERNATIVE A6: EXCAVATION AND OFF-SITE DISPOSAL COSTS

Description	Quantity	Unit	Unit Cost	Cost
Summary of Capital Costs				
Mobilization	4	per person	$61.84	$250
Demobilization (3% of the capital costs)	1	lump sum	$14,120	$14,120
Site services (utilities, survey, etc.)	1	lump sum	$14,140	$14,140
Health and safety (PPE)	1	lump sum	$19,090	$19,090
Soil Excavation	1,300	cubic yard	$2.62	$3,410
Soil Handling/Loading	1,300	cubic yard	$1.38	$1,790
Temporary Cover	3,940	square yard	$0.07	$280
Transportation (100 mi. round trip)	70	dump truck	$683.63	$47,850
Disposal	1,300	cubic yard	$111.31	$144,700
Verification sampling	1	lump sum	$3,810	$3,810
Verification analysis	106	each	$792.16	$83,970
TCLP sampling	1	lump sum	$3,810	$3,810
TCLP analysis	106	each	$866.37	$91,840
Backfill and compaction	1,300	cubic yard	$5.00	$6,500
6-inch Topsoil	660	cubic yard	$24.71	$16,310
Seeding	0.81	acre	$1,488.73	$1,210
Subtotal Capital				$453,080
10% legal, administrative, and engineering fees				$45,308
10% contingencies				$45,308
Total Capital Costs				$543,696
Total Monitoring Present Worth (see table below)				$19,850
Total Present Worth - Alternative A6				**$563,550**

Table 5-6 (continued)

DRMO YARD SOILS
ALTERNATIVE A6: EXCAVATION AND OFF-SITE DISPOSAL COSTS

Monitoring Costs
Interest rate (%): 6
Operation and Maintenance (years): 5

Description	Quantity/Year	Units	Unit Cost	Annual Cost
Groundwater Monitoring (5 existing wells)				
Sampling equipment (containers, coolers, bailers, etc.)	1	lump sum	$1,510	$1,510
Safety equipment (monitoring devices, clothing)	1	lump sum	$510	$510
Shipping (equipment, protective clothing, samples)	550	lb.	$1.50	$830
Sample collection - labor (2-man team)	1	lump sum	$400	$400
Travel expenses (air fare, per diem [meals], van rental, fuel)	1	lump sum	$1,250	$1,250
Sample analysis costs (VOCs, PCBs/ pest., metals - filtered and unfiltered; includes duplicate, trip blank, and rinsate blank samples)	1	lump sum	$10,760	$10,760
Data Validation	40	hr.	$23.50	$940
Summary Report	1	lump sum	$1,190	$1,190
Site Evaluation after 5 years	1	lump sum	$4,750	$4,750
Subtotal Monitoring				$22,140
10% legal, administrative, and engineering fees				$2,214
10% contingencies				$2,214
Total Future Monitoring Costs				$26,568
Total Monitoring Present Worth (1 event in 5 years)				$19,850

Note: Costs were rounded to the nearest $10.

Table 5-7

DRMO YARD SOILS
ALTERNATIVE COST SUMMARY

Alternative	Capital Cost	O&M and Monitoring Present Worth Costs	Total Present Worth Cost
A1: No Further Action	$0	$80,380	$80,380
A2: Institutional Actions	$17,950	$85,740	$103,690
A3: Containment Via Capping	$470,320	$366,200	$836,520
A4: Excavation, Solidification, and On-site Disposal	$490,870	$287,270	$778,140
A6: Excavation and Off-site Disposal	$543,696	$19,850	$563,550

Table 5-8

UST-13 GROUNDWATER COST SUMMARY ALTERNATIVE B1: NO FURTHER ACTION

Interest rate (%): 6
Operation and Maintenance (years): 5

Description	Annual Cost
Groundwater Monitoring (4 existing wells)	
Sampling equipment (Labor, ODCS)	$4,320
Sample analysis costs (VOCs, PCBs/pest., metals - filtered and unfiltered; includes duplicate, trip blank, and rinsate blank samples)	$9,320
Summary Report and Site Evaluation	$1,366
Subtotal Monitoring	$15,006
20% legal, administrative, and engineering fees/contingency	$3,000
Total Monitoring Costs for 1 Year	$18,000
Total Monitoring Present Worth (Annual for 5 years)	$75,820
Total Present Worth - Alternative B1	**$75,820**

Note: Costs were rounded to the nearest $10.

Table 5-9

UST-13 GROUNDWATER COST SUMMARY
ALTERNATIVE B2: INSTITUTIONAL ACTIONS

Interest rate (%): 6
Operation and Maintenance (years): 30

Description	Years	Annual Cost
Groundwater Monitoring (4 existing wells)		
Sampling (labor, ODCs)	0, 5, 10, 15, 20, 25, 30	$4,320
Sample analysis costs (VOCs, PCBs/pest., metals - filtered and unfiltered; includes duplicate, trip blank, and rinsate blank samples)	0, 5, 10, 15, 20, 25, 30	$9,320
Summary Report and Site Evaluation	0, 5, 10, 15, 20, 25, 30	$6,195
Subtotal Monitoring Cost (every 5 years)		$19,840
20% legal, administrative, and engineering fees/contingency		$3,968
Total Monitoring Cost (every 5 years)		$23,810
Subtotal Costs for 30 years - every 5 years (7 times)		$166,670
Total Monitoring Present Worth (every 5 years for 30 years)		$81,950
Total Present Worth - Alternative B2		**$81,950**

Note: Costs were rounded to the nearest $10.

Table 5-10

UST-13 GROUNDWATER COST SUMMARY
ALTERNATIVE B3: INTRINSIC REMEDIATION

Interest rate (%): 6
Operation and Maintenance (years): 30

Description	Quantity/Year	Annual Cost
Well installation	4 wells/Year 1	$5,870
Sampling (labor, other direct costs (ODCs))	Year 1	$6,580
Analytical Costs	Year 1	$6,980
Report, Modeling, Site Evaluation	Year 1	$32,710
Fees and Contingency (20%)	Year 1	$6,542
Subtotal	Year 1	$58,682
Total Present Worth	**Year 1**	**$55,360**
Sampling Wells (labor, ODCs)	Years 2 to 4 (ea)	$6,580
Analytical Costs	Years 2 to 4 (ea)	$6,980
Report, Site Evaluation	Years 2 to 4 (ea)	$3,680
Fees and Contingency (20%)	Years 2 to 4 (ea)	$3,448
Subtotal Yearly Cost	Years 2 to 4 (ea)	$20,688
Total Present Worth	**Years 2 to 4 (all)**	**$52,170**
Sampling Wells (labor, ODCs)	Year 5	$6,580
Analytical Costs	Year 5	$6,980
Report, Site Evaluation	Year 5	$8,070
Fees and Contingency (20%)	Year 5	$4,326
Subtotal Cost	Year 5	$25,956
Total Present Worth	**Year 5**	**$19,395**
Annual Cost	Years 10, 15, 20, 25, and 30	$25,956
Subtotal Cost	Years 10, 15, 20, 25, and 30	$129,780
Total Present Worth	**Years 10, 15, 20, 25, and 30**	**$43,985**
Total Present Worth	**Years 1 through 30**	**$170,910**

Note: Costs were rounded to the nearest $10.

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Table 5-11

POL STORAGE AREA/DRMO YARD GROUNDWATER COST SUMMARY ALTERNATIVE C1: NO FURTHER ACTION

Interest rate (%): 6
Operation and Maintenance (years): 5

Description	Year	Annual Cost
Groundwater Monitoring (11 existing wells)		
Sampling (labor, other direct costs (ODCs))	1 to 5 Years	$4,460
Analytical Cost	1 to 5 Years	$10,760
Report and Site Evaluation	1 to 5 Years	$1,560
Fee and Contingency (20%)	1 to 5 Years	$3,360
Subtotal Yearly Cost		$20,140
Total Monitoring Present Worth	Annual for 5 Years	$84,840
Total Present Worth - Alternative 1		**$84,840**

Note: Costs were rounded to the nearest $10.

Table 5-12

POL STORAGE AREA/DRMO YARD GROUNDWATER COST SUMMARY ALTERNATIVE C2: INSTITUTIONAL CONTROLS

Interest rate (%): 6
Operation and Maintenance (years): 30

Description	Years	Annual Cost
Groundwater Monitoring (11 existing wells)		
Sampling (labor, other direct costs (ODCs))	0, 5, 10, 15, 20, 25, 30	$4,500
Analytical Cost	0, 5, 10, 15, 20, 25, 30	$10,760
Report and Site Evaluation	0, 5, 10, 15, 20, 25, 30	$1,560
Fees and Contingency (20%)	0, 5, 10, 15, 20, 25, 30	$3,360
Subtotal Monitoring Cost (every 5 years)		$20,180
Subtotal costs for 30 years - every 5 years (7 times)		$141,260
Total Monitoring Present Worth	30 Years Monitoring	$69,460
Total Present Worth - Alternative 2		**$69,460**

Note: Costs were rounded to the nearest $10.

Table 5-13

POL STORAGE AREA/DRMO YARD GROUNDWATER COST SUMMARY ALTERNATIVE C3: INTRINSIC REMEDIATION

Interest rate (%): 6
Operation and Maintenance (years): 30

Description	Quantity/Year	Annual Cost
Well installation	5 wells/Year 1	$10,350
Sampling (labor, other direct costs (ODCs))	5 wells/Year 1	$11,260
Analytical Costs	5 wells /Year 1	$11,460
Report, Site Modeling, and Evaluation	Year 1	$41,280
Fee and Contingency (20%)	Year 1	$14,870
Subtotal Year 1		$89,220
Present Worth Year 1		**$84,170**
Sampling (labor, ODCs)	Years 2 to 4 (ea)	$11,260
Analytical Costs	Years 2 to 4 (ea)	$11,460
Report, Site Evaluation	Years 2 to 4 (ea)	$4,830
Fees and Contingency (20%)	Years 2 to 4 (ea)	$5,510
Subtotal Years 2 to 4 (ea)		$33,060
Present Worth Years 2 to 4 (total)		**$83,370**
Sampling (labor, ODCs)	Year 5	$11,260
Analytical Costs	Year 5	$11,460
Report, Site Evaluation	Year 5	$8,450
Fee and Contingency (20%)	Year 5	$6,230
Subtotal Year 5		$37,400
Present Worth Year 5		**$27,950**
Sampling/Site Evaluation	Years 10, 15, 20, 25, and 30	$187,000
Present Worth Years 10, 15, 20, 25, and 30		**$63,380**
Total Present Worth Years 1 through 30		**$258,870**

Note: Costs were rounded to the nearest $10.

Table 5-14

ARARS AND TBCS FOR SOILS REMEDIAL ALTERNATIVES (DRMO YARD)

Federal Regulation	Medium Regulated	Specific Requirements
Chemical-Specific ARARs/TBCs (see Table 2-1)		
Toxic Substance Control Act (TSCA) 40 CFR 761.125(c)(4)	Surface Soil (0 to 10 inches) Subsurface Soil (below 10 inches)	Unrestricted Access less than 1 mg/kg PCBs. Unrestricted Access less than 10 mg/kg PCBs.
To Be Considered (TBC)		
EPA Region III Risk-Based Concentration Table	Soil	Exposure levels to numerous chemicals under specific scenarios.
Resource Conservation and Recovery Act (RCRA) Corrective Action Levels 55 FR 30798, July 1990	Soil	To establish the need for a corrective measures study. Numerous chemicals.
Revised Interim Soil Lead Guidance for CERCLA Sites and RCRA Corrective Action Facilities. EPA OSWER Directive 9355.4-12, July 1994	Soil	Health-based soil lead screening value of 400 mg/kg for residential areas.
Background levels for metals	Soil	Candidate Cleanup goal not to be below background.
Massachusetts Contingency Plan (MCP) 310 CMR 40.09705(6)(a)	Soil	Total Petroleum Hydrocarbons not to exceed 500 mg/kg.
Federal and State Regulation Location-Specific ARARs		
There are no location-specific ARARs for the DRMO Yard (AOC 32). See Table 2-4)	Not Applicable	None
Federal and State Regulation Action-Specific ARARs		
If specific remedial actions generate hazardous waste or dispose of hazardous waste (53 FR 51437), then action-specific ARARs may specify particular performance standards or technology under a number of Federal laws (RCRA, CAA, CWA, SDWA, TSCA, etc)	All	None established. No hazardous waste is expected to be generated or identified in the DRMO Soils Operable Unit.
Massachusetts Hazardous Waste Management Rules (310 CMR 30.00) would also have to be complied with	All	None established. No hazardous waste is expected to be generated from DRMO Soils Operable Unit.

Table 5-15

FEDERAL AND STATE ARARS FOR AOCS 32 AND 43A POL STORAGE AREAS/DRMO YARD GROUNDWATER

Authority	Medium Regulated	Specific Requirements
Federal Regulatory Authority (Location-Specific)	Groundwater	No location-specific ARARs identified.
Federal Regulatory Authority SDWA - National Primary Drinking Water Standards, MCLs (40 CFR 141.11 to 141.16 and 141.50 to 141.53) (Chemical-Specific)	Potential Drinking Water Supplies (at AOCs)	MCLs have been established for many inorganics and organics which may not be exceeded in public drinking water supplies. Monitoring is required to ensure ARARs (MCLs) not exceeded.
Federal Regulatory Authority (Action-Specific)	Groundwater in place	If monitoring only, no action-specific ARARs must be met (action-specific ARARs apply to extraction/treatment).
State Regulatory Authority (Location-Specific) [314 CMR 6.00]	Groundwater classified as Class 1 (potential source of potable water)	Groundwater quality shall be maintained and protected in all Class 1 aquifers.
Massachusetts Groundwater Quality Standards [314 CMR 6.00] (Chemical-Specific)	Groundwater classified as Class 1 (potential source of potable water)	Standards have been set for many inorganics and organics which may not be exceeded in Class 1 aquifers unless from naturally occurring sources. Often equivalent to MCLs, but may differ.
State Regulatory Authority (Action-Specific)	Groundwater in place.	If monitoring only, no action-specific ARARs must be met (action-specific ARARs apply to extraction and treatment).

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APPENDIX A

PARTICLE TRACKING SIMULATION RESULT FOR FORT DEVENS MAIN POST: FROM POL STORAGE YARD TO THE MACPHERSON WELL

(PERFORMED BY ENGINEERING TECHNOLOGIES ASSOCIATES, INC.)

Engineering Technologies Associates, Inc.
Engineers • Planners • Surveyors

3458 Ellicott Center Drive, Suite 101
Ellicott City, MD 21043

Baltimore Area (410) 461-9920
Washington Area (301) 621-4690
FAX: (410) 750-8565

RECEIVED
JUN 29 1995
ECOLOGY & ENVIRONMENT, INC.
ARLINGTON, VIRGINIA

June 27, 1995

Robert King
Ecology & Environment, Inc.
1700 N. Moore St.
Arlington, VA 22209

Re: Particle tracking simulation result for Fort Devens Main Post: from POL storage yard to the MacPherson well.

Dear Bob:

Engineering Technologies Associates, Inc. (ETA) was retained by the Ecology and Environment, Inc. to perform the particle tracking analysis for the ground water flow system of the POL storage yard at Fort Devens, Massachusetts. The objective of the analysis is to define the flow path and to estimate the travel time from the POL storage yard to the MacPherson well under a Zone II delineation flow field. This letter serves as a short technical report of ETA's analysis.

ETA has previously performed detailed flow modeling and Zone II delineation at the Main and North Post of Fort Devens. Zone II delineations were made using three different procedures. The POL storage yard was within the Zone II area of the MacPherson well when the revised MADEP procedure was used (ETA, 1995). The particle tracking analysis estimated the travel time and flow path from POL storage yard to MacPherson well.

In the particle analysis, the hydraulic head output from the regional transient flow model was utilized to calculate the ground water velocity vectors through a postprocessor program, PREMOD3D. (ETA, 1994). The calculated velocity data were then input into the RAND3D, a three dimensional ground water, solute transport model (ETA,1993), to trace the flow path and to estimate the particle migration time. The same input packages used in the flow model were used in the calculation of the velocity. In the particle tracking analysis, the same effective porosity's of 0.2 for layers one and two, and 0.05 for the bedrock used in the previous transport model were employed.

Ten particle points were placed within the designated area to simulate the tracer. The starting point of each particle is at the water table. No retardation or biotransformation effects were taken into account during the particle transport process. All the particles migrate toward the MacPherson well on a similar path. The particle transport slowly at the beginning due to the long distance from the pumping well. It took thirteen years for the first particle to migrate to the pumping well and seventeen years for the last particle to reach the pumping well. The following figures show the particle flow paths and locations at different time intervals. Figure one indicates the flow paths and particle locations after five years. Figures 2 to 13 show particle paths at one year intervals.

The analysis is unrealistic for a number of reasons. The pumping scenario used was unrealistic. It assumed the MacPherson well was pumping at 1,000 gallons per minute (gpm) during the model steady state simulation. Recharge was then assumed to be zero and the MacPherson well continued pumping at 1,000 gpm during a six month transient simulation. The analysis used the flow stream lines at the end of the six month transient simulation. The MacPherson well normally pumps about 700 gpm for short periods. The average pumpage for 1993 was 70 gpm (ETA, 1995).

The analysis ignores the effect of adsorption. Adsorption of hydrophobic organic chemicals will retard the travel of any contamination.

The analysis ignores the impact of biodegradation on organic chemicals that are in ground water beneath the POL yard.

The analysis shows that a conservative tracer would take between thirteen and seventeen years to travel from the POL yard to the MacPherson well under one set of conditions dictated by the MADEP for Zone II well head protection zone analysis.

The above is the analysis of the particle tracking simulation for this project. Please feel free to call us should you have any questions.

Truly yours,

Song Jiang

Song Jiang
Hydrogeologist

Don Koch, P.E.
Vice President

Attachment

Reference List

Engineering Technologies Associates, Inc. 1993, A Three Dimensional, Ground Water, Solute Transport Model, Users' Manual, Contract DAAA15-89-D-0009/0003.

Engineering Technologies Associates, Inc. 1994, A RAND3D Preprocessor to Prepare Input From MODFLOW, Users' Manual.

Engineering Technologies Associates, Inc. 1995, Detailed Flow Model for Main and North Post, Fort Devens, Massachusetts, Final Report, Contract DACA31-92-D-0045/0004.

Figure 1 (Five years after particle release)

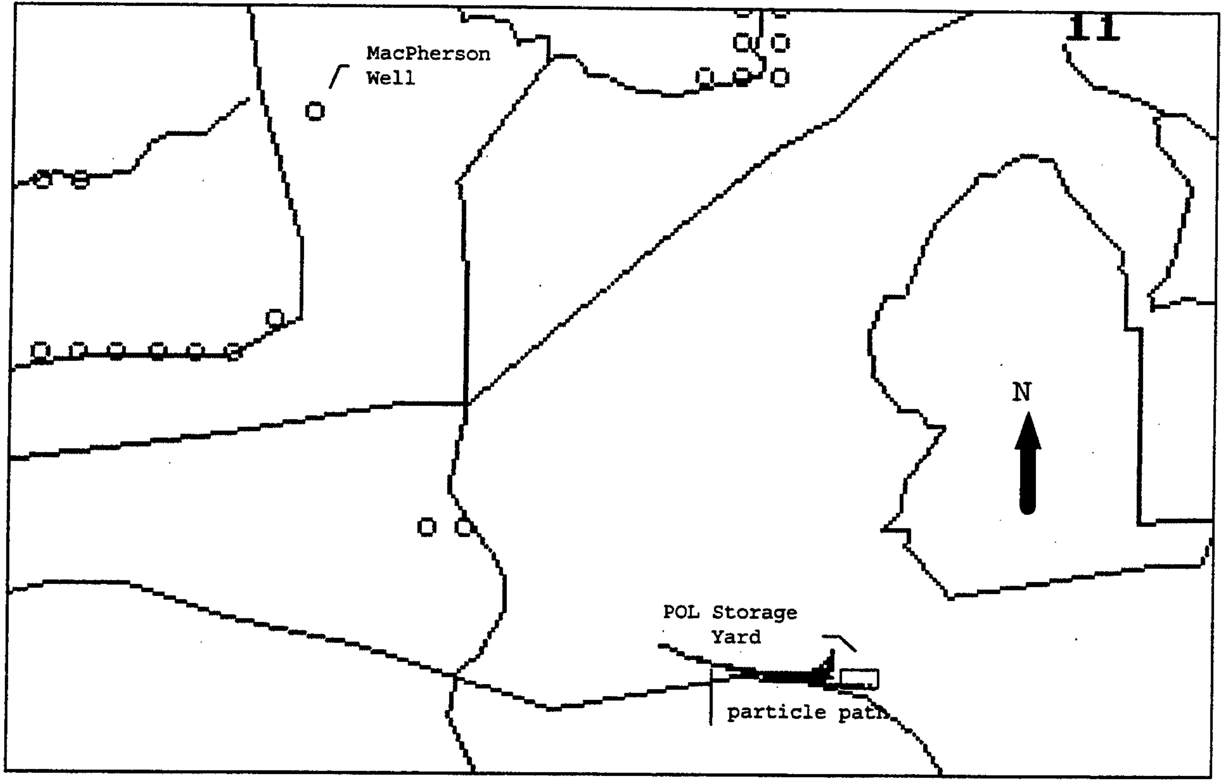


Figure 2 (Six years after particle release)

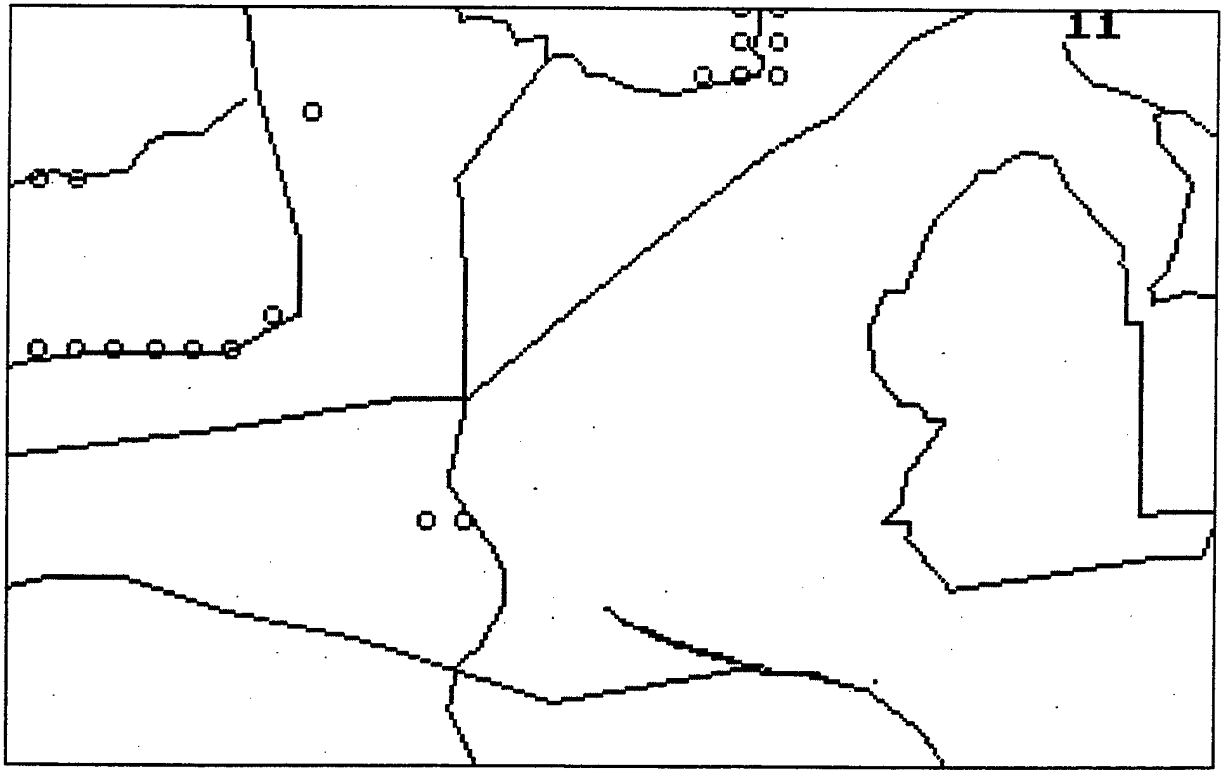


Figure 3 (Seven years after particle release)

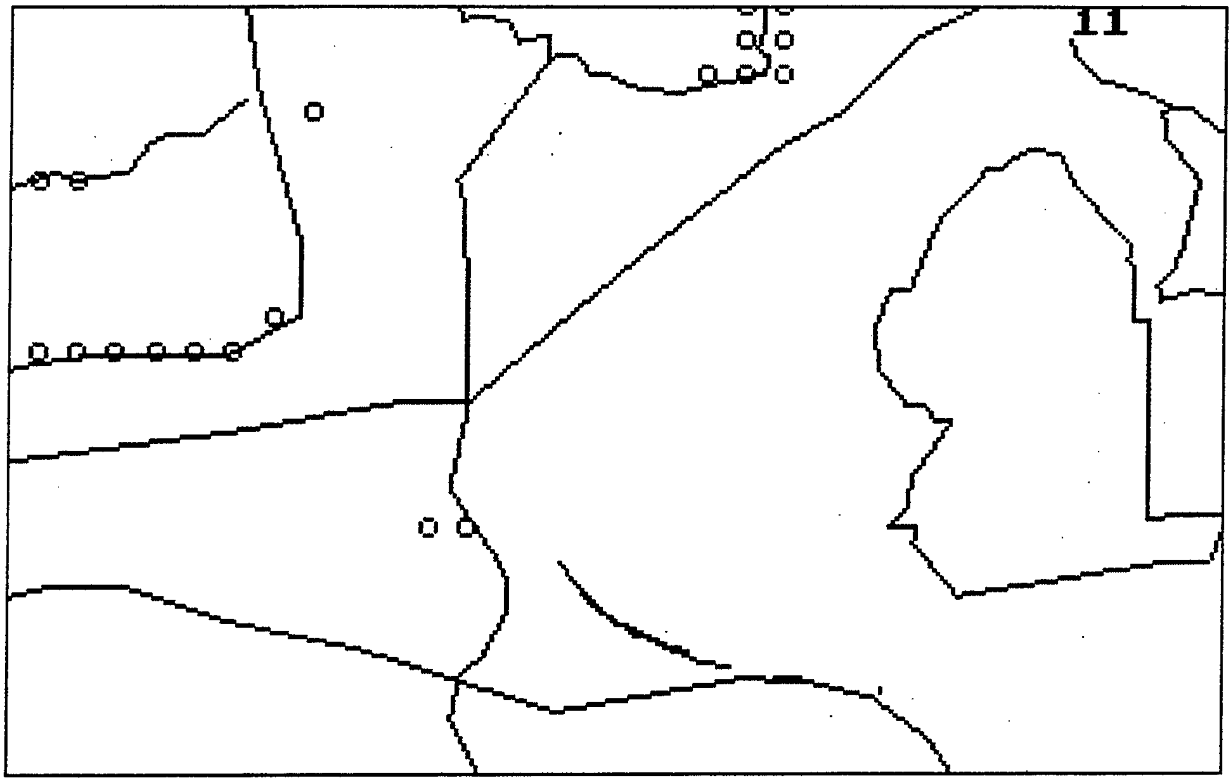


Figure 4 (Eight years after particle release)

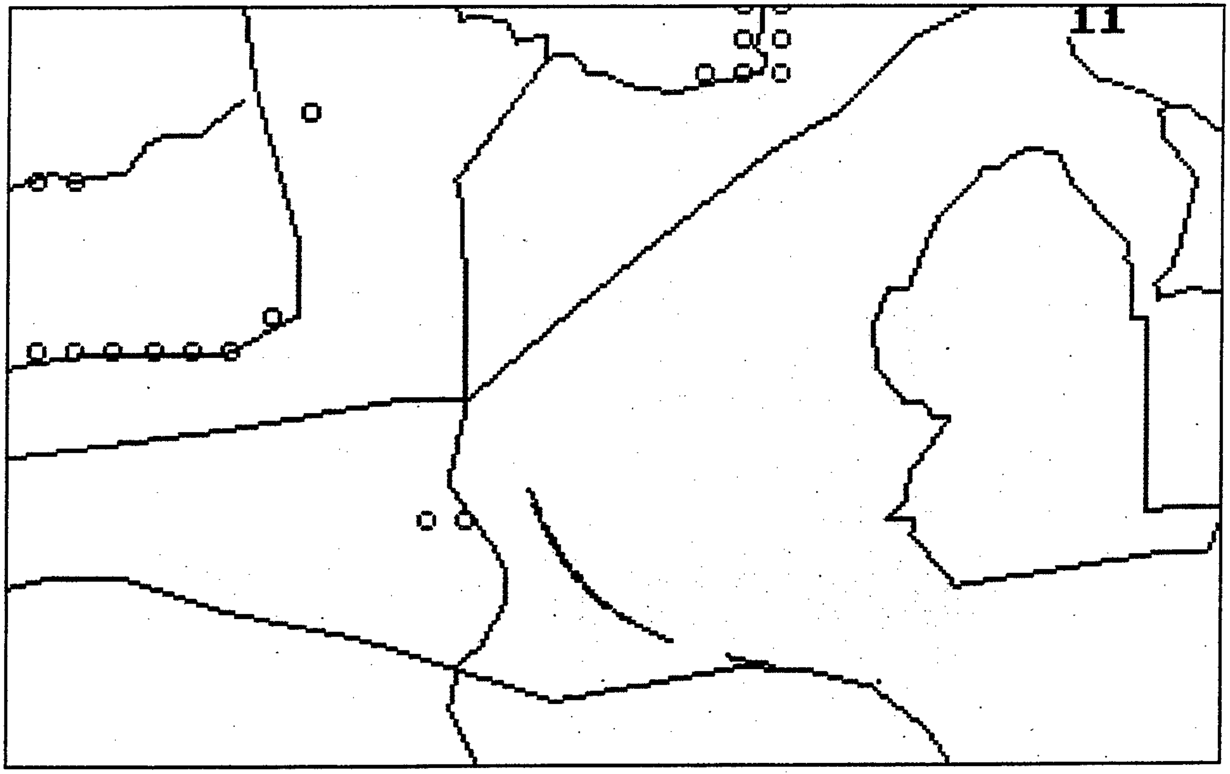


Figure 5 (Nine years after particle release)

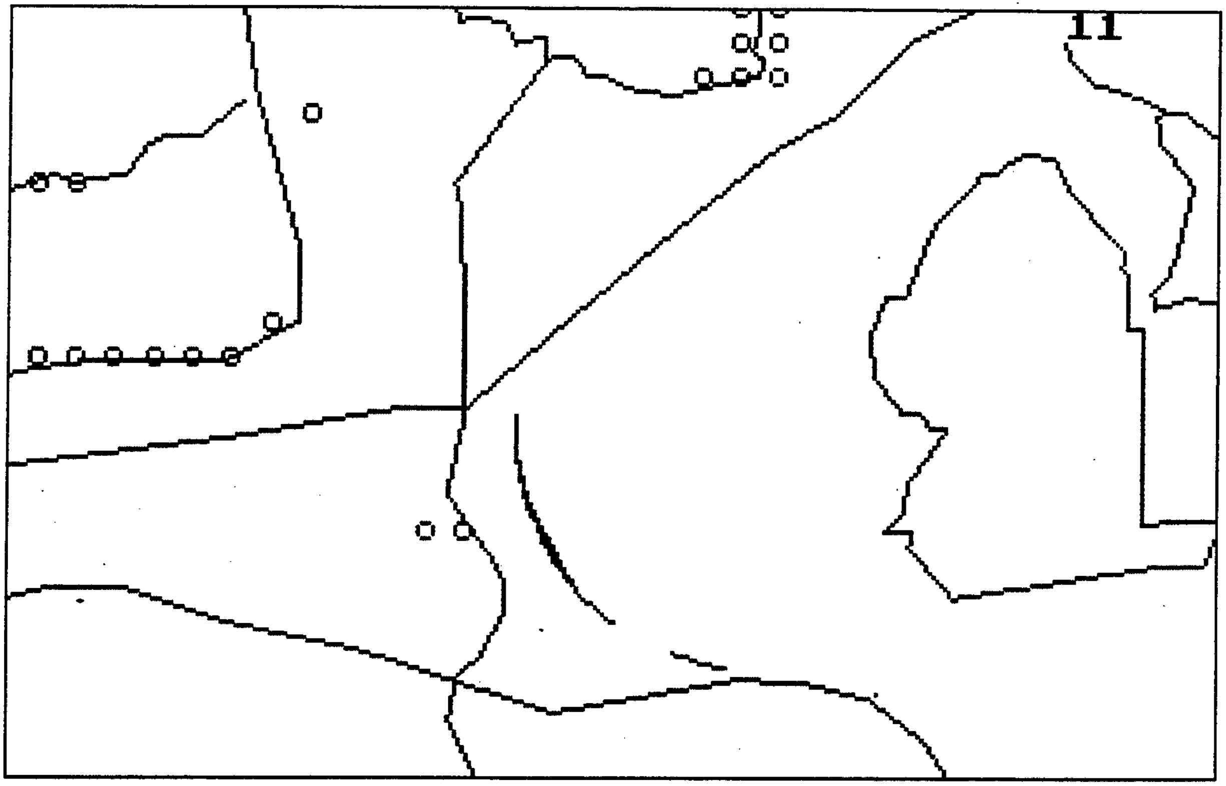


Figure 6 (Ten years after particle release)

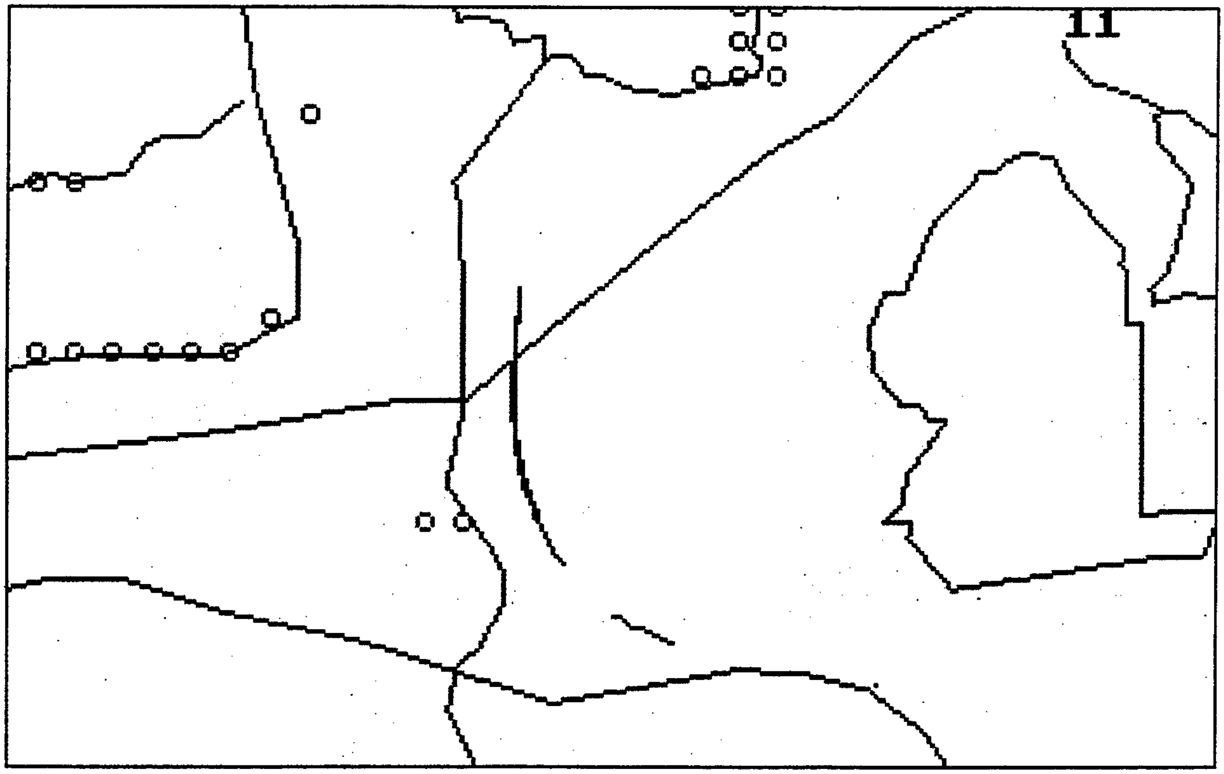


Figure 7 (Eleven years after particle release)

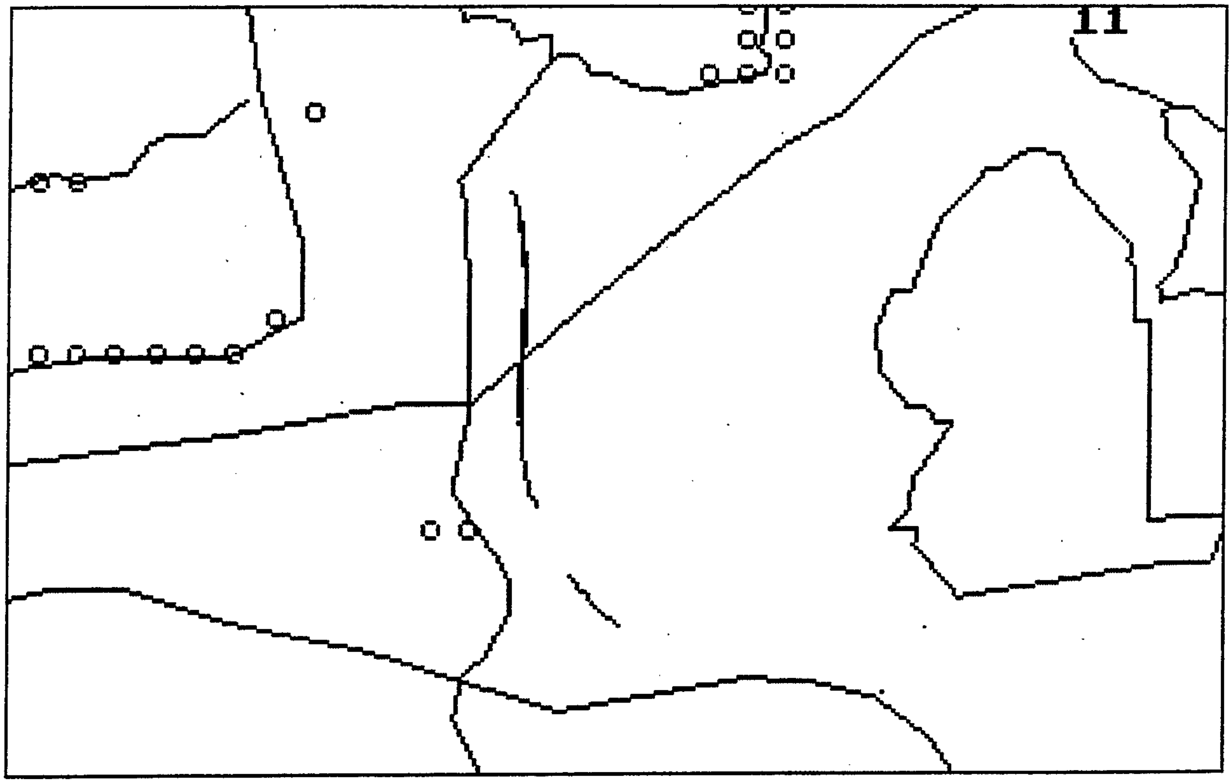


Figure 8 (Twelve years after particle release)

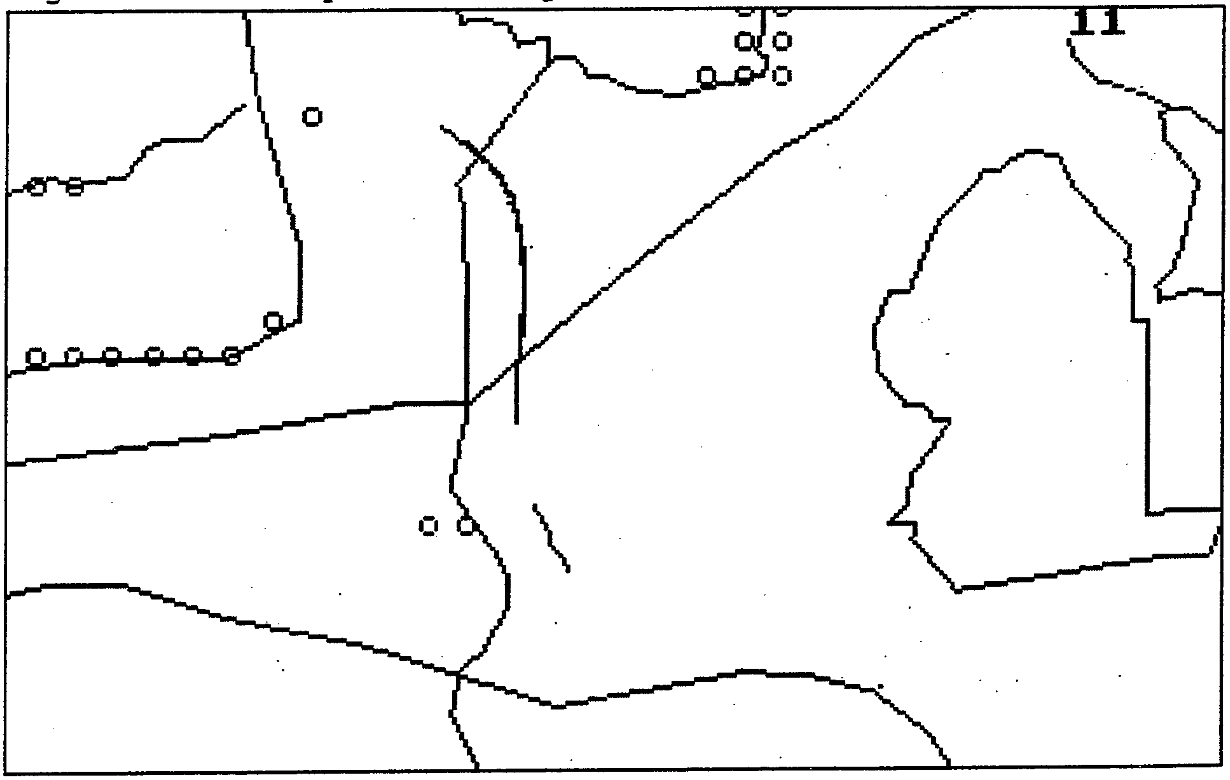


Figure 9 (Thirteen years after particle release)

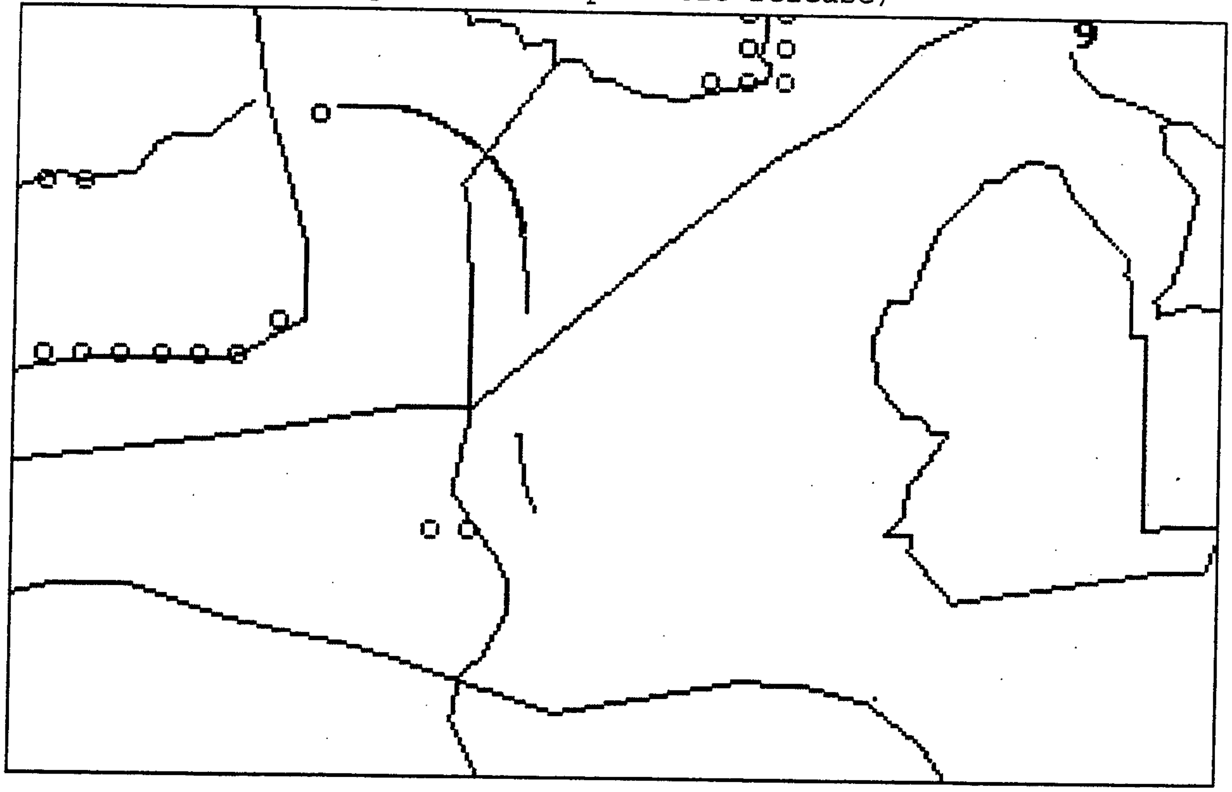


Figure 10 (Fourteen years after particle release)

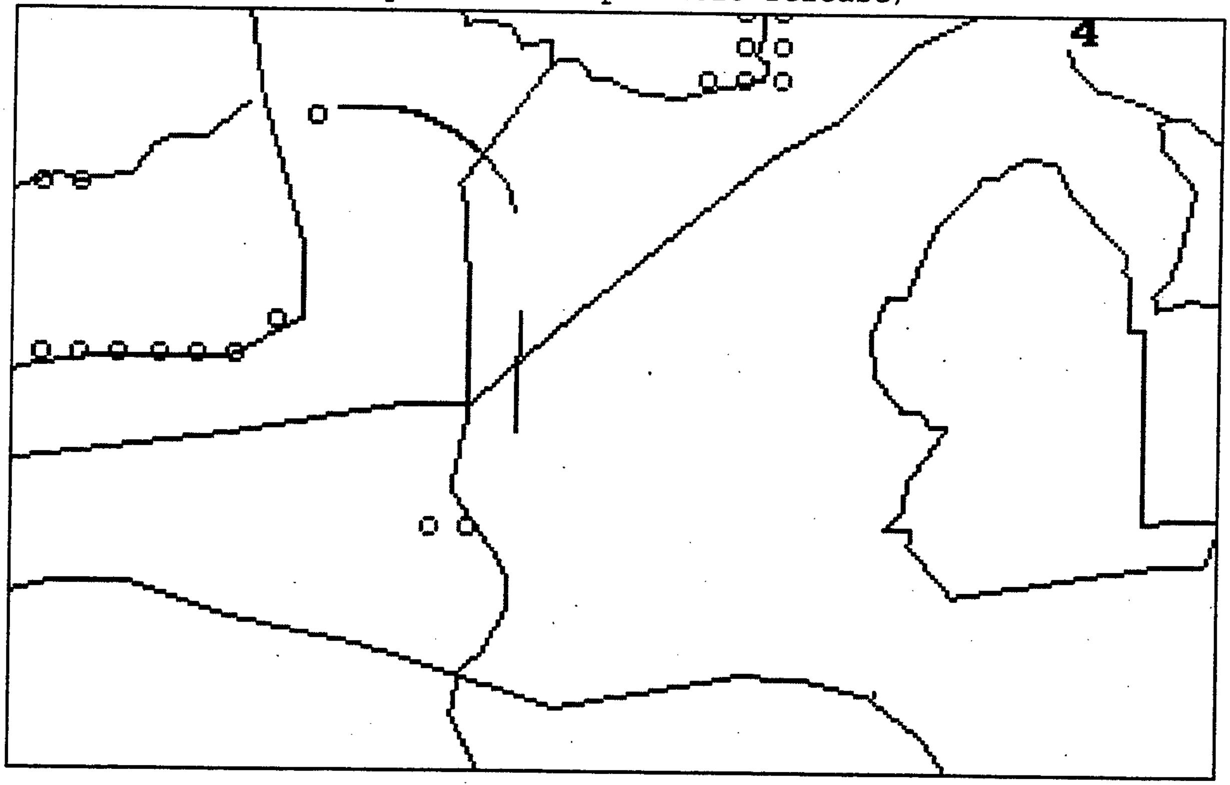


Figure 11 (Fifteen years after particle release)

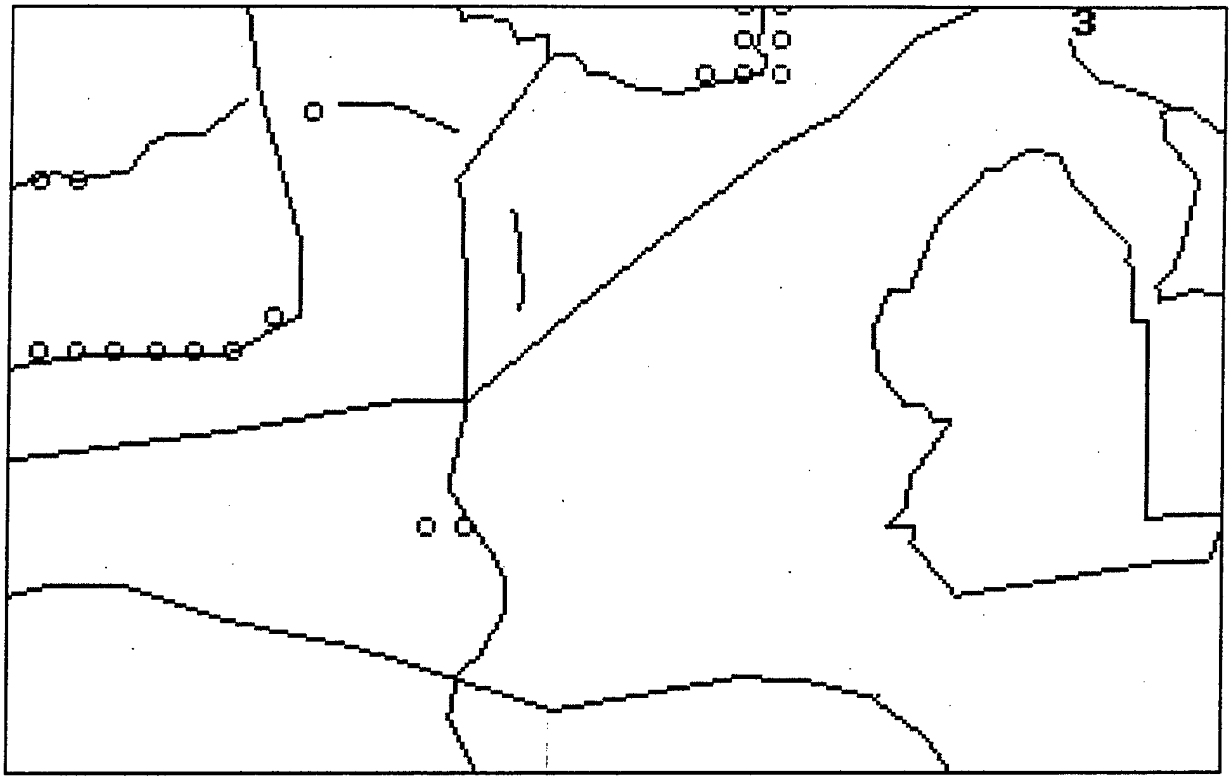


Figure 12 (Sixteen years after particle release)

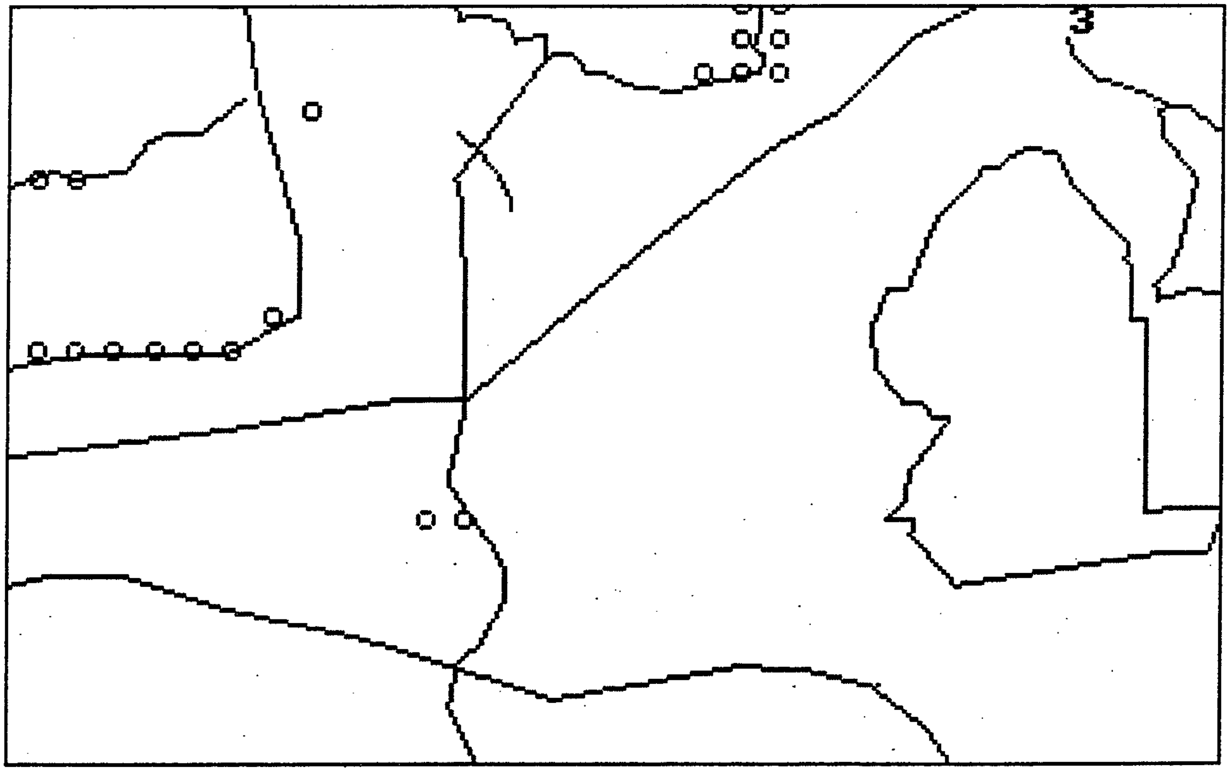
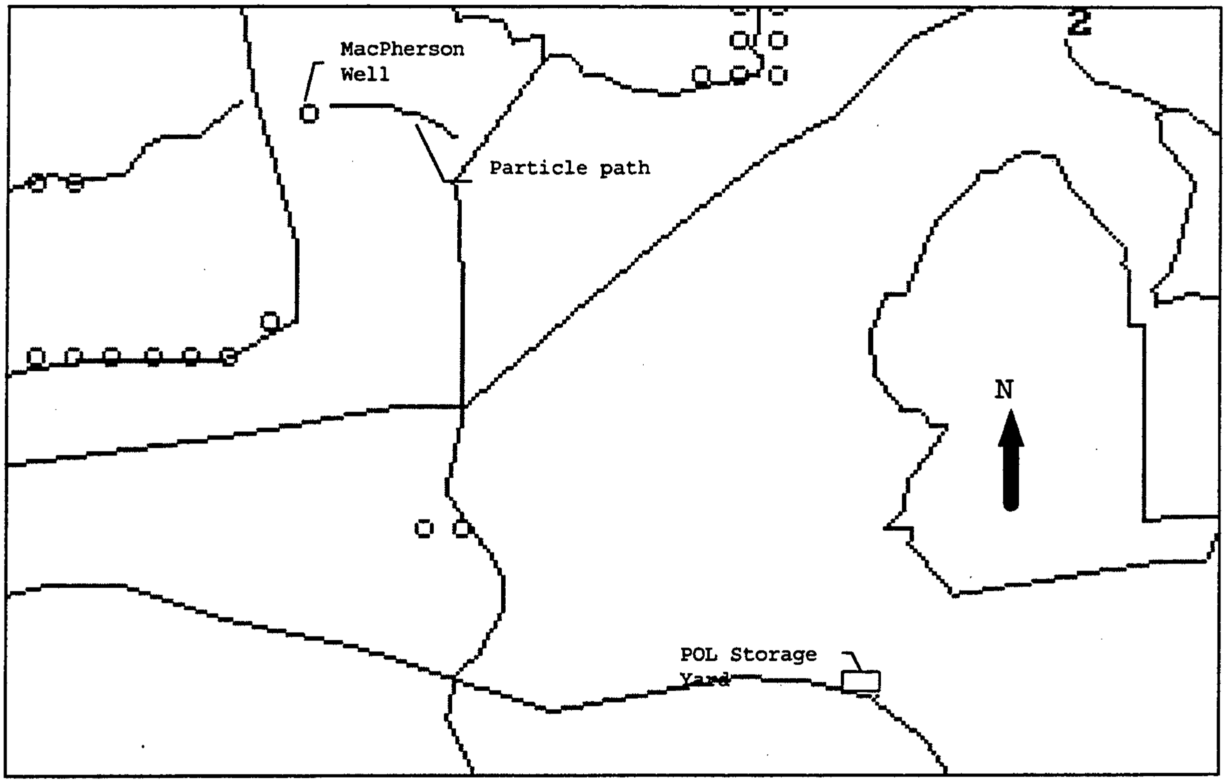


Figure 13 (Seventeen years after particle release)



All figures have the same scale of approximate 1"=1100'.

APPENDIX B

BACK-UP COST CALCULATIONS

B.1 DRMO YARD BACK-UP COST CALCULATIONS

MONITORING COSTS

DRMO YARD
MONITORING OF SOILS REMEDIATION

SAMPLING EQUIPMENT COSTS	Unit	Unit Cost	Quantity	Cost	Source
Well Development Equipment Rental (pH, Temp., Conductivity, Turbidity meters)	Day	$115.37	3	$346.11	A
2 inch submersible pump	Day	$61.84	3	$185.52	A
5 kW Generator	Day	$55.66	3	$166.98	A
40 mL VOC vials	Each	$1.53	20	$30.60	A
1 L plastic metals bottle	Each	$2.88	9	$25.92	A
1 Gal. glass container	Each	$9.59	17	$163.03	A
1 7/8 inch teflon bailers	Each	$48.23	10	$482.30	A
48 Qt. coolers (shipping)	Each	$39.52	2	$79.04	A
1/4 inch cotton rope	100 feet	$10.70	3	$32.10	B
				$1,511.60	

Notes:
A: Environmental Restoration Assemblies/Unit Cost Book
1995- Environmental Cost Handling Options and Solutions
B: Hector's Hardware 2/96 rate

Assumptions:
1. 3-day rental (1 day each to mob, use, and demob eqpt.)
2. Labels, C-O-C forms, etc... incl. with bottles/containers
3. Assumes 20% greater containers than will actually be needed to account for breakage/errors, etc...
4. 50 feet of rope needed per well
5. Assumes 2 bailers per well to account for loss
6. 2 coolers needed for sample shipment

DRMO YARD
MONITORING OF SOILS REMEDIATION

SAFETY EQUIPMENT COSTS	Unit	Unit Cost	Quantity	Cost	Source
Organic Vapor Analyzer	Day	$123.68	3	$371.04	A
Gas Monitor	Day	$15.46	3	$46.38	A
Tyvek Suit	Each	$8.06	8	$64.48	A
Reusable Butyl Outer Gloves	Pair	$2.86	4	$11.44	A
Latex Inner Gloves	Pair	$0.30	16	$4.80	A
Disposable Tyvek Boots	Pair	$1.42	8	$11.36	A
				$509.50	

Notes:

A: Environmental Restoration Assemblies/Unit Cost Book
1995- Environmental Cost Handling Options and Solutions

Assumptions:
1. 3-day rental (1 day each to mob, use, and demob. eqpt.)
2. 2- person work team
3. One full day of work
4. Each person to go through 4 tyvek suits per day
5. One pair each of outer gloves per person; and one extra pair per person in the event of tears/rips
6. Each person to go through 8 pair of inner gloves per day
7. Each person has as part of their gear a full-face respirator, cartriges, a hard hat, leather steel-toed boots, and safety glasses
8. Each person to go through 4 pair of disposable boots per day

DRMO YARD
MONITORING OF SOILS REMEDIATION

SHIPPING COSTS	Unit	Unit Cost	Quantity	Cost	Source
Sampling Equipment	lb.	$1.50	300	$450.00	A
Safety Equipment	lb.	$1.50	100	$150.00	A
Samples	lb.	$1.50	150	$225.00	A
				$825.00	

Notes:
A: Federal Express 2/96 shipping rates

Assumptions:
1. Sampling equipment weighs 300 lbs.
2. Safety equipment weighs 100 lbs.
3. Samples weigh 150 lbs. when ready for shipment

DRMO YARD
MONITORING OF SOILS REMEDIATION

LABOR RATES FOR SAMPLE COLLECTION, DATA VALIDATION, SUMMARY REPORT, AND SITE EVALUATION

SAMPLE COLLLLECTION	Unit	Unit Cost	Quantity	Cost	Source
Health and Safety Officer	Hr.	$18.55	12	$222.60	A
Field Technician	Hr.	$14.84	12	$178.08	A
				$400.68	
DATA VALIDATION					
Senior Chemist	Hr.	$23.50	20	$470.00	A
SUMMARY REPORT					
Staff Engineer	Hr.	$23.50	20	$470.00	A
Word Processing/Clerical	Hr.	$12.37	10	$123.70	A
				$593.70	
Site Evaluation					
Senior Project Manager	Hr.	$49.47	10	$494.70	A
				$494.70	

Notes:
A: Environmental Restoration Assemblies/Unit Cost Book
1995- Environmental Cost Handling Options and Solutions

Assumptions:
1. Sample collection team members work a full 12 hour day by labor levels shown
2. Data validation requires 20 hours to complete by labor level shown
3. Summary report requires 20 hours to be written by labor level shown
4. Summary report requires 10 hours of word processing and editing time by labor level shown
5. Site evaluation requires 10 hours to conduct by labor level shown

DRMO YARD
MONITORING OF SOILS REMEDIATION

TRAVEL EXPENSES	Unit	Unit Cost	Quantity	Cost	Source
Air Fare	Per Person	$554.00	2	$1,108.00	A
Meals	Per Person	$30.00	2	$60.00	B
Van Rental	Day	$69.99	1	$69.99	C
Fuel	Gal.	$1.22	10	$12.20	D
				$1,250.19	

Notes:

A: US Air 2/8/96 R/T air fare from Washington Int'l Airport to Logan Int'l

B: Ecology & Environment 2/96 per diem (meals only) rate

C: Hertz 2/8/96 7-passenger mini-van rate - pick up and drop off at Logan Int'l.

D: Leominster, Mass. Shell Oil Gas 2/8/96 regular unleaded fule rate

Assumptions:

1. 2-person work team
2. Arrive and depart from site same day
3. Use 10 gal. fuel

DRMO YARD
MONITORING OF SOILS REMEDIATION

SAMPLE ANALYTICAL COSTS	Unit	Unit Cost	Quantity	Cost	Source
VOCs	Sample	$324.66	16	$5,194.56	A
PCBs/Pesticides	Sample	$213.96	7	$1,497.72	A
TAL Metals	Sample	$290.64	14	$4,068.96	A
				$10,761.24	

Notes:

A: Environmental Restoration Assemblies/Unit Cost Book
1995- Environmental Cost Handling Options and Solutions

Assumptions:

1. 1 unfiltered sample taken of each contaminant group per each of the 5 wells
2. 1 filtered sample taken of TAL metals per each of the 5 wells
3. 2 VOC samples taken per each of the 5 wells, the duplicate, and the blanks
4. 1 unfilted duplicate sample taken of each contaminant group
5. 1 filtered sample taken of TAL metals
6. 1 rinsate blank taken of each contaminant group of the metals filter
7. 1 trip blank (VOCs only) taken
8. Army does not require MS/MSD samples to be taken
9. Each well has a dedicated bailer, therefore, no rinsate on bailer needed

B.2 DRMO YARD BACK-UP COST CALCULATIONS

ALTERNATIVE CAPITAL AND O&M COSTS

DRMO AREA - ALTERNATIVE 2: INSTITUTIONAL ACTIONS

CAPITAL COSTS	Unit	Unit Cost	Quantity	Cost	Source
MOBILIZATION COSTS	perper person	$61.84	4	$247.36	A
DEMOBILIZATION COSTS	3% of capital costs		-	$500.00	A
HEALTH AND SAFETY COSTS:					
Organic Vapor Analyzer	Day	$123.68	5	$618.40	A
Gas Monitor	Day	$15.46	5	$77.30	A
Tyvek Suit	Each	$8.06	48	$386.88	A
Reusable Butyl Outer Gloves	Pair	$2.86	24	$68.64	A
Latex Inner Gloves	Pair	$0.30	96	$28.80	A
Disposable Tyvek Boots	Pair	$1.42	48	$68.16	A
				$1,248.18	
FENCE MOVING	Linear foot	$14.55	840	$12,222.00	B
ADDITION OF NEW FENCING	Linear foot	$12.35	60	$741.00	B
OPERATION AND MAINTENENCE COSTS					
FENCE MAINTENANCE	Linear Foot	$12.60	50	$630.00	–

Notes:

A: Environmental Restoration Assemblies/Unit Cost Book
1995- Environmental Cost Handling Options and Solutions
B: Means Site Work & Landscape Cost Data- 1996- 15th Edition

Assumptions:

1. 5-day equipment rental (1 day to mob., 3 days to use, and 1 day to demob.)
2. Local 4-person work team for fence work (used to calculate mobilization and health and safety costs)
3. Each person to go through 4 tyvek suits per day
4. One pair of outer gloves per person per day; and one extra pair per person per day in the event of tears/rips
5. Each person to go through 8 pr. of inner gloves per day
6. Each person has as part of their gear a full-face respirator, cartriges, a hard hat, leather steel-toed boots, and safety glasses.
7. O & M costs include replacing 50 feet of fencing semiannually
8. Assuming 3 days of initial site work
9. Each person to go through 4 pair of disposable boots per day

DRMO AREA - ALTERNATIVE 3: CONTAINMENT VIA CAPPING

CAPITAL COSTS	Unit	Unit Cost	Quantity	Cost	Source
MOBILIZATION COSTS	per person	$61.84	6	$371.04	A
DEMOBILIZATION COSTS	3% of capital costs		-	$12,635.70	A
HEALTH AND SAFETY COSTS:					
Organic Vapor Analyzer	Day	$123.68	90	$11,131.20	A
Gas Monitor	Month	$309.20	3	$927.60	A
Tyvek Suit	Each	$8.06	2160	$17,409.60	A
Reusable Butyl Outer Gloves	Pair	$2.86	1080	$3,088.80	A
Latex Inner Gloves	Pair	$0.30	4320	$1,296.00	A
Disposable Tyvek Boots	Pair	$1.42	2160	$3,067.20	A
				$36,920.40	
SITE SERVICES:					
Survey	Day	$789.71	5	$3,948.55	A
Electric	KWH	$0.06	900	$55.62	A
Water	KGAL	$6.18	27	$166.97	A
Fuel (diesel)	Gal	$1.24	12150	$15,066.00	A
				$19,237.14	
EXCAVATION, BACKFILL, AND CONSOLIDATION OF DITCHES:					
Excavation	CY	$2.62	360	$943.20	B
Backfill	CY	$1.51	360	$543.60	B
Consolidation	CY	$5.25	360	$1,890.00	B
				$3,376.80	
TEMPORARY COVER:					
Reinforced Tarpaulin	SY	$0.07	5425	$379.75	B
CAP:					
Regrading	SY	$1.36	5425	$7,378.00	B
18-inch clay layer	CY	$16.10	2713	$43,679.30	A
6-inch sand drainage layer	CY	$9.79	904	$8,850.16	A
6-inch topsoil	CY	$24.71	904	$22,337.84	A

DRMO AREA - ALTERNATIVE 3: CONTAINMENT VIA CAPPING (cont'd)

	Unit	Unit Cost	Quantity	Cost	Source
SEEDING (VEGETATIVE COVER)	Acre	$1,488.73	1.13	$1,682.26	A
RIP-RAP	CY	$28.50	904	$25,764.00	B
VERIFICATION SAMPLING:					
Sampling Equipment:					
Hand Auger	Day	$59.07	5	$295.35	A
40 ml. glass vials	Each	$1.53	256	$391.68	A
8 oz. glass jar	Each	$2.76	256	$706.56	A
48 oz cooler (for shipping)	Each	$39.52	8	$316.16	A
Labor:					
Health and Safety Officer	Hr.	$18.55	36	$667.80	A
Field Technician	Hr.	$14.84	36	$534.24	A
Sample Shipmet to Lab	lb.	$1.50	600	$900.00	A
				$3,811.79	
VERIFICATION ANALYSIS:					
VOCs	Each	$324.66	106	$34,413.96	A
TAL metals	Each	$253.54	106	$26,875.24	A
PCBs/Pesticides	Each	$213.96	106	$22,679.76	A
				$83,968.96	
TCLP SAMPLING:					
Sampling Equipment:					
Hand Auger	Day	$59.07	5	$295.35	A
40 ml. glass vials	Each	$1.53	256	$391.68	A
8 oz. glass jar	Each	$2.76	256	$706.56	A
48 oz cooler (for shipping)	Each	$39.52	8	$316.16	A
Labor:					
Health and Safety Officer	Hr.	$18.55	36	$667.80	A
Field Technician	Hr.	$14.84	36	$534.24	A
Sample Shipment to Lab	lb.	$1.50	600	$900.00	A
				$3,811.79	

DRMO AREA - ALTERNATIVE 3: CONTAINMENT VIA CAPPING (cont'd)

	Unit	Unit Cost	Quantity	Cost	Source
TCLP ANALYSIS:					
TCLP VOCs, Metals	Each	$866.37	106	$91,835.22	A
FENCE MOVING	Linear foot	$14.55	840	$12,222.00	B
ADDITION OF NEW FENCING	Linear foot	$12.35	60	$741.00	B
OPERATION AND MAINTENENCE:					
Fence	Linear foot	$12.60	50	$630.00	B
Cap:					
Mowing	Acre	$21.47	1.13	$24.26	A
Re-seeding	Acre	$1,436.07	0.1	$143.61	A
Replace topsoil	CY	$22.67	90	$2,040.30	A
Replace Rip-Rap	CY	$21.97	90	$1,977.30	A
				$4,185.47	

Notes:

A: Environmental Asseblies/Unit Cost Book
1995- Environmental Cost Handling Options and Solutions

B: Means Site Work & Landscape Cost Data- 1996- 15th Edition

Assumptions:

1. 90 days of site work
2. 6-member team for excavation/capping work
3. 2-member survey team
4. 5 days of survey work
5. 3 days of verification sampling work
6. 3 days of TCLP sampling work
7. 10-hour work days
8. 90-day safety equipment rental
9. Each person to go through 4 tyvek suits per day
10. One pair each of outer gloves per person per day; and one extra pair of each per day per person in the event of tears/rips
11. Each person to go through 8 pair of inner gloves per day
12. Each person, as part of their gear, has a full-face respirator, cartriges, a hard hat, leather steel-toed boots, and safety glasses
13. Using 27 KGAL of water (300 gal/day for 90 days)
14. Using 900 KWH of electricity (1 KW for 90 days at 10hrs./day)
15. Using 12,150 gal. diesel fuel (135 gallons/day for 90 days)
16. Soil capping materials obtained off-site
17. Backfill material obtained from on-site stockpiles
18. 5-day sampling equipment rental (1 day to mob., 3 days to use, 1 day to demob.)
19. 2 VOC samples taken for each verification sampling and TCLP sampling location
20. 1 metals sample taken for each verification sampling and TCLP sampling location
21. 1 Pesticide/PCB sample taken for each verification sampling and TCLP sampling location
22. 5 duplicate samples taken of each contaminant group for verification and TCLP sampling
23. 1 rinsate blank sample taken of auger for each contaminant group for verification and TCLP sampling

DRMO AREA - ALTERNATIVE 3: CONTAINMENT VIA CAPPING (cont'd)

24. Army does not require MS/MSD samples to be taken
25. 2-member team for verification and TCLP sampling work
26. 100 verification and TCLP field samples taken
27. 2 jars required for each VOC sample location, 1 jar required for each metals sample location, and 1 jar required for each PCB/Pesticide sample location for verification and TCLP sampling with an additional 20% added in the event of breakage/resampling
28. Verification and TCLP samples to be shipped for analysis each weigh 600 lbs.
29. 8 coolers needed to ship verification samples; 8 needed to ship TCLP samples
30. No soil samples fail TCLP tests
31. Annual cap mowing required
32. 10% of cap requires re-seeding annually
33. 10% of cap requires replacement of top soil annually
34. 10% of cap requires rip-rap replacement annually
35. 50 linear feet of fencing requires replacement annually
36. Each person to go through 4 pair of disposable boots per day

DRMO AREA - ALTTERNATIVE 4: EXCAVATION, SOLIDIFICATION, AND ON-SITE DISPOSAL

CAPITAL COSTS	Unit	Unit Cost	Quantity	Cost	Source
MOBILIZATION COSTS	per person	$61.84	6	$371.04	A
DEMOBILIZATION COSTS	3% capital costs		-	$14,094.00	A
HEALTH AND SAFEFETY COSTS:					
Organic Vapor Analyzer	Day	$123.68	120	$14,841.60	A
Gas Monitor	Month	$309.20	4	$1,236.80	A
Tyvek Suit	Each	$8.06	2880	$23,212.80	A
Reusable Butyl Outer Gloves	Pair	$2.86	1440	$4,118.40	A
Latex Inner Gloves	Pair	$0.30	5760	$1,728.00	A
Disposable Tyvek Boots	Pair	$1.42	2880	$4,089.60	A
				$49,227.20	
SITE SERVICES:					
Survey	Day	$789.71	5	$3,948.55	A
Electric	KWH	$0.06	1200	$74.16	A
Water	KGAL	$6.18	36	$222.62	A
Fuel (diesel)	Gal	$1.24	16200	$20,088.00	A
				$24,333.33	
SOIL EXCAVATIONON	CY	$2.62	1300	$3,406.00	B
ADDITIONAL EXCACAVATION	CY	2.62	325	$851.50	B
BACKFILL	CY	$1.51	1300	$1,963.00	B
BACKFILL AND COCOMPACTION OF TREATED SOILS:					
Backfill	CY	$1.51	1625	$2,453.75	B
Compaction	CY	$3.49	1625	$5,671.25	B
				$8,125.00	
GRADING	SY	$1.36	3940	$5,358.40	B
SOIL HANDLING/LOADING	CY	$1.38	1300	$1,794.00	A
TEMPORARY COVER:					
Reinforced Tarpaulin	SY	$0.07	3940	$275.80	B

DRMO AREA - ALTTERNATIVE 4: EXCAVATION, SOLIDIFICATION, AND ON-SITE DISPOSAL (cont'd)

	Unit	Unit Cost	Quantity	Cost	Source
6-INCH TOPSOIL	CY	$24.71	660	$16,308.60	A
SEEDING (VEGETATIVE COVER)	Acre	$1,488.73	0.81	$1,205.87	A
VERIFICATION SAMPLING:					
Sampling Equipment:					
Hand Auger	Day	$59.07	5	$295.35	A
40 ml. glass vials	Each	$1.53	256	$391.68	A
8 oz. glass jar	Each	$2.76	256	$706.56	A
48 oz cooler (for shipping)	Each	$39.52	8	$316.16	A
Labor:					
Health and Safety Officer	Hr.	$18.55	36	$667.80	A
Field Technician	Hr.	$14.84	36	$534.24	A
Sample Shipment to Lab	lb.	$1.50	600	$900.00	A
				$3,811.79	
VERIFICATION ANALYSIS:					
VOCs	Each	$324.66	106	$34,413.96	A
TAL metals	Each	$253.54	106	$26,875.24	A
PCBs/Pesticides	Each	$213.96	106	$22,679.76	A
				$83,968.96	

DRMO AREA - ALTTERNATIVE 4: EXCAVATION, SOLIDIFICATION, AND ON-SITE DISPOSAL (cont'd)

	Unit	Unit Cost	Quantity	Cost	Source
TCLP SAMPLING:					
Sampling Equipment:					
Hand Auger	Day	$59.07	5	$295.35	A
40 ml. glass vials	Each	$1.53	256	$391.68	A
8 oz. glass jar	Each	$2.76	256	$706.56	A
48 oz cooler (for shipping)	Each	$39.52	8	$316.16	A
Labor:					
Health and Safety Officer	Hr.	$18.55	36	$667.80	A
Field Technician	Hr.	$14.84	36	$534.24	A
Sample Shipment to Lab	lb.	$1.50	600	$900.00	A
				$3,811.79	
TCLP ANALYSIS:					
TCLP VOCs, Metals	Each	$866.37	106	$91,835.22	A
TRANSPORTATION	CY	$0.87	1300	$1,131.00	A
TREATMENT:					
Portland cement	Ton	$68.02	423	$28,772.46	A
Labor	Hr.	$37.72	300	$11,316.00	A
100 CY bulk mixing system	Mo.	$12,023.82	1	$12,023.82	A
Ancillary equipment	Lump sum	$7,420.69	1	$7,420.69	A
Mobilization/demobilization	Lump Sum	$12,259.60	1	$12,259.60	A
Equipment/system maintenence	Mo.	$446.38	1	$446.38	A
				$72,238.95	

Notes:

A: Environmental Asseblies Cos/Unit Cost Book
1995- Environmental Cost Handling Options and Solutions

B: Means Site Work & Landscape Cost Data- 1996- 15th Edition

DRMO AREA - ALTTERNATIVE 4: EXCAVATION, SOLIDIFICATION, AND ON-SITE DISPOSAL (cont'd)

Assumptions:

1. 120 days of site work
2. 6-member team for excavation/solidification/disposal work
3. 2-member survey team
4. 5 days of survey work
5. 3 days of verification sampling work
6. 3 days of TCLP sampling work
7. 10-hour work days
8. 120-day safety equipment rental
9. Each person to go through 4 tyvek suits per day
10. One pair each of outer gloves per person per day; and one extra pair of each per day per person in the event of tears/rips
11. Each person to go through 8 pair of inner gloves per day
12. Each person, as part of their gear, has a full-face respirator, cartriges, a hard hat, leather steel-toed boots, and safety glasss
13. Using 36 KGAL of water *30 (300 gal/day for 120 days)
14. Using 1200 KWH of electricity (1 KW for 6 for 120 days at 10 hrs/day)
15. Using 16,200 gal. diesel fel fuel (135 gal/day for 120 days)
16. Portland cement used in solidification process
17. Amount of portland cement needed is 25% of total soil volume; therefore, excavation needs to be expanded 25%
18. 5-day sampling equipment rental (1 day to mob., 3 days to use, 1 day to demob.)
19. 2 VOC samples taken for each verification sampling locatng and TCLP sampling location
20. 1 metals sample taken for each verification sampling and TCLP sampling location
21. 1 Pesticide/PCB sample taken for each verification sampling and TCLP sampling location
22. 5 duplicate samples taken of each contaminant group for verification and TCLP sampling
23. 1 rinsate blank sample tak taken of auger for each contaminant group for verification and TCLP sampling
24. Army does not require MS/MSD samples to be taken
25. 2-member team for verificatication and TCLP sampling work
26. 100 verification and TCLP field samples taken
27. 2 jars required for each VOC sample location, 1 jar required for each metals sample location, and 1 jar required for each PCB/Pesticide sample location for verification and TCLP sampling with an additional 20% added in the event of breakage/resampling
28. Verification and TCLP samples to be shipped for analysis each weigh 600 lbs.
29. 8 coolers needed to ship verification samples; 8 needed to ship TCLP samples
30. No soil samples fail TCLP tests
31. 5 miles from round trip from excavation to staging area
32. Assume treatability study costs $25,000
33. Each person to go through 4 pair of disposable boots per day

DRMO AREA - ALTERNATIVE 6:EXCAVATION AND OFF-SITE DISPOSAL

CAPITAL COSTS	Unit	Unit Cost	Quantity	Cost	Source
MOBILIZATION COSTS	per person	$61.84	4	$247.36	A
DEMOBILIZATION COSTS	3% of capital costs		-	$14,120.00	A
HEALTH AND SAFETY COSTS:					
Organic Vapor Analyzer	Day	$123.68	60	$7,420.80	A
Gas Monitor	Month	$309.20	2	$618.40	A
Tyvek Suit	Each	$8.06	960	$7,737.60	A
Reusable Butyl Outer Gloves	Pair	$2.86	480	$1,372.80	A
Latex Inner Gloves	Pair	$0.30	1920	$576.00	A
Disposable Tyvek Boots	Pair	$1.42	960	$1,363.20	A
				$19,088.80	
SITE SERVICES:					
Survey	Day	$789.71	5	$3,948.55	A
Electric	KWH	$0.06	600	$37.08	A
Water	KGAL	$6.18	18	$111.31	A
Fuel (diesel)	Gal	$1.24	8100	$10,044.00	A
				$14,140.94	
SOIL EXCAVATION	CY	$2.62	1300	$3,406.00	B
BACKFILL AND COMPACTION:					
Backfill	CY	$1.51	1300	$1,963.00	B
Compaction	CY	$3.49	1300	$4,537.00	B
SOIL HANDLING/LOADING	CY	$1.38	1300	$1,794.00	A
TEMPORARY COVOVER:					
Reinforced Tarpaulin	SY	$0.07	3940	$275.80	B
6-INCH TOPSOIL	CY	$24.71	660	$16,308.60	A
SEEDING (VEGETATIVE COVER)	Acre	$1,488.73	0.81	$1,205.87	A

DRMO AREA - ALTERNATIVE 6:EXCAVATION AND OFF-SITE DISPOSAL (cont'd)

	Unit	Unit Cost	Quantity	Cost	Source
VERIFICATION SAMPLING:					
Sampling Equipment:					
Hand Auger	Day	$59.07	5	$295.35	A
40 ml. glass vials	Each	$1.53	256	$391.68	A
8 oz. glass jar	Each	$2.76	256	$706.56	A
48 oz cooler (for shipping)	Each	$39.52	8	$316.16	A
Labor:					
Health and Safety Officer	Hr.	$18.55	36	$667.80	A
Field Technician	Hr.	$14.84	36	$534.24	A
Sample Shipment to Lab	lb.	$1.50	600	$900.00	A
				$3,811.79	
VERIFICATION ANALYSIS:					
VOCs	Each	$324.66	106	$34,413.96	A
TAL metals	Each	$253.54	106	$26,875.24	A
PCBs/Pesticides	Each	$213.96	106	$22,679.76	A
				$83,968.96	
TCLP SAMPLING:					
Sampling Equipment:					
Hand Auger	Day	$59.07	5	$295.35	A
40 ml. glass vials	Each	$1.53	256	$391.68	A
8 oz. glass jar	Each	$2.76	256	$706.56	A
48 oz cooler (for shipping)	Each	$39.52	8	$316.16	A
Labor:					
Health and Safety Officer	Hr.	$18.55	36	$667.80	A
Field Technician	Hr.	$14.84	36	$534.24	A
Sample Shipment to Lab	lb.	$1.50	600	$900.00	A
				$3,811.79	

DRMO AREA - ALTERNATIVE 6:EXCAVATION AND OFF-SITE DISPOSAL (cont'd)

	Unit	Unit Cost	Quantity	Cost	Source
TCLP ANALYSIS:					
TCLP VOCs, Metals	Each	$866.37	106	$91,835.22	A
TRANSPORTATION	Dump truck	$683.63	70	$47,854.10	A
DISPOSAL	CY	$111.31	1300	$144,703.00	A

Notes:

A: Environmental Asseblies/Unit Cost Book
1995- Environmental Cost Handling Options and Solutions

B: Means Site Work & Landscape Cost Data- 1996- 15th Edition

Assumptions:

1. 60 days of site work
2. 4-member team for excavation work
3. 2-member survey team
4. 5 days of survey work
5. 3 days of verification sampling work
6. 3 days of TCLP sampling work
7. 10-hour work days
8. 60-day safety equipment rental
9. Each person to go through 4 tyvek suits per day
10. One pair each of outer gloves per person per day; and one extra pair of each per day per person in the event of tears/rips
11. Each person to go through 8 pair of inner gloves per day
12. Each person, as part of their gear, has a full-face respirator, cartriges, a hard hat, leather steel-toed boots, and safety glasss
13. Using 18 KGAL of water (300 GAL/day for 60 days)
14. Using 600 KWH of electricity (1 kw for 60 days at 10 hrs/day)
15. Using 8,100 gal. diesel fuel (90 gal./day for 60 days)
16. No staging needed
17. Backfill material obtained from on-site stockpiles
18. 5-day sampling equipment rental (1 day to mob., 3 days to use, 1 day to demob.)
19. 2 VOC samples taken for each verification sampling and TCLP sampling location
20. 1 metals sample taken for each verification sampling and TCLP sampling location
21. 1 Pesticide/PCB sample taken for each verification sampling and TCLP sampling location
22. 5 duplicate samples taken of each contaminant group for verification and TCLP sampling
23. 1 rinsate blank sample taken of auger for each contaminant group for verification and TCLP sampling
24. Army does not require MS/MSD samples to be taken
25. 2-member team for verification and TCLP sampling work
26. 100 verification and TCLP field samples taken
27. 2 jars required for each VOC sample location, 1 jar required for each metals sample location, and 1 jar required for each PCB/Pesticide sample location for verification and TCLP sampling with an additional 20% added in the event of breakage/resampling
28. Verification and TCLP samples to be shipped for analysis each weigh 600 lbs.
29. 8 coolers needed to ship verification samples; 8 needed to ship TCLP samples
30. No soil samples fail TCLP tests
31. 200 cubic yard dump trucks used
32. Soil transported to non-hazardous waste landfill
33. 100 mile round trip from site to landfill
34. Each person to go through 4 pair of disposable boots per day

B.3 UST-13 GROUNDWATER AREA BACK-UP COST CALCULATIONS

MONITORING COSTS

UST-13 AREA
ALTERNATIVE 1: NO FURTHER ACTION

LABOR RATES FOR SAMPLE COLLECTION, DATA VALIDATION, SUMMARY REPORT, AND SITE EVALUATION

SAMPLE COLLLLECTION	Unit	Unit Cost	Quantity	Cost	Source
Health and Safety Officer	Hr.	$18.55	12	$222.60	A
Field Technician	Hr.	$14.84	12	$178.08	A
				$400.68	
DATA VALIDATION					
Senior Chemist	Hr.	$23.50	16	$376.00	A
SUMMARY REPORT					
Staff Engineer	Hr.	$23.50	20	$470.00	A
Word Processing/Clerical	Hr.	$12.37	10	$123.70	A
				$593.70	
Site Evaluation					
Senior Project Manager	Hr.	$49.47	8	$395.76	A

Notes:
A: Environmental Restoration Assemblies/Unit Cost Book
1995- Environmental Cost Handling Options and Solutions

Assumptions:
1. Sample collection team members work a full 12 hour day by labor levels shown
2. Data validation requires 16 hours to complete by labor level shown
3. Summary report requires 20 hours to be written by labor level shown
4. Summary report requires 10 hours of word processing and editing time by labor level shown
5. Site evaluation requires 10 hours to conduct by labor level shown

UST-13 AREA
ALTERNATIVE 1: NO FURTHER ACTION

SAMPLE ANALYTICAL COSTS	Unit	Unit Cost	Quantity	Cost	Source
VOCs	Sample	$324.66	14	$4,545.24	A
PCBs/Pesticides	Sample	$213.96	6	$1,283.76	A
TAL Metals	Sample	$290.64	12	$3,487.68	A
				$9,316.68	

Notes:

A: Environmental Restoration Assemblies/Unit Cost Book
1995- Environmental Cost Handling Options and Solutions

Assumptions:

1. 1 unfiltered sample taken of each contaminant group per each of the 5 wells
2. 1 filtered sample taken of TAL metals per each of the 5 wells
3. 2 VOC samples taken per each of the 5 wells, the duplicate, and the blanks
4. 1 unfilted duplicate sample taken of each contaminant group
5. 1 filtered sample taken of TAL metals
6. 1 rinsate blank taken of each contaminant group of the metals filter
7. 1 trip blank (VOCs only) taken
8. Army does not require MS/MSD samples to be taken
9. Each well has a dedicated bailer, therefore, no rinsate on bailer needed

UST-13 AREA
ALTERNATIVE 1: NO FURTHER ACTION

TRAVEL EXPENSES	Unit	Unit Cost	Quantity	Cost	Source
Air Fare	Per Person	$554.00	2	$1,108.00	A
Meals	Per Person	$30.00	2	$60.00	B
Van Rental	Day	$69.99	1	$69.99	C
Fuel	Gal.	$1.22	10	$12.20	D
				$1,250.19	

Notes:
A: US Air 2/8/96 R/T air fare from Washington Int'l Airport to Logan Int'l
B: Ecology & Environment 2/96 per diem (meals only) rate
C: Hertz 2/8/96 7-passenger mini-van rate - pick up and drop off at Logan Int'l.
D: Leominster, Mass. Shell Oil Gas 2/8/96 regular unleaded fule rate

Assumptions:
1. 2-person work team
2. Arrive and depart from site same day
3. Use 10 gal. fuel

UST-13 AREA
ALTERNATIVE 1: NO FURTHER ACTION

SHIPPING COSTS	Unit	Unit Cost	Quantity	Cost
Sampling Equipment	lb.	$1.50	290	$435.00
Safety Equipment	lb.	$1.50	100	$150.00
Samples	lb.	$1.50	130	$195.00
				$780.00

Notes:
A: Federal Express 2/96 shipping rates

Assumptions:
1. Sampling equipment weighs 290 lbs.
2. Safety equipment weighs 100 lbs.
3. Samples weigh 130 lbs. when ready for shipment

UST-13 AREA
ALTERNATIVE 1: NO FURTHER ACTION

SAFETY EQUIPMENT COSTS	Unit	Unit Cost	Quantity	Cost	Source
Organic Vapor Analyzer	Day	$123.68	3	$371.04	A
Gas Monitor	Day	$15.46	3	$46.38	A
Tyvek Suit	Each	$8.06	8	$64.48	A
Reusable Butyl Outer Gloves	Pair	$2.86	4	$11.44	A
Latex Inner Gloves	Pair	$0.30	16	$4.80	A
Disposable Tyvek Boots	Pair	$1.42	8	$11.36	A
				$509.50	

Notes:
A: Environmental Restoration Assemblies/Unit Cost Book
1995- Environmental Cost Handling Options and Solutions

Assumptions:
1. 3-day rental (1 day each to mob, use, and demob. eqpt.)
2. 2- person work team
3. One full day of work
4. Each person to go through 4 tyvek suits per day
5. One pair each of outer gloves per person; and one extra pair per person in the event of tears/rips
6. Each person to go through 8 pair of inner gloves per day
7. Each person has as part of their gear a full-face respirator, cartriges, a hard hat, leather steel-toed boots, and safety glasses
8. Each person to go through 4 pair of disposable boots per day

UST-13 AREA
ALTERNATIVE 1: NO FURTHER ACTION

SAMPLING EQUIPMENT COSTS	Unit	Unit Cost	Quantity	Cost	Source
Well Development Equipment Rental (pH, Temp., Conductivity, Turbidity meters)	Day	$115.37	3	$346.11	A
2 inch submersible pump	Day	$61.84	3	$185.52	A
5 kW Generator	Day	$55.66	3	$166.98	A
40 mL VOC vials	Each	$1.53	17	$26.01	A
1 L plastic metals bottle	Each	$2.88	8	$23.04	A
1 Gal. glass container	Each	$9.59	15	$143.85	A
1 7/8 inch teflon bailers	Each	$48.23	8	$385.84	A
48 Qt. coolers (shipping)	Each	$39.52	2	$79.04	A
1/4 inch cotton rope	100 feet	$10.70	2	$21.40	B
				$1,377.79	

Notes:

A: Environmental Restoration Assemblies/Unit Cost Book
1995- Environmental Cost Handling Options and Solutions
B: Hector's Hardware 2/96 rate

Assumptions:
1. 3-day rental (1 day each to mob, use, and demob eqpt.)
2. Labels, C-O-C forms, etc... incl. with bottles/containers
3. Assumes 20% greater containers than will actually be needed to account for breakage/errors, etc...
4. 50 feet of rope needed per well
5. Assumes 2 bailers per well to account for loss
6. 2 coolers needed for sample shipment

UST-13 AREA
ALTERNATIVE 2: INSTITUTIONAL CONTROLS
YEARS 0, 5, 10, 15, 20, 25, 30

LABOR RATES FOR SAMPLE COLLECTION, DATA VALIDATION, SUMMARY REPORT, AND SITE EVALUATION

SAMPLE COLLLLECTION	Unit	Unit Cost	Quantity	Cost	Source
Health and Safety Officer	Hr.	$18.55	12	$222.60	A
Field Technician	Hr.	$14.84	12	$178.08	A
				$400.68	
DATA VALIDATION					
Senior Chemist	Hr.	$23.50	16	$376.00	A
SUMMARY REPORT					
Staff Engineer	Hr.	$23.50	20	$470.00	A
Word Processing/Clerical	Hr.	$12.37	10	$123.70	A
				$593.70	
Site Evaluation					
Senior Project Manager	Hr.	$49.47	8	$395.76	A

Notes:
A: Environmental Restoration Assemblies/Unit Cost Book
1995- Environmental Cost Handling Options and Solutions

Assumptions:
1. Sample collection team members work a full 12 hour day by labor levels shown
2. Data validation requires 16 hours to complete by labor level shown
3. Summary report requires 20 hours to be written by labor level shown
4. Summary report requires 10 hours of word processing and editing time by labor level shown
5. Site evaluation requires 10 hours to conduct by labor level shown

UST-13 AREA
ALTERNATIVE 2: INSTITUTIONAL CONTROLS
YEARS 0, 5, 10, 15, 20, 25, 30

SAMPLING EQUIPMENT COSTS

	Unit	Unit Cost	Quantity	Cost	Source
Well Development Equipment Rental (pH, Temp., Conductivity, Turbidity meters)	Day	$115.37	3	$346.11	A
2 inch submersible pump	Day	$61.84	3	$185.52	A
5 kW Generator	Day	$55.66	3	$166.98	A
40 mL VOC vials	Each	$1.53	17	$26.01	A
1 L plastic metals bottle	Each	$2.88	8	$23.04	A
1 Gal. glass container	Each	$9.59	15	$143.85	A
1 7/8 inch teflon bailers	Each	$48.23	8	$385.84	A
48 Qt. coolers (shipping)	Each	$39.52	2	$79.04	A
1/4 inch cotton rope	100 feet	$10.70	2	$21.40	B
				$1,377.79	

Notes:
A: Environmental Restoration Assemblies/Unit Cost Book
1995- Environmental Cost Handling Options and Solutions
B: Hector's Hardware 2/96 rate

Assumptions:
1. 3-day rental (1 day each to mob, use, and demob eqpt.)
2. Labels, C-O-C forms, etc... incl. with bottles/containers
3. Assumes 20% greater containers than will actually be needed to account for breakage/errors, etc...
4. 50 feet of rope needed per well
5. Assumes 2 bailers per well to account for loss
6. 2 coolers needed for sample shipment

UST-13 AREA
ALTERNATIVE 2: INSTITUTIONAL CONTROLS
YEARS 0, 5, 10, 15, 20, 25, 30

SAFETY EQUIPMENT COSTS	Unit	Unit Cost	Quantity	Cost	Source
Organic Vapor Analyzer	Day	$123.68	3	$371.04	A
Gas Monitor	Day	$15.46	3	$46.38	A
Tyvek Suit	Each	$8.06	8	$64.48	A
Reusable Butyl Outer Gloves	Pair	$2.86	4	$11.44	A
Latex Inner Gloves	Pair	$0.30	16	$4.80	A
Disposable Tyvek Boots	Pair	$1.42	8	$11.36	A
				$509.50	

Notes:

A: Environmental Restoration Assemblies/Unit Cost Book
1995- Environmental Cost Handling Options and Solutions

Assumptions:

1. 3-day rental (1 day each to mob, use, and demob. eqpt.)
2. 2- person work team
3. One full day of work
4. Each person to go through 4 tyvek suits per day
5. One pair each of outer gloves per person; and one extra pair per person in the event of tears/rips
6. Each person to go through 8 pair of inner gloves per day
7. Each person has as part of their gear a full-face respirator, cartriges, a hard hat, leather steel-toed boots, and safety glasses
8. Each person to go through 4 pair of disposable boots per day

UST-13 AREA
ALTERNATIVE 2: INSTITUTIONAL CONTROLS
YEARS 0, 5, 10, 15, 20, 25, 30

SHIPPING COSTS	Unit	Unit Cost	Quantity	Cost
Sampling Equipment	lb.	$1.50	290	$435.00
Safety Equipment	lb.	$1.50	100	$150.00
Samples	lb.	$1.50	130	$195.00
				$780.00

Notes:
A: Federal Express 2/96 shipping rates

Assumptions:
1. Sampling equipment weighs 290 lbs.
2. Safety equipment weighs 100 lbs.
3. Samples weigh 130 lbs. when ready for shipment

UST-13 AREA
ALTERNATIVE 2: INSTITUTIONAL CONTROLS
YEARS 0, 5, 10, 15, 20, 25, 30

TRAVEL EXPENSES	Unit	Unit Cost	Quantity	Cost	Source
Air Fare	Per Person	$554.00	2	$1,108.00	A
Meals	Per Person	$30.00	2	$60.00	B
Van Rental	Day	$69.99	1	$69.99	C
Fuel	Gal.	$1.22	10	$12.20	D
				$1,250.19	

Notes:

A: US Air 2/8/96 R/T air fare from Washington Int'l Airport to Logan Int'l
B: Ecology & Environment 2/96 per diem (meals only) rate
C: Hertz 2/8/96 7-passenger mini-van rate - pick up and drop off at Logan Int'l.
D: Leominster, Mass. Shell Oil Gas 2/8/96 regular unleaded fule rate

Assumptions:

1. 2-person work team
2. Arrive and depart from site same day
3. Use 10 gal. fuel

UST-13 AREA
ALTERNATIVE 2: INSTITUTIONAL CONTROLS
YEARS 0, 5, 10, 15, 20, 25, 30

SAMPLE ANALYTICAL COSTS	Unit	Unit Cost	Quantity	Cost	Source
VOCs	Sample	$324.66	14	$4,545.24	A
PCBs/Pesticides	Sample	$213.96	6	$1,283.76	A
TAL Metals	Sample	$290.64	12	$3,487.68	A
				$9,316.68	

Notes:

A: Environmental Restoration Assemblies/Unit Cost Book
1995- Environmental Cost Handling Options and Solutions

Assumptions:

1. 1 unfiltered sample taken of each contaminant group per each of the 5 wells
2. 1 filtered sample taken of TAL metals per each of the 5 wells
3. 2 VOC samples taken per each of the 5 wells, the duplicate, and the blanks
4. 1 unfilted duplicate sample taken of each contaminant group
5. 1 filtered sample taken of TAL metals
6. 1 rinsate blank taken of each contaminant group of the metals filter
7. 1 trip blank (VOCs only) taken
8. Army does not require MS/MSD samples to be taken
9. Each well has a dedicated bailer, therefore, no rinsate on bailer needed

UST 13 (AOC 32) GROUNDWATER
INTRINSIC REMEDIATION
YEAR 1

SAMPLING EQUIPMENT COSTS	Unit	Unit Cost	Quantity	Cost	Source
Teflon tubing	Linear Foot	$1.73	120	$207.60	A
Well Development Equipment Rental (pH, Temp., Conductivity, Turbidity meters; O2 meter, Redox)	Day	$115.37	4	$461.48	B
Peristaltic pump	Day	$61.84	4	$247.36	B
5 kW Generator	Day	$55.66	4	$222.64	B
40 mL VOC vials	Each	$1.53	26	$39.78	B
1 L plastic metals bottle	Each	$2.88	55	$158.40	B
1 L glass container	Each	$9.59	12	$115.08	B
48 Qt. coolers (shipping)	Each	$39.52	6	$237.12	B
Filter (barrel/pressure)	Day	$15.00	3	$45.00	C
				$1,734.46	
WELL INSTALLATION	Each	$1,955.00	3	$5,865.00	D

Notes:
A: Environmental Restoration Assemblies/Unit Cost Book
1996- Environmental Cost Handling Options and Solutions
B: Environmental Restoration Asseblies/Unit Cost Book
1995- Environmental Cost Handling Options and Solutions
C: Ecology & Environment, Inc. 1996
D: Competitive bids for similar wells in New York State

Assumptions:
1. 5-day rental (1 day to mob and demob equip, 3 days field use)
2. Labels, C-O-C forms, etc... incl. with bottles/containers
3. Assumes 20% greater containers than will actually be needed to account for breakage/errors, etc...
4. Ten coolers for sample shipment.

UST 13 (AOC 32) GROUNDWATER
INTRINSIC REMEDIATION
YEARS 2- 5

SAMPLING EQUIPMENT COSTS	Unit	Unit Cost	Quantity	Cost	Source
Teflon tubing	Linear Foot	$1.73	120	$207.60	A
Well Development Equipment Rental (pH, Temp., Conductivity, Turbidity meters; O2 meter, Redox)	Day	$115.37	4	$461.48	B
Peristaltic pump	Day	$61.84	4	$247.36	B
5 kW Generator	Day	$55.66	4	$222.64	B
40 mL VOC vials	Each	$1.53	26	$39.78	B
1 L plastic metals bottle	Each	$2.88	55	$158.40	B
1 L glass container	Each	$9.59	12	$115.08	B
48 Qt. coolers (shipping)	Each	$39.52	6	$237.12	B
Filter (barrel/pressure)	Day	$15.00	3	$45.00	C
TOTAL SAMPLING EQUIPMENT COSTS YEARS 2 - 5				$1,734.46	

Notes:
A: Environmental Restoration Assemblies/Unit Cost Book
1996- Environmental Cost Handling Options and Solutions
B: Environmental Restoration Asseblies/Unit Cost Book
1995- Environmental Cost Handling Options and Solutions
C: Ecology & Environment, Inc. 1996

Assumptions:
1. 5-day rental (1 day to mob and demob equip, 3 days field use)
2. Labels, C-O-C forms, etc... incl. with bottles/containers
3. Ten coolers needed for sample shipment.

UST 13 (AOC 32) GROUNDWATER
INTRINSIC REMEDIATION

YEARS 1 - 5

TRAVEL EXPENSES	Unit	Unit Cost	Quantity	Cost	Source
Air Fare	Per Person	$554.00	2	$1,108.00	A
Meals	Per Person	$30.00	6	$180.00	B
Van Rental	Day	$69.99	3	$209.97	C
Fuel	Gal.	$1.22	20	$24.40	D
Lodging	day/person	$48.00	6	$288.00	E
TOTAL TRAVEL YEARS 1 - 5				$1,810.37	

Notes:

A: US Air 2/8/96 R/T air fare from Washington Int'l Airport to Logan Int'l
B: Ecology & Environment 2/96 per diem (meals only) rate
C: Hertz 2/8/96 7-passenger mini-van rate - pick up and drop off at Logan Int'l.
D: Leominster, Mass. Shell Oil Gas 2/8/96 regular unleaded fule rate
E: Holiday Inn, Leominster, MA, 2/96 quote

Assumptions:

1. 2-person work team
2. Half-day mob and half-day demob, 2 days on-site

UST 13 (AOC 32) GROUNDWATER
INTRINSIC REMEDIATION

YEARS 1 - 5

SHIPPING COSTS	Unit	Unit Cost	Quantity	Cost	Source
Sampling Equipment	lb.	$1.50	290	$435.00	A
Safety Equipment	lb.	$1.50	100	$150.00	A
Samples	lb.	$1.50	360	$540.00	A
TOTAL SHIPPING YEARS 1 - 5				$1,560.00	

Notes:
A: Federal Express 2/96 shipping rates

Assumptions:
1. Sampling equipment weighs 290 lbs.
2. Safety equipment weighs 100 lbs.
3. Samples weigh 650 lbs. when ready for shipment

UST 13 (AOC 32) GROUNDWATER
INTRINSIC REMEDIATION

YEARS 1 - 5

SAFETY EQUIPMENT COSTS	Unit	Unit Cost	Quantity	Cost	Source
Organic Vapor Analyzer	Day	$123.68	4	$494.72	A
Gas Monitor	Day	$15.46	4	$61.84	A
Tyvek Suit	Each	$8.06	10	$80.60	A
Reusable Butyl Outer Gloves	Pair	$2.86	6	$17.16	A
Latex Inner Gloves	Pair	$0.30	20	$6.00	A
Disposable Tyvek Boots	Pair	$1.42	10	$14.20	A
TOTAL SAFETY EQUIPMENT COSTS YEARS 1 - 5				$674.52	

Notes:

A: Environmental Restoration Assemblies/Unit Cost Book
1995- Environmental Cost Handling Options and Solutions

Assumptions:

1. Each person has as part of their gear a full-face respirator, cartridges, hard hat leather steel-toed boots, and safety glasses

UST 13 (AOC 32) GROUNDWATER
INTRINSIC REMEDIATION

YEARS 1 - 5

SAMPLE ANALYTICAL COSTS	Unit	Unit Cost	Quantity	Cost	Source
Nitrate	Sample	$35.68	11	$392.48	A
Nitrite	Sample	$35.68	11	$392.48	A
Phosphate	Sample	$29.73	11	$327.03	A
Sulfate	Sample	$14.27	11	$156.97	A
Sulfide	Sample	$55.90	11	$614.90	A
Total Iron	Sample	$20.00	11	$220.00	B
Soluble Iron (ferric)	Sample	$20.00	11	$220.00	B
BTEX Volatiles	Sample	$89.19	12	$1,070.28	A
As, Fe, Mn (filtered)	Sample	$150.00	11	$1,650.00	B
Alkalinity	Sample	$21.40	11	$235.40	A
Ammonia-Nitrogen	Sample	$41.63	11	$457.93	A
TPHC	Sample	$112.98	11	$1,242.78	A
TOTAL ANALYTICAL YEARS 1 - 5				$6,980.25	

Notes:

A: Environmental Restoration Assemblies/Unit Cost Book
1996- Environmental Cost Handling Options and Solutions
B: Ecology & Environment, Inc. 1996

Assumptions:

1. Total iron is unfiltered.
2. Ferric (soluble) iron is filtered.
3. Filtered arsenic, iron and manganganese are filtered.
4. All other samples are filtered.
5. Disposable tubing is used for collection.
6. Only one trip blank (BTEX VOAs) is taken.
7. One duplicated is taken + matrix spike and MS duplicate.
8. Assume USEPA protocols not USAEC.

UST 13 (AOC 32) GROUNDWATER
INTRINSIC REMEDIATION
YEAR 1
LABOR RATES FOR SAMPLE COLLECTION, DATA VALIDATION, SUMMARY REPORT, AND SITE EVALUATION/GROUNDWATER MODEL

SAMPLE COLLECTION	Unit	Unit Cost	Quantity	Cost	Source
Health and Safety Officer	Hr.	$18.55	24	$445.20	A
Field Technician	Hr.	$14.84	24	$356.16	A
				$801.36	
DATA VALIDATION					
Senior Chemist	Hr.	$23.50	16	$376.00	A
SUMMARY REPORT					
Project Hydrogeologist	Hr.	$29.74	48	$1,427.52	B
Staff Engineer	Hr.	$23.50	48	$1,128.00	A
Word Processing/Clerical	Hr.	$12.37	16	$197.92	A
				$2,753.44	
Site Evaluation/Groundwater Model/Well Installation					
Senior Project Manager	Hr.	$49.47	40	$1,978.80	A
Senior Project Hydrogeologist	Hr.	$41.63	320	$13,321.60	B
Project Hydrogeologist	Hr.	$29.74	480	$14,275.20	B
				$29,575.60	
TOTAL LABOR YEAR 1				$33,506.40	

Notes:
A: Environmental Restoration Assemblies/Unit Cost Book
1995- Environmental Cost Handling Options and Solutions
B: Environmental Restoration Assemblies/Unit Cost Book
1996- Environmental Cost Handling Options and Solutions

Assumptions:
1. Sample collection team members work 12-hour days.

UST 13 (AOC 32) GROUNDWATER
INTRINSIC REMEDIATION

YEARS 2 - 4

LABOR RATES FOR SAMPLE COLLECTION, DATA VALIDATION, SUMMARY REPORT, AND SITE EVALUATION

SAMPLE COLLECTION	Unit	Unit Cost	Quantity	Cost	Source
Health and Safety Officer	Hr.	$18.55	24	$445.20	A
Field Technician	Hr.	$14.84	24	$356.16	A
				$801.36	
DATA VALIDATION					
Senior Chemist	Hr.	$23.50	16	$376.00	A
SUMMARY REPORT					
Project Hydrogeologist	Hr.	$29.74	16	$475.84	B
Staff Engineer	Hr.	$23.50	16	$376.00	A
Word Processing/Clerical	Hr.	$12.37	12	$148.44	A
				$1,000.28	
Site Evaluation/Groundwater Model					
Senior Project Manager	Hr.	$49.47	12	$593.64	A
Senior Project Hydrogeologist	Hr.	$41.63	24	$999.12	B
Project Hydrogeologist	Hr.	$29.74	24	$713.76	B
				$2,306.52	
TOTAL LABOR YEARS 2 - 4				$4,484.16	

Notes:

A: Environmental Restoration Assemblies/Unit Cost Book
1995- Environmental Cost Handling Options and Solutions

B: Environmental Restoration Assemblies/Unit Cost Book
1996- Environmental Cost Handling Options and Solutions

Assumptions:

1. Sample collection team members work 12-hour days.

UST 13 (AOC 32) GROUNDWATER
INTRINSIC REMEDIATION

YEAR 5

LABOR RATES FOR SAMPLE COLLECTION, DATA VALIDATION, SUMMARY REPORT, AND SITE EVALUATION

SAMPLE COLLECTION	Unit	Unit Cost	Quantity	Cost	Source
Health and Safety Officer	Hr.	$18.55	24	$445.20	A
Field Technician	Hr.	$14.84	24	$356.16	A
				$801.36	
DATA VALIDATION					
Senior Chemist	Hr.	$23.50	16	$376.00	A
SUMMARY REPORT					
Project Hydrogeologist	Hr.	$29.74	32	$951.68	B
Staff Engineer	Hr.	$23.50	20	$470.00	A
Word Processing/Clerical	Hr.	$12.37	10	$123.70	A
				$1,545.38	
Site Evaluation					
Senior Project Hydrogeologist	Hr.	$41.63	64	$2,664.32	A
Project Hydrogeologist	Hr.	$29.74	64	$1,903.36	B
Senior Project Manager	Hr.	$49.47	32	$1,583.04	B
				$6,150.72	
TOTAL LABOR YEAR 5				$8,873.44	

Notes: A: Environmental Restoration Assemblies/Unit Cost Book
1995- Environmental Cost Handling Options and Solutions
B: Environmental Restoration Assemblies/Unit Cost Book
1996- Environmental Cost Handling Options and Solutions

Assumptions:
1. Sample collection team members work 12-hour days.

B.4 POL STORAGE AREA/DRMO YARD GROUNDWATER AREA BACK-UP COST CALCULATIONS

POL AREA/DRMO YARDS GROUNDWATER
ALTERNATIVE 1: NO FURHTER ACTION
YEARS 1 - 5

SAMPLING EQUIPMENT COSTS	Unit	Unit Cost	Quantity	Cost	Source
Well Development Equipment Rental (pH, Temp., Conductivity, Turbidity meters)	Day	$115.37	3	$346.11	A
2 inch submersible pump	Day	$61.84	3	$185.52	A
5 kW Generator	Day	$55.66	3	$166.98	A
40 mL VOC vials	Each	$1.53	2	$3.06	A
1 L plastic metals bottle	Each	$2.88	9	$25.92	A
1 Gal. glass container	Each	$9.59	17	$163.03	A
1 7/8 inch teflon bailers	Each	$48.23	10	$482.30	A
48 Qt. coolers (shipping)	Each	$39.52	2	$79.04	A
1/4 inch cotton rope	100 feet	$10.70	2	$21.40	B
				$1,473.36	

Notes:
A: Environmental Restoration Assemblies/Unit Cost Book
1995- Environmental Cost Handling Options and Solutions
B: Hector's Hardware 2/96 rate

Assumptions:
1. 3-day rental (1 day each to mob, use, and demob eqpt.)
2. Labels, C-O-C forms, etc... incl. with bottles/containers
3. Assumes 20% greater containers than will actually be needed to account for breakage/errors, etc...
4. 50 feet of rope needed per well
5. Assumes 2 bailers per well to account for loss
6. 2 coolers needed for sample shipment

POL AREA/DRMO YARDS GROUNDWATER
ALTERNATIVE 1: NO FURTHER ACTION
YEARS 1 - 5

SAFETY EQUIPMENT COSTS	Unit	Unit Cost	Quantity	Cost	Source
Organic Vapor Analyzer	Day	$123.68	3	$371.04	A
Gas Monitor	Day	$15.46	3	$46.38	A
Tyvek Suit	Each	$8.06	8	$64.48	A
Reusable Butyl Outer Gloves	Pair	$2.86	4	$11.44	A
Latex Inner Gloves	Pair	$0.30	16	$4.80	A
Disposable Tyvek Boots	Pair	$1.42	8	$11.36	A
				$509.50	

Notes:

A: Environmental Restoration Assemblies/Unit Cost Book
1995- Environmental Cost Handling Options and Solutions

Assumptions:

1. 3-day rental (1 day each to mob, use, and demob. eqpt.)
2. 2- person work team
3. One full day of work
4. Each person to go through 4 tyvek suits per day
5. One pair each of outer gloves per person; and one extra pair per person in the event of tears/rips
6. Each person to go through 8 pair of inner gloves per day
7. Each person has as part of their gear a full-face respirator, cartriges, a hard hat, leather steel-toed boots, and safety glasses
8. Each person to go through 4 pair of disposable boots per day

POL AREA/DRMO YARDS GROUNDWATER
ALTERNATIVE 1: NO FURHTER ACTION
YEARS 1 - 5

SHIPPING COSTS	Unit	Unit Cost	Quantity	Cost
Sampling Equipment	lb.	$1.50	300	$450.00
Safety Equipment	lb.	$1.50	100	$150.00
Samples	lb.	$1.50	150	$225.00
				$825.00

Notes:
A: Federal Express 2/96 shipping rates

POL AREA/DRMO YARDS GROUNDWATER
ALTERNATIVE 1: NO FURTHER ACTION
YEARS 1 - 5

LABOR RATES FOR SAMPLE COLLECTION, DATA VALIDATION, SUMMARY REPORT, AND SITE EVALUATION

SAMPLE COLLLLECTION	Unit	Unit Cost	Quantity	Cost	Source
Health and Safety Officer	Hr.	$18.55	12	$222.60	A
Field Technician	Hr.	$14.84	12	$178.08	A
				$400.68	
DATA VALIDATION					
Senior Chemist	Hr.	$23.50	20	$470.00	A
SUMMARY REPORT					
Staff Engineer	Hr.	$23.50	20	$470.00	A
Word Processing/Clerical	Hr.	$12.37	10	$123.70	A
				$593.70	
Site Evaluation					
Senior Project Manager	Hr.	$49.47	10	$494.70	A

Notes:
A: Environmental Restoration Assemblies/Unit Cost Book
1995- Environmental Cost Handling Options and Solutions

Assumptions:
1. Sample collection team members work a full 12 hour day by labor levels shown
2. Data validation requires 20 hours to complete by labor level shown
3. Summary report requires 20 hours to be written by labor level shown
4. Summary report requires 10 hours of word processing and editing time by labor level shown
5. Site evaluation requires 10 hours to conduct by labor level shown

POL AREA/DRMO YARDS GROUNDWATER
ALTERNATIVE 1: NO FURTHER ACTION
YEARS 1 - 5

TRAVEL EXPENSES	Unit	Unit Cost	Quantity	Cost	Source
Air Fare	Per Person	$554.00	2	$1,108.00	A
Meals	Per Person	$30.00	2	$60.00	B
Van Rental	Day	$69.99	1	$69.99	C
Fuel	Gal.	$1.22	10	$12.20	D
				$1,250.19	

Notes:

A: US Air 2/8/96 R/T air fare from Washington Int'l Airport to Logan Int'l

B: Ecology & Environment 2/96 per diem (meals only) rate

C: Hertz 2/8/96 7-passenger mini-van rate - pick up and drop off at Logan Int'l.

D: Leominster, Mass. Shell Oil Gas 2/8/96 regular unleaded fule rate

Assumptions:
1. 2-person work team
2. Arrive and depart from site same day
3. Use 10 gal. fuel

POL AREA/DRMO YARDS GROUNDWATER
ALTERNATIVE 1: NO FURHTER ACTION
YEARS 1 - 5

SAMPLE ANALYTICAL COSTS	Unit	Unit Cost	Quantity	Cost	Source
VOCs	Sample	$324.66	16	$5,194.56	A
PCBs/Pesticides	Sample	$213.96	7	$1,497.72	A
TAL Metals	Sample	$290.64	14	$4,068.96	A
				$10,761.24	

Notes:
A: Environmental Restoration Assemblies/Unit Cost Book
1995- Environmental Cost Handling Options and Solutions

Assumptions:
1. 1 unfiltered sample taken of each contaminant group per each of the 5 wells
2. 1 filtered sample taken of TAL metals per each of the 5 wells
3. 2 VOC samples taken per each of the 5 wells, the duplicate, and the blanks
4. 1 unfilted duplicate sample taken of each contaminant group
5. 1 filtered sample taken of TAL metals
6. 1 rinsate blank taken of each contaminant group of the metals filter
7. 1 trip blank (VOCs only) taken
8. Army does not require MS/MSD samples to be taken
9. Each well has a dedicated bailer, therefore, no rinsate on bailer needed

POL AREA/DRMO YARDS GROUNDWATER
ALTERNATIVE 2: INSTITUTIONAL CONTROLS
YEARS 0, 5, 10, 15, 20, 25, 30

SAMPLING EQUIPMENT COSTS	Unit	Unit Cost	Quantity	Cost	Source
Well Development Equipment Rental (pH, Temp., Conductivity, Turbidity meters)	Day	$115.37	3	$346.11	A
2 inch submersible pump	Day	$61.84	3	$185.52	A
5 kW Generator	Day	$55.66	3	$166.98	A
40 mL VOC vials	Each	$1.53	20	$30.60	A
1 L plastic metals bottle	Each	$2.88	9	$25.92	A
1 Gal. glass container	Each	$9.59	17	$163.03	A
1 7/8 inch teflon bailers	Each	$48.23	10	$482.30	A
48 Qt. coolers (shipping)	Each	$39.52	2	$79.04	A
1/4 inch cotton rope	100 feet	$10.70	3	$32.10	B
				$1,511.60	

Notes:
A: Environmental Restoration Assemblies/Unit Cost Book
1995- Environmental Cost Handling Options and Solutions
B: Hector's Hardware 2/96 rate

Assumptions:
1. 3-day rental (1 day each to mob, use, and demob eqpt.)
2. Labels, C-O-C forms, etc... incl. with bottles/containers
3. Assumes 20% greater containers than will actually be needed to account for breakage/errors, etc...
4. 50 feet of rope needed per well
5. Assumes 2 bailers per well to account for loss
6. 2 coolers needed for sample shipment

POL AREA/DRMO YARDS GROUNDWATER
ALTERNATIVE 2: INSTITUTIONAL CONTROLS
YEARS 0, 5, 10, 15, 20, 25, 30

SAFETY EQUIPMENT COSTS	Unit	Unit Cost	Quantity	Cost	Source
Organic Vapor Analyzer	Day	$123.68	3	$371.04	A
Gas Monitor	Day	$15.46	3	$46.38	A
Tyvek Suit	Each	$8.06	8	$64.48	A
Reusable Butyl Outer Gloves	Pair	$2.86	4	$11.44	A
Latex Inner Gloves	Pair	$0.30	16	$4.80	A
Disposable Tyvek Boots	Pair	$1.42	8	$11.36	A
				$509.50	

Notes:

A: Environmental Restoration Assemblies/Unit Cost Book
1995- Environmental Cost Handling Options and Solutions

Assumptions:

1. 3-day rental (1 day each to mob, use, and demob. eqpt.)
2. 2- person work team
3. One full day of work
4. Each person to go through 4 tyvek suits per day
5. One pair each of outer gloves per person; and one extra pair per person in the event of tears/rips
6. Each person to go through 8 pair of inner gloves per day
7. Each person has as part of their gear a full-face respirator, cartriges, a hard hat, leather steel-toed boots, and safety glasses
8. Each person to go through 4 pair of disposable boots per day

POL AREA/DRMO YARDS GROUNDWATER
ALTERNATIVE 2: INSTITUTIONAL CONTROLS
YEARS 0, 5, 10, 15, 20, 25, 30

SHIPPING COSTS	Unit	Unit Cost	Quantity	Cost
Sampling Equipment	lb.	$1.50	300	$450.00
Safety Equipment	lb.	$1.50	100	$150.00
Samples	lb.	$1.50	150	$225.00
				$825.00

Notes:
A: Federal Express 2/96 shipping rates

POL AREA/DRMO YARDS GROUNDWATER
ALTERNATIVE 2: INSTITUTIONAL CONTROLS
YEARS 0, 5, 10, 15, 20, 25, 30

LABOR RATES FOR SAMPLE COLLECTION, DATA VALIDATION, SUMMARY REPORT, AND SITE EVALUATION

SAMPLE COLLLLECTION	Unit	Unit Cost	Quantity	Cost	Source
Health and Safety Officer	Hr.	$18.55	12	$222.60	A
Field Technician	Hr.	$14.84	12	$178.08	A
				$400.68	
DATA VALIDATION					
Senior Chemist	Hr.	$23.50	20	$470.00	A
SUMMARY REPORT					
Staff Engineer	Hr.	$23.50	20	$470.00	A
Word Processing/Clerical	Hr.	$12.37	10	$123.70	A
				$593.70	
Site Evaluation					
Senior Project Manager	Hr.	$49.47	10	$494.70	A

Notes:
A: Environmental Restoration Assemblies/Unit Cost Book
1995- Environmental Cost Handling Options and Solutions

Assumptions:
1. Sample collection team members work a full 12 hour day by labor levels shown
2. Data validation requires 20 hours to complete by labor level shown
3. Summary report requires 20 hours to be written by labor level shown
4. Summary report requires 10 hours of word processing and editing time by labor level shown
5. Site evaluation requires 10 hours to conduct by labor level shown

POL AREA/DRMO YARDS GROUNDWATER
ALTERNATIVE 2: INSTITUTIONAL CONTROLS
YEARS 0, 5, 10, 15, 20, 25, 30

TRAVEL EXPENSES	Unit	Unit Cost	Quantity	Cost	Source
Air Fare	Per Person	$554.00	2	$1,108.00	A
Meals	Per Person	$30.00	2	$60.00	B
Van Rental	Day	$69.99	1	$69.99	C
Fuel	Gal.	$1.22	10	$12.20	D
				$1,250.19	

Notes:

A: US Air 2/8/96 R/T air fare from Washington Int'l Airport to Logan Int'l
B: Ecology & Environment 2/96 per diem (meals only) rate
C: Hertz 2/8/96 7-passenger mini-van rate - pick up and drop off at Logan Int'l.
D: Leominster, Mass. Shell Oil Gas 2/8/96 regular unleaded fule rate

Assumptions:

1. 2-person work team
2. Arrive and depart from site same day
3. Use 10 gal. fuel

POL AREA/DRMO YARDS GROUNDWATER
ALTERNATIVE 2: INSTITUTIONAL CONTROLS
YEARS 0, 5, 10, 15, 20, 25, 30

SAMPLE ANALYTICAL COSTS	Unit	Unit Cost	Quantity	Cost	Source
VOCs	Sample	$324.66	16	$5,194.56	A
PCBs/Pesticides	Sample	$213.96	7	$1,497.72	A
TAL Metals	Sample	$290.64	14	$4,068.96	A
				$10,761.24	

Notes:
A: Environmental Restoration Assemblies/Unit Cost Book
1995- Environmental Cost Handling Options and Solutions

Assumptions:
1. 1 unfiltered sample taken of each contaminant group per each of the 5 wells
2. 1 filtered sample taken of TAL metals per each of the 5 wells
3. 2 VOC samples taken per each of the 5 wells, the duplicate, and the blanks
4. 1 unfilted duplicate sample taken of each contaminant group
5. 1 filtered sample taken of TAL metals
6. 1 rinsate blank taken of each contaminant group of the metals filter
7. 1 trip blank (VOCs only) taken
8. Army does not require MS/MSD samples to be taken
9. Each well has a dedicated bailer, therefore, no rinsate on bailer needed

POL AREA/DRMO YARD
INTRINSIC REMEDIATION

YEARS 1 - 5

SAMPLE ANALYTICAL COSTS	Unit	Unit Cost	Quantity	Cost	Source
Nitrate	Sample	$35.68	18	$642.24	A
Nitrite	Sample	$35.68	18	$642.24	A
Phosphate	Sample	$29.73	18	$535.14	A
Sulfate	Sample	$14.27	18	$256.86	A
Sulfide	Sample	$55.90	18	$1,006.20	A
Total Iron	Sample	$20.00	18	$360.00	B
Soluble Iron (ferric)	Sample	$20.00	18	$360.00	B
BTEX Volatiles	Sample	$89.19	20	$1,783.80	A
As, Fe, Mn (filtered)	Sample	$150.00	18	$2,700.00	B
Alkalinity	Sample	$21.40	18	$385.20	A
Ammonia-Nitrogen	Sample	$41.63	18	$749.34	A
TPHC	Sample	$112.98	18	$2,033.64	A
TOTAL ANALYTICAL YEARS 1 - 5				$11,454.66	

Notes:

A: Environmental Restoration Assemblies/Unit Cost Book
1996- Environmental Cost Handling Options and Solutions
B: Ecology & Environment, Inc. 1996

Assumptions:

1. Total iron is unfiltered.
2. Ferric (soluble) iron is filtered.
3. Filtered arsenic, iron and manganganese are filtered.
4. All other samples are filtered.
5. Disposable tubing is used for collection.
6. Only one trip blank (BTEX VOAs) is taken.
7. One duplicated is taken + matrix spike and MS duplicate.
8. Assume USEPA protocols not USAEC.

POL AREA/DRMO YARD
INTRINSIC REMEDIATION
YEAR 1

SAMPLING EQUIPMENT COSTS	Unit	Unit Cost	Quantity	Cost	Source
Teflon tubing	Linear Foot	$1.73	420	$726.60	A
Well Development Equipment Rental (pH, Temp., Conductivity, Turbidity meters; O2 meter, Redox)	Day	$115.37	5	$576.85	B
Peristaltic pump	Day	$61.84	5	$309.20	B
5 kW Generator	Day	$55.66	5	$278.30	B
40 mL VOC vials	Each	$1.53	40	$61.20	B
1 L plastic metals bottle	Each	$2.88	90	$259.20	B
1 L glass container	Each	$9.59	18	$172.62	B
48 Qt. coolers (shipping)	Each	$39.52	10	$395.20	B
Filter (barrel/pressure)	Day	$15.00	3	$45.00	C
TOTAL SAMPLING EQUIPMENT COSTS YEAR 1				$2,824.17	
ELL INSTALLATION	Each	$2,069.00	5	$10,345.00	D

Notes:

A: Environmental Restoration Assemblies/Unit Cost Book
1996- Environmental Cost Handling Options and Solutions
B: Environmental Restoration Assebiles/Unit Cost Book
1995- Environmental Cost Handling Options and Solutions
C: Ecology & Environment, Inc. 1996
D: Competitive bids for similar wells in New York State

Assumptions:

1. 5-day rental (1 day to mob and demob equip, 3 days field use)
2. Labels, C-O-C forms, etc... incl. with bottles/containers
3. Assumes 20% greater containers than will actually be needed to account for breakage/errors, etc...
4. Ten coolers needed for sample shipment

POL AREA/DRMO YARD
INTRINSIC REMEDIATION
YEARS 2 - 5

SAMPLING EQUIPMENT COSTS

	Unit	Unit Cost	Quantity	Cost	Source
Teflon tubing	Linear Foot	$1.73	420	$726.60	A
Well Development Equipment Rental (pH, Temp., Conductivity, Turbidity meters; O2 meter, Redox)	Day	$115.37	5	$576.85	B
Peristaltic pump	Day	$61.84	5	$309.20	B
5 kW Generator	Day	$55.66	5	$278.30	B
40 mL VOC vials	Each	$1.53	40	$61.20	B
1 L plastic metals bottle	Each	$2.88	90	$259.20	B
1 L glass container	Each	$9.59	18	$172.62	B
48 Qt. coolers (shipping)	Each	$39.52	10	$395.20	B
Filter (barrel/pressure)	Day	$15.00	3	$45.00	C
TOTAL SAMPLING EQUIPMENT COSTS YEARS 2 - 5				$2,824.17	

Notes:
A: Environmental Restoration Assemblies/Unit Cost Book
1996- Environmental Cost Handling Options and Solutions
B: Environmental Restoration Asseblies/Unit Cost Book
1995- Environmental Cost Handling Options and Solutions
C: Ecology & Environment, Inc. 1996

Assumptions:
1. 5-day rental (1 day to mob and demob equip, 3 days field use)
2. Labels, C-O-C forms, etc... incl. with bottles/containers
3. Ten collers needed for sample shipment.

POL AREA/DRMO YARD
INTRINSIC REMEDIATION

YEAR 1

LABOR RATES FOR SAMPLE COLLECTION, DATA VALIDATION, SUMMARY REPORT, AND SITE EVALUATION/GROUNDWATER MODEL

SAMPLE COLLECTION	Unit	Unit Cost	Quantity	Cost	Source
Health and Safety Officer	Hr.	$18.55	72	$1,335.60	A
Field Technician	Hr.	$14.84	72	$1,068.48	A
				$2,404.08	
DATA VALIDATION					
Senior Chemist	Hr.	$23.50	32	$752.00	A
SUMMARY REPORT					
Project Hydrogeologist	Hr.	$29.74	64	$1,903.36	B
Staff Engineer	Hr.	$23.50	64	$1,504.00	A
Word Processing/Clerical	Hr.	$12.37	20	$247.40	A
				$3,654.76	
Site Evaluation/Groundwater Model/Well Installation					
Senior Project Manager	Hr.	$49.47	48	$2,374.56	A
Senior Project Hydrogeologist	Hr.	$41.63	400	$16,652.00	B
Project Hydrogeologist	Hr.	$29.74	600	$17,844.00	B
				$36,870.56	
TOTAL LABOR YEAR 1				$43,681.40	

Notes:

A: Environmental Restoration Assemblies/Unit Cost Book
1995- Environmental Cost Handling Options and Solutions

B: Environmental Restoration Assemblies/Unit Cost Book
1996- Environmental Cost Handling Options and Solutions

Assumptions:

1. Sample collection team members work 12-hour days.

POL AREA/DRMO YARD
INTRINSIC REMEDIATION

YEARS 2 - 4

LABOR RATES FOR SAMPLE COLLECTION, DATA VALIDATION, SUMMARY REPORT, AND SITE EVALUATION

SAMPLE COLLECTION	Unit	Unit Cost	Quantity	Cost	Source
Health and Safety Officer	Hr.	$18.55	72	$1,335.60	A
Field Technician	Hr.	$14.84	72	$1,068.48	A
				$2,404.08	
DATA VALIDATION					
Senior Chemist	Hr.	$23.50	32	$752.00	A
SUMMARY REPORT					
Project Hydrogeologist	Hr.	$29.74	16	$475.84	B
Staff Engineer	Hr.	$23.50	16	$376.00	A
Word Processing/Clerical	Hr.	$12.37	12	$148.44	A
				$1,000.28	
Site Evaluation/Groundwater Model					
Senior Project Manager	Hr.	$49.47	16	$791.52	A
Senior Project Hydrogeologist	Hr.	$41.63	32	$1,332.16	B
Project Hydrogeologist	Hr.	$29.74	32	$951.68	B
				$3,075.36	
TOTAL LABOR YEARS 2 - 4				$7,231.72	

Notes:

A: Environmental Restoration Assemblies/Unit Cost Book
1995- Environmental Cost Handling Options and Solutions

B: Environmental Restoration Assemblies/Unit Cost Book
1996- Environmental Cost Handling Options and Solutions

Assumptions:

1. Sample collection team members work 12-hour days.

POL AREA/DRMO YARD
INTRINSIC REMEDIATION
YEAR 5

LABOR RATES FOR SAMPLE COLLECTION, DATA VALIDATION, SUMMARY REPORT, AND SITE EVALUATION

SAMPLE COLLECTION	Unit	Unit Cost	Quantity	Cost	Source
Health and Safety Officer	Hr.	$18.55	72	$1,335.60	A
Field Technician	Hr.	$14.84	72	$1,068.48	A
				$2,404.08	
DATA VALIDATION					
Senior Chemist	Hr.	$23.50	32	$752.00	A
SUMMARY REPORT					
Project Hydrogeologist	Hr.	$29.74	32	$951.68	B
Staff Engineer	Hr.	$23.50	20	$470.00	A
Word Processing/Clerical	Hr.	$12.37	10	$123.70	A
				$1,545.38	
Site Evaluation					
Senior Project Hydrogeologist	Hr.	$41.63	64	$2,664.32	A
Project Hydrogeologist	Hr.	$29.74	64	$1,903.36	B
Senior Project Manager	Hr.	$49.47	32	$1,583.04	B
				$6,150.72	
TOTAL LABOR YEAR 5				$10,852.18	

Notes:
A: Environmental Restoration Assemblies/Unit Cost Book
1995- Environmental Cost Handling Options and Solutions
B: Environmental Restoration Assemblies/Unit Cost Book
1996- Environmental Cost Handling Options and Solutions

Assumptions:
1. Sample collection team members work a full 12 hour day by labor levels shown

POL AREA/DRMO YARD
INTRINSIC REMEDIATION

YEARS 1 - 5

TRAVEL EXPENSES	Unit	Unit Cost	Quantity	Cost	Source
Air Fare	Per Person	$554.00	4	$2,216.00	A
Meals	Per Person	$30.00	16	$480.00	B
Van Rental	Day	$69.99	5	$349.95	C
Fuel	Gal.	$1.22	20	$24.40	D
Lodging	day/person	$48.00	12	$576.00	E
TOTAL TRAVEL YEARS 1 - 5				$3,646.35	

Notes:

A: US Air 2/8/96 R/T air fare from Washington Int'l Airport to Logan Int'l

B: Ecology & Environment 2/96 per diem (meals only) rate

C: Hertz 2/8/96 7-passenger mini-van rate - pick up and drop off at Logan Int'l.

D: Leominster, Mass. Shell Oil Gas 2/8/96 regular unleaded fule rate

E: Holiday Inn, Leminster, MA, 2/96 quote

Assumptions:

1. 4-person work team
2. 1 day mob, 1 day demob, 3 days field work

POL AREA/DRMO YARD
INTRINSIC REMEDIATION
YEARS 1 - 5

SHIPPING COSTS	Unit	Unit Cost	Quantity	Cost	Source
Sampling Equipment	lb.	$1.50	290	$435.00	A
Safety Equipment	lb.	$1.50	100	$150.00	A
Samples	lb.	$1.50	650	$975.00	A
TOTAL SHIPPING YEARS 1 - 5				$1,560.00	

Notes:
A: Federal Express 2/96 shipping rates

Assumptions:
1. Sampling equipment weighs 290 lbs.
2. Safety equipment weighs 100 lbs.
3. Samples weigh 650 lbs when ready for shipment

POL AREA/DRMO YARD
INTRINSIC REMEDIATION
YEARS 1 - 5

SAFETY EQUIPMENT COSTS	Unit	Unit Cost	Quantity	Cost	Source
Organic Vapor Analyzer	Day	$123.68	5	$618.40	A
Gas Monitor	Day	$15.46	5	$77.30	A
Tyvek Suit	Each	$8.06	10	$80.60	A
Reusable Butyl Outer Gloves	Pair	$2.86	10	$28.60	A
Latex Inner Gloves	Pair	$0.30	20	$6.00	A
Disposable Tyvek Boots	Pair	$1.42	10	$14.20	A
TOTAL SAFETY EWUIPMENT COSTS YEARS 1 - 5				$825.10	

Notes:
A: Environmental Restoration Assemblies/Unit Cost Book
1995- Environmental Cost Handling Options and Solutions

Assumptions:
1. Each person has a full-face respirator, cartridges,, hard hat, leather steel-toed boots, and safety glasses.

APPENDIX C

RESPONSE TO COMMENTS RECEIVED ON THE DRAFT AND FINAL FEASIBILITY STUDY

Response to Comments

Final Feasibility Study for Functional Area II (AOCs 32, 43A)

Fort Devens, Massachusetts

United States Environmental Protection Agency Region I (New England)

November 8, 1996

General Comments

Comment 1: The range of remedial alternatives proposed for Functional Area II soils is adequate. For the groundwater however, we feel an additional alternative needs to be evaluated. Further, the remedial strategy for the groundwater needs to be reconsidered.

In regard to the above, EPA would propose evaluating an intrinsic remediation/long-term monitoring (IR/LTM) with a technical impracticability component for the UST 13 area. This remedial alternative should at a minimum, include: an evaluation as to whether additional source control actions are needed (UST 13 & POL Yard); expansion of the existing monitoring network; continuation of the groundwater modeling effort; and IR/LTM plan that follows the recently published "Technical Protocol for implementing Intrinsic Remediation with Long-Term Monitoring for Natural Attenuation of Fuel Contamination Dissolved in Groundwater" and the soon to be finalized (May 1997) "Draft Technical Protocol for evaluating Natural Attenuation of Chlorinated Solvents in Groundwater"; expansion of the contaminant list to include bioremediation indicator analytes and compounds; and consideration for setting a point at which action may need to be taken to protect the MADEP designated potentially productive aquifer which underlies the area.

Response: Agreed. The FS will be modified to incorporate intrinsic remediation as a remedial alternative.

Comment 1 continued: We also feel that it would make sense to treat the groundwater as one operable unit for the following reasons: We feel there is insufficient consideration, both in terms of data and analysis, in the RI/FS reports relative for the UST-13 area to potentially be the source of the low levels of chlorinated solvent contamination identified to the southwest, in DRMO and POL area monitoring wells. Also, there is insufficient information concerning the several fuel plumes which were delineated on the basis of screening samples. Although "confirmatory" samples generally did not confirm the presence of these plumes, it is highly questionable that the current monitoring well network is spatially placed in a fashion which would allow for confirmation. In fact, cross sections of the plumes presented in the RI indicate that the bottoms of the plumes were not identified. This information, as well as general water level fluctuations will require that additional screens be added to deeper portions of the overburden aquifer, which currently only contains monitoring well screens in the uppermost portion.

The amount and type of additional evaluation needed as a result of our interpretations will in part depend upon which remedial alternative is selected and can be discussed in greater detail once that selection is made. In order to keep the process moving along, any additional work that is required can accomplished during the RD/RA phase of the project.

Response: The groundwater will be evaluated as two separate operable units (GWOU1 and GWOU2) as discussed during our meeting on 23 October 1996. The GWOU1 will contain the groundwater which flows under the east and west yards of the DRMO Yard, across Market Street and through the POL site area (AOC 43A). The GWOU1 will contain the groundwater under the UST 13 area, which is east of the groundwater divide.

Additional monitoring wells will be installed and analytical data will be collected to further characterize GWOU1 and GWOU2 to determine if natural attenuation is occurring. This information will be collected during the RD/RA phase of the project.

Since the USEPA reviewed, commented, and approved the RI workplans and the RI Report, the claim that "insufficient consideration" was given to both "data and analysis in the RI/FS reports relative for the UST 13 area..." seem inappropriate at this time. However, the Army does plan to collect additional information at both the UST 13 and DRMO Yard/POL Storage areas during the RD/RA phase as discussed during our meeting on 23 October 1996.

Comment 2: The ARARS Tables will need to be upgraded and expanded. Typically in an FS, separate ARARs Tables (action, chemical, & location-specific) are created for each alternative evaluated. Further, in rebuttal to your response on our previous ARAR table comment, Table 508 of the Final Shepley's Hill Landfill FS contains an acceptable format, as does the Final FSs for both Barnum Road Maintenance Yard and AOCs 43G & J. Please review these examples and include the proper format in the revised FS.

Response: Individual tables will be developed for each operable unit as requested, using examples from one of the FSs cited.

SPECIFIC COMMENTS

Comment 3: Page 1-12, Section 1.2.1.4: Please update the second paragraph based on the intended reuse for this area from the 1994 reuse plan.

Response: The text has been amended based on the November 1996 Reuse Plan.

Comment 4: Page 1-25, Section 1.3: POL Yard groundwater might need to be considered for remedial action because of the potential migration of CERCLA contaminants from DRMO Yard and possibly UST-13.

Response: An operable unit for POL Storage Area/DRMO Yard groundwater has been considered for remedial action, and text has been added to the study.

Comment 5: Page 2-7, Section 2.4.3: In that this is a CERCLA cleanup, the EPA Risk Range of 10E4 to 10E6 should have been used, not 10E5.

Response: The text has been modified to state that a 10E4 to 10E6 range has been used.

Response to Comments on
DRAFT FEASIBILITY STUDY
FUNCTIONAL AREA II
AOC 32 AND AOC 43A
FORT DEVENS, MASSACHUSETTS
(March 1995)

January 1996

Comments Received From:

UNITED STATES ENVIRONMENTAL PROTECTION AGENCY (EPA)
MASSACHUSETTS DEPARTMENT OF ENVIRONMENTAL PROTECTION (MDEP)

(NOTE: Comments were retyped exactly as submitted.)

EPA COMMENTS

GENERAL COMMENTS

Comment-1: During the review of the RI for Functional Area I & II, EPA provided a general comment that agreed with the conclusions and recommendations concerning AOC 43A, POL Storage Yard. However, as part of this agreement, EPA suggested that the remainder of the POL Area be paved to prevent further contamination of the surface/subsurface soils and exposures to site workers. The Army did not agree with these additional measures in their response. Even though the risks presented by 43A are acceptable, we still think it would be prudent for the Army to consider paving the remainder of POL Yard.

Response: Paving the POL area would have little or no impact on human health risks, which were found to be minimal. The risk assessment revealed only one pathway (unfiltered groundwater consumption by future site workers) which exceeded the current recommended EPA risk threshold of 10^{-4}. Paving the area would have no impact on a worker's exposure to groundwater. The exceedance of the threshold was slight (1.9×10^{-4}), and the scenario is so improbable that it is not worth consideration. Furthermore, the risk is based on beryllium, which was only detected once above the detection limit and was found at much lower concentrations (below the detection limit) in filtered samples. The beryllium levels almost certainly represent the natural presence of beryllium sorbed onto aquifer particles (the one sample with a beryllium level above the detection limit had high concentrations of a variety of metals).

Three additional pathways, all for soil, exceeded the 10^{-5} threshold, favored by MDEP, being used in the revised FS for the determination of cleanup goals. One of these pathways, future construction workers (performing excavations, etc.), would not be mitigated by paving. For the other two pathways, (current and future site workers), the risks were due almost entirely to incidental ingestion. These risks were based on the presence of five PAHs in one sample and arsenic in another sample. The PAHs were detected from 2 to 4 μg/g, below the candidate cleanup goal of 7 μg/g (based on a 10^{-5} risk threshold) and well within the range normally found in areas near fossil fuel combustion sources. This sample is much more likely to reflect ambient conditions at Fort Devens than a source of contamination. Arsenic, which was consistently found in background samples, was detected at a high concentration (210 μg/g) in one sample. This detection level is ten times greater than background, which is the cleanup goal. This sporadic detection is much more likely to represent natural variation than site contamination. In summary, the risks from contamination detected in soils did not greatly exceed the MDEP threshold for any pathway and were due to the highly sporadic detection of a naturally occurring metal and the low level contamination of five organics which are commonly found in urban areas. It is not appropriate to perform any remedial action in response to these "risks".

Three pathways were identified as having a hazard index greater than 1. Two of them are for worker consumption of groundwater (filtered and unfiltered) both highly unlikely scenarios since area users are served by municipal wells. Moreover, the risks were due to manganese, which was detected at its highest concentration in a background well north of AOC 32 (indicating its natural presence) and lead, which had drastically reduced concentrations in filtered samples (indicating its presence as particulate matter).

The other pathway is future construction workers' exposure to soil, and the hazard index value is the result of arsenic, which is not considered a significant contaminant, as discussed above. Paving would have no impact on any of these pathways.

Comment-2: Section 2 is fairly comprehensive and presents a very logical approach to establishing clean-up goals. A narrative section on key ARARs - CERCLA, RCRA, HSWA, etc would be beneficial. Identification of areas and volume of environmental media based on the established clean-up goals would also be very helpful. Table 2-1 through 2-3 are very useful.

Response: Noted. A discussion of several key ARARs has been added to the revised FS. Areas and volumes of contamination are presented in Section 2 of the FS, in the discussion of cleanup goals and exceedances.

Comment-3: Section 4 - Based on the FS format established in the NCP, the screening stage should be based on effectiveness, implementability and relative costs. Although cost evaluation is the least important factor of the three at this stage, you do not present cost information in Section 4 as established by the NCP format.

Response: Section 4 has been reformatted to explicitly include discussions on effectiveness, implementability, and relative cost.

Comment-4: Section 5 - Back-up cost estimating calculations are not provided.

Response: More detail on the cost estimates, including back-up information, has been added to the revised FS.

Comment-5: The ARARs Tables and discussions need upgrading. Please see recent examples of EPA-approved FSs such as the Shepley's Hill Landfill FS.

Response: This comment is non-specific and is not explained by other comments. It seems to be inconsistent with general comment 2. It is unclear exactly what "upgrading" the commenter is hoping to see. Some detail regarding background information on key ARARs has been added to the revised FS. The ARAR discussion in the Shepley's Hill Landfill FS does not include any tables or discussion regarding ARAR selection and cleanup goal development.

SPECIFIC COMMENTS

Comment-1: Section 1.2.1.3, Page 1-3, Paragraph 4: The Nature and Extent of Contamination section frequently refers to "screening values" without clearly defining or explaining what they are. A brief explanation of these values would be appropriate.

Response: The following summary has been placed at the beginning of Section 1.2.1.3 and referenced in Section 1.2.2.3.

During the RI, screening values were compiled by E & E for each analyte for comparison against sampling results. Most screening values were based on chemical-specific ARARs identified for this project by Oak Ridge National Laboratories, although where no ARARs existed, other levels to be considered (TBCs) were used. E & E developed a set of numerical criteria, entered the values into the Site Master Database, and ran a comparison of analytical results for each medium against the screening values. Screening values are not intended to be cleanup goals, i.e. goals used to identify areas requiring remediation. These are developed in Section 2 of the FS. Screening values are merely used to identify areas where contamination may exceed regulatory levels and to assist in the nature and extent of contamination discussions.

A detailed discussion of the ARAR selection process and the development of screening values can be found in Section 7 of Volumes II and III of the Functional Area II RI report (E & E 1994). A summary of ARARs by medium is provided here:

- **Soils: Massachusetts Contingency Plan (MCP) Method I was identified by Oak Ridge National Laboratories as an ARAR, and was used for the screening values of contaminants in soil. Where no values existed, the EPA Region III risk-based concentrations (RBCs) for commercial/industrial soils were used as screening values. For lead, the EPA Interim Guidance on Soil Lead Cleanup levels at Superfund sites was used.**

- **Sediment: There are no promulgated maximum allowable concentrations for chemicals in sediments under Massachusetts or Federal Law. Therefore, results were compared to screening values developed for soils.**

- **Surface Water: From surface water, the lowest of two levels identified in the Clean Water Act (CWA) Ambient Water Quality Criteria (AWQC) was chosen: one for the protection of human health from risks due to water and fish consumption, and a second for the protection of aquatic organisms in freshwater due to chronic effects. The AWQC criteria were identified as ARARs by Oak Ridge National Laboratory.**

- **Groundwater: Screening values in groundwater were based on the lowest of the following criteria: Safe Drinking Water Act (SDWA) Maximum Contaminant Levels (MCLs), the Massachusetts MCL (MMCL), MCP GW-1 water standards, the SDWA MCL Goal (MCLG) and Massachusetts Secondary MCL (SMCL). All were identified as chemical specific ARARs by Oak Ridge. Where no ARAR existed, SDWA SMCLs, EPA Office of Water Lifetime Health Advisories (HA), and Massachusetts Office of Research and Standards Guidelines (ORSG) were reviewed. Although these standards are only TBC guidance, the lowest value was selected.**

Comment-2: Section 2.4.1, Page 2-3, last paragraph: The Massachusetts Contingency Plan (MCP) should be considered for applicability as an ARAR for the site. The February 1, 1995 MCP has soil and groundwater standards which may be relevant to the site.

Response: Subsequent to this comment being submitted, EPA has determined that the MCP should not be used as an ARAR.

Comment-3: Section 2.7.1, Page 2-8, last paragraph: The 210 mg/kg concentration of arsenic noted in this paragraph appears to significantly exceed the cleanup goal of 19 mg/kg specified for the site. Also the report focuses solely on lead and PCBs and dismisses other contaminants (arsenic, beryllium and PAHs) noted in Table 2.1 as exceeding cleanup goals. Please provide the rational for dismissing these contaminants. This further supports General Comment 1 and the request for additional measures at this site.

Response: The text has been amended to note that one detection of arsenic was significantly above the cleanup goal. The only contaminant detected above cleanup goals in AOC 43A soils was arsenic (PAHs no longer exceed cleanup goals, which are now based on an acceptable risk threshold of 10^{-5}, as favored by MDEP). Because only one arsenic detection greatly exceeded cleanup goals (the same detection was responsible for the identified risk) and there is no identifiable source of contamination, no remedial action is warranted for AOC 43A soils. Beryllium was responsible for the identified risk in groundwater. However, as described in the FS Section 1.2.2.4 and in the response to general comment 1, it is not appropriate to perform remedial action for this contaminant which is almost certainly naturally present. Furthermore, it does not exceed cleanup goals for either soil or groundwater.

The report focuses on lead, cadmium and pesticides (in the revised FS), and PCBs because these were the contaminants causing problems in AOC 32 soil (which is the only soil operable unit carried through the FS). The rationale for dismissing other contaminants detected above cleanup goals at AOC 32 is included in the revised text (Section 2.7.2.3). Essentially, arsenic did not significantly exceed the cleanup goals at AOC 32, and it appears that they are naturally occurring. Regardless, most of the areas where these detections occurred will be handled by the proposed remedial action anyway. The

pesticides above cleanup goals (DDT, DDD, and DDE) were detected in the northeast portion of the east yard and are considered in the revised FS.

Comment-4: Section 3.2.5.3, Page 3-5, 3rd paragraph: Asphalt batching should be considered a remedial action technology in this section. Asphalt batching would be a logical choice at this site based on the contaminants involved, the media contaminated (soil and asphalt) and the fact that asphalt batching has been successfully used as a remediation technique at Fort Devens.

Response: Asphalt batching has been added to Section 3.2.5.3.

Comment-5: Section 4.1.4, Page 4-3, 3rd paragraph: See comment above.

Response: In response to Comment-4 asphalt batching was added to Section 3.2.5.3 but was subsequently screened out based on implementability concerns and therefore is not included in any alternative in Section 4.

Comment-6: Section 5.1.3.1, Page 5-6, 4th paragraph: Consolidation of the material into a much smaller area would seem a more logical approach to minimize the area to be capped and minimize final cover costs.

Response: It is true that additional excavation of soils would reduce the size of the area requiring cover. However, this would have negative impacts on the short-term effectiveness of this alternative. It would result in increased dust production which could pose a hazard to the community. In addition, it may be preferable to minimize the higher grade resulting from the cap, in order to provide for sufficient runoff control while maintaining usage of Cook Street. Finally, although increased consolidation would reduce the capping costs, this savings would be significantly offset by the increased excavation and verification sampling costs.

Comment-7: Section 5.1.4.1, Page 5-11, 1st paragraph: TCLP testing would have to be modified to include PCBs as an analysis parameter since they are not included in the standard suite of parameters analyzed.

Response: The recommendation for TCLP testing has been amended to include analysis for PCBs. However, no regulatory level exists for PCB TCLP analysis. An action level for PCB leaching from the solidified mass would need to be negotiated between the EPA and the Army.

Comment-8: Section 5.1.4.1, Page 5-11, 2nd paragraph: Placing a layer of solidified material six inches below the ground surface without designing a means for controlling precipitation infiltration will likely result in problems with frequent saturation of the overlying topsoil. This issue must be addressed at some point in the design process.

Response: Agreed. This section has been amended to introduce the issue of drainage and the need to address it in the design process.

Comment-9: Section 5.1.4.2, Page 5-12, 3rd paragraph: Please verify the last sentence in the paragraph is, in fact, intended to refer to PCBs regarding a permanent solution. The initial discussion indicated the permanent solution was for lead.

Response: The last sentence in this paragraph does, in fact, refer to PCBs (and pesticides). This alternative is certainly considered permanent for lead (and cadmium), which will bind chemically to the cement matrix, and therefore be essentially removed from the soils. Organic compounds will not bind chemically to the matrix, they will be physically bound. Therefore, if infiltrating rainwater were able to pass through the monolith, some organic constituents could potentially dissolve and be transported out of the matrix. However, PCBs (and pesticides) are highly insoluble and are noted for their extreme partitioning to solid particles. Therefore, it is very unlikely that detectable quantities of PCBs (and pesticides) would leach out of the cement matrix, even if considerable amount of rainwater were to percolate through. For these reasons, this alternative can be considered a permanent solution for PCBs (and pesticides). The discussion in Section 5.1.4.2 has been clarified to make this point.

Comment-10: Section 5.1.5.1, Page 5-13, last paragraph: Since TCLP testing has not been performed, it is premature to state that there are no RCRA hazardous wastes. It is possible that the soil could fail TCLP testing based on lead concentrations and be classified as a hazardous waste based on the Toxicity Characteristic.

Response: Extraction Procedure (EP) toxicity characteristics testing was performed on the most contaminated soils during the SI. All soils were negative for EP toxicity. It is therefore unlikely that they would fail TCLP. Nevertheless, this section has been revised to include the possibility that both lead and cadmium could fail TCLP tests.

Comment-11: Section 5.1.6, Page 5-15, 3rd paragraph: Alternative A2 does not eliminate exposure routes to the environment, although ecological risks are concluded to be low. The use of the word (as in EPA comment) "minimize" rather than "eliminate" with regard to risks would be more appropriate.

Response: Alternative A2 would not have any effect on ecological risks, although, as stated in the comment, ecological risks are minimal to begin with. A2 would, however, significantly reduce risks to human health. The word "eliminate" has been replaced with "minimize".

Comment-12: Section 5.1.6,, Page 5-15, 4th paragraph: Explain how the no action alternative (A1) will eliminate the possibility that the RCRA action-specific ARAR would apply.

Response: The RCRA action-specific ARAR refers to the placement of excavated soils failing RCRA characteristics in RCRA-landfills. The No Further Action alternative, which does not include the excavation of soil, would eliminate the possibility that this ARAR could apply.

Comment-13: Section 5.1.6, Page 5-15, 5th paragraph: In the second to last sentence, based on the evaluation of Alternative A4 the "uncertain" effect on volume would be an increase.

Response: The text has been changed. However, as discussed in Section 5.1.4.1, it is not certain that the volume would increase.

Tables 5-3 through 5-9

The cost tables were reviewed and the following comments were noted:

- Additional details or backup information is necessary to fully review/check the tables. For example, sample analytical parameters associated with monitoring activities are important to accurately evaluate the costs.
- The validation costs appear to be low.
- The health and safety costs are low and do not appear to cover air monitoring equipment which can be a significant cost.
- PPE costs should be per person per day to be more accurate.
- The report text specifies an 18-inch thick cap layer while 24 inches is noted in Table 5-4.
- In Table 5-4, the Total O&M Present Worth is annual for 30 years, not 1 event in 5 years as noted on bottom line. Realistically, sampling frequency would probably decrease over time, if concentrations decreased.
- In Table 5-5, the Soil treatment unit cost of $150 per cubic yard appears high if bulk mixing is being proposed.

Response: Additional details and back-up information have been included in the revised FS. The comments pertaining to validation, health and safety, PPE, total O & M present worth, and soil treatment unit costs have been reviewed, and the text and tables amended as necessary. In addition, the inconsistency between the text and Table 5-4 regarding the cap layer depth has been corrected.

APPENDIX A

Comment 7: Section 4 references to "No Action" should also be revised to "No Further Action" for consistency.

Response: This alternative has been changed to "No Further Action" throughout the text.

Comment 17: Protection of the community description should mention air monitoring activities proposed during excavation activities.

Response: The text has been amended to include air monitoring activities.

MDEP COMMENTS

GENERAL COMMENTS

Comment-1: The MADEP concurs with the development of and retention of a remedial alternative for the AOC 32 soils, containment via capping (A3). Although this remedial alternative is based upon the Toxic Substance Control Act (TSCA), the MADEP notes that the selection of this alternative would also meet MCP based cleanup goals.

Response: Note also that two other remedial actions were retained for AOC 32 soils, Excavation, Solidification, and On-site Disposal (A4), and Excavation and Off-Site Disposal (A6).

Comment-2: The MADEP maintains its position that 310 CMR 40.000 should be designated as an ARAR when it is the more stringent regulation consistent with the requirements of CERCLA 121 (d) (2) (A) (ii), especially where remediation of petroleum hydrocarbons is outside CERCLA purview. MCP Method 1, a previously acknowledged ARAR for oil contaminated sites, provides particular petroleum standards and 310 CMR 40.0996(5) provides upper concentration limits (UCL) for certain contaminants including those at FA II.

In light of the exceedences of the standards cited above, the lack of a retained remedial alternative for contaminated groundwater in the UST 13 grave should be readdressed. The Army's decision to not remediate groundwater at this location, based on low well yield, might be premature in that the feasibility of groundwater collection and treatment has not yet been examined. The analyzed presence of TPH, trichloroethylene and dichlorobenzene in excess of MCP standards is problematical.

The MADEP notes that the most recently available groundwater flow model indicates groundwater flow in the AOC 32 area to be towards the northeast which potentially allows the transport of AOC 32 contaminants to the Fort Devens Grove Pond Well Field. Historically these wells have shown some indication of impacts due to synthetic organic contaminants. In addition, the estimated lifetime cancer risk (ELCR) to a future site worker from the UST 13 groundwater of 5.2×10^{-3} exceeds the MCP ELCR of 1×10^{-5} promulgated in 310 CMR 40.0993(6).

Response: EPA has determined that the MCP is not an ARAR for these sites. The revised FS includes several alternatives which address the contaminated groundwater at UST 13. Groundwater flow at UST 13 is fairly complex, but it flows to the northeast toward Shepley's Hill Landfill and Plow Shop Pond and it cannot impact the Grove Pond well field at current rates of pumping.

Comment-3: The MADEP is concerned with the proximity of AOC 43A to the McPherson Well draft Zone II. The MADEP notes the potential for contaminated site soil, in excess of MCP upper concentration limits, to leach into the water table and impact the underlying aquifer. A review of the estimated excess cancer risks associated with AOC 43A detailed in the FA II remedial investigation note exceedences of the MCP promulgated ELCRs for both soil and groundwater exposures. The exceedences of the MCP ELCR limit combined with the potential for further groundwater contamination require the consideration of remedial alternatives for the site.

Response: The response to specific comment 4 discusses the McPherson well and the most recent groundwater model. See responses to specific comments 6 and 7 for a discussion of the risk estimates at AOC 43A. The recently completed particle tracking model shows that the POL area could have only negligible impact on the McPherson well (see specific comment response no. 4). Therefore, no alternatives were developed for AOC 43A.

SPECIFIC COMMENTS

Comment-1: Section 1.2.1.1, Page 1-2, Paragraph 3: The MADEP recommends that the Army consider conducting a radiological survey of the yard on the east side of Cook Street due to the former use of the area as a motor vehicle scrap yard.

Response: A radiological survey has been performed, and the results have been included in Section 1 of the revised FS.

Comment-2: Section 1.2.1.3, Page 1-4, Paragraph 2: Arsenic concentrations in excess of screening values appear to be present in at least four subsurface soil samples as opposed to the one sample mentioned in the report. Samples with high arsenic concentrations include 32B-92-08X, 32B-92-09X, 32B-92-11X and 32B-92-12X. Please edit.

Response: The text is correct as written. Arsenic screening samples were exceeded in the 10-foot sample from 32B-92-08X and the 5-foot sample from 32B-92-15X. One test pit sample (32E-92-01X) in the UST area also had elevated arsenic.

Comment-3: Section 1.2.1.3, Page 1-6, Paragraph 4: The MADEP recommends that the report note that concentrations of TPH and dichlorobenzene were also analyzed in groundwater samples collected from 32M-92-06X and 32M-92-04X in excess of MCP reportable quantities. Trichloroethylene was noted in groundwater from 32M-92-06X in excess of MCP Method 1 standards.

Additionally, the MADEP notes that the most recent round of groundwater sampling from 32M-92-04X indicated a TPH concentration of 360,000 ug/l. This points to a substantial presence of organics in the area which would require remedial activity.

Response: This section has been revised to specifically mention these detections. However, please note that the EPA has determined that the MCP is not an ARAR.

Comment-4: Section 1.2.1.4, Page 1-9, Paragraph 2: The MADEP recommends that the report note the presence of arsenic in excess of background values in groundwater samples from 32M-92-06X and 32M-92-07X. Although the report states that any future use of area groundwater as drinking water is unlikely, the western portion of the site is immediately adjacent to the draft Zone II of the McPherson well based on the Preliminary Zone II Analysis for Production Wells at Fort Devens (ETA, January 20, 1994). The MADEP recommends a meeting to discuss all available Zone II data to determine if the site could have a potential impact on area drinking water supplies.

Response: Arsenic is discussed both in Section 1.2.1.3 (Nature and Extent of Contamination) and in Section 1.2.1.4 (Human Health Risk Assessment Summary). Arsenic

exceeded screening values and was primarily responsible for the estimates of risk due to the future usage of groundwater. However, as discussed in Section 1.2.1.3, as well as in Section 5.4.2 of the RI, arsenic is clearly related to particulate matter in the aquifer. Arsenic concentrations dropped dramatically in filtered samples, often by several orders of magnitude, to below the detection limit. Also, based on the correlation between aluminum, iron, and the other heavy metals, it appears that arsenic is naturally occurring. As discussed in Section 1.2.1.4, as well as in Section 8.5.2.2 of the RI, the human health risks are considerably lower when filtered data are used. Furthermore, Section 8.5.4 of the RI discusses risks associated with exposure to ambient levels of arsenic, which far exceed EPA acceptable risk thresholds.

A solute transport model was recently completed by Engineering Technologies Associates, Inc. (ETA) to assess the possibility that contamination from AOC 43A could impact the McPherson well. ETA's report is included as an appendix to the revised FS. The report analyzes the potential for xylene, the only contaminant confirmed in groundwater samples at AOC 43A, to impact the McPherson well. The analysis accounts for retardation, dispersion, and biodegradation. The model shows that all of the xylene will degrade before leaving the POL area, far upgradient of the well, using conservative decay rates. Even when retardation, dispersion, and biodegradation effects are ignored, the model predicts maximum xylene concentrations in McPherson well of only 1.29×10^{-3} $\mu g/L$, which is not even detectable. Moreover, the model is extremely conservative, using the highly unrealistic scenario of pumping McPherson well at 1,000 gallons per minute for 180 days without any aquifer recharge. Finally, the model would actually overestimate the impact of arsenic at AOC 32 on the McPherson well. AOC 32 is further from McPherson well than AOC 43A, and arsenic will be hindered by stronger sorption effects than xylene. Thus, the model clearly demonstrates that the contaminants at AOCs 32 and 43A cannot have any measurable impact on the McPherson well.

Comment-5: Section 1.3, Page 1-21, Paragraph 4: No remedial alternatives for UST 13 groundwater were noted in the Feasibility Study. Please note our general comments.

Response: Several remedial alternatives for UST 13 groundwater have been developed in Section 4.2 of the revised FS.

Comment-6: Section 1.3, Page 1-21, Paragraph 5: The MADEP does not concur with the recommendation for No-Remedial-Action at AOC 43A. The presence of heavy metals and organics in site soils as detailed in Section 1.2.2.3 of this report combined with an excess lifetime cancer risk (ELCR) of 1×10^{-4}, which exceeds the Massachusetts ELCR of 1×10^{-5}, requires development of remedial alternatives for site surface soils. The MADEP recommends nomination of 310 CMR 40.0993(6) as an ARAR, which states requirements for Massachusetts cumulative cancer risk limits.

Response: As stated in the comment, the excess lifetime cancer risk (ELCR) associated with AOC 43A soils was estimated at 1×10^{-4}. The 10^{-5} threshold was exceeded in two

other pathways at AOC 43A. The ELCR for all three were due entirely to arsenic and PAHs (detected in only one sample). (Similarly, the maximum health index (HI) calculated for AOC 43A soils was due to arsenic.) However, as previously stated, the detections of PAHs and arsenic were extremely sporadic. As discussed in the RI (FAII, Vol II, Section 8.5.3), arsenic is a naturally occurring metal, and estimated daily exposures to arsenic would correspond to an estimated cancer risk of up to 1 x 10^{-3} and a health index of 2.4. Arsenic was consistently detected in background samples and was detected at a high concentration (210 μg/g) in only one sample. PAHs are common in areas exposed to vehicular traffic and the maximum concentrations (2 to 4 ppm in only one sample) are similar to those found in other traffic areas and below the candidate cleanup goal of 7 μg/g (based on 10^{-5} risk threshold). In summary, the detections of arsenic and PAHs are sporadic, and in most cases very slightly elevated. The presence of these compounds is clearly associated with ambient conditions and not a contaminant source. The time and expense required to implement a remedial program for a non-existent source is clearly unwarranted.

The subsurface screening samples indicated three plumes of TPHC and/or BTEX contamination. However, confirmatory sampling did not confirm any of the field screening for BTEX, and only two of the three TPHC plumes were confirmed. The lack of confirmation for TPHC in the other plumes was attributed either to a high "background" of TPHC during the field screening or to variability in the screening analysis. BTEX compounds were not detected at any concentration in any of the laboratory-analyzed surface or subsurface samples. Where TPHC and BTEX detected by the field screening were unconfirmed, the screening results were not considered usable for the risk assessment or the feasibility study. The screening samples were limited to assessing likely "hot spots," in order to place boreholes for laboratory analysis. At the eastern and western TPHC plumes, the screening samples appear to reflect site conditions, based on one laboratory analysis of samples from two boreholes. However, the plumes clearly are not migrating off site, and, as discussed in the response to Comment-4, the ETA model shows that contaminants will not impact McPherson well. Petroleum hydrocarbons are generally very degradable and sorb more strongly than xylenes. Even more importantly, all of the TPHC was encountered at depth, so the suggestion in the comment that remedial alternatives are required for surface soils is not accurate.

Comment-7: Section 2.7.1, Page 2-8, Paragraph 2: The MADEP continues to be concerned with the analyzed presence of BTEX, TPH, and arsenic in AOC 43A groundwater and recommends that the presence of these contaminants be addressed in the section.

Response: The detections of BTEX and TPHC at high concentrations in the field screening samples were not confirmed in groundwater samples taken from completed monitoring wells. Wells were completed in the "hot spots" as revealed by the field screening, but the well samples showed only very sporadic hits at concentrations much lower (by orders of magnitude) than those found in the screening samples. In fact, the groundwater screening samples were determined to not be representative of the groundwater conditions, based on sampling methodology. Borings were advanced with an auger

bit until the water table was reached. Groundwater filled the hole, and this water was sampled. Any contamination which may have been present in the soils would be free to fall down into the water in the bottom of the bore hole. Therefore, it is not possible to differentiate between contamination in the groundwater and contamination in the soils (BTEX was also not confirmed in soil samples) from field screening samples. Furthermore, it was not possible to purge the water samples obtained with field screening methodology, as is normal protocol for well sampling. Therefore, TPHC and BTEX were not found to be above cleanup goals after groundwater screening samples not confirmed in monitoring wells were eliminated from consideration.

Arsenic was detected above its screening value in approximately half of the unfiltered samples. However, the concentrations dropped dramatically, usually to below the detection limit, in all of the filtered groundwater samples. This clearly shows that the arsenic is naturally occurring and sorbed to mineral particles in the matrix. Further evidence to support this is provided by the high correlation between aluminum and iron and all of the heavy metals. Such correlation would be expected in environments with a significant mineral presence. There would be no reason to develop remedial alternatives for naturally-occurring metals, which are immobilized within the aquifer matrix.

These detections are discussed further in Section 1. Because the unconfirmed BTEX and TPHC detections are not useable for the risk assessment or feasibility study, it is not appropriate to discuss them in Section 2.7, where cleanup goals are discussed. Because arsenic does not exceed cleanup goals at POL, it is not discussed either. Moreover, the ETA model (see response to Comment-4) clearly indicates that contamination in the POL groundwater will not impact the McPherson well, or even migrate off site. Although the model was performed on xylenes, it is relevant for TPHC, which is also biodegradable and generally more sorbing.

<u>Comment-8</u>: Section 4.2.5, Page 4-9, Paragraph 4: Although AOC 32 UST Grave 13 groundwater treatment was dropped by the Army as an alternative in the screening document for FAs I and II, due to low expected yield, the MADEP continues to recommend that the Army consider analyzing the feasibility of potential remedial alternatives for the contaminated groundwater in the bedrock. The contaminant persistence and increased concentrations at this site exceed the Massachusetts upper concentration limits (UCL) of 100,000 ug/l. The MADEP recommends that 310 CMR 40.0996(5), which details UCLs be nominated as an Applicable or Relevant and Appropriate Requirement (ARAR).

Since the groundwater contamination is moving very slowly, a low yield recovery well may be quite acceptable. Therefore, the MADEP recommends that the Army retain remedial alternative B-4, Capping and Groundwater Extraction with Off-Site Treatment.

Response: Several remedial alternatives for UST 13 groundwater have been developed in Section 4.2 of the revised FS. The feasibility of these alternatives is discussed there. As stated above, EPA has determined that the MCP is not an ARAR. The alternatives were developed not because of the UCL exceedance but because the PCBs and chlorobenzenes

exceed cleanup goals, result in ELCRs exceeding 10^{-4}, and represent contamination from the former UST. For AOC 43A soils and groundwater, on the other hand, no source is present to explain the risks to human health due to arsenic and PAHs, which only slightly exceed the 10^{-5} threshold and reflect ambient conditions.