PROGRAM MANAGER
ROCKY MOUNTAIN ARSENAL

U.S. ARMY
MATERIEL COMMAND

—COMMITTED TO PROTECTION OF THE ENVIRONMENT—

FINAL DETAILED ANALYSIS OF ALTERNATIVES REPORT

Version 4.1

Soil DAA
Volume II of VII

October 1995

Contract No. DAAA 05-92-D-0002

FOSTER WHEELER ENVIRONMENTAL CORPORATION

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TECHNICAL SUPPORT FOR
ROCKY MOUNTAIN ARSENAL

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DIRECTORY

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LIST OF ACRONYMS AND ABBREVIATIONS

14DCLB	1,4-Dichlorobenzene
3-D	three-dimensional
ACGIH	American Conference of Governmental Industrial Hygienists
ACM	asbestos–containing material
ALDRN	Aldrin
AMC	Army Materiel Command
AOC	Area of Contamination
AOPs	advanced oxidation processes
AR	Army Regulations
ARARs	applicable or relevant and appropriate requirements
Army	U.S. Army
atm-m^3/mol	atmospheres per cubic meter per mole
ATP	Anaerobic Thermal Processor
ATSDR	Agency for Toxic Substances and Disease Registry
B	Soil Density
BCRL	Below Certified Reporting Limit
BCS	Boundary Containment System
BCY	bank cubic yard
BDA	Bilateral Destruction Agreement
BDAT	best demonstrated available technology
BEST	Basic Extraction Sludge Treatment
BFI	Browning Ferris Industries
BOD	Biological Oxygen Demand
BRRN	North Bedrock Ridge Plume
BRRS	South Bedrock Ridge Plume
BTEX	benzene, toluene, ethylbenzene, and xylenes
BTU	British thermal unit
CAMU	Corrective Action Management Unit
CAR	Contamination Assessment Report
CCA	chromated-copper-arsenate
CCR	Code of Colorado Regulations
CD	Cadmium
CERCLA	Comprehensive Environmental Response, Compensation, and Liability Act
cfm	cubic feet per minute
CFR	Code of Federal Regulations
CFS	Confined Flow System
CH2CL2	Methylene Chloride
CHCL3	Chloroform
CL6BZ	Hexachlorobenzene
CLC2A	Chloroacetic Acid
cm/sec	centimeters per second

cm^2	centimeters squared
CMP	Comprehensive Monitoring Program
COC	contaminant of concern
CPE	chlorinated polyethylene
CPMS	p-Chlorophenylmethyl Sulfide
CPRP	Chemical Personnel Reliability Program
CRL	certified reporting limit
CSI	Conservation Services, Inc.
CSPE	chlorosulfonated polyethylene
Cu	copper
CWA	Clean Water Act
CWC	Chemical Weapons Convention
CY	cubic yards
DA	Department of the Army
DAA	Detailed Analysis of Alternatives
DADS	Denver Arapahoe Disposal Service, Inc.
db(A)	decibels
DBCP	dibromochloropropane
DCE	Dichoroethylene
DCPD	dicyclopentadiene
DDE	2,2-bis(p-Chlorophenyl)-1,1-dichloroethene
DDT	2,2-bis(p-Chlorophenyl)-1,1,1-trichloroethane
DHHS	Department of Health and Human Services
DIMP	diisopropylmethyl phosphonate
DMMP	Dimethylmethylphosponate
DNAPL	dense nonaqueous phase liquid
DOD	Department of Defense
DOT	Department of Transportation
DRE	destruction/removal efficiency
DRMO	Defense Reutilization and Marketing Office
DSA	Development and Screening of Alternatives
DTG	Design treatment goal
DWELS	Drinking Water Equivalent Levels
EA	Endangerment Assessment
Ecology	U.S. Ecology, Inc.
EDSVEP	Enhanced Deep Soil Vapor Extraction Process
EIF	enter into force
ENSCO	Environmental Systems Company
Envirosafe	Envirosafe Services of Idaho, Inc.
EOD	Explosive Ordnance Disposal
EPA	U.S. Environmental Protection Agency
ERC	Ecological Risk Characterization
ESSVEP	Enhanced Surface Soil Vapor Extraction Process

ETTS	Ecotechniek Thermal Treatment System
FC2A	fluoroacetic acid
FFA	Federal Facility Agreement
FML	flexible membrane liner
foc	Fraction Organic Carbon in Soil
fpm	feet per minute
FRP	fiber - reinforced plastic
FRG	final remediation goal
FS	feasibility study
ft	feet or foot
ft/day	feet per day
ft^3	cubic feet
GAA	granulated activated alumina
GAC	granular activated carbon
GB	isopropylmethylphosphonofluoridate (nerve agent-sarin)
GIS	Geographical Information System
GMP	Groundwater Monitoring Program
gpm	gallons per minute
H:V	horizontal to vertical
H_2O_2	hydrogen peroxide
HA	Health Advisories
HBCs	Health based criteria
HBr	hydrogen bromide
HCCPD	hexachlorocyclopentadiene
HCL	hydrochloric acid
HCPD	Hexachloropentadiene
HD	mustard
HDPE	high-density polyethylene
HE	high explosive(s)
HEP	habitat evaluation protocol
HEPA	high efficiency particulate air
HF	hydrofluoric acid
HHEA	Human Health Exposure Assessment
HHRC	Human Health Risk Characterization
HI	hazard index
ICP	inductively coupled plasma
ICS	Irondale Containment System
IDLH	Immediately Dangerous to Life and Health
IEA	Integrated Endangerment Assessment
IITRI	IIT Research Institute
IMPA	Isopropyl Methylphosponic Acid
INCS	Internal Containment System
IRA	interim response action

IT	International Technology
IWT	International Waste Technologies
Kg	Kilogram
K_{oc}	partition coefficient
Kp	Partitioning Coefficient for Soil
kW	Kilowatt
kWh	Kilowatt hour
L	Lewisite
lbs	pounds
lbs/acre	pounds per acre
LCY/hr	loose cubic yards per hour
LCY	loose cubic yards
LDR	land disposal restriction
LF	linear foot
LNAPL	light nonaqueous phase liquid
LT^3	Low-Temperature Thermal Treatment
LTTA	Low-Temperature Thermal Aeration
MCL	Maximum Containment Level
MEXCLR	Methoxychlor
mg/l	milligrams per liter
mg/m^3	milligrams per cubic meter
mg/kg	milligrams per kilogram
mg/cm^3	milligrams per cubic centimeter
MGL	milligrams per liter
MKE	Morrison–Knudsen Engineering
ml/g	milliliters per gram
mm	millimeters
MMBTU	million British thermal units
MOU	Memorandum of Understanding
MPA	Methylphosphonic Acid
mph	miles per hour
MTR	minimum technology requirement
n	Total Porosity
NaOH	sodium hydroxide
NAPL	Nonaqueous Phase Liquid
NBCS	North Boundary Containment System
NCP	National Contingency Plan
NDMA	Nitrosodimethylamine
NEPA	National Environmental Policy Act
NNDMEA	N-Nitrosodimethylamine
NWBCS	Northwest Boundary Containment System
O&M	operations and maintenance
OAS	Organizations and State

°C	degrees Centigrade
OCP	organochlorine pesticides
°F	degrees Fahrenheit
OPHGB	organophosphorus compounds, GB-agent related
OPHP	organophosphorus compounds; pesticide related
OSCH	organosulfur compounds; herbicide related
OSCM	organosulfur compounds; mustard agent related
OSHA	Occupational Safety and Health Administration
PAHs	polynuclear aromatic hydrocarbons
PBC	probabalistic biota criteria
PCB	polychlorinated biphenyl
pcf	pounds per cubic foot
PCP	pentachlorophenol
PDA	Pilot Demolition Assessment
PEC	plume evaluation criteria
PKPP	potassium pyrophosphate
ppb	parts per billion
PPDDE	dichlorodiphenyldichloroethylene
PPDDT	dichlorodiphenyltrichloroethane
PPE	personal protective equipment
PPLV	preliminary pollutant limit value
ppm	parts per million
ppt	Parts per Trillion
PQL	practical quantitation limit
PRG	preliminary remediation goal
psi	pounds per square inch
PVC	polyvinyl chloride
QA/QC	quality assurance/quality control
RAO	remedial action objective
RC	Risk Characterization
RCRA	Resource Conservation and Recovery Act
RF	radio frequency
Ri	Retardation Factor
RI	remedial investigation
RISR	Remedial Investigation Summary Report
RMA	Rocky Mountain Arsenal
ROD	Record of Decision
RPO	representative process option
SACWSD	South Adams County Water and Sanitation District
SAR	Study Area Report
SARA	Superfund Amendments and Reauthorization Act
SCC	Secondary Combustion Chamber
SEC	Site evaluation criteria

SF	square feet
SFS	Supplemental Field Study
Shell	Shell Oil Company
SHO	Semivolatile halogenated organics
SITE	Superfund Innovative Technology Evaluation
SPNP	South Plants North Plume
SPNS	South Plants North Source Plume
SPSE	South Plants Southeast Plume
SQI	submerged quench incinerator
STC	Silicate Technology Corporation
STF	South Plants Tank Farm
SVE	soil vapor extraction
SVOCs	semivolatile organic compounds
SY	square yards
TBCs	to be considered criteria
TCLP	toxicity characteristic leaching procedure
TEA	triethylamine
TEC	Target Effluent Concentration
TIS	transportable incineration system
TMV	toxicity, mobility, and volume
TOC	total organic carbon
tpd	tons per day
TSCA	Toxic Substances Control Act
TSD	Treatment Storage and Disposal
TSGM	two-step geometric mean
UFS	Unconfined Flow System
μg/g	micrograms per gram
μg/l	micrograms per liter
USCS	Unified Soil Classification System
USDA	U.S. Department of Agriculture
USFWS	U.S. Fish and Wildlife Service
USGS	U.S. Geological Survey
USPCI	U.S. Pollution Control, Inc.
UST	Underground Storage Program
UV	ultraviolet
UXO	unexploded ordnance
VAO	volatile aromatic organic compounds
VHC	volatile hydrocarbon compounds
VHO	volatile halogenated organics
Vi	Velocity of Component i in Aquifer
VOC	volatile organic compound
VX	ethyl s-dimethyl aminoethyl methyl phosphonothiolate
WES	Waterways Experimental Station

Section 1

1.0 INTRODUCTION

The Detailed Analysis of Alternatives (DAA) for the soil medium at Rocky Mountain Arsenal (RMA) was performed to provide the basis for the identification of the preferred alternatives for the Record of Decision (ROD). The DAA is the final step of the overall remedial investigation/feasibility study (RI/FS) being conducted at RMA. The FS is being conducted in accordance with the provisions of the Comprehensive Environmental Response, Compensation and Liability Act (CERCLA) (EPA 1988) as amended by the Superfund Amendments and Reauthorization Act (SARA), the National Contingency Plan (NCP) (EPA 1990a), the National Environmental Policy Act (NEPA) (1988), the RMA Federal Facility Agreement (FFA) (EPA et al. 1989), and U.S. Environmental Protection Agency (EPA) guidance. The FS is designed to develop protective, cost-effective, and technically feasible remedial alternatives that address contamination identified during the RI and subsequent studies.

The DAA report is divided into five parts: Executive Summary and Introduction (Volume I); separate volumes for Soil (Volumes II-IV), Water (Volume V), and Structures (Volume VI) Media; and Technology Descriptions and ARARs (Volume VII). The Soil DAA report further defines the alternatives selected in the Soil Development and Screening of Alternatives (DSA) (EBASCO 1992b), which is the first step of the FS process, by evaluating the alternatives based on the DAA evaluation criteria, as provided in the NCP (EPA 1990a), and by performing a comparative analysis of the alternatives, and selecting a final remedy for the soil medium.

The soil medium consists of unsaturated soil, bedrock, fill material, process water lines, chemical and sanitary sewer lines, lake sediments, and soil/debris mixtures in disposal trenches or landfills. The term "soil", used for convenience in this document, refers to any of these materials. The Soil DAA also considers interactions with other media of concern at RMA—water and structures—where it is clear that interactions occur among the media.

This report is divided into the following sections:

- Section 1—Describes the purpose of the DAA, overall background of RMA, remedial action objectives (RAOs), site evaluation criteria, characterization of sites, and detailing of alternatives.

- Section 2—Describes the approach to dealing with interactions between the soil medium and the surface water, groundwater, structures, biota, and air media.

- Section 3—Describes the methodology employed in the Soil DAA as well as changes in approach since the DSA was conducted.

- Section 4—Provides a discussion of the modifications to the alternatives retained in the DSA and a detailed description of all alternatives used for the soil medium groups.

- Sections 5 through 19—Present the evaluation of alternatives for each medium group and subgroup and identify alternatives to be considered in the development of sitewide alternatives.

- Section 20—Provides a summary of the sitewide alternatives, presents the evaluation of each sitewide alternative, and documents the selection of a preferred alternative.

1.1 PURPOSE

The overall objective of the RI/FS process is to gather information sufficient to support an informed risk management decision regarding the most appropriate site remedies (OERR-EPA 1988). To that end, it is the objective of the DAA to select a preferred alternative based on an evaluation and comparison of alternatives that achieve the RAOs and are protective of human health and the environment. Accordingly, the DAA serves to accomplish the following:

- It further defines each alternative retained in the DSA (EBASCO 1992b), as necessary, with respect to the volumes or areas of contaminated media to be addressed, the technologies to be used, and any performance requirements associated with those technologies.

- It assesses each alternative against the DAA evaluation criteria identified in the NCP (EPA 1990a) and defined in EPA guidance (OERR-EPA 1988).

- It performs a comparative analysis among the alternatives to evaluate the relative performance of each alternative with respect to each evaluation criterion and with respect to each other.

- It selects one or more alternatives for each medium group or subgroup, based on the comparative analysis, to be considered in the development of sitewide alternatives.

- It develops and evaluates a range of sitewide alternatives, and selects a preferred alternative

The Soil DAA is completed in a sequential process, the steps of which are described in more detail in Section 3. Due to the complexity of RMA sites and the unique combinations of contaminants, the standard EPA guidance steps are adapted to site-specific conditions. At RMA, for example, "medium groups" were used to identify and evaluate remedial alternatives for soil sites, groundwater plumes, and structures having similar historical usage and/or containing similar contaminants and contaminant distributions. Additional RMA-specific modifications to the DAA process are necessary to integrate the three contaminated media—soil, water, and structures—because the proposed remedial alternative for soil may have a critical impact on proposed alternatives for both water and structures. Therefore, the Soil DAA develops sitewide alternatives that integrate soil, groundwater, and structures alternatives into overall RMA remediation alternatives.

The seven criteria used to evaluate the alternatives in the DAA, which are discussed in detail in Section 3.2 of the DAA Executive Summary, include the following:

1. Overall protection of human health and the environment

2. Compliance with ARARs

3. Long-term effectiveness and permanence

4. Reduction in toxicity, mobility, and volume (TMV)

5. Short-term effectiveness

6. Implementability

7. Present worth cost

The remaining two EPA evaluation criteria, state and community acceptance, are formally addressed as part of the responsiveness summary in the ROD.

1.2 BACKGROUND

RMA was established in 1942 by the U.S. Army (Army) and was used as a manufacturing facility for the production and dismantling of chemical and incendiary munitions. Industrial and agricultural chemicals, primarily pesticides and herbicides, also were manufactured at RMA by several lessees, most notably Shell Oil Company (Shell).

The introduction to the DSA (EBASCO 1992b) summarizes the history of manufacturing operations at RMA as well as the administrative and regulatory compliance actions undertaken at RMA, including the FFA (EPA et al. 1989), RI/FS, and interim response actions (IRAs). The complete history of RMA is described in detail in the Final Remedial Investigation Summary Report (RISR) (EBASCO 1992a). In addition to the RISR, the nature and extent of soil contamination at RMA is addressed on a site-by-site basis in the contaminant assessment reports (CARs) and study area reports (SARs).

Of particular importance to the RI/FS, the FFA (EPA et al. 1989) prohibits certain land-use activities at RMA including residential development, consumption of game and fish taken at RMA, use of groundwater as a potable water source, and agriculture activities (except for those related to erosion control or remediation). The agreement outlines specific goals for implementing IRAs and for conducting the RI/FS that ensure that the provisions of CERCLA are met, provide that a health assessment be conducted by the Agency for Toxic Substances and Disease Registry (ATSDR), and ensure that health-based remediation goals are met. The FFA (EPA et al. 1989) also states that the goal for future land use at RMA is to set aside large areas of land as open space. On October 9, 1992, RMA was designated as a future National Wildlife Refuge (upon completion of cleanup), (RMA 1992) which significantly constrains potential future land use.

Following initial investigations, contamination sources were identified and initial source-control actions were developed. Soil actions included controlling fugitive dust emissions from the basins and removing portions of the chemical sewer system. In addition to the source-control actions, and in accordance with the FFA (EPA et al. 1989), 14 IRAs were established for implementation prior to the ROD. Section 2.2 of the DAA Executive Summary Volume describes these IRAs. The IRAs were designed to provide immediate containment or treatment of some of the more highly contaminated areas, thus minimizing the potential for exposure to or migration of contamination.

Four of the IRAs directly impact the evaluation of soil remedial alternatives in the DAA:

- Installation of a soil cover to contain the Lime Settling Basins in Section 36
- Installation of a soil cover and vertical barrier to contain the Shell Trenches and reduce migration of groundwater away from the trenches
- Excavation of 580,000 bank cubic yards (BCY) of sludges and contaminated soil from Basin F and placement of the materials in a double-lined and covered wastepile
- Installation of a soil cover to contain the contaminated soil remaining in Basin F

During the course of the on-post RI, nearly 14,000 samples were collected, including more than 9,600 soil samples from more than 4,000 borings. Samples were analyzed for as many as 60 specific chemical analytes and were screened for hundreds of others. The RI results are presented in more than 230 reports that are summarized in the Final RISR (EBASCO 1992a). Additional information gathered during the evaluation and implementation of IRAs and ongoing monitoring programs, has also been used by both the Integrated Endangerment Assessment/Risk Characterization (IEA/RC) and the FS.

In addition to the analytical information collected through the drilling and sampling program, considerable amounts of nonanalytical information were collected from both Army and Shell records, operations logs, and employee interviews. The qualitative information was used to supplement the quantitative information in the assessment of site risk and site remediation.

The bulk of the contamination is contained in the central sections of RMA in and around the manufacturing complexes, solid waste disposal areas, and liquid waste basins. Data from the RI regarding the levels and extent of contamination were used in the IEA/RC to assess risks and develop preliminary health-based cleanup criteria and in the FS to develop and evaluate remedial alternatives for RMA.

During the course of the FS, certain data needs were identified. These included determining all contaminant levels in surficial soil (0-2 inches deep); verifying detections of fluoroacetic acid (FC2A) during the RI; additional screening of sites with potential agent presence; and verifying previous sampling data. In addition, a number of treatability studies were performed. These additional data were necessary to more thoroughly develop and select the preferred alternative for on-post soil. The structures pilot demolition program, which was designed to evaluate structure sampling, decontamination, and demolition methods, also provided information used in evaluation of soil remedial alternatives for those soil sites that interact with the structures medium.

In 1989, the Army initiated the FS for the on-post operable unit at RMA. The FS developed a range of remedial alternatives in accordance with EPA guidance (OERR-EPA 1988) and the NCP (EPA 1990a). This range of alternatives, and the results of screening these alternatives based on effectiveness, implementability, and cost, were presented in the DSA report (EBASCO 1992b), which was issued in final form on December 21, 1992.

During the DSA, alternatives were developed and screened for each of the soil medium groups identified as posing an unacceptable risk to human health or biota, and both quantitative and qualitative criteria were used to evaluate risk and identify the appropriate remedial alternatives. During the DAA, the alternatives from the DSA report (EBASCO 1992b) are analyzed in further technical detail and are compared using the EPA criteria outlined in the NCP (EPA 1990a) and CERCLA guidance (OERR-EPA 1988 and EPA 1988) in a process that ultimately leads to the selection of a preferred sitewide alternative for RMA.

Section 121(d) of CERCLA establishes a process for developing and selecting remedial actions that are protective of human health and the environment. For human health, remedial actions are defined as protective if they limit the excess lifetime cancer risk to between 10^{-4} and 10^{-6} for an individual potentially exposed to carcinogenic contaminants, and if they limit the adverse noncarcinogenic effects to a hazard index (HI) value of less than or equal to 1.0 for an individual for a lifetime or partial lifetime exposure (EPA 1990a Section 430(e)(2)). As part of the RMA RI/FS, the IEA/RC was performed to determine potential risk to humans and biota from exposure to RMA soil. Section 1.4 presents the results of the IEA/RC, including the identification of contaminants of concern (COCs) for both humans and biota; Section 1.4 also discusses the physical hazards associated with unexploded ordnance (UXO) and the acute chemical hazards associated with agent.

1.3 REMEDIAL ACTION OBJECTIVES

To ensure that the FS process results in the selection of remedial alternatives that are protective of human health and the environment, the NCP (EPA 1990a) requires that RAOs and preliminary remediation goals (PRGs) be established based on applicable or relevant and appropriate requirements (ARARs) and other directives, standards, or guidance to be considered (TBCs) (EPA 1990a).

At RMA, RAOs must be broad enough in scope to allow the development and evaluation of a range of remedial alternatives. RAOs were developed on a medium-specific basis to focus the development, evaluation, and selection of remedial alternatives that minimize potential threats to human health and the environment. For the soil medium, RAOs were developed during the DSA that defined a level of protectiveness for human and ecological receptors based on exposure to contaminated soil and sediments and based on the provisions of the FFA (EPA et al. 1989).

The RAOs identified for the soil medium are the following:

Human Health Protection

- Prevent ingestion of, inhalation of, or dermal contact with soil or sediments containing COCs* in excess of on-post remediation goals.**

- Prevent inhalation of COC* vapors emanating from soil or sediments in excess of on-post remediation goals** for the vapor pathway, as established in the on-post human health risk characterization

- Prevent migration of COCs* from soil or sediment that may result in off-post groundwater, surface water, or windblown particulate contamination in excess of off-post remediation goals.

- Prevent contact with physical hazards such as UXO.

- Prevent ingestion of, inhalation of, or dermal contact with acute chemical agent hazards.

Ecological Protection

- Ensure that biota are not exposed to COCs* in surface water, due to migration from soil or sediment, at concentrations capable of causing acute or chronic toxicity via direct exposure or bioaccumulation.

- Ensure that biota are not exposed to COCs* in soil and sediments at toxic concentrations via direct exposure or bioaccumulation.

1.4 SITE EVALUATION CRITERIA

To evaluate the protectiveness of a remedial alternative, site evaluation criteria (SEC) are used to determine when remedial actions are warranted at a site and the goals to be achieved by a remedial action. These criteria are used to determine which sites may require remedial action and are to be evaluated as part of the DAA. As discussed in the DSA (EBASCO 1992b) and summarized in Section 1.4.2, SEC are used to evaluate human health exposure and are based on

* COCs are defined as those contaminants specifically identified through the on-post Human Health Risk Characterization and the Ecological Risk Characterization, and the off-post endangerment assessment.

** The development of preliminary and final remediation goals, in accordance with the NCP, is an ongoing process requiring continual evaluation of site-specific conditions and evolving health-based criteria and regulatory standards. Remediation goals may change as the FS progresses. Preliminary remediation goals are currently being established for the on-post and off-post operable units through the evaluation of ARARs, human health risk-based criteria, Army regulations, the FFA, ecological risk-based criteria, ambient concentrations of naturally occurring or anthropogenic chemicals, and detection or remediation technology limits.

an excess human health cancer risk greater than 10^{-4}, and a noncarcinogenic human health HI of 1.0. In addition, the SEC included an acute human health exposure HI of 1.0 for near-surface soil (0- to 1-foot [ft] interval). The DSA (EBASCO 1992b) included specific evaluation criteria for biota relative to a HI of 10; however, the DAA evaluates the potential risks to biota estimated by integrating a revised food-web model with a geographic information system (GIS) program as reported in the Final IEA/RC (EBASCO 1994a), and described in Section 2.4 of the Executive Summary and Section 1.4.2.2 of this volume. The food-web model estimates specific biota receptor's soil exposure as a function of the receptor's foraging range. The DAA also considers the potential presence of agent and UXO as evaluation criteria.

Once the decision is reached to consider remedial actions, a range of remedial alternatives is evaluated against the PRGs to determine their protectiveness. The PRGs, discussed in Section 1.4.1, are risk reduction goals that are set at an excess cancer risk of 10^{-6} and a human health noncarcinogenic HI of 1.0. The PRGs represent the preferred residual risk, although a remedial alternative is considered protective if the residual risk is between the PRGs and SEC (i.e., the excess cancer risk is between 10^{-4} and 10^{-6}).

Both the PRGs and SEC are based on ARARs, human health risk-based criteria, Army regulations, ambient concentrations of naturally occurring or anthropogenic chemicals, and technical limitations. As defined in Section 121(d) of CERCLA, an ARAR is "any standard, requirement, criterion, or limitation under any Federal environmental law ... or ... any promulgated standard, requirement, criterion, or limitation under a State environmental or facility siting law that is more stringent than any Federal standard ... [that is] legally applicable to the hazardous substance or pollutant or contaminant or is relevant and appropriate under the circumstances of the release or threatened release" at the designated site.

At RMA, potential ARARs were identified according to the procedures outlined in the most recent EPA guidance (OERR-EPA 1988, EPA 1988) and the NCP (EPA 1990a). The ROD will identify the ARARs that will be attained by the selected remedies as well as any federal or state

ARARs that the selected remedies will not meet. In those circumstances in which an ARAR will not be attained, the ROD will also identify the waivers that will be invoked and the justification for invoking each waiver.

Potential location-, action-, and chemical-specific ARARs pertinent to the soil medium were investigated as part of the PRG identification process in the DSA (EBASCO 1992b). It was determined that the only chemical-specific ARAR for contaminants found in RMA soil is the Toxic Substances Control Act (TSCA) with regard to polychlorinated biphenyls (PCBs). The chemical-, location-, and action-specific ARARs are presented in Appendix A of the Technology Descriptions Volume (Volume VII). Land disposal restrictions (LDRs) are action-specific ARARs for alternatives that involve off-post treatment or disposal of wastes regulated under the Resource Conservation and Recovery Act (RCRA), or on-post treatment or disposal of wastes subject to LDRS (see Executive Summary, Section 3.3.1.4 for discussion).

In the absence of chemical-specific ARARs, human health risk-based criteria are the primary sources of PRGs and SEC. The Human Health PRGs and SEC are based on preliminary pollutant limit values (PPLVs) developed as part of the human health risk characterization portion of the IEA/RC. Specifically, the Human Health PRGs are based on the industrial worker and biological worker exposure scenarios for the Open Space land use, as discussed in the Soil DSA (Volume I) and Section 2.4 of the DAA Executive Summary.

The results of the quantitative evaluations must be interpreted within the context of the inherent limitations and uncertainties of the overall risk assessment process. The factors and assumptions contributing to the uncertainty of estimated risks include the following: limitations of the chemical database, the reliability of the methods used to estimate exposure concentrations, uncertainties in human and biota exposure scenarios used in the risk assessment, uncertainties in the dose-response models used to develop toxicity estimates, and the uncertainties in the models and parameters used to characterize risks. Given these uncertainties, parameters were assigned reasonable but conservative values to ensure protection of the potentially exposed populations.

Principal threat human health criteria are also evaluated in the DAA to focus the cleanup on the areas with the highest levels of contamination. As discussed in Section 1.4.3, the principal threat criteria consist of a 10^{-3} excess cancer risk and a noncarcinogenic HI of 1,000, and are applied to areas exceeding the Human Health SEC.

1.4.1 Preliminary Remediation Goals

PRGs are the chemical-specific criteria that identify the remediation and treatment goals that are capable of achieving the RAOs defined above. PRGs were identified in the DSA (EBASCO 1992b) phase of the FS process; however, as the FS progresses, PRGs may be modified or redefined as more information about the site and additional details on the performance of alternatives become available. Final remediation goals will be determined when the remedy is selected and the ROD is issued. The development of PRGs is an ongoing process requiring continuous evaluation of site-specific conditions and evolving health-based and regulatory standards. Human Health PRGs include the following:

- Achieve the reduction, elimination, or control of human exposure to COCs in residual contaminated soil exceeding the Human Health SEC so that the cumulative lifetime exposure risk does not exceed 10^{-6} for carcinogens (as a point of departure) or an HI of 1.0 for noncarcinogens.

- Achieve the reduction, elimination, or control of biota exposure to Biota COCs in contaminated soil that poses significant potential risks to biota based on the exposure range evaluation presented in the IEA/RC.

- Achieve overall remediation of RMA within a time frame goal of 10 to 30 years.

In accordance with the NCP (EPA 1990a, Section 300.430(e)(i)), PRGs were identified after considering ARARs, human health risk-based criteria, factors related to technical limitations (e.g., detection limits or treatment limits), ambient concentrations of naturally occurring or anthropogenic chemicals, reasonable future land-use scenarios, and ecological criteria. Table 1.4-1 lists the SEC and PRGs for human health. For each COC, the lower of the industrial worker or biological worker PPLVs for the future Open Space land-use scenario was used to determine Human Health PRGs (see EBASCO 1992b). The risk-based criteria for human health are based on two different exposure durations and soil-depth intervals: chronic exposure at the 0- to 10-ft interval and acute exposure at the 0- to 1-ft interval. Biota risks are evaluated by considering the exposure of biota over an exposure range as discussed in the ecological risk characterization portion of the Final IEA/RC report (EBASCO 1994a).

As discussed in the Soil DSA, the NCP (EPA 1990a) states that the acceptable exposure levels for a carcinogenic compound are between 10^{-4} and 10^{-6}. Once a decision is reached to evaluate remedial actions (based on exceeding the SEC), EPA (EPA 1991) states a preference for cleanups to achieve the more protective end of the range (i.e., 10^{-6} excess cancer risk). As a result, the Human Health PRGs are established at a 10^{-6} excess cancer risk and are to be met, consistent with the NCP (EPA 1990a). However, an alternative that reduces the residual risk to greater than 10^{-6}, but less than 10^{-4}, may be chosen based on site-specific circumstances.

1.4.2 Site Evaluation Criteria

A total of 178 soil contamination sites were identified in the SARs (EBASCO 1989a–f), and two additional soil contamination sites were evaluated during the DSA (EBASCO 1992b). The first of these additional sites was the Basin F Wastepile, which was constructed in 1989 as part of the Basin F IRA. The second additional site was the Surficial Soil site (EBASCO 1991), which included potential contamination outside the boundaries of the SAR sites. In the DAA, a third site was also evaluated. As identified in the RISR, this site consists of soil beneath three buildings in North Plants with potential agent presence (EBASCO 1992a).

1.4.2.1 Human Health Site Evaluation Criteria

The NCP (EPA 1990a) indicates that acceptable exposure levels for suspected carcinogens are "generally concentration levels that represent an excess upper bound lifetime cancer risk to an individual of between 10^{-4} and 10^{-6}." EPA (1991) indicates that action generally is not warranted for sites with additive excess cancer risks less than 10^{-4} and an HI less than 1.0 for noncarcinogenic contaminants. Therefore, the SEC are defined as the additive excess cancer risks of COCs equal to 10^{-4} and/or additive noncarcinogenic HIs equal to 1.0. A boring-by-boring analysis was performed to identify the areas of each site, if any, that exceeded the SEC. Sites with contaminant concentrations that result in exceedances of these criteria are termed exceedance sites, and their contaminants and resultant volumes are referred to as exceedance COCs and exceedance volumes. Table 1.4-1 presents both the Human Health SEC (EBASCO 1994a), which are based on a 10^{-4} excess cancer risk and noncarcinogenic HI of 1.0, as well as the Human Health PRGs, which are based on 10^{-6} excess cancer risks. The Human Health SEC are based on the lower of the industrial or biological worker PPLVs for each COC.

Acute (one-time exposure) risks were calculated as part of the Human Health Exposure Assessment Addendum (EBASCO 1992c) using a methodology different from the IEA (deterministic, rather than probabilistic) and relatively conservative exposure parameters. Acute risk criteria were developed as a screening tool to ensure that no sites were designated as "no action" if they had potential acute risks. Since this was not the case, the draft final DAA did not include a site-by-site evaluation of acute risk exceedances. As a result of organization and state (OAS) comments on that document, however, which requested that potential acute risk exceedance areas be explicitly evaluated in the DAA, the acute risk criteria have been incorporated into the calculation of human health exceedance areas and volumes. Table 1.4-1 lists acute risk criteria where they are lower than the corresponding chronic risk SEC. In this version of the DAA, any acute risk exceedance areas are addressed as part of the alternatives developed.

1.4.2.2 Evaluation of Biota Risks

A number of unique concepts and methods were used in the ecological risk assessment portion of the IEA/RC to provide useful input to risk management decisions regarding the eventual cleanup of RMA. One of the objectives of the ecological risk assessment was to evaluate the spatial relationship of existing contamination and the estimated risks in order to establish a more realistic basis for future risk management decisions. To accomplish this objective, the potential risks to the primary biota receptors were estimated by integrating a food-web model with a GIS program. Because actual soil exposure conditions for biota populations are difficult to measure, the exposure soil concentrations were estimated by spatially averaging soil concentrations within "exposure areas," i.e., well-defined areas selected to correlate with the foraging range of the target biota receptor for which the risks were estimated. Through the use of the foraging-range-based exposure areas, exposures that ranged from hot spots to relatively clean areas were taken into account by quantifying contaminant biomagnification (contaminants such as organochlorine pesticides (OCPs) and mercury, which may bioaccumulate in biota tissue) throughout the various trophic levels of the food webs selected to represent contaminant impacts or potential risks to the RMA ecosystem.

The GIS-produced maps presented in the final IEA/RC provide an overview of the target biota that are potentially affected and show the spatial extent to which potential exposure and related risk could occur at RMA. In addition, the use of the GIS enabled approximate identification of contaminated areas driving the risks and enhanced the ability to make recommendations and decisions on the best approach regarding priorities for risk management and cleanup on the basis of potential biota impacts.

These estimates must be considered in conjunction with the inherent limitations and uncertainties surrounding assumptions as presented in Section 1.4 when applied to the actual extent of remediation. For example, risks to biota due to mercury, one of the driver contaminants, were calculated using the assumption that all mercury (100 percent) was in the more bioavailable, more toxic form of methylmercury. These risks were then translated into exceedance areas for use in the DAA. Recent soil sampling and analysis performed by Shell/Morrison Knudson Engineering (MKE) indicates that the methylmercury content in these soils is approximately 2.5 percent or less of total mercury present (Shell/MKE Letter Technical Report, November 1994). This information, if incorporated into the risk calculations and exceedance area estimates, would substantially reduce the areas of exceedance for all trophic levels (although aldrin/dieldrin still leads to the majority of the risk exceedance areas). This information, as well as other new information being developed under the Supplemental Field Study (SFS) and by USFWS, is important and will be considered in determining the extent of remediation for protection of biota health.

As described in Section 2.4 of the Executive Summary, areas of potential biota risk at RMA were calculated in the IEA/RC (EBASCO 1994a) for seven different species, each representing a different trophic box. Since the potential risk areas for each species are based on average concentrations (calculated on a 100-yard grid system over the entire area of RMA), these areas often do not contain high concentrations of contaminants throughout. Areas of potential biota risk were calculated in the IEA/RC by averaging contaminant concentration levels. The defined area of risk from excessive exposures can often be inflated by data from isolated hot spots (or smaller areas containing higher concentrations of contaminants), especially for species with larger home ranges. Consequently, the focused remediation of such heterogeneous, higher concentration areas would substantially reduce actual and projected biota risk based on this average mapping depiction.

Generally, the results of ecological risk assessment showed that the areas of highest potential risk are located in the central portions of RMA and are associated with major chemical manufacturing or a disposal area. However, the Army, Shell, and EPA developed different sets of biomagnification factors (BMFs) to use in estimating risks to wildlife. While all three estimates agree regarding risks in the central areas of RMA, they differ in their estimates of the extent and magnitude of ecological risk in other parts of RMA. The areas where one estimate predicts an unacceptable HQ while another does not is called the Areas of Dispute. Table 1.4-2 illustrates the effects different BMF values have in the calculation of "biota soil criteria". These values are not cleanup criteria—they represent soil COC concentrations that, if achieved on average over a foraging range, would yield HQs equal to one for that foraging range. The evaluation of which estimate is more accurate will be resolved by an ongoing study of contaminant concentrations in several species of wildlife within the Area of Dispute, since scientific differences of opinion remain on the approach to determining field BMF values and residual risk to biota for one of seven particular species under study.

While the SFS is being conducted, certain areas of higher concentration in surficial soil have been identified as candidates for initial focused remediation. These areas to be remediated through appropriate surficial soil remediation technologies are included in the green area on Figure 1.4-1. The process outlined in the Conceptual Agreement, and summarized below, will be followed to further investigate other identified areas of potential residual risk in order to more accurately characterize actual biota risk and impacts and to formulate only additional recommended remedial responses. This process includes the following:

- An FFA Subcommittee of technical experts from the Parties (such as ecotoxicologists, biologists, and range/reclamation specialists) will focus on the plans for and conduct of both the U.S. Fish and Wildlife Service (USFWS) biomonitoring programs and the Supplemental Field Study (SFS) risk assessment process. The Subcommittee will provide interpretation of results and recommendations to the Parties' decision makers.

- The ongoing USFWS biomonitoring programs and the SFS/risk assessment process will be used to delineate areas of surficial soil and aquatic contamination to be remediated.

    — Phase I and the potential Phase II of the SFS will be used to refine the general areas of surficial soil contamination concern called the Area of Dispute (Figure 1.4-1). The field BMFs will be used to quantify ecological risks in the area of dispute, identify risk-based soil concentrations considered safe for biota, and thus refine the area of concern.

    — Pursuant to the FFA process, USFWS will conduct detailed site-specific exposure studies of contaminant effects and exposure (tissue levels and Army-provided abiotic sampling) on sentinel or indicator species of biota (including the six key species identified in the IEA/RC). These studies will address both the aquatic resources and at least the surficial soil Area of Dispute. These site-specific studies will be used in refining contamination impact areas in need of further remediation.

    — Results from both the SFS/risk-assessment process and the site-specific studies will be considered in risk management decisions, which may further refine the areas of surficial soil and aquatic contamination to be remediated.

- The Subcommittee will analyze site-specific resource values, levels of contamination impact on biota, long-term/short-term impacts and benefits to biota, and/or engineering considerations to identify the most appropriate of the selected remedial options to implement and to evaluate the potential for site-specific exclusions from the remediation. The Subcommittee will make recommendations to the Parties' decision makers.

The remedy implementation will:

- Be staged, to allow habitat recovery.
- Be performed first on locations selected through a balance of factors such as:
  - — The parties agree an area has an impact on fish or wildlife
  - — The effort will not be negated by recontamination from other remediation activities
  - — The existing fish and wildlife resource value
- Include revegetation of a type specified by USFWS; if initial revegetation is not successful, make appropriate adjustments then again revegetate.
- Provide that the locations and timing of remediation are to be determined with consideration of and coordination with USFWS Refuge management plans and activities.

1.4.2.3 Potential Unexploded Ordnance or Army Agent Presence

Any site that potentially contains UXO or Army agent, as identified in the RISR (EBASCO 1992a) or subsequent sampling programs, is also identified as an exceedance site. The RISR considered historical site usage and agent-screening investigations performed during the RI to identify UXO and agent sites.

1.4.2.4 Evaluation Criteria Summary

In summary, the criteria for evaluating which sites require remedial actions are the following:

- Human Health SEC—Excess cancer risk greater than 10^{-4} and/or a chronic noncarcinogenic HI >1.0 for the 0- to 10-ft interval or an acute exposure HI >1.0 for the 0- to 1-ft interval
- Biota Risk—Based on exposure range risk evaluation and risk management approach discussed above
- UXO Presence—Known, expected, or potential presence of UXO
- Agent Presence—Known, expected, or potential presence of agent

From the total of 181 sites, 114 sites were identified as exceedance sites using these evaluation criteria considering potential impacts to human health, potential impacts to biota, potential presence of UXO, and potential presence of agent.

Some areas at RMA that are known to be highly contaminated and/or that present special safety concerns based on historical information were not extensively sampled. Consequently, a qualitative assessment was conducted to identify areas of concern that were not addressed in the quantitative assessment. The qualitative assessment focused on the following areas: sites with potential agent or UXO presence, drum disposal sites, underground storage tanks (USTs), burn sites, trenches, sanitary landfills, and spill sites. Additionally, the chemical database was re-evaluated to identify sites where exposure to tentatively identified compounds/unknowns and other chemicals not selected as COCs could pose potential unquantified risks. Results of the qualitative assessment were used to document qualitative risks for sites included in the current FS process to ensure all potential risk areas are considered in the FS and to evaluate the 67 FS no-action sites to identify any potential qualitative risk not considered in the determination of the no-action designation.

1.4.3 Principal Threat Criteria

The concept of a principal threat is developed in the preamble to the NCP (EPA 1990a) and EPA guidance documents (OERR-EPA 1991). Although EPA guidance allows for considerable interpretation in identifying specific sites or areas as principal threats, the EPA fact sheet, A Guide to Principal Threat and Low-Level Threat Wastes (OERR-EPA 1991), provides the following general definitions of principal threats, low-level threats and source material as well as guidance on determining the threat of a source material:

Principal Threats—

> ... those source materials considered to be highly toxic or highly mobile that generally cannot be reliably contained or would present a significant risk to human health or the environment should exposure occur. They include liquids or other highly mobile materials (e.g., solvents) or materials having high concentrations of toxic compounds. No

"threshold level" of toxicity/risk has been established to equate to "principal threat." However, where toxicity and mobility of source material combine to pose a potential [excess] cancer risk of 10^{-3} or greater, generally treatment alternatives should be evaluated.

Low-Level Threats—

> ... those source materials that generally can be reliably contained and that would present only a low risk in the event of release. They include source materials that exhibit low toxicity, low mobility in the environment, or are near health-based levels.

Source Material—

> ... material that includes or contains hazardous substances, pollutants or contaminants that act as a reservoir for migration of contamination to groundwater, to surface water, to air, or acts as a source for direct exposure. Contaminated groundwater generally is not considered to be a source material although non-aqueous phase liquids (NAPLs) may be viewed as source materials.

Additional guidance includes the following:

> ... Determinations as to whether a source material is a principal or low-level threat waste should be based on the inherent toxicity as well as a consideration of the physical state of the material (e.g., liquid), the potential mobility of the wastes in the particular environmental setting, and the lability and degradation products of the material. However, this concept of principal and low-level threat waste should not necessarily be equated with the risks posed by site contaminants via various exposure pathways. Although the characterization of some material as principal or low-level threats takes into account toxicity (and is thus related to degree of risk posed assuming exposure occurs), characterizing a waste as a principal threat does not mean that the waste poses the primary risk at the site. For example, buried drums leaking solvents into groundwater would be considered a principal threat waste, yet the primary risk at the site (assuming little or no direct contact threat) could be ingestion of contaminated groundwater.

Principal threats, as defined in EPA's Guide to Selecting Superfund Remedial Actions (EPA 1990b), include the following:

- Areas contaminated with high concentrations of toxic compounds

- Liquids and other highly mobile materials

- Contaminated media (e.g., sediment or soil) that pose a significant risk of exposure
- Media containing contaminants several orders of magnitude above health-based levels

The objective of identifying the principal threat wastes is to focus the cleanup on the areas of highest risk to human health and the environment. This is especially appropriate to RMA because many sites combine large areas of minimal or low-level contamination with small areas of high-level contamination that fall within the definition of principal threats. EPA's Guide to Selecting Superfund Remedial Actions (EPA 1990b) further explains this approach: "Areas on site with contaminant concentrations several orders of magnitude above these preliminary remediation goals are candidate areas for treatment. Areas on site with contaminant concentrations within several orders of magnitude of these preliminary remediation goal levels are candidate areas for containment."

However, according to the guidance (OERR-EPA 1991), identification of sites or areas of sites as principal threats does not necessarily imply treatment is required.

Specific situations that may limit the use of treatment include any one of the following:

- The treatment technologies are not technically feasible or are not available within a reasonable time frame.
- The extraordinary volume of materials or complexity of the site make implementation of treatment technologies impracticable.
- The implementation of a treatment-based remedy would result in greater overall risk to human health and the environment due to risks posed to workers or the surrounding community during implementation.
- Severe effects across environmental media would occur as a result of implementation.

Conversely, there may be situations where treatment will be selected for both principal threat wastes and low-level threat wastes.

Since 10^{-4} is considered by guidance to be within the acceptable risk range, the principal threat criteria for RMA soil were established at a 10^{-3} excess cancer risk and a noncarcinogenic HI of 1,000, which is consistent with the above-referenced definition of principal threat wastes. These levels are compared to the Human Health PRGs and SEC in Table 1.4-1. This definition of principal threat levels is consistent with the guidance because it is several orders of magnitude higher than the Human Health PRGs and because it allows an accurate assessment of principal threat areas. In addition, if an area fails to meet one of the other above-listed principal threat criteria, the area may be considered a principal threat regardless of established risk levels.

For the purposes of the DAA, all areas exceeding a potential risk of 10^{-3} are considered principal threats. The wording in the guidance that indicates that principal threat sites cannot be reliably contained was not used in making this determination. In fact, given the physical setting in which they occur, these sites can be reliably contained even though they could pose significant risk to human health or the environment should exposure occur. Thus, containment alternatives are evaluated for each of the principal threat sites. These areas can be reliably contained to provide long-term protection of human health and the environment, and the evaluation of alternatives for medium groups containing principal threat areas balances the short-term risks associated with treatment of principal threat volumes with the long-term risks associated with the containment of these volumes.

With the use of the principal threat approach, some alternatives developed in the DSA were modified to reflect treatment of the principal threat volumes and containment of the remainder of the site (full treatment alternatives are also retained and evaluated where applicable). An example of this modification is the installation of a cap at Basin A. In the DSA (EBASCO 1992b), Alternative 6: Caps/Covers consisted of containment of the entire site with a multilayer cap. In the DAA, a new containment alternative was added that includes the thermal treatment of all principal threat volumes followed by containment of the remaining exceedance area with a multilayer cap.

1.5 CHARACTERIZATION AND GROUPING OF SOIL SITES

A total of 178 potentially contaminated soil sites were investigated during the RI, and three sites were added during the FS as a result of additional IRA and RI investigation efforts. Of the 181 sites investigated, 114 were determined to require further evaluation in the FS based on the evaluation criteria described in Section 1.4.2. These 114 sites are organized into "exceedance categories" based on the soil evaluation methodology in the DSA (EBASCO 1992b). The four exceedance categories are as follows:

- Potential UXO Presence—Potential presence of UXO identified as the only evaluation criteria exceeded

- Potential Agent Presence—Potential presence of Army chemical agent identified as the only evaluation criteria exceeded

- Biota Risk—Potential risk only to biota based on the evaluations in the final IEA/RC (EBASCO 1994a)

- Human Health Exceedance—Exceedance of Human Health SEC, (EBASCO 1994a) although portions of these sites may also potentially contain UXO, potentially contain agent, and/or pose potential risks to biota

The large number of RMA sites were addressed in the DSA using "medium groups," which are groups of sites within each exceedance category that are similar in site type and contamination patterns (e.g., sanitary landfills with metallic debris and rubbish). The grouping of sites was modified during the DAA so that the screened alternatives from the DSA could be applied to the subgroups of sites in each medium group. Table 1.5-1 is a list of the medium groups and subgroups that were developed for each soil exceedance category based on the criteria outlined in Section 3.1.1.

1.6 DETAILING OF SOIL ALTERNATIVES

In keeping with the NCP (EPA 1990a), the DAA evaluated the range of potentially effective, implementable, and cost-effective remedial alternatives that were retained in the DSA. These alternatives vary in approach from no additional action to containment or treatment.

The level of detail describing the component process options in the alternatives retained in the DSA was increased in the DAA to permit the detailed analysis of alternatives according to the evaluation criteria. However, design-level details regarding the operation of treatment processes are not developed at this stage of the FS process since they are not required to properly evaluate the alternatives against the seven DAA evaluation criteria.

In the DAA, the time frame to construct and implement each alternative is listed. The overall time frame includes the time to obtain needed equipment and specialists, obtain and construct alternative components, perform system startup and testing, operate the system until remedial goals are met, and demobilize the alternative (if necessary). However, it should be noted that remediation of all medium groups/subgroups at RMA cannot be started simultaneously due to materials handling and process sequencing. Thus, while the alternative for a specific group may take 3 years to implement, it may not be initiated until year 6 of the cleanup, depending on the overall cleanup schedule. The overall time frame for cleanup is discussed in Section 20 as part of the development of sitewide alternatives.

The level of detail and accuracy of cost estimates for each alternative is also increased in the DAA. The capital and operating costs include the following cost items:

- Direct capital costs including construction, equipment, and buildings
- Indirect capital costs including engineering, permit compliance, startup, and contingency costs
- Annual operating and maintenance costs including operating labor, maintenance material and labor, materials and energy, disposal, sampling/monitoring, administrative, permit compliance, replacement equipment, and site review costs
- Long-term monitoring and maintenance costs including labor, materials, and replacement equipment

Since the DAA is the last step in the FS process leading to the ROD, the focus of the document includes a consideration of combined alternatives and integrated remedies (Section 3.0). For example, a centralized thermal desorption facility was considered in the DAA to take advantage of economies of scale when treating multiple sites. In another instance, the consolidation of soil from many sites under a single cap in Basin A was considered to avoid the installation of multiple caps and cap-monitoring requirements at scattered sites. As discussed in Sections 3.1.2 and 3.1.3, the cost efficiencies for centralized treatment or containment facilities are dependent on the volumes addressed at each facility. For the evaluation of alternatives on a medium group/subgroup level, the maximum volume that could be processed at a given facility is estimated for each medium group and the centralized facility is sized accordingly. However, the cost efficiencies associated with this evaluation would not be valid if the volumes to be processed were decreased dramatically. As a result, several sitewide alternatives are developed in Section 20 to properly evaluate the cost-efficiencies of centralized treatment and containment facilities for overall RMA remediation approaches. The sizing of centralized treatment and containment facilities for sitewide alternatives also includes wastes from structures and groundwater alternatives.

Alternatives carried forward from the DSA were also modified or simplified in the DAA when the characteristics of the medium group or subgroup would allow. For example, sites not contaminated with inorganics do not require solidification after organic contaminants are removed by thermal desorption. In these cases, the thermal desorption/solidification alternative was modified to include thermal desorption only.

The DAA also takes a consistent approach to the application of alternatives for soil that only poses a potential risk to biota. The inclusion of acute exposure levels for human health in the DAA has resulted in substantially lower residual concentrations of contaminants in soil that may pose a risk to biota than in the DSA. Because of this, several of the alternatives retained in the DSA for biota are not applicable in the DAA. These alternatives include both direct and in-situ thermal treatment. Section 4.5 provides a more detailed discussion of the alternatives considered for areas that only pose potential risks to biota.

Table 1.4-1 Soil Site Evaluation Criteria and Preliminary Remediation Goals (in ppm)

		Chronic Risk-Based Criteria 0- to 10-ft Interval		Acute and Subchronic Risk-Based Criteria 0- to 1-ft Interval (where lower than chronic)
Contaminants of Concern	Principal Threat Criteria	Site Evaluation Criteria	Preliminary Remediation Goals	Site Evaluation Criteria
Aldrin	720	71	0.72	3.8
Benzene	10,400	1,040	10	
Carbon Tetrachloride[1]	2,300	30	2.3	
Chlordane[1]	3,700	55	3.7	12
Chloroacetic Acid[1]	77,000	77	77	
Chlorobenzene[1]	850,000	850	850	
Chloroform[1]	48,000	370	48	
PPDDE	13,000	1,300	13	
PPDDT[1]	14,000	410	14	14
DBCP	200	8	0.2	
1,2-Dichloroethane	3,200	320	3.2	
1,1-Dichloroethene	520	52	0.52	
Dicyclopentadiene[1]	NA	3,700	3,700	
Dieldrin	410	41	0.41	3.7
Endrin[1]	230,000	230	230	56
HCCPD[1]	NA	1,100	1,100	
Isodrin[1]	52,000	52	52	
Methylene Chloride[1]	35,000	2,300	35	
1,1,2,2-Tetrachloroethane	1,500	150	1.5	
Tetrachloroethylene[1]	5,400	410	5.4	
Toluene[1]	NA	7,200	7,200	
Trichloroethylene	28,000	2,800	28	
Arsenic	4,200	420	4.2	270
Cadmium[1]	24,000	530	50	140
Chromium[1]	7,500	39	7.5	
Lead[1]	NA	2,200	2,200	
Mercury[1]	570,000	570	570	82

[1] SEC based on noncarcinogenic PPLV

Table 1.4-2 Biota Soil Criteria for the Bioaccumulative COCs[1,2]

A. Using Army BMFs

	Ald/Dld	DDT/DDE	Endrin	Mercury
Small Bird	2.3E+00	4.1E-02	4.7E-01	1.5E-01
Small Mammal	7.7E-01	3.5E-01	5.3E-01	2.1E-01
Medium Mammal	4.7E-01	4.4E-01	5.0E-01	1.4E-01
Kestrel	4.5E-01	4.4E-01	2.7E-01	5.2E-02
Great Horned Owl	1.2E-01	1.7E-02	9.9E-01	6.4E-02
Shorebird	4.1E+00	2.9E-02	5.2E-02	1.1E+00
Great Blue Heron	3.0E-01	1.3E+00	3.9E-01	1.3E-01
Bald Eagle	5.8E-02	1.1E-01	4.6E-01	2.4E-02

B. Using EPA BMFs

	Ald/Dld	DDT/DDE	Endrin	Mercury
Small Bird	4.8E-01	7.9E-03	5.7E-02	5.7E-02
Small Mammal	1.4E-01	4.9E-02	7.0E-02	3.6E-02
Medium Mammal	1.7E-01	6.2E-02	8.1E-02	4.0E-02
Kestrel	5.2E-02	7.8E-02	3.9E-02	9.0E-02
Great Horned Owl	2.3E-02	1.5E-03	6.3E-02	3.5E-03
Shorebird	7.2E-01	9.1E-03	4.6E-02	4.7E-02
Great Blue Heron	1.0E-01	3.6E-01	2.7E-01	1.2E-01
Bald Eagle	1.3E-02	9.9E-03	2.4E-02	1.0E-03

C. Using Shell BMFs

	Ald/Dld	DDT/DDE	Endrin	Mercury
Small Bird	1.3E+00	3.4E-02	4.1E-01	1.0E-01
Small Mammal	3.7E-01	2.6E-01	4.0E-01	6.7E-02
Medium Mammal	3.2E-01	3.3E-01	3.9E-01	6.7E-02
Kestrel	2.4E-01	3.2E-01	2.0E-01	2.4E-01
Great Horned Owl	1.4E-01	3.1E-03	2.2E-01	6.9E-02
Shorebird	3.1E+00	2.3E-02	8.7E-02	9.5E-02
Great Blue Heron	2.9E-01	8.2E-01	4.1E-01	1.3E-01
Bald Eagle	8.0E-02	1.9E-02	7.7E-02	2.1E-02

[1] This table presents the soil concentrations (ppm), that, if measured using sampling and laboratory procedures as in the RMA-IEA/RC, and if achieved on average over a foraging range, would yield HQ = 1 for the trophic box/COC in question at the grid point at the center of that foraging range.

[2] These values are not cleanup criteria, i.e., they do not represent the maximum soil concentrations that could be allowed without exceeding risk-based cleanup objectives. Proper interpretation of the biota soil criteria is provided in the IEA/RC (Ebasco 1994a).

Human Health Exceedance Category

- Basin A Medium Group

- Basin F Medium Group
  - Basin F Wastepile Subgroup
  - Former Basin F Subgroup

- Secondary Basins Medium Group

- Sewer Systems Medium Group
  - Chemical Sewers Subgroup
  - Sanitary/Process Water Sewers Subgroup

- Disposal Trenches Medium Group
  - Complex Trenches Subgroup
  - Shell Trenches Subgroup
  - Hex Pit Subgroup

- Sanitary Landfills Medium Group

- Lime Basins Medium Group
  - Section 36 Lime Basins Subgroup
  - Buried M-1 Pits Subgroup

- South Plants Medium Group
  - South Plants Central Processing Area Subgroup
  - South Plants Ditches Subgroup
  - South Plants Balance of Areas Subgroup

- Buried Sediments/Ditches Medium Group
  - Buried Sediments Subgroup
  - Sand Creek Lateral Subgroup

- Undifferentiated Medium Group
  - Section 36 Balance of Areas Subgroup
  - Burial Trenches Subgroup

Biota Exceedance Category

- Surficial Soil Medium Group

- Lake Sediments Medium Group

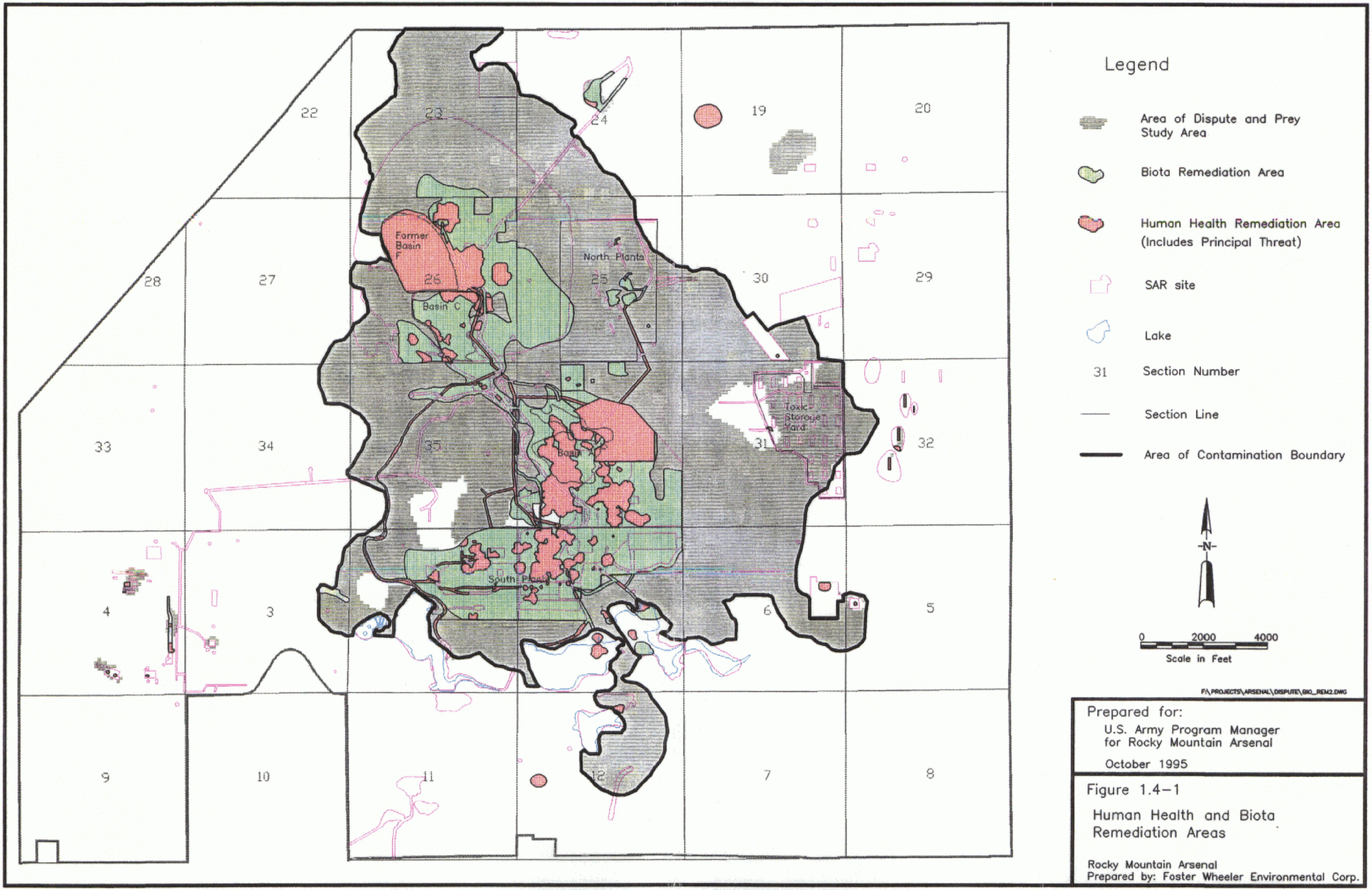
- Ditches/Drainage Areas Medium Group

Potential Agent Presence Category

- Agent Storage Medium Group
  - North Plants Subgroup
  - Toxic Storage Yards Subgroup

Potential UXO Presence Category

- Munitions Testing Medium Group



Prepared for:
U.S. Army Program Manager
for Rocky Mountain Arsenal

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Figure 1.4–1
Human Health and Biota Remediation Areas

Rocky Mountain Arsenal
Prepared by: Foster Wheeler Environmental Corp.

Section 2

2.0 MEDIA INTERACTIONS

This section describes the interaction between alternatives developed for the soil medium and those developed for the water and structures media, as well as the cross-media impacts of soil remediation on the biota and air media. As explained in the DSA (EBASCO 1992b), alternatives were not specifically developed for air and biota media since they are only affected by the remediation of the other three media. The interactions among soil, structures, and groundwater are evaluated as part of the development of sitewide alternatives in Section 20.

2.1 WATER/SOIL INTERACTION

Interactions between soil and water include impacts of soil alternatives on both surface water and groundwater as well as the impact of certain groundwater alternatives on soil.

2.1.1 Surface Water Interactions

The use of surface water is restricted by the FFA (EPA et al. 1989), so exposure potential is limited. The soil RAOs evaluate the migration of contaminants from soil to surface water that may result in off-post surface water contamination in excess of off-post remediation goals. Soil interactions with surface water are relatively direct: if surface water comes into contact with contaminated soil (e.g., in a ditch or pond), the contamination can, depending on the compounds involved, be readily transferred to water and transported to other sediments or surface-water bodies.

The sediment contamination in the lakes in Sections 1 and 2 of RMA, as well as the Havana Street Ponds in Section 11, is, in general, a result of surface-water transport of contaminants and contaminated soil and of periodic releases of process water into the cooling water system during manufacturing operations. The evaluation of contamination present in the lake sediments in the IEA/RC report (EBASCO 1994a) indicated that the sediments did not pose a discernable risk to aquatic biota. In addition, any contaminants present in the surface water appear to be related to contaminated runoff from South Plants and not from contact with lake sediments. Soil alternatives developed for the Lake Sediments Medium Group directly address these contaminated sediments (Section 7), and soil alternatives developed for South Plants Medium Group (Section 17) address the future reduction of contaminated runoff from soil in contaminated areas. The reduction of potential future impacts of contaminants in the Havana Ponds is outside the scope of this FS since the sources are not located on post.

2.1.2 Groundwater Interactions

The interactions between soil and groundwater at RMA are complex due to the number of sites potentially contributing to multiple groundwater plumes. The use of groundwater at RMA is restricted by the FFA (EPA et al. 1989), so exposure of humans to contaminated groundwater is limited. In addition, three groundwater systems have been installed at the boundaries of RMA to intercept and treat contaminated groundwater, and several systems have been installed at interior sites.

Certain soil alternatives directly impact groundwater alternatives and vice-versa. Soil alternatives that involve excavation in areas of shallow groundwater tables require the installation of dewatering wells and the treatment of extracted water at the CERCLA Wastewater Treatment Plant or another on-post system. Conversely, long-term groundwater dewatering alternatives lower water tables and may reduce the need for short-term construction dewatering related to soil alternatives (although area-wide dewatering may take many years, and soil remediation may be required before this is accomplished). Most of the interactions between soil and groundwater occur in Section 36 and South Plants.

For example, the shallow groundwater table in parts of Section 36 requires construction dewatering before contaminated soil can be excavated. The location of wells and the pumping rates are based on the Basin A/South Plants Groundwater Model, which is used in the Water DAA (Volume V) to evaluate groundwater control alternatives. These systems are installed several years before construction activities, and the water removed from these systems is treated at the CERCLA Wastewater Treatment Plant or a groundwater treatment plant constructed in the vicinity of Basin A/South Plants. The Water DAA evaluates several different groundwater removal and treatment systems in Basin A for long-term dewatering. The overlap of soil containment and treatment alternatives and long-term dewatering alternatives is noted in the detailed evaluation of alternatives for each medium group/subgroup. If the selected groundwater alternative consists of a long-term dewatering alternative, the location and removal rate of the dewatering alternative is evaluated in the development of sitewide alternatives (Section 20) to determine whether the long-term dewatering alternative can eliminate the need for construction dewatering related to soil remediation. The evaluation of soil and groundwater interactions in Section 36 also considers the presence of the Basin A Neck IRA downgradient of Basin A. The presence of this system influences the components required for the protection of groundwater during the construction of in situ containment alternatives.

Although the groundwater table is shallow in portions of South Plants, construction dewatering steps are not required prior to excavation activities in most areas. The Basin A/South Plants Groundwater Model indicates that the water table in South Plants will drop by 10 to 15 ft when the manmade recharge sources (i.e., leaking sewer lines) are removed. Similar to Basin A, the Water DAA considers several different groundwater removal and treatment systems in South Plants for long-term dewatering. The overlap of soil containment and treatment alternatives and long-term dewatering alternatives is noted in the detailed evaluation of alternatives for each medium group/subgroup in South Plants. If the selected groundwater alternative consists of a long-term dewatering alternative, the location and removal rate of the dewatering alternative is evaluated in the development of sitewide alternatives (Section 20) to ensure that the phasing of excavation activities and startup of the dewatering alternative are compatible.

In situ soil flushing alternatives require the controlled pumping, treatment, and reinjection of flushing solutions, which could require the modification of existing groundwater extraction and treatment systems. However, groundwater pump-and-treat alternatives could be integrated with soil flushing alternatives. Soil flushing is evaluated for Basin A and incorporates portions of groundwater alternatives for the Basin A Plume Group.

In addition to in situ flushing, other processes that form part of various soil alternatives generate liquid sidestreams requiring treatment. Some of these processes (e.g., soil washing) have the liquids-treatment unit built into the soil treatment system, with costs for treating the liquid sidestream included in the overall cost of the process. Others, e.g., in situ radio frequency (RF) heating, create liquid sidestreams that must be treated separately either on post or off post prior to discharge. These sidestreams can be treated along with contaminated groundwater. Soil and groundwater interactions such as these are identified as they occur in the evaluation of alternatives (Sections 5 through 19) and are specifically included in the evaluation of sitewide alternatives. The DAA Technology Descriptions Volume provides a detailed discussion of the soil and groundwater technologies themselves.

PCB-contaminated soil has been identified under the PCB IRA program. The results of this program are to be presented in the PCB IRA completion report. Concentrations used to identify PCB contamination and action levels are presented in Section A.5.0, Volume VII of this report (ARARs Section). Soil noted as PCB contaminated in this report will be disposed in accordance with TSCA requirements and guidance. The remediation activities for PCB-contaminated soil are dependent on the concentration and location:

- The three PCB-contaminated soil areas identified by the PCB IRA with concentrations of 250 ppm or greater will be removed. The limits of contamination will be determined based on visual evidence with immunoassay field confirmation sampling (SW-846).

- There are five PCB-contaminated soil areas identified by the PCB IRA with concentrations form 50 ppm to below 250 ppm. These areas will receive a minimum of 3 feet of soil cover, and the PCB-contaminated soil there will be left in place. The soil cover will be maintained as part of the wildlife refuge and is subject to the institutional controls of the FFA.

- No remaining areas of PCB-contaminated soil with concentrations above 50 ppm have been identified by the PCB IRA. If necessary, any suspected PCB soil contamination areas will be characterized further during the remedial design. If additional PCB-contaminated soil is found with concentrations of 50 ppm or above, the Army will determine any necessary remedial action in consultation with EPA.

2.2 STRUCTURES/SOIL INTERACTION

Unlike groundwater/soil interactions, structures alternatives are closely tied to soil alternatives because most of the structures at RMA are located in areas of soil contamination. Accordingly, if either a landfill disposal or treatment alternative is selected for contaminated soil associated with or underlying structures, these structures must be demolished and removed to reach the underlying soil. If an in-situ containment alternative is selected for the soil medium, the foundation and structural debris left in place could be covered with the cap. Alternately, if the No Additional Action or Institutional Controls alternative is selected for soil underlying structures, the structures may still be demolished in accordance with the alternative selected in the Structures DAA. The interaction between the soil and structures media primarily occurs in the South Plants and North Plants.

Due to economies of scale for all direct treatment processes, centralized facilities are to be constructed for the common treatment of soil from multiple medium groups (Section 3.1.2). These large facilities require from 1 to 2 years to design and construct, during which time structures can be removed from the site. Many of the planned or ongoing removal activities for process equipment, non-process equipment, materials containing PCBs and asbestos-containing materials (ACM) require many months to complete. These efforts are currently in the planning stages or are underway. In addition, some structures demolition alternatives include salvage, which could require additional time. This delay may not impact remediation if soil from sites not in proximity to structures is processed first, allowing additional time for structures remediation. While an initial evaluation of the phasing of remedial activities is presented in Section 20, the remediation phasing will be determined in the remedial design phase (following the ROD) to match available funding, maximize efficiency, and minimize time to complete cleanup.

2.3 BIOTA/SOIL INTERACTIONS

The areas of RMA that pose a potential risk to biota were delineated in the ecological risk characterization portion of the IEA/RC. The risk management approach to be taken in the DAA is described in Section 1.4.2.2, and soil alternatives are evaluated to specifically address the areas identified through this approach. In addition to the potential toxicological impacts, biota are also impacted through the modification or elimination of habitat resulting from soil remediation. Wildlife management and habitat management have been and continue to be important considerations in the selection of remedial strategies, particularly since RMA will become a National Wildlife Refuge following cleanup. While vegetation values over RMA vary, RMA continues to maintain one of the largest undisturbed wildlife populations along the Rocky Mountain Front Range due to the lack of human activity and intervention, large amounts of open space, and use restrictions specifically designed to benefit wildlife. Remedial activities at RMA, unless properly managed, could threaten these populations through the disruption of habitat, increase in human interaction, and elimination of areas for wildlife activity.

To account for habitat values and wildlife needs, technical assistance from the USFWS was requested. USFWS is performing habitat and vegetation surveys to determine ways to minimize the disruption of wildlife habitat. In addition, USFWS is preparing a refuge management plan that, when complete, will indicate areas that should be revegetated to a specific habitat value. Because RMA was recently designated a National Wildlife Refuge, the Army is attempting to minimize the number of areas that will be restricted to habitat or wildlife following remediation.

2.4 AIR/SOIL INTERACTIONS

As defined in the DSA (EBASCO 1992b), the air medium is considered an impacted medium, one which will be protected through the selection of appropriate soil, water, and structures alternatives. Action-specific ARARs are evaluated as part of the evaluation of alternatives developed for the three contaminated media. All of the selected alternatives will comply with the identified air ARARs. The interactions between soil and air consider emissions associated with excavation activities and emissions from treatment units. Several types of engineering controls are evaluated in subsequent chapters to address dust, vapors, and odors. Dust is controlled using water spraying as part of excavation alternatives. Areas to be excavated or disturbed that contain high levels of volatile contaminants or odor-causing contaminants are addressed by installing a vapor enclosure over the excavation to control and collect any vapors/odors generated. Areas to be excavated or disturbed that contain low levels of volatile contaminants or odor-causing contaminants are addressed by limiting the area excavated and by placing temporary soil covers, tarps, or foams over the excavated area during inactive periods (e.g., overnight). Both vapor enclosures and vapor controls decrease the efficiency of excavation activities and increase the cost of excavation. The use of vapor enclosures also increases the short-term risks to site workers during excavation since the excavation area is a confined space. In addition, the air quality within the vapor enclosure can only be maintained if the air emissions treatment system is effectively operated.

Section 3

3.0 METHODOLOGY

This section presents a summary of the methodology used during the DAA to evaluate, compare, and select alternatives for the soil medium. In the DAA, the retained alternatives from the DSA (EBASCO 1992b) are described in greater detail prior to being evaluated according to criteria set forth in the NCP (EPA 1990a). The Executive Summary presents these criteria in detail. Section 3.1 describes how the medium groups developed in the DSA were analyzed in greater detail, and how the subgroups are developed based on a number of criteria. In addition, Section 3.1 introduces the idea of centralized treatment and containment facilities. Section 3.2 briefly describes how seven of the nine EPA evaluation criteria for the DAA are used to evaluate each alternative for each subgroup. The remaining two criteria are to be evaluated as part of the responsiveness summary in the ROD. Section 3.3 describes how the detailed alternatives are compared for each medium group or subgroup, and how candidate alternatives for developing sitewide alternatives are selected. Finally, Section 3.4 describes how sitewide alternatives are developed and a preferred sitewide alternative is selected.

3.1 DETAILING OF ALTERNATIVES

In the DSA (EBASCO 1992b), medium groups were developed to minimize the repetition of developing alternatives for sites with similar contaminants, site types, and waste disposal criteria. The use of the medium-group approach was appropriate for developing and screening alternatives using the evaluation criteria of effectiveness, implementability, and cost.

In the DAA, however, a more detailed evaluation is required for the alternatives applied to each site. The concept of combining sites into medium groups still applies, since many sites are similar enough for a single group of alternatives to apply, even though the medium groups are to be evaluated on a more detailed basis. Section 3.1.1 describes how the medium groups were evaluated during the DAA and presents a list of the subgroups that were developed as a result of that evaluation.

Because many of the alternatives for many of the medium groups are similar or contain similar technologies, the concept of constructing and using large, centralized facilities for treatment and containment is thoroughly evaluated in the DAA. Section 3.1.2 presents the details of the centralized treatment facilities, and Section 3.1.3 presents the details of the centralized containment facilities.

The groundwater control/treatment alternatives presented in the DAA are not final designs that will actually be constructed. They are preliminary designs that have been developed for relative comparison and evaluation during the FS process. Each alternative has been carried to a preliminary design level because only at this level can actual size, effectiveness and costs be evaluated appropriately. Sufficient detail is provided for each alternative to allow its merits and drawbacks to be easily compared.

The final control/treatment alternative that is selected for a given plume group will be determined as part of the Record of Decision (ROD), the negotiation and decision-making process by which the final site remediation is selected by the Parties. When the alternatives for the plume group have been selected the remediation will enter a design phase. During the design phase, site specific information will be collected about current site conditions, and a control/treatment system will be designed to meet the specific goals stated in the ROD. Such a design will be generally based on one or more of the alternatives described here, but will undoubtedly differ from it to some degree. For instance, a technology utilized in an alternative may be replaced by a technology that appears to be more appropriate or desirable at the time of design based on new site conditions, costs, results of pilot and treatability studies and other factors. As long as the new technology can be applied to meet the goals of the selected alternative this change can be made.

3.1.1 Evaluation of Medium Groups

Sixteen soil medium groups were initially developed during the DSA (EBASCO 1992b). The South Plants-Biota and South Plants Medium Groups were combined in the DAA due to their spatial proximity and similar contamination patterns, resulting in 15 medium groups. Each site within the medium group was evaluated individually to determine the applicability of remedial alternatives to that particular site. Due to the increased level of detail and specificity required in this phase, chemical or physical variations between sites within the same medium group were used to develop subgroups. Depending on site size, location, physical characteristics, and contamination pattern, these subgroups may contain one or several sites. As a result, 8 of these 15 medium groups were further subdivided into subgroups (seven of the medium groups do not contain subgroups) to make the evaluation of alternatives more effective. A total of 18 subgroups were developed based on sites with similar contaminant types or concentrations, physical or depositional characteristics, the results of IRAs, or interactions with structures or groundwater plumes. Therefore, the DAA groups individual sites into 25 medium groups/subgroups (Table 3.1-1). The following paragraphs describe the DAA site-characterization methods.

Additional site characterization, involving collection of information from the Contaminant Assessment Reports (CARs), as cited in RISR (EBASCO 1992a), Human Health Endangerment Assessment (HHEA) (EBASCO 1990), and IEA/RC reports (EBASCO 1994a), FS data collection reports (HLA 1994b), and Soil Volume Refinement Program Report (EBASCO 1994b), was performed to provide sufficient information for evaluating the applicability of the retained alternatives to each site in a medium group. The site characteristics that were used to develop subgroups fall into nine general criteria, which are described as follows:

- Depth of Contaminated Soil—This criterion is evaluated since the depth of contamination may limit the suitability of particular remedial technologies. For example, technologies such as surface heating are effective for shallow contamination only.

- Driver Contaminants—The types of contaminants that comprise the exceedance volumes influence the evaluation of alternatives. A primary remedial technology should therefore be developed for the most prevalent contaminant(s). A secondary treatment system or systems can be used for the remainder of the contamination. In some cases, however, one treatment technology may provide effective remediation for all contaminants detected at the site.

- Depth to Groundwater—Thickness of the vadose zone varies across the site, and treatment technologies may require a minimum thickness for installation and function of the system. For example, in situ vitrification and RF heating require a minimum unsaturated soil thickness to operate.

- Major Soil Type—The total of 10 soil units that have been identified at RMA were divided into four soil types based on texture, clay content, and soil permeability for the purpose of evaluating subgroups. Soil types may increase or reduce treatment effectiveness. For example, soil venting is more effective on a sandy loam than on a clay loam due to the increased porosity and permeability of a sandy unit.

- Soil/Groundwater Interactions—Soil/groundwater interactions are evaluated at each site to assess the potential impacts of soil alternatives on groundwater alternatives. Sites are identified that might impact remediation of groundwater plumes during soil remedial actions.

- IRAs—IRAs that have been or are being performed at sites are identified. Sites with IRAs may not need further remediation if the IRA is determined to provide long-term protection of human health and the environment.

- Site Configuration—Site shapes vary and are categorized as either square to oblate or extremely narrow. The shape of a site can affect the selection of an alternative. For example, extremely narrow sites, such as ditches, may not be obstructed by structures, but also are not favorable locations for access controls like habitat modifications.

- Agent/UXO Presence—Agent and/or UXO along with Human Health COCs or contaminants that pose potential risk to biota may be present at some of the sites. Sites are identified that potentially contain agent and/or UXO based on historical usage of the site as presented in the RISR (EBASCO 1992a). Additional FS data-collection programs have been performed to further define the extent of agent contamination.

- Site Type/Usage—Each site was evaluated for site type or usage, and eight categories were developed in the RISR (EBASCO 1992a). The site type/usage categories include surface soil/windblown; ordnance testing and disposal; spills/isolated; lake sediments, ditches, and ponds; basins or lagoons; buildings, equipment, and storage; sewer systems; and buried waste.

Table 3.1-1 identifies the sites within each medium group/subgroup and summarizes the characteristics of each group and Figure 3.1-1 shows the locations of the 15 medium groups. Sections 5 to 19 present the characteristics of the 25 medium groups/subgroups in more detail. In the DSA (EBASCO 1992b), site NCSA-3 (Former Basin F) was included in the Secondary

Basin Medium Group; however, this site has since been moved to the Basin F Medium Group (as an individual subgroup) based on similarities between Former Basin F and the Basin F Wastepile. These similarities include similar types and levels of contamination, the presence of existing soil covers constructed during the Basin F IRA, and the interrelation between CERCLA and RCRA for sites associated with Basin F liquids. In addition, site NCSA-4b (Basin F Exterior) was included in the Secondary Basins Medium Group in the DSA (EBASCO 1992b), but this site has been combined with the Surficial Soil Medium Group based on the similar contamination patterns of low levels of organochlorine pesticides (OCPs) in near-surface soil that mainly pose potential risks to biota. Figure 3.1-2 shows the locations of the human health and biota exceedance areas and principal threat areas for all of the medium groups. The principal threat areas are located in the South Plants, in Section 36, and in Basin F. In addition, this figure shows the potential biota risk areas as they would exist without remediation of volumes posing potential threats to human health. The biota risk management approach is described in Section 1.4.2.2. Figure 3.1-3 presents the areas potentially containing agent and/or UXO.

3.1.1.1 Evaluation of Fluoroacetic Acid Data

In the DSA (EBASCO 1992b), detections of fluoroacetic acid (FC2A) resulted in the calculation of large exceedance volumes. These detections, obtained during the Phase II RI, have been technically questioned due to new information regarding FC2A and the laboratory method used during the RI. FC2A is a highly toxic noncarcinogen, having a human health PRG of 0.24 parts per million (ppm).

The laboratory method used during the Phase II RI to test for FC2A cannot distinguish between FC2A and formic acid, a naturally occurring organic acid that is a breakdown product of certain plants. Formic acid is not considered a risk to human health or biota due to its low toxicity and ubiquitous nature. Therefore, new analytical methods were developed and used to analyze for FC2A, without formic acid interference, in the Soil Volume Refinement Program (EBASCO 1994b). Although several samples from that program were identified as containing FC2A by a single method, no sample contained detections of FC2A by confirmatory methods.

FC2A is listed in the RMA Chemical Index (EBASCO 1988), but no evidence of its use, production, or disposal at RMA has ever been reported. FC2A has been suggested as a possible byproduct or degradation product of the manufacture or use of nerve agent, but FC2A has not been identified in association with the production of sarin or GB. Sarin hydrolyzes in the environment to form isopropyl methylphosphonic acid (IMPA), isopropylmethyl phosphonate, methylphosphonic acid (MPA), and ultimately, phosphate. The fluorine that is present in sarin is ionized to fluoride when sarin is initially hydrolyzed by water.

A potential source of FC2A at RMA is the limited use of its sodium salt, sodium fluoroacetate, as a rodenticide. Known as Compound 1080, Fractol, or Yasoknock, sodium fluoroacetate was formerly registered for use in controlling rats. The salt is extremely toxic to rats, but also to humans and other mammals. However, the use of sodium fluoroacetate as a rodenticide is unlikely to result in the uniform, widespread, low-level concentrations (David and Gardiner 1966) detected in RMA soil or in many of the areas where FC2A was reported.

Based on the lack of detections of FC2A in the Soil Volume Refinement Program and the geochemical conditions governing the presence of FC2A in soil, FC2A is not considered a COC at RMA. The removal of the FC2A exceedance volume reduced the human health exceedance volumes substantially since the conduct of the DSA.

3.1.2 Centralized Treatment Facilities

In the DSA, alternatives were developed and screened based on individual medium group volumes and areas. In the DAA, attention was given to recognizing economies of scale wherever possible. After reviewing the retained alternatives from the DSA, it became obvious that most of the retained alternatives included common treatment processes such as thermal desorption, incineration, and solidification. To maximize economies of scale and minimize site preparation costs at each site, centralized treatment facilities were developed for these three treatment processes. These facilities include single or multiple treatment units sized to handle the combined soil volume from all medium groups that may require that treatment process. The processing rates for these facilities need to be adjusted for the on-line percentage and operating time per day in order to calculate the operating time for the associated remedial alternatives.

For example, instead of providing facilities and setup for 13 small, transportable thermal desorption units, one large facility is constructed in a centralized location for treatment of all of the soil volume from the 13 subgroups for which thermal desorption could potentially be selected. Treatment rates and soil retention times are varied as required to achieve PRGs. The cost of treatment for each of these subgroups is based on a pro-rated portion of the cost of the centralized facility based on the quantities treated from that subgroup. This economy of scale is only valid if thermal desorption is selected as the preferred alternative for all 13 subgroups. However, these treatment costs are adequate to estimate costs for the evaluation of alternatives for an individual medium group/subgroup.

The centralized thermal desorption facility sized to treat a total volume for all subgroups of 2,500,000 BCY is nearly the same as the basis of estimate for the scale-up costs of thermal desorption from treatability studies (see the Technology Descriptions Volume Section 7.1), which was sized to treat 3,000,000 BCY of contaminated soil within 10 years (two 37-ton/hour desorption units).

The centralized incineration facility is sized to treat 540,000 BCY of contaminated soil and debris from disposal trenches. As discussed in Section 7.2 of the Technology Descriptions Volume, the throughput of the centralized facility is 56 tons/hour (based on two individual kilns, within an overall facility). One of the proposed alternatives may require treating up to 170,000 BCY of inorganics-contaminated soil by solidification/stabilization using a 150-ton/hour facility (see the Technology Descriptions Volume, Section 10).

Following the development of sitewide alternatives, the actual volumes to be addressed by each of these facilities are re-evaluated. The costs for these facilities, and consequently the unit prices for each treatment process, are then adjusted for each of the sitewide alternatives to reflect the volumes that they are expected to handle (see Section 20).

The final siting and sizing of these facilities is an issue to be determined in the remedial design phase, which follows the issuance of the ROD. Due to new advances in technology or increases in throughput by existing systems, the number of treatment units and the type of system may be changed based on final estimates of soil volumes to be treated.

3.1.3 Centralized Containment Facilities

Much like the centralized treatment facilities described in Section 3.1.2, centralized containment facilities were developed to accommodate the disposal of contaminated soil in a hazardous waste landfill and the consolidation of soil with low levels of contamination in Basin A and the South Plants Central Processing Area before these areas are capped.

The centralized, RCRA-compliant hazardous waste landfill containing multiple landfill cells is discussed in Section 6.5 of the Technology Descriptions Volume. The costs for landfilling soil from all the medium groups are prorated based on the maximum volume to be landfilled in the centralized facility, which will hold 5,100,000 CY. In order to address this volume, the centralized hazardous waste landfill includes four individual cells, each capable of containing approximately 1,275,000 CY. All contaminated soil and debris will be placed in a hazardous-waste RCRA-compliant landfill cell even if the material is not specifically classified as a hazardous waste.

In order to maximize available habitat, minimize the areas disturbed by excavation of borrow materials required for capping, and minimize the capped and landfill areas requiring long-term monitoring and maintenance, consolidation is used in some alternatives to contain contaminated soil. Consolidation involves the movement of soil with low levels of contamination (i.e., soil posing risk to biota) to areas with higher levels of contamination for incorporation into a single capped area. Three locations are evaluated as potential sites for consolidation: Basin A, Former

Basin F and the South Plants Central Processing Area. In the case of Basin A, approximately 2.5 million cubic yards of soil are needed as grading fill prior to completing the cap, while for the South Plants Central Processing Area 560,000 BCY are required. Using soil from other sites as grading fill that contains low levels of contamination which poses potential risk to biota serves several purposes. First, it removes contaminated soil from many sites, allowing unrestricted access to the sites by both humans and biota. Second, it is a cost-effective use of soil since it both minimizes the total surface area to be capped and reduces the need for excavation of clean fill to achieve appropriate drainage of the overlying caps. If clean fill were to be used, it would be considered tainted because it would have been consolidated with contaminated soil, thereby increasing overall soil volumes (contrary to the "reduction of toxicity, mobility, or volume" criterion).

Following the development of sitewide alternatives, the actual volumes to be addressed by each of these facilities are re-evaluated. The costs for the hazardous waste landfill and consolidation, and consequently the unit prices for each facility, were adjusted (see Section 20) for each of the sitewide alternatives to reflect the volumes that these facilities are expected to handle.

As with centralized treatment facilities, the final sizing and siting of the containment facilities will be determined in the remedial design phase, which follows the issuance of the ROD. Based on estimated quantities at that time, the unit price could change due to the number of cells to be constructed in the landfill or to the additional clean fill necessary to bring the capped area up to final design grade after placing the consolidated soil.

3.2 EVALUATION OF INDIVIDUAL ALTERNATIVES

During the DSA (EBASCO 1992b), a range of remedial alternatives was developed and screened based upon the three criteria of effectiveness, implementability, and cost to eliminate alternatives that did not achieve these criteria. Figures 3.2-1 through 3.2-15 portray the results of the DSA screening. In the DAA, these retained alternatives are again evaluated and compared, although at a much more detailed level. In addition, any alternatives reinstated in the DAA (i.e., Alternative 3: Landfill (On-Post Landfill) for the Basin F Wastepile Subgroup) are also evaluated.

Since the subgroups in any one medium group do not necessarily require the same types of remediation, the full range of alternatives retained in the DSA (EBASCO 1992b) may not necessarily be appropriate for all of the subgroups. For example, the Burial Trenches Subgroup does not have any exceedance volume for OCP or volatile organic compounds (VOCs), so treatment alternatives addressing organic contamination, such as direct thermal desorption and in situ thermal treatment, are not evaluated for that subgroup.

In Sections 5 through 19, for each medium group or subgroup, each alternative is compared and analyzed against the seven DAA evaluation criteria that are described in Section 3.2 of the Executive Summary Volume. State and community acceptance, which are acknowledged in the evaluation of implementability, are not formally evaluated at this stage of the FS process, but are to be evaluated during the responsiveness summary of the ROD. The site-specific considerations, described in Section 3.3 of the Executive Summary Volume, are also discussed. The results are discussed for each alternative and are summarized in a summary table for each subgroup.

3.3 COMPARISON OF ALTERNATIVES

Once the alternatives for each subgroup have been individually analyzed based on the seven evaluation criteria, the alternatives are first compared based on the two threshold criteria: compliance with ARARs, and overall protection of human health and the environment. Any alternative that fails to be protective of human health and the environment is dropped from further consideration. Any alternative that cannot comply with ARARs and also fails to qualify for waivers available under CERCLA is also dropped from further consideration. The consideration of these two factors is based on the statutory requirements of the NCP (EPA 1990a).

The remaining protective and ARAR-compliant alternatives are then compared against each other using the five balancing criteria: long-term effectiveness TMV reduction, short-term effectiveness, implementability, and cost. Preliminary determinations are made as to which alternatives are cost effective, and alternatives are evaluated to determine whether they achieve the NCP preference of utilizing permanent solutions and treatment technologies to the maximum extent practicable (EPA 1990a). The relative performance of alternatives is established by evaluating the extent to which each alternative satisfies the requirements of the balancing criteria and the site-specific considerations. Based on these considerations, one or more alternatives are retained for each medium group/subgroup to develop the sitewide alternatives.

Depending on site characteristics, risks, and contaminant types and concentrations, the balancing criteria may vary in their relative importance. For example, for a very large volume of material that is only marginally above health-based risk levels, processing capacity may limit the implementability of treatment options, and the cost of aggressive treatment may be prohibitive. In this case, implementability and cost are the most important balancing criteria, and the remaining questions of long-term effectiveness, TMV reduction, and short-term effectiveness have relatively less impact on the comparison of alternatives. The comparison of alternatives also balances the potential short-term impacts on worker health and safety, the community, and biota during remedial actions, against TMV reductions and long-term effectiveness. In instances where the short-term risks result in a greater overall risk to workers or the environment, the short-term effectiveness has a greater weight than TMV reduction.

3.4 SELECTION OF A PREFERRED SITEWIDE ALTERNATIVE

The sitewide alternatives were developed (see Section 20) based on combining retained alternatives for each medium group or subgroup into several overall RMA remedies, each of which represents a distinct remedial approach. For example, alternatives involving the installation of caps/covers over contaminated soil are combined to form an in-place containment sitewide alternative, and alternatives involving the landfilling of contaminated soils are combined into an overall landfill disposal sitewide alternative.

Sitewide alternatives permit the quantification of cost efficiencies associated with addressing different medium groups or subgroups with the same technologies, and the evaluation of interactions among media. As discussed in Sections 3.1.2 and 3.1.3, centralized treatment and containment facilities are considered in the DAA to maximize the economies of scale and minimize site preparation costs. However, the estimated costs of centralized facilities are accurate only if the majority of the soil considered in the economy of scale are actually treated or contained. Thus, the development of sitewide alternatives permits the realistic evaluation of economies of scale. The preferred alternatives for structures and groundwater are also incorporated into sitewide alternatives to evaluate impacts among the media.

Similar to the individual medium group or subgroup alternative evaluations, each sitewide alternative is analyzed using the seven DAA evaluation criteria. The site-specific considerations are also discussed for the sitewide alternatives, and the results are discussed for each alternative and presented in a summary table (see Section 20). However, since all of the specific alternatives used in developing sitewide alternatives are considered to be protective of human health and the environment and to comply with ARARs, the selection of the preferred sitewide alternative primarily focuses on providing a cost-effective alternative but also considers using permanent solutions and alternative treatment technologies to the maximum extent practicable and using treatment as a principal element.

Medium Groups	Subgroup	Sites	Description
Munitions Testing	—	CSA-2c CSA-2d ESA-1a ESA-1b ESA-1c ESA-1d ESA-4a ESA-4b	These sites have similar site histories and uses, and are considered potential HE-filled UXO presence areas. The sites, predominantly located in the eastern portions of RMA, were used for testing or destruction of nonchemical munitions. These sites typically contain slag, debris, and potential UXO in the uppermost 1 ft of soil and therefore present physical hazards. Site ESA-4a may contain UXO at depths as deep as 6 ft since it was an impact area for mortars. COC concentrations were not detected above Human Health SEC at any of the sites.
Agent Storage	North Plants	NPSA-2 NPSA-3 NPSA-5 NPSA-6 Bldg. 1601 Bldg. 1606 Bldg. 1607	These sites have potential agent presence but do not contain human health exceedances except as isolated detections. They are located in the North Plants GB manufacturing area. These sites are presumed to contain agent based on use histories and detections of agent breakdown products. Isolated detections of arsenic exceed the Human Health SEC. Portions of the sites in this subgroup potentially pose risks to biota.
	Toxic Storage Yards	ESA-3a ESA-3b ESA-3c ESA-3d ESA-3e ESA-3f ESA-3g ESA-3h ESA-3i	These sites are located in the storage areas in the eastern portion of RMA and are considered to potentially contain agent based on use histories and detections of agent breakdown products. However, sampling conducted during a recent field program did not indicate agent was present at these sites (EBASCO 1994b). Sites ESA-3a and ESA-3b (Old Toxic Storage Yards) were retained as sites presumed to contain agent. Isolated detections of CLC2A and arsenic exceed the Human Health SEC.

Medium Groups	Subgroup	Sites	Description
Lake Sediments	—	NCSA-7 SSA-1b SSA-1c SSA-1e SSA-5b	Sites within this medium group include sediments from lakes located in the southern portion of RMA and sediments from the North Bog. They were grouped together based on the potential risk they present to ecological receptors. Contamination has resulted from the influx of suspended solid- or dissolved-phase contaminants transported to the lakes by surface water or groundwater. Isolated exceedances of Human Health SEC include chlordane and chromium and acute exceedances of aldrin and dieldrin. Water is not currently allowed to pond in Upper Derby Lake, and portions of Upper Derby Lake contain soil that poses a potential risk to biota.
Surficial Soils	—	NCSA-4b Surficial Soil Survey	This medium group consists of areas of contamination posing risk to biota outside the SAR sites and within the Basin F Exterior. Affected soil contains OCPs, and was investigated to a depth of 2 inches. Portions of this group contain OCPs above Human Health SEC. This group also contains the pistol and rifle ranges.
Ditches/Drainage Areas	—	CSA-2b ESA-6c NCSA-1c NCSA-1d NCSA-1f NCSA-5d NPSA-8c NPSA-9f SSA-2c	Exceedance sites within this medium group have various disposal and release histories and are contaminated with low levels of contaminants, primarily OCPs, that pose risks to biota.
Basin A	—	NCSA-1a NCSA-1e	This medium group is comprised of two sites within the Basin A high-water line. Basin A contains soil and sediment that were contaminated by organic and inorganic chemicals from manufacturing wastewater discharged to the basin. The medium group is also characterized by the potential presence of agent and agent-filled UXO. Agent was detected in the southern portion of Basin A during a recent field program (EBASCO 1994b). COCs detected above the Human Health SEC include primarily OCPs, and soil near the center of the basin exceeds the principal threat criteria. Individual subgroups were not developed for this medium group.

Medium Groups	Subgroup	Sites	Description
Basin F	Basin F Wastepile	Basin F Wastepile	This subgroup consists of the Basin F Wastepile that was formed as a result of the Basin F IRA. The IRA has included the transfer of Basin F liquids to temporary storage tanks, excavation of Basin F soil from below the original asphalt liner and the final grading, capping, and revegetation of the excavated area. The Basin F Wastepile consists of the excavated sediment and soil that are contaminated with high levels of organic compounds, arsenic, and metals at concentrations above Human Health SEC and principal threat criteria. The total concentrations of organics are inferred to be on the order of 1,000 to 10,000 ppm. This material also contains elevated levels of salts due to the high chloride content wastewater stored in the former Basin F.
	Former Basin F	NCSA-3	The former Basin F site consists of the former basin area, including the area below the Basin F Wastepile. Basin F received wastewaters through the chemical sewer system, and the site is expected to contain somewhat elevated levels of salts due to the high chloride content in the wastewater. COCs remaining in the soil exceeding Human Health SEC include OCPs and CLC2A, and large portions of the former basin exceed principal threat criteria. The Basin F IRA included the installation of a soil cover.
Secondary Basins	—	NCSA-2a NCSA-2b NCSA-2c NCSA-4a NCSA-5a	Sites within this subgroup consist of four liquid disposal basins (Basins B, C, D, and E) that collected overflow water from Basin A, and the former deep disposal well. These sites are expected to contain somewhat elevated levels of salts that are a result of the storage of wastewater with high chloride content. COCs detected in the soil above Human Health SEC include OCPs, although the majority of contamination potentially poses risks to biota.
Sewer Systems	Sanitary/ Process Sewers	NCSA-8a SPSA-11 SPSA-12 WSA-7a	Sites within this subgroup consist of sanitary and process water sewers. Soil around these sewer lines does not exceed Human Health SEC and does not pose risks to biota based on the depth of the sewer lines; however, these sewer lines potentially serve as conduits for the migration of groundwater contamination.
	Chemical Sewers	CSA-3 NCSA-6a NCSA-6b NPSA-1 SPSA-10	Sites within this subgroup consist of chemical sewers. COCs in the soil exceeding Human Health SEC and principal threat criteria in portions of South Plants include OCPs, volatile organics, and CLC2A. These sewers are further characterized by the potential presence of agent.

Medium Groups	Subgroup	Sites	Description
Disposal Trenches	Complex Trenches	CSA-1c	This subgroup is characterized by trenches or pits that were filled with trash and manufacturing/military wastes. Wastes are suspected to consist of drums of solid and liquid material, wood, glass, metal, laboratory and manufacturing equipment, and miscellaneous material. This subgroup is further characterized by the potential presence of agent and agent-filled UXO.
	Shell Trenches	CSA-1a	This subgroup is characterized by trenches or pits that were filled with trash and manufacturing/military wastes in the area of the Shell Trenches. Wastes are suspected to consist of drums of solid and liquid material. IRA activities at this site have consisted of the placement of a soil cap across the entire site and a vertical barrier surrounding the site.
	Hex Pit	SPSA-1f	This site was historically used for disposal of residual materials (hex bottoms) resulting from the production of HCCPD. This material was buried in thin-gauge caustic barrels and in bulk.
Sanitary Landfills	—	CSA-1d ESA-2b SSA-4 WSA-2 WSA-3c WSA-5a WSA-5c WSA-5d	This medium group consists of sanitary landfills and inferred trenches that are predominantly located in the eastern and western portion of RMA. These sites contain trash and rubbish, but are not anticipated to contain drums of hazardous material, agent, or UXO.
Lime Basins	Section 36 Lime Basins	NCSA-1b	The Section 36 Lime Basins were used for the neutralization of process wastes related to agent production, and are characterized by soil/sludge mixtures with high pH levels and the potential presence of agent. COCs in the soil/sludge exceeding Human Health SEC include primarily OCPs; low-level inorganic contamination is also present. IRA activities at this site involved placing a soil cap across the entire site.
	M-1 Pits	SPSA-1e	The Buried M-1 Pits, used for the neutralization of process wastes related to agent production, are characterized by soil/sludge mixtures with high pH levels and the potential presence of agent. COCs in the soil/sludge exceeding Human Health SEC and principal threat criteria primarily consist of arsenic and mercury. This subgroup is distinguished by percentage levels of arsenic and mercury.

Medium Groups	Subgroup	Sites	Description
South Plants	South Plants Central Processing Area	SPSA-1a	This subgroup consists of the main processing area within South Plants. Contamination has resulted from manufacture, storage, and disposal of chemicals from the demilitarization of agent-filled ordnance. A wide range of COCs in the soil exceeding Human Health SEC and principal threat criteria include volatiles, OCPs, and arsenic. The soil in this area potentially contains agent.
	South Plants Ditches	SPSA-1d SPSA-2d SPSA-3a SPSA-4a SPSA-5a SPSA-7a SPSA-8b SPSA-9a	This subgroup consists of the drainage ditches within South Plants. Contamination has resulted from manufacture, storage, and disposal of chemicals from the demilitarization of agent-filled ordnance. COCs in the soil exceeding Human Health SEC and principal threat criteria include primarily OCPs. Also, contaminated soil in these ditches potentially poses risk to biota.
	South Plants Balance of Areas	SPSA-1b SPSA-1c SPSA-1g SPSA-2a SPSA-2b SPSA-2c SPSA-2e SPSA-3b SPSA-3c SPSA-3d SPSA-3e SPSA-4b SPSA-5b SPSA-6 SPSA-7b SPSA-7c SPSA-8a SPSA-8c SPSA-9b SPSA-12a SPSA-12b	The remainder of the sites within South Plants were placed in this subgroup. Contamination at these sites has resulted from manufacture, storage, and disposal of chemicals from the demilitarization of agent-filled ordnance, and from wind-blown dispersion of contaminants from the Central Processing Area. COCs in the soil exceeding the Human Health SEC and principal threat criteria primarily consist of OCPs and ICP metals. Most of the contaminated soil in the balance of South Plants potentially poses risks to biota. This subgroup is also characterized by the potential presence of HE-filled UXO and agent.

Medium Groups	Subgroup	Sites	Description
Buried Sediments/ Ditches	Buried Sediments	SSA-3a SSA-3b	This subgroup consists of two sites that contain contaminated sediments that were dredged from the adjacent lakes (Lake Ladora and Derby Lakes), deposited in unlined ditches at their current locations, and covered with clean soil. COCs exceeding Human Health SEC include OCPs.
	Sand Creek Lateral	NCSA-2d NCSA-5b NCSA-5c NCSA-8b NPSA-4 SSA-2a SSA-2b WSA-1f WSA-6a	This subgroup consists of the northern and southern segments of the Sand Creek Lateral that transported runoff from the South Plants Central Processing Area during storm events and snowmelt, and of the drainage ditches used to transport water to and from the Secondary Basins and to drain the South Plants and North Plants process areas. COCs in the soil exceeding Human Health SEC primarily consist of OCPs.
Undifferentiated	Section 36 Balance of Areas	NCSA-1g CSA-1b CSA-2a CSA-4	Sites within this subgroup are located in the southern area of Section 36, predominantly in the Central Study Area. They do not have unique site-type characteristics or contamination patterns. COCs in the soil exceeding Human Health SEC include OCPs and CLC2A. This subgroup is also characterized by the potential presence of agent and agent-filled UXO.
	Burial Trenches	ESA-2a ESA-2c	Sites within this subgroup consist of trenches that are located in Sections 30 and 32 in the Eastern Study Area, related to munitions testing and disposal. COCs in the soil exceeding Human Health SEC include chromium and lead. The sites are also characterized by the potential presence of HE-filled UXO.

Figure 3.2-1 Alternatives Screening Summary for Munitions Testing Medium Group, Potential UXO Presence Exceedance Category

ALTERNATIVES DEVELOPED	ALTERNATIVES RETAINED
No Action and Institutional Controls Alternatives	
U1. No Additional Action (Provisions of FFA)	U1. No Additional Action (Provisions of FFA)
Containment Alternatives	
U2. Caps/Covers (Soil Cover)	U2. Caps/Covers (Soil Cover)
Treatment Alternatives	
U3. Incineration/Pyrolysis (Rotary Kiln)	U3. Incineration/Pyrolysis (Rotary Kiln)
U4. Incineration/Pyrolysis (Off-Post Incineration)	U4. Incineration/Pyrolysis (Off-Post Incineration)

Figure 3.2-2 Alternatives Screening Summary for Agent Storage Medium Group, Potential Agent Presence Category

ALTERNATIVES DEVELOPED		ALTERNATIVES RETAINED
No Action and Institutional Controls Alternatives		
A1. No Additional Action (Provisions of FFA)	—	A1. No Additional Action (Provisions of FFA)
Containment Alternatives		
A2. Caps/Covers (Soil Cover)	—	A2. Caps/Covers (Soil Cover)
Treatment Alternatives		
A3. Direct Soil Washing (Solution Washing); Landfill (On-Post Landfill)	—	A3. Direct Soil Washing (Solution Washing): Landfill (On-Post Landfill)
A4. Incineration/Pyrolysis (Rotary Kiln)	—	A4. Incineration/Pyrolysis (Rotary Kiln)

Figure 3.2-3 Alternatives Screening Summary for Lake Sediments Medium Group, Biota Risk Category

ALTERNATIVES DEVELOPED	ALTERNATIVES RETAINED
No Action/Institutional Controls Alternatives	
B1. No Additional Action (Provisions of FFA)	B1. No Additional Action (Provisions of FFA)
Containment Alternatives	
B3. Landfill (On-Post Landfill)	B3. Landfill (On-Post Landfill)
B4. Landfill (Off-Post RCRA Hazardous Waste Landfill)	
Treatment Alternatives	
B6. Direct Thermal Desorption (Direct Heating)	B6. Direct Thermal Desorption (Direct Heating)
B7. Incineration/Pyrolysis (Rotary Kiln)	
B8. Incineration/Pyrolysis (Off-Post Incineration)	
B10. In Situ Biological Treatment (Aerobic Biodegradation)	B10. In Situ Biological Treatment (Aerobic Biodegradation)

Figure 3.2-4 Alternatives Screening Summary for Surficial Soil Medium Group, Biota Risk Category

ALTERNATIVES DEVELOPED	ALTERNATIVES RETAINED
No Action/Institutional Controls Alternatives	
B1. No Additional Action (Provisions of FFA)	B1. No Additional Action (Provisions of the FFA)
Containment Alternatives	
B3. Landfill (On-Post Landfill)	B3. Landfill (On-Post Landfill)
B4. Landfill (Off-Post RCRA Hazardous Waste Landfill)	
Treatment Alternatives	
B6. Direct Thermal Desorption (Direct Heating)	
B7. Incineration/Pyrolysis (Rotary Kiln)	
B8. Incineration/Pyrolysis (Off-Post Incineration)	
B9. In Situ Biological Treatment (Landfarm/Agricultural Practice)	B9. In Situ Biological Treatment (Landfarm/Agricultural Practice)
B11. In Situ Thermal Treatment (Surface Soil Heating)	B11. In Situ Thermal Treatment (Surface Soil Heating)

Figure 3.2-5 Alternatives Screening Summary for Ditches/Drainage Areas Medium Group, Biota Risk Category

ALTERNATIVES DEVELOPED	ALTERNATIVES RETAINED
No Action/Institutional Controls Alternatives	
B1. No Additional Action (Provisions of FFA)	B1. No Additional Action (Provisions of the FFA)
B2. Biota Management (Exclusion)	B2. Biota Management (Exclusion)
Containment Alternatives	
B3. Landfill (On-Post Landfill)	B3. Landfill (On-Post Landfill)
B4. Landfill (Off-Post RCRA Hazardous Waste Landfill)	
B5. Caps/Covers (Clay/Soil Cap)	B5. Caps/Covers (Clay/Soil Cap)
Treatment Alternatives	
B6. Direct Thermal Desorption (Direct Heating)	B6. Direct Thermal Desorption (Direct Heating)
B7. Incineration/Pyrolysis (Rotary Kiln)	
B8. Incineration/Pyrolysis (Off-Post Incineration)	
B9. In Situ Biological Treatment (Landfarm/Agricultural Practice)	B9. In Situ Biological Treatment (Landfarm/Agricultural Practice)
B11. In Situ Thermal Treatment (RF/Microwave Heating)	B11. In Situ Thermal Treatment (RF/Microwave Heating)

Figure 3.2-6 Alternatives Screening Summary for Basin A Medium Group, Human Health Exceedance Category

ALTERNATIVES DEVELOPED	ALTERNATIVES RETAINED
No Action/Institutional Controls Alternatives	
1. No Additional Action (Provisions of FFA)	1. No Additional Action (Provisions of FFA)
Containment Alternatives	
3. Landfill (On-Post Landfill)	3. Landfill (On-Post Landfill)
4. Landfill (Off-Post RCRA Hazardous Waste Landfill)	
5. Caps/Covers (Clay/Soil Cap); Vertical Barriers (Slurry Wall)	5. Caps/Covers (Clay/Soil Cap); Vertical Barriers (Slurry Wall)
Treatment Alternatives	
8. Direct Soil Washing (Solvent Washing)	
9. Direct Soil Washing (Solution Washing); Direct Thermal Treatment	9. Direct Soil Washing (Solution Washing); Direct Thermal Treatment[1]
12. Direct Soil Washing (Solution Washing); Direct Biological Treatment (Aerobic Bioreactor)	
13. Direct Thermal Desorption (Direct Heating)	13. Direct Thermal Desorption (Direct Heating)[2]
14. Incineration/Pyrolysis (Rotary Kiln)	
15. Incineration/Pyrolysis (Off-Post Incineration)	
17. In Situ Physical/Chemical Treatment (Soil Flushing); In Situ Thermal Treatment (Surface Soil Heating)	17. In Situ Physical/Chemical Treatment (Soil Flushing); In Situ Thermal Treatment (Surface Soil Heating)
18. In Situ Thermal Treatment (RF/Microwave Heating); Direct Solidification/Stabilization (Cement-Based Solidification)	
19. In Situ Thermal Treatment (RF/Microwave Heating); In Situ Solidification/Stabilization (Cement-Based Solidification)	19. In Situ Thermal Treatment (RF/Microwave Heating); In Situ Solidification/Stabilization (Cement-Based Solidification)
20. In Situ Thermal Treatment (Surface Soil Heating); Direct Thermal Treatment	

[1] Alternative 9. Direct Soil Washing (Solution Washing); Direct Thermal Treatment retained pending favorable treatability study results.
[2] Alternative 13 retained pending favorable treatability study results for thermal desorption. Alternative 14 will be reinstated in the DAA if the anticipated efficiencies are not achieved.

Figure 3.2-7 Alternatives Screening Summary for Basin F Wastepile Medium Group, Human Health Exceedance Category

ALTERNATIVES DEVELOPED	ALTERNATIVES RETAINED
No Action/Institutional Controls Alternatives	
1. No Additional Action (Provisions of FFA)	1. No Additional Action (Provisions of FFA)
2. Access Restrictions (Modifications to FFA)	2. Access Restrictions (Modifications to FFA)
Containment Alternatives	
6. Caps/Covers (Clay/Soil Cap)	
Treatment Alternatives	
8. Direct Soil Washing (Solvent Washing)	
9. Direct Soil Washing (Solution Washing); Direct Thermal Treatment	9. Direct Soil Washing (Solution Washing); Direct Thermal Treatment[1]
13. Direct Thermal Desorption (Direct Heating)	13. Direct Thermal Desorption (Direct Heating)[2]
14. Incineration/Pyrolysis (Rotary Kiln)	
15. Incineration/Pyrolysis (Off-Post Incineration)	
18. In Situ Thermal Treatment (RF/Microwave Heating); Direct Solidification/Stabilization (Cement-Based Solidification)	

[1] Alternative 9, Direct Soil Washing (Solution Washing); Direct Thermal Treatment retained pending favorable treatability study results.
[2] Alternative 13 retained pending favorable treatability study results for thermal desorption. Alternative 14 will be reinstated in the DAA if the anticipated efficiencies are not achieved.

Figure 3.2-8 Alternatives Screening Summary for Secondary Basins Medium Group, Human Health Exceedance Category

ALTERNATIVES DEVELOPED	ALTERNATIVES RETAINED
No Action/Institutional Controls Alternatives	
1. No Additional Action (Provisions of FFA)	1. No Additional Action (Provisions of FFA)
2. Access Restrictions (Modifications to FFA)	2. Access Restrictions (Modifications to FFA)
Containment Alternatives	
3. Landfill (On-Post Landfill)	3. Landfill (On-Post Landfill)
4. Landfill (Off-Post RCRA Hazardous Waste Landfill)	
5. Caps/Covers (Clay/Soil Cap); Vertical Barriers (Slurry Wall)	5. Caps/Covers (Clay/Soil Cap); Vertical Barriers (Slurry Wall)
Treatment Alternatives	
8. Direct Soil Washing (Solvent Washing)	
9. Direct Soil Washing (Solution Washing); Direct Thermal Treatment	9. Direct Soil Washing (Solution Washing); Direct Thermal Treatment[1]
12. Direct Soil Washing (Solution Washing); Direct Biological Treatment (Aerobic Bioreactor)	
13. Direct Thermal Desorption (Direct Heating)	13. Direct Thermal Desorption (Direct Heating)[2]
14. Incineration/Pyrolysis (Rotary Kiln)	
15. Incineration/Pyrolysis (Off-Post Incineration)	
17. In Situ Physical/Chemical Treatment (Soil Flushing); In Situ Thermal Treatment (Surface Soil Heating)	17. In Situ Physical/Chemical Treatment (Soil Flushing); In Situ Thermal Treatment (Surface Soil Heating)
18. In Situ Thermal Treatment (RF/Microwave Heating); Direct Solidification/Stabilization (Cement-Based Solidification)	
19. In Situ Thermal Treatment (RF/Microwave Heating); In Situ Solidification/Stabilization (Cement-Based Solidification)	19. In Situ Thermal Treatment (RF/Microwave Heating); In Situ Solidification/Stabilization (Cement-Based Solidification)
20. In Situ Thermal Treatment (Surface Soil Heating); Direct Thermal Treatment	

[1] Alternative 9, Direct Soil Washing (Solution Washing); Direct Thermal Treatment retained pending favorable treatability study results.

[2] Alternative 13 retained pending favorable treatability study results for thermal desorption. Alternative 14 will be reinstated in the DAA if the anticipated efficiencies are not achieved.

Figure 3.2-9 Alternatives Screening Summary for Sewer Systems Medium Group, Human Health Exceedance Category

ALTERNATIVES DEVELOPED	ALTERNATIVES RETAINED
No Action/Institutional Controls Alternatives	
1. No Additional Action (Provisions of FFA)	1. No Additional Action (Provisions of FFA)
2. Access Restrictions (Modifications to FFA)	2. Access Restrictions (Modifications to FFA)
Containment Alternatives	
3. Landfill (On-Post Landfill)	3. Landfill (On-Post Landfill)
4. Landfill (Off-Post RCRA Hazardous Waste Landfill)	
Treatment Alternatives	
8. Direct Soil Washing (Solvent Washing)	
9. Direct Soil Washing (Solution Washing); Direct Thermal Treatment	
12. Direct Soil Washing (Solution Washing); Direct Biological Treatment (Aerobic Bioreactor)	
13. Direct Thermal Desorption (Direct Heating)	13. Direct Thermal Desorption (Direct Heating)[1]
14. Incineration/Pyrolysis (Rotary Kiln)	
15. Incineration/Pyrolysis (Off-Post Incineration)	

[1] Alternative 13 retained pending favorable treatability study results for thermal desorption. Alternative 14 will be reinstated in the DAA if the anticipated efficiencies are not achieved.

Figure 3.2-10 Alternatives Screening Summary for Disposal Trenches Medium Group, Human Health Exceedance Category

ALTERNATIVES DEVELOPED	ALTERNATIVES RETAINED
No Action/Institutional Controls Alternatives	
1. No Additional Action (Provisions of FFA)	1. No Additional Action (Provisions of FFA)
Containment Alternatives	
3. Landfill (On-Post Landfill)	
4. Landfill (Off-Post RCRA Hazardous Waste Landfill)	
5. Caps/Covers (Clay/Soil Cap); Vertical Barriers (Slurry Wall)	5. Caps/Covers (Clay/Soil Cap); Vertical Barriers (Slurry Wall)
Treatment Alternatives	
13. Direct Thermal Desorption (Direct Heating)	
14. Incineration/Pyrolysis (Rotary Kiln)	14. Incineration/Pyrolysis (Rotary Kiln)
15. Incineration/Pyrolysis (Off-Post Incineration)	

Figure 3.2-11 Alternatives Screening Summary for Sanitary Landfills Medium Group, Human Health Exceedance Category

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ALTERNATIVES DEVELOPED	ALTERNATIVES RETAINED
No Action/Institutional Controls Alternatives	
1. No Additional Action (Provisions of FFA)	1. No Additional Action (Provisions of FFA)
2. Access Restrictions (Modifications to FFA)	2. Access Restrictions (Modifications to FFA)
Containment Alternatives	
3. Landfill (On-Post Landfill)	3. Landfill (On-Post Landfill)
4. Landfill (Off-Post RCRA Hazardous Waste Landfill)	
5. Caps/Covers (Clay/Soil Cap); Vertical Barriers (Slurry Wall)	5. Caps/Covers (Clay/Soil Cap); Vertical Barriers (Slurry Wall)
Treatment Alternatives	
9. Direct Soil Washing (Solution Washing); Direct Thermal Treatment	
13. Direct Thermal Desorption (Direct Heating)	13. Direct Thermal Desorption (Direct Heating)[1]
14. Incineration/Pyrolysis (Rotary Kiln)	
15. Incineration/Pyrolysis (Off-Post Incineration)	

[1] Alternative 13 retained pending favorable treatability study results for thermal desorption. Alternative 14 will be reinstated in the DAA if the anticipated efficiencies are not achieved.

Figure 3.2-12 Alternatives Screening Summary for Lime Basins Medium Group, Human Health Exceedance Category

ALTERNATIVES DEVELOPED	ALTERNATIVES RETAINED
No Action/Institutional Controls Alternatives	
1. No Additional Action (Provisions of FFA)	1. No Additional Action (Provisions of FFA)
Containment Alternatives	
3. Landfill (On-Post Landfill)	3. Landfill (On-Post Landfill)
4. Landfill (Off-Post RCRA Hazardous Waste Landfill)	
5. Caps/Covers (Clay/Soil Cap); Vertical Barriers (Slurry Wall)	
Treatment Alternatives	
8. Direct Soil Washing (Solvent Washing)	
9. Direct Soil Washing (Solution Washing); Direct Thermal Treatment	
10. Direct Solidification/Stabilization (Proprietary Agent Solidification)	10. Direct Solidification/Stabilization (Proprietary Agent Solidification)[1]
12. Direct Soil Washing (Solution Washing); Direct Biological Treatment (Aerobic Bioreactor)	
13. Direct Thermal Desorption (Direct Heating)	13. Direct Thermal Desorption (Direct Heating)[2]
14. Incineration/Pyrolysis (Rotary Kiln)	
15. Incineration/Pyrolysis (Off-Post Incineration)	
18. In Situ Thermal Treatment (RF/Microwave Heating); Direct Solidification/Stabilization (Cement-Based Solidification)	
19. In Situ Thermal Treatment (RF/Microwave Heating); In Situ Solidification/Stabilization (Cement-Based Solidification)	19. In Situ Thermal Treatment (RF/Microwave Heating); In Situ Solidification/Stabilization (Cement-Based Solidification)
21. In Situ Thermal Treatment (Vitrification)	21. In Situ Thermal Treatment (Vitrification)

[1] Alternative 10, Direct Solidification/Stabilization (Proprietary Agent Solidification) retained pending favorable treatability study results for immobilizing organics and inorganics.

[2] Alternative 13 retained pending favorable treatability study results for thermal desorption. Alternative 14 will be reinstated in the DAA if the anticipated efficiencies are not achieved.

Figure 3.2-13 Alternatives Screening Summary for South Plants Medium Group, Human Health Exceedance Category

ALTERNATIVES DEVELOPED	ALTERNATIVES RETAINED
No Additional Action/Institutional Controls Alternatives	
1. No Additional Action (Provisions of FFA)	1. No Additional Action (Provisions of FFA)
Containment Alternatives	
3. Landfill (On-Post Landfill)	3. Landfill (On-Post Landfill)
4. Landfill (Off-Post RCRA Hazardous Waste Landfill)	
5. Caps/Covers (Clay/Soil Cap); Vertical Barriers (Slurry Wall)	5. Caps/Covers (Clay/Soil Cap); Vertical Barriers (Slurry Wall)
Treatment Alternatives	
8. Direct Soil Washing (Solvent Washing)	
9. Direct Soil Washing (Solution Washing); Direct Thermal Treatment	
13. Direct Thermal Desorption (Direct Heating)	13. Direct Thermal Desorption (Direct Heating)[1]
14. Incineration/Pyrolysis (Rotary Kiln)	
15. Incineration/Pyrolysis (Off-Post Incineration)	
16. In Situ Physical/Chemical Treatment (Vacuum Extraction); In Situ Solidification/Stabilization (Proprietary Agent Solidification)	16. In Situ Physical/Chemical Treatment (Vacuum Extraction); In Situ Solidification/Stabilization (Proprietary Agent Solidification)
18. In Situ Thermal Treatment (RF/Microwave Heating); Direct Solidification/Stabilization (Cement-Based Solidification)	
19. In Situ Thermal Treatment (RF/Microwave Heating); In Situ Solidification/Stabilization (Cement-Based Solidification)	19. In Situ Thermal Treatment (RF/Microwave Heating); In Situ Solidification/Stabilization (Cement-Based Solidification)
20. In Situ Thermal Treatment (Surface Soil Heating); Direct Thermal Treatment	20. In Situ Thermal Treatment (Surface Soil Heating); Direct Thermal Treatment

[1] Alternative 13 retained pending favorable treatability study results for thermal desorption. Alternative 14 will be reinstated in the DAA if the anticipated efficiencies are not achieved.

Figure 3.2-14 Alternatives Screening Summary for Buried Sediments/Ditches Medium Group, Human Health Exceedance Category

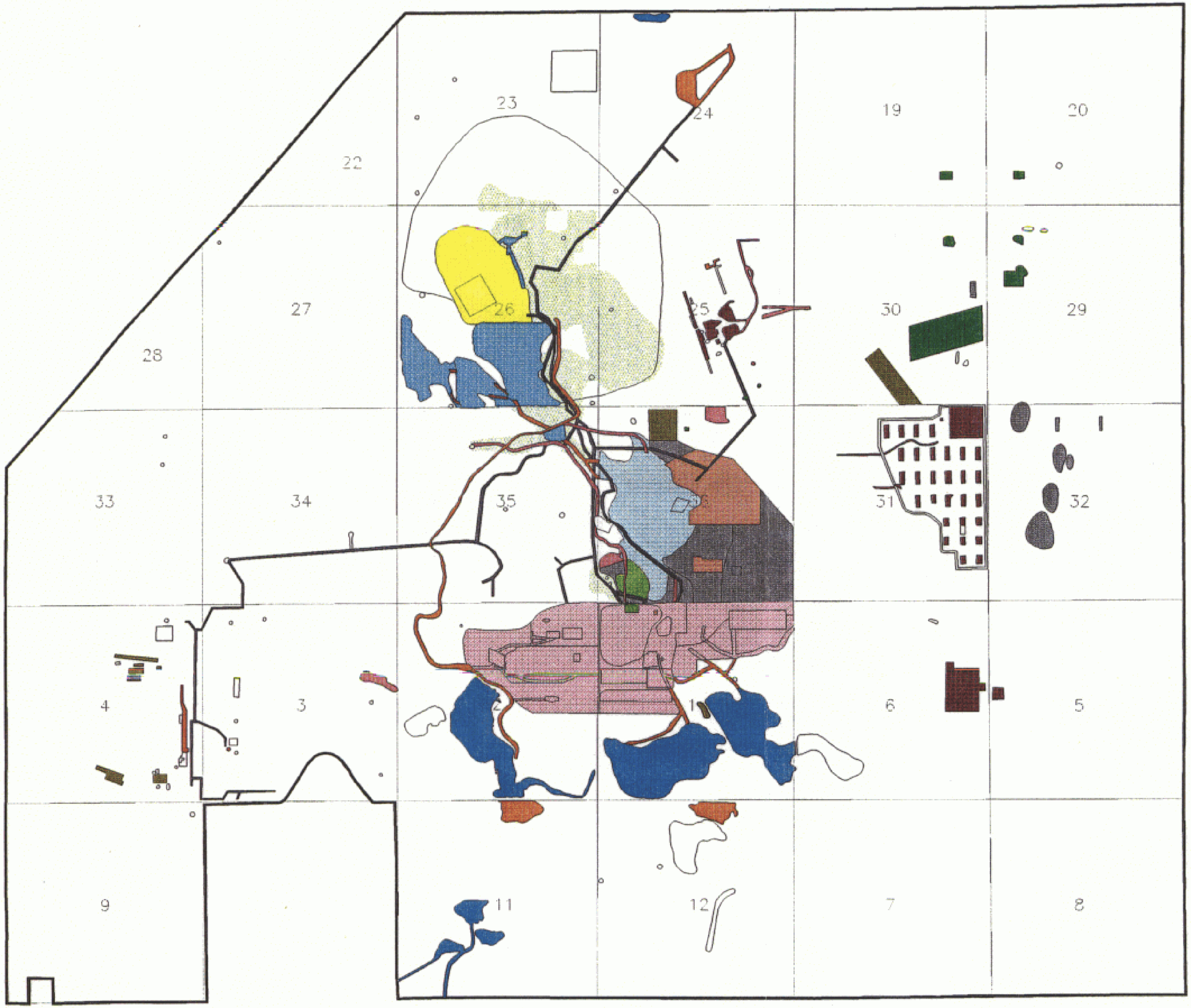
ALTERNATIVES DEVELOPED	ALTERNATIVES RETAINED
No Action/Institutional Controls Alternatives	
1. No Additional Action (Provisions of FFA)	1. No Additional Action (Provisions of FFA)
2. Access Restrictions (Modifications to FFA)	2. Access Restrictions (Modifications to FFA)
Containment Alternatives	
3. Landfill (On-Post Landfill)	3. Landfill (On-Post Landfill)
4. Landfill (Off-Post RCRA Hazardous Waste Landfill)	
6. Cap/Covers (Clay/Soil Cap)	6. Cap/Covers (Clay/Soil Cap)
Treatment Alternatives	
7. Direct Physical/Chemical Treatment (Dechlorination)	
8. Direct Soil Washing (Solvent Washing)	
9. Direct Soil Washing (Solution Washing); Direct Thermal Treatment	
10. Direct Solidification/Stabilization (Proprietary Agent Solidification)	10. Direct Solidification/Stabilization (Proprietary Agent Solidification)
11. Direct Biological Treatment (Aerobic Bioreactor)	
12. Direct Soil Washing (Solution Washing); Direct Biological Treatment (Aerobic Bioreactor)	
13. Direct Thermal Desorption (Direct Heating)	13. Direct Thermal Desorption (Direct Heating)[1]
14. Incineration/Pyrolysis (Rotary Kiln)	
15. Incineration/Pyrolysis (Off-Post Incineration)	
18. In Situ Thermal Treatment (RF/Microwave Heating); Direct Solidification/Stabilization (Cement-Based Solidification)	
19. In Situ Thermal Treatment (RF/Microwave Heating); In Situ Solidification/Stabilization (Cement-Based Solidification)	19. In Situ Thermal Treatment (RF/Microwave Heating); In Situ Solidification/Stabilization (Cement-Based Solidification)
20. In Situ Thermal Treatment (Surface Soil Heating); Direct Thermal Treatment	

[1] Alternative 13 retained pending favorable treatability study results for thermal desorption. Alternative 14 will be reinstated in the DAA if the anticipated efficiencies are not achieved.

Figure 3.2-15 Alternatives Screening Summary for Undifferentiated Medium Group, Human Health Exceedance Category

ALTERNATIVES DEVELOPED	ALTERNATIVES RETAINED
No Action/Institutional Controls Alternatives	
1. No Additional Action (Provisions of FFA)	1. No Additional Action (Provisions of FFA)
Containment Alternatives	
3. Landfill (On-Post Landfill)	3. Landfill (On-Post Landfill)
4. Landfill (Off-Post RCRA Hazardous Waste Landfill)	
5. Caps/Covers (Clay/Soil Cap); Vertical Barriers (Slurry Wall)	5. Caps/Covers (Clay/Soil Cap); Vertical Barriers (Slurry Wall)
Treatment Alternatives	
8. Direct Soil Washing (Solvent Washing)	
9. Direct Soil Washing (Solution Washing); Direct Thermal Treatment	
10. Direct Solidification/Stabilization (Proprietary Agent Solidification)	10. Direct Solidification/Stabilization (Proprietary Agent Solidification)[1]
11. Direct Biological Treatment (Aerobic Bioreactor)	
12. Direct Soil Washing (Solution Washing); Direct Biological Treatment (Aerobic Bioreactor)	
13. Direct Thermal Desorption (Direct Heating)	13. Direct Thermal Desorption (Direct Heating)[2]
14. Incineration/Pyrolysis (Rotary Kiln)	
15. Incineration/Pyrolysis (Off-Post Incineration)	
18. In Situ Thermal Treatment (RF/Microwave Heating); Direct Solidification/Stabilization (Cement-Based Solidification)	
19. In Situ Thermal Treatment (RF/Microwave Heating); In Situ Solidification/Stabilization (Cement-Based Solidification)	
20. In Situ Thermal Treatment (Surface Soil Heating); Direct Thermal Treatment	

[1] Alternative 13 retained pending favorable treatability study results for thermal desorption. Alternative 14 will be reinstated in the DAA if the anticipated efficiencies are not achieved.



Legend

- Arsenal Boundary
- Munitions Testing
- Agent Storage {North Plants, Toxic Storage Yards}
- Lake Sediments
- Surficial Soil
- Ditches/Drainage Areas
- Basin A
- Basin F {Former Basin F, Basin F Wastepile}
- Secondary Basins
- Sewer Systems
- Disposal Trenches {Complex Trenches, Shell Trenches, Hex Pit}
- Sanitary Landfills
- Lime Basins {Section 36 Lime Basins, M-1 Pits}
- South Plants (Central Proc., Ditches, Balance)
- Buried Sediments/Sand Creek Lateral
- Undifferentiated {Section 36 Balance of Areas, Burial Trenches}
- 5 Section Number

N

1500 0 1500 3000 Feet

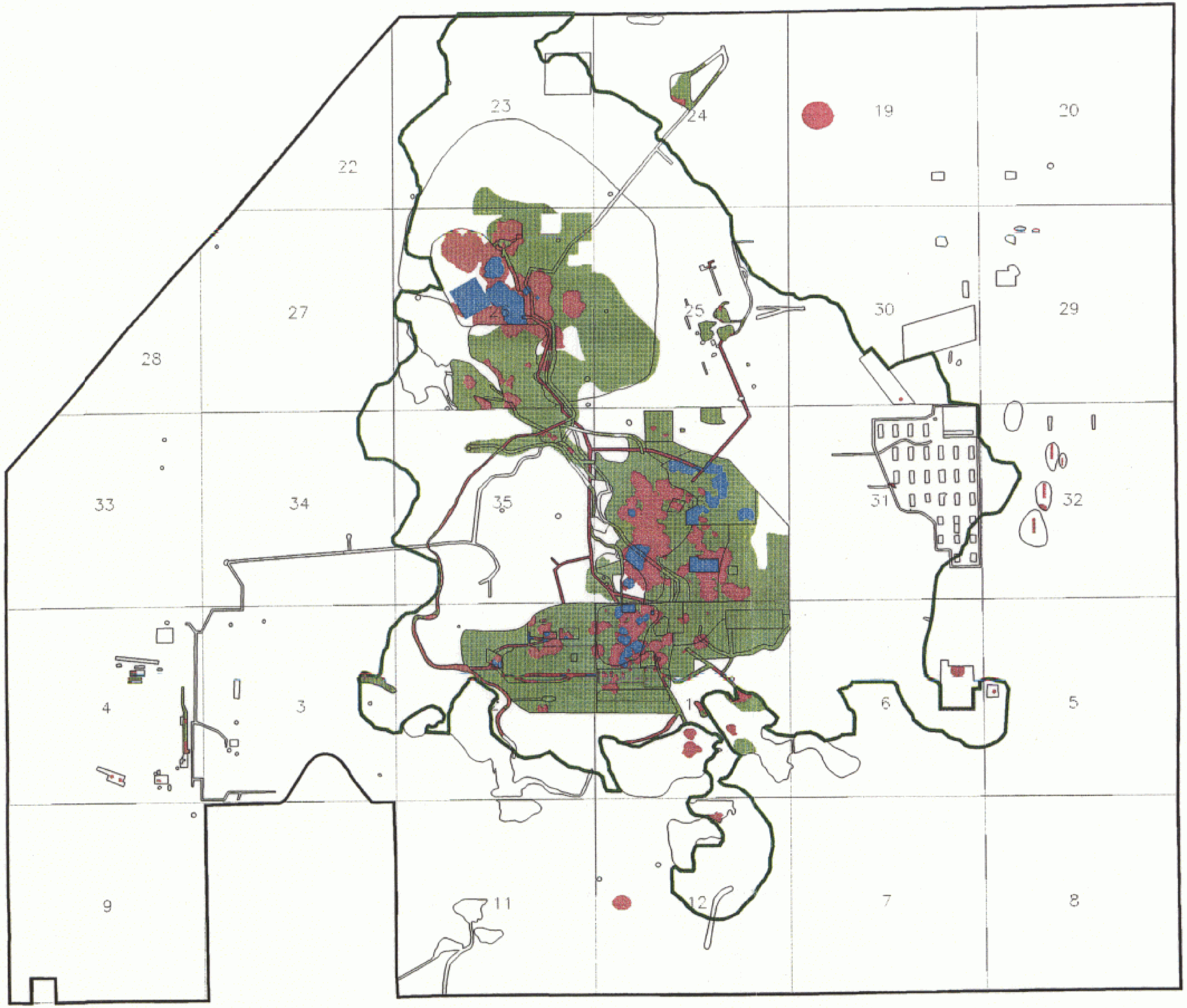
Prepared for: U.S. Army Program Manager for Rocky Mountain Arsenal

Figure 3.1-1

RMA Soil Medium Groups

Foster Wheeler Environmental Corporation
October 1995

Revision NO. 3 | File Name: C:\SOILS\MEDGRP | Date 10/06/95 | Drawn by XG | Approved by | Checked by



Legend

Arsenal Boundary

SARsite Boundary

Principal Threat Exceedance Area

Human Health Exceedance Area

Excess Biota Exceedance Area

5 Section Number

Area of Contamination Boundary

-N-

1000 0 1000 3000 Feet

Prepared for: U.S. Army Program Manager for Rocky Mountain Arsenal

Figure 3.1–2

Human Health Exceedance Areas and Potential Biota Risk Area

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Checked by

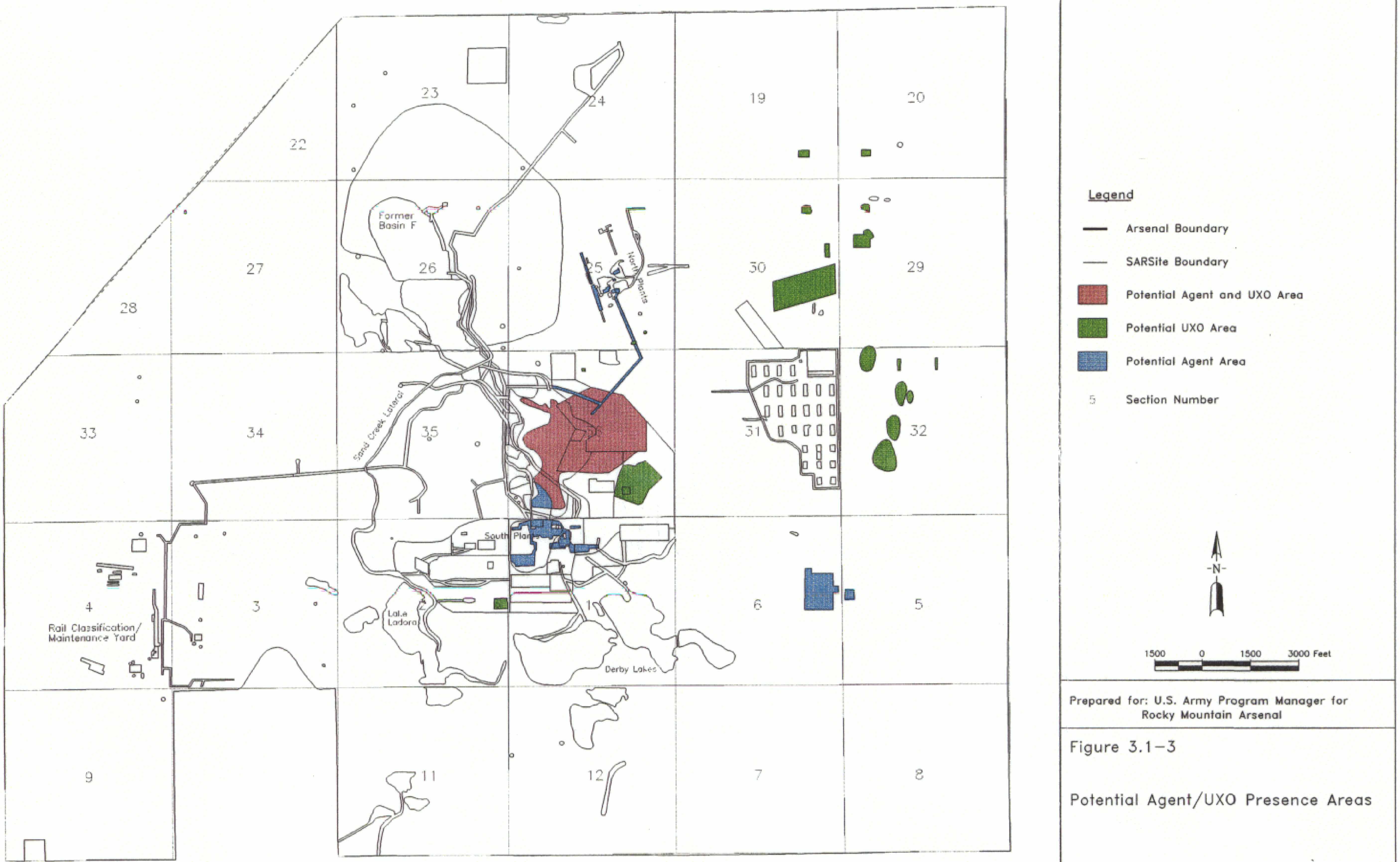

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Figure 3.1-3

Potential Agent/UXO Presence Areas

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Section 4

4.0 DETAILING OF ALTERNATIVES

This section describes in detail the alternatives evaluated in the Soil DAA for each of the exceedance categories (Table 4.0-1). While most of the alternatives described below were retained without modification from the DSA, several alternatives were either modified or added to better accommodate the consolidation or treatment of the contaminated soil volumes. To provide the proper context for the alternative descriptions that follow, both the assumptions used to develop the alternatives and an overview of the modifications made to the alternatives are provided (Section 4.1 and 4.2, respectively). For reasons of brevity, the alternative descriptions only refer to technologies or representative process options that are more fully detailed in the Technology Descriptions Volume.

4.1 BASIS OF ALTERNATIVE DETAILING

The following section discusses several assumptions regarding the detailing of alternatives including environmental monitoring, the availability of borrow soil, and the use of centralized treatment/disposal facilities.

Ambient air, surface water and groundwater monitoring are currently being conducted under the CMP to collect data on current conditions at RMA. While the CMP program may be continued, reduced or discontinued during the following remediation, monitoring is required to evaluate the long-term protectiveness in those areas where contamination above cleanup goals is left in place. Thus, a compliance monitoring program is required for alternatives that leave human health exceedances in-place, including no action, access restrictions, in-place containment, consolidation and landfill alternatives. It is plausible that some of the existing CMP wells can be used for compliance monitoring. Although the details of the compliance monitoring program will be developed during the remedial design, costs for groundwater compliance monitoring are included for each soil alternative (for each medium group or subgroup) that leaves human health exceedances in-place..

The alternatives described in the following sections specify the use of common soil for backfill, soil/vegetation layers for caps/covers, and low-permeability soil for caps/covers and liners. Geotechnical studies have been performed as part of the Soil FS Support Study to identify potential borrow areas for both common soil and low-permeability soil. The detailing of alternatives is based on the evaluations from these studies that common soil is readily available and that low-permeability soil (i.e., soil with a higher clay content) is available primarily in the northeast portion of RMA, although the New Toxic Storage Yards could also be used.

4.2 OVERVIEW OF ALTERNATIVE MODIFICATIONS

The alternatives retained in the Soil DSA were selected from the following general response action categories: No Action/Institutional Controls, Containment, and Treatment. During the DAA, alternatives were modified to address principal threat volumes, potential risks to biota, and procedures for treating UXO. For example, alternatives were developed that address principal threat volumes through treatment and the balance of each site through engineering or institutional controls or through containment. The use of containment has resulted in the creation of several new alternatives and the modification of a number of alternatives (Section 4.2.1). A number of alternatives were modified to account for consolidating soil with low levels of contamination into nearby areas for containment, thereby minimizing the areas requiring long-term maintenance and maximizing unrestricted habitat areas (Section 4.2.2). Section 4.2.2 also presents an overview of the changes relative to consolidation, and Section 4.2.3 summarizes the changes relative to determining treatment that is only required for organic contaminants (and not inorganic contaminants). Several alternatives were also modified to address residual contamination below 10 ft through containment (Section 4.2.4).

Modifications to alternatives that address potential risks to biota were made based on changes in the human health and biota risk evaluations in the IEA/RC (EBASCO 1994a); Section 4.2.5 presents an evaluation of these alternatives. Finally, modifications regarding treatment of UXO involved the addition of two alternatives (U3a and U4a) to address procedures for treating UXO filled with high explosives (HE-filled UXO) only.

4.2.1 Principal Threat Alternatives

As discussed in Section 1.4.3, principal threat volumes were estimated based on an excess cancer risk of 10^{-3} and an HI of 1,000. Existing alternatives retained in the DSA were modified to address these volumes. For the human health no additional action alternatives, two additional alternatives were considered to address treatment of principal threat volumes. Under Alternative 1a, the principal threat volume, consisting only of organic contaminants, is excavated, transported, and treated by thermal desorption. Under Alternative 1b, the organic principal threat volume is thermally desorbed and the inorganic volume is treated by solidification. The treated principal threat volumes are then returned to the site as backfill.

The entire contaminated soil volumes for the Basin F Wastepile, Buried M-1 Pits, and identified disposal trenches within the Complex Trenches, Hex Pit, and Shell Trenches subgroups were designated as principal threat volumes. Therefore, full treatment or full containment alternatives were evaluated for these subgroups; alternatives consisting of combinations of treatment and containment were not developed. Some of the soil in the Section 36 Lime Basins Subgroup exceeds the principal threat criteria. However, alternatives consisting of combinations of treatment and containment were not considered for this subgroup based on concerns regarding the ability to identify and excavate isolated soil volumes with principal threat exceedances.

Institutional controls and containment alternatives (Alternative 2: Access Restrictions (Modifications to FFA [EPA et al. 1989]), Alternative 3: Landfill (On-Post Landfill), and Alternative 6: Caps/Covers (Multilayer Cap)) were modified to include treatment of principal threat volumes for the Basin A Medium Group and Former Basin F, Chemical Sewers, South Plants Ditches, and South Plants Balance of Areas subgroups. In these alternatives, the principal threat volume is excavated, transported, and treated by thermal desorption then either returned to the site as backfill or landfilled. Upon treatment of the principal threat volume, the containment or institutional controls portion of the alternative is implemented for the balance of these areas. The modified alternatives are as follows:

- Alternative 2a: Direct Thermal Desorption (Direct Heating) of Principal Threat Volume; Access Restrictions (Modifications to FFA)

- Alternative 3a: Direct Thermal Desorption (Direct Heating) of Principal Threat Volume; Landfill (On-Post Landfill)

- Alternative 6b: In Situ Solidification/Stabilization (Silica/Proprietary Agent-Based Solidification) of Principal Threat Volume; Caps/Covers (Multilayer Cap)

- Alternative 6c: Direct Thermal Desorption (Direct Heating) of Principal Threat Volume; Caps/Covers (Multilayer Cap)

For the South Plants Central Processing Area Subgroup, where the principal threat volume includes both organic and inorganic contaminants, the principal threat volume is excavated, transported, and the organic exceedance volume is treated by thermal desorption followed by solidification of the inorganic exceedance volume; the treated soil is either returned to the site as backfill or is landfilled (for Alternative 3d). As with the alternatives above, after treatment of the principal threat volume, the containment or institutional controls portion of the alternative is implemented for the balance of a site. The modified alternatives are as follows:

- Alternative 3d: Direct Thermal Desorption (Direct Heating) and Direct Solidification/Stabilization (Cement-Based Solidification) of Principal Threat Volume; Landfill (On-Post Landfill); Caps/Covers (Multilayer Cap)

- Alternative 6a: Direct Thermal Desorption (Direct Heating) and Direct Solidification/Stabilization (Cement-Based Solidification) of Principal Threat Volume; Caps/Covers (Multilayer Cap)

4.2.2 Incorporation of Consolidation Alternatives

As discussed in Section 3.1, consolidation of contaminated soil into Basin A and the South Plants Central Processing Area is considered for several reasons, including minimizing areas at RMA requiring long-term maintenance; reducing borrow material, cap, revegetation, and maintenance costs; and minimizing habitat restrictions. The excavated areas that pose potential risks to biota are backfilled with borrow material and revegetated with native grasses in accordance with a refuge management plan. The modified containment alternatives for the soil to be consolidated are as follows:

- Alternative 3f: Landfill (On-Post Landfill); Caps/Covers (Multilayer Cap) with Consolidation

- Alternative 3g: Landfill (On-Post Landfill); Caps/Covers (Multilayer Cap) with Consolidation; Caps/Covers (Soil Cover)

For the Buried Sediments, Sand Creek Lateral, and Section 36 Balance of Areas Subgroups and the Secondary Basins and Sanitary Landfills Medium Groups, Alternative 6: Caps/Covers (Multilayer Cap) (which does not include consolidation) was evaluated. For the South Plants Ditches and South Plants Balance of Areas Subgroups, Alternative 6: Caps/Covers (Multilayer Cap), as well as the modified Alternative 6c: Direct Thermal Desorption (Direct Heating) of Principal Threat Volume; Caps/Covers (Multilayer Cap) were evaluated.

In order to achieve the design grades for capping, Basin A will require approximately 2,500,000 BCY of gradefill and South Plants Central Processing Area will require approximately 560,000 BCY of gradefill. Most of the alternatives evaluated for these two sites included installing a cap/cover to address residual contamination (see Section 4.2.4) or untreated human health exceedances; however, the volume of material to be consolidated depends on the alternatives selected for the Buried Sediments, Sand Creek Lateral, Section 36 Balance of Areas, South Plants Ditches, and South Plants Balance of Areas subgroups and the Secondary Basins and Sanitary Landfills medium groups. As a result, the description of alternatives for Basin A and South Plants Central Processing Area identify the potential for consolidating soil from other sites. The volume of materials consolidated into these two sites is addressed as part of the development and evaluation of sitewide alternatives in Section 20.

For the Ditches/Drainage Areas, Lake Sediments, and Surficial Soil medium groups, Alternative B5a: Caps/Covers (Multilayer Cap) with Consolidation was evaluated in addition to Alternative B5: Caps/Covers (Multilayer Cap). Soil posing a potential risk to biota is excavated and consolidated into Basin A prior to containment by capping under this alternative. The excavated site is then returned to grade using borrow material and revegetated to restore habitat.

Alternatives for the biota exceedance portion of several Human Health Exceedance Category subgroups also include consolidation.

4.2.3 Treatment Alternatives

Some of the treatment alternatives retained in the DSA (EBASCO 1992b) (Alternatives 8, 13, and 19) were modified in the DAA to address treatment of soil exceedance volumes that contain organic contaminants only. By refining contaminated soil volumes and characteristics of the subgroups, many were found to contain organic exceedances only. For these subgroups, solidification of inorganics is not required and has been deleted. The modified alternatives are as follows:

- Alternative 8a: Direct Soil Washing (Solvent Washing)
- Alternative 13a: Direct Thermal Desorption (Direct Heating)
- Alternative 19a: In Situ Thermal Treatment (RF/Microwave Heating)

Solidification is retained, however, for the Basin A Medium Group and the Buried M-1 Pits, South Plants Central Processing Area, South Plants Balance of Areas, Sand Creek Lateral, and Burial Trenches subgroups, which do contain inorganic exceedances.

4.2.4 Residual Containment Alternatives

Some of the alternatives retained in the DSA (EBASCO 1992b) (Alternatives 3, 8, 13, and 19) were modified in the DAA to address containment of residual soil exceedance volumes. Several areas at RMA have contamination more than 10 ft below ground surface, which was the cut-off level for determining the PPLVs used in the IEA/RC (EBASCO 1994a).

Once the exceedance volumes are removed to a depth of 10 ft or to the water table, the risks posed to humans and biota from direct exposure are addressed. However, residual contamination in the soil at depths below 10 ft may continue to impact groundwater. Given these depths, additional excavation is neither cost effective nor efficient. Containment, on the other hand, presents a cost-effective approach that would efficiently reduce the infiltration of contaminants to groundwater. For these areas, therefore, a multilayer cap or a soil cover is installed to contain residual contamination following the treatment or containment of the exceedance volume in the 0- to 10-ft depth interval. Soil covers are used to contain residual contamination in a few instances but multilayer capping is the default Representative Process Option (as discussed in Section 6.2 of the Technology Descriptions Volume). Containment of residual contamination was added for the Basin A Medium Group and Former Basin F and South Plants Central Processing Area Subgroups. The modified alternatives are as follows:

- Alternative 3b: Landfill (On-Post Landfill); Caps/Covers (Soil Cover or Multilayer Cap)

- Alternative 3c: Direct Thermal Desorption (Direct Heating) of Principal Threat Volume; Landfill (On-Post Landfill); Caps/Covers (Multilayer Cap)

- Alternative 3d: Direct Thermal Desorption (Direct Heating) and Direct Solidification/Stabilization (Cement-Based Solidification) of Principal Threat Volume; Landfill (On-Post Landfill); Caps/Covers (Multilayer Cap)

- Alternative 8b: Direct Soil Washing (Solvent Washing); Direct Solidification/Stabilization (Cement-Based Solidification); Caps/Covers (Multilayer Cap)

- Alternative 13c: Direct Thermal Desorption (Direct Heating); Caps/Covers (Multilayer Cap)

- Alternative 13d: Direct Thermal Desorption (Direct Heating); Direct Solidification/Stabilization (Cement-Based Solidification); Caps/Covers (Multilayer Cap)

- Alternative 19b: In Situ Thermal Treatment (RF/Microwave Heating); In Situ Solidification/Stabilization (Cement-Based Solidification); Caps/Covers (Multilayer Cap)

- Alternative 19c: In Situ Thermal Treatment (RF/Microwave Heating); Caps/Covers (Multilayer Cap)

4.2.5 Treatment Alternatives for Biota Risk Category

During the DSA, four treatment alternatives involving direct and in situ treatment technologies were retained for soil that potentially presents risks to biota. However, since the DSA was ways. First, the Human Health SEC (EBASCO 1994a) for OCPs decreased approximately an order of magnitude as a result of the inclusion of acute exposure criteria. Therefore, soil that had previously been at the high end of the concentration range of potential biota risk soil (i.e., with concentrations between the acute criteria and the Human Health SEC [EBASCO 1994a]) was recategorized as human health exceedance soil and addressed under the human health alternatives. The effect of this change was to reduce the average concentrations of contaminants in the potential biota risk soil areas. Second, the areas that present potential risks to biota were determined based on consideration of exposure over a given foraging range (as discussed in Section 1.4.2.2), instead of on a boring-by-boring basis. This re-estimation resulted in an increased biota volume (EBASCO 1994a). Therefore, the following intensive treatment alternatives were determined not to be cost-effective for the large volumes of low concentration potential biota risk soil, and they were eliminated from consideration for the DAA.

- Alternative B6: Direct Thermal Desorption (Direct Heating)
- Alternative B10: In Situ Biological Treatment (Aerobic Biodegradation)
- Alternative B11: In Situ Thermal Heating (Surface Soil Heating)

However, a less intensive treatment alternative, Alternative B9: In Situ Biological Treatment (Landfarm/Agricultural Practice) was retained. Alternative 20: In Situ Thermal Treatment (Surface Soil Heating); Direct Thermal Desorption (Direct Heating); Direct Solidification/Stabilization (Cement-Based Solidification) was retained in the DSA for the South Plants Balance of Areas Subgroup. This alternative addressed shallow contamination for both human health and biota exceedances by surface soil heating, and addressed the remaining human health exceedances by thermal desorption and solidification/stabilization. However, the elimination of treatment alternatives for soil that poses risks to biota, including Alternative B11: In Situ Thermal Treatment (Surface Soil Heating), also leads to the elimination of Alternative 20 in the DAA.

4.3 ALTERNATIVES FOR THE POTENTIAL UXO PRESENCE CATEGORY

Four alternatives were retained for the Potential UXO Presence Category that involve no additional action, containment, and on-post or off-post demilitarization of UXO. The Munitions Testing Medium Group is the only medium group within this exceedance category. The alternatives developed for this medium group in the DSA were modified for the DAA as described in the following sections. The alternatives for addressing UXO consider Department of Defense (DOD) regulations governing the demilitarization of munitions. Excavated UXO filled with HE are to be transported to a demolition site or detonated on site if the munitions are considered unsafe for transport (AMC-R 385-100) (AMC 1985). If the excavated UXO contain Army agent, the munitions are incinerated in a specially designed incinerator after the fuses are removed, packaged and transported to an off-post Army facility for demilitarization, or packed with C-4 and detonated in place.

The Munitions Testing Medium Group, South Plants Balance of Areas Subgroup, and Burial Trenches Subgroup contain potential UXO presence areas where HE-filled UXO were tested or detonated. As such, these areas are evaluated for the potential presence of HE-filled munitions. The remaining areas with the potential presence of UXO are evaluated for the potential presence of agent-filled UXO. The two modified alternatives, Alternative U3a and Alternative U4a, account for the different procedures used to treat HE-filled UXO only. The six alternatives for this category are also evaluated as part of the overall remedial alternatives for Human Health Exceedance Category subgroups that potentially contain UXO. The modified alternatives are as follows:

- Alternative U3a: Detonation (On-Post Detonation)
- Alternative U4a: Detonation (Off-Post Facility)

In addition to the Munitions Testing Medium Group, UXO may be found at other RMA sites in the Basin A, Complex Trenches, South Plants, and Undifferentiated medium groups. However, the areas with potential UXO presence in these medium groups generally overlap with human health and/or biota exceedances, so UXO is dealt with as part of the human health or biota alternatives for these medium groups.

4.3.1 Alternative U1: No Additional Action (Provisions of FFA)

Alternative U1 is a no action/institutional controls alternative. Under this alternative, no specific actions are taken to address the physical hazards associated with potential UXO. The major components of Alternative U1 are the following:

- No further action beyond the FFA restrictions (EPA et al. 1989)
- Monitoring through site reviews to observe site conditions

The provisions of the FFA (EPA et al. 1989) promote protection of human health by prohibiting residential development, consumption of all game and fish taken at RMA, and agricultural activities other than erosion control or those related to remedial activities. No IRAs have been implemented at UXO sites within the Munitions Testing Medium Group, although the Army continues to investigate new technologies for identifying subsurface UXO and the Army is developing an IRA Decision Document. Under the no action alternative, site conditions are monitored as part of the 5-year site review procedure, but no additional soil sampling is conducted.

4.3.2 Alternative U2: Caps/Covers (Multilayer Cap)

Alternative U2 is a containment alternative that reduces physical hazards associated with UXO by interrupting exposure pathways. The major components of Alternative U2 are the following:

- Surface sweep and geophysical clearance of surface soil
- Containment of areas potentially containing UXO by installing a 4-ft-thick soil cover that prevents exposure
- Monitoring through site reviews and maintenance operations to determine effectiveness of containment systems

The 4-ft-thick soil cover consists of clean, noncohesive borrow material to provide a uniform cover. The uppermost 6 inches of the cover are supplemented with conditioners to support the development of vegetation (Section 6.1.1 of the Technology Descriptions Volume). The cover is slightly convex, with an upper slope that ranges between 3 and 5 percent to reduce infiltration and erosion of the cover. The native perennial grasses used to cover the top layer are capable of surviving at a sufficient density to minimize erosion of the cover with little or no maintenance. The grasses impede erosion, but also allow surface runoff from major storm events.

Prior to placing the soil cover, surface sweeps and geophysical surveys are conducted to ensure the safety of personnel working at the site and prevent damage to equipment. The surface sweep is conducted to identify any near-surface UXO or debris. If UXO are identified during the survey, clearance is conducted as described in Section 4.3.3.

Following the installation of the cover, site controls are implemented to maintain the integrity of the cover and to ensure that the cover limits potential physical hazards to humans and biota from soil containing UXO. Access controls ensure that the cover is not disturbed or excavated. Maintenance activities ensure the repair of any erosion damage, and the integrity of the cover is evaluated as part of the 5-year review.

4.3.3 Alternative U3: Detonation (On-Post Detonation); Incineration/Pyrolysis (Rotary Kiln Incineration)

Alternative U3 is a treatment alternative that involves demilitarization of HE-filled and agent-filled UXO on post. The major components of Alternative U3 are the following:

- Geophysical clearance of sites to identify UXO prior to excavation
- Excavation of soil with UXO, separation of UXO from excavated material, and identification of UXO as being filled with agent or HE
- Removal of fuses (if fuses can be removed) from agent-filled UXO and treatment of agent-filled casing using on-post rotary kiln incineration and detonation of HE-filled UXO and fuses removed from agent-filled UXO

- Excavation of surface debris and contaminated soil (as defined by the RCRA Toxicity Characteristic Leaching Procedure (TCLP) test on composite samples) and disposal in the on-post hazardous waste landfill as discussed in Section 4.6.6

A magnetometer survey or other field screening method is used to identify the locations of UXO prior to excavation. If geophysical anomalies are detected during the survey, they are investigated using conventional earth-moving equipment (e.g., backhoes, bulldozers) adapted with safety shields or other specialized equipment as necessary to guard against explosions. Once the overlying soil has been scraped away from the areas of interest, the anomalies can be investigated. If the geophysical anomaly consists of UXO, the UXO and surrounding soil are excavated from the site, and the UXO are separated and packaged for on-post transportation.

The surficial soil and debris excavated during the removal of UXO are placed in the centralized on-post landfill (Section 4.6.6). During UXO removal operations, dust emissions are suppressed as described in Section 4.1.2 of the Technology Descriptions Volume. Equipment operators are to be highly trained in explosive ordnance identification and are required to wear appropriate protective clothing. Excavation procedures are developed to avoid accidental detonation of UXO. To avoid erosion at the disturbed area, runoff-control measures are applied as necessary, and the site is backfilled and regraded. The uppermost 6 inches of soil over the disturbed area are supplemented with conditioners and revegetated with native grasses in accordance with a refuge management plan.

Agent-filled UXO are inspected following excavation to identify those munitions that pose an immediate hazard and those that cannot be safely transported. Such UXO require emergency disposal action, which consists of detonating the UXO in place (under backfill) or rendering the UXO nonimminent hazards. UXO that does not pose an immediate hazard are transported to the on-post rotary kiln incinerator for demilitarization. The fuses and explosive components of agent-filled UXO are removed and detonated if possible. The remaining casing is then drained of all agent and the empty casing is processed through a rotary kiln incinerator at 1,000 degrees Fahrenheit (°F) for 15 minutes to destroy any remaining agent in accordance with Army Material

Command regulations (AMC-R 385-131) (AMC 1987). The agent is stored in a storage tank from which it is later injected into the secondary chamber of the rotary kiln using a liquid nozzle. The secondary combustion chamber operates at a temperature of 2,250°F, which is above the 1,000°F minimum (AMC-R 385-131) (AMC 1987) required for 5X decontamination. Section 9.1.1 of the Technology Descriptions Volume provides a description of the rotary kiln incineration of UXO, including the off-gas system.

The Technology Descriptions Volume presents the criteria for siting the detonation areas for HE-filled UXO and fuses/detonators. Site ESA-4b was historically used for detonation of munitions (Site 29-04) (ESE 1988) and is considered adequate for detonation of fuses and explosive components.

4.3.4 Alternative U3a: Detonation (On-Post Detonation)

Alternative U3a is a treatment alternative that involves demilitarization of HE-filled UXO on post. This alternative was developed for areas that include HE-filled UXO only. The major components of Alternative U3a are the following:

- Geophysical clearance of sites to identify UXO prior to excavation
- Excavation of soil with HE-filled UXO and separation of UXO from excavated material
- Detonation of HE-filled UXO in the designated detonation area
- Excavation of surface debris and contaminated soil (as defined by the RCRA TCLP test on composite sample) and disposal in the on-post hazardous waste landfill as discussed in Section 4.6.6

A magnetometer survey or other field screening method is used to identify the locations of UXO prior to excavation. Excavation and UXO removal are conducted as described in Section 4.3.3 and HE-filled UXO are hauled to a detonation area. As discussed above, Site ESA-4b has been used for the detonation of HE-filled UXO. To prevent erosion of the disturbed area, runoff-control measures are applied as necessary, and the site is backfilled and regraded. The uppermost

6 inches of soil over the disturbed area are supplemented with conditioners and revegetated with native grasses in accordance with a refuge management plan.

4.3.5 Alternative U4: Detonation (Off-Post Army Facility); Incineration/Pyrolysis (Off-Post Incineration)

Alternative U4 is a treatment alternative for UXO that involves transport of HE-filled and agent-filled UXO to an off-post facility for demilitarization. The major components of Alternative U4 are the following:

- Geophysical clearance of sites to identify UXO prior to excavation
- Excavation of soil with UXO, separation of UXO from excavated material, and packaging and transport of the UXO to an existing off-post Army facility
- Treatment of agent-filled UXO at an existing off-post Army incinerator and detonation of HE-filled UXO at an existing off-post Army facility
- Excavation of contaminated soil (as defined by the RCRA TCLP test on composite samples) and debris and disposal in the on-post hazardous waste landfill

As discussed in Section 4.3.3, a magnetometer survey or other field screening method is used to identify the locations of UXO prior to excavation. If the geophysical anomaly consists of UXO, the UXO and the surrounding soil are excavated from the site, and the UXO are separated and packaged for on-post transportation. UXO that cannot be safely transported are detonated in place. The surficial soil and debris excavated during the removal of UXO are placed in the centralized on-post landfill (Section 4.6.6). During excavation, runoff-control measures are implemented as necessary to prevent erosion. The disturbed area is backfilled, regraded, and the uppermost 6 inches supplemented with conditioners. The area is then revegetated in accordance with a refuge management plan. Specialized equipment to ensure the safety of personnel may be required to safely excavate the UXO. As with other UXO alternatives, only personnel trained in ordnance identification and handling are to be involved in remediation at sites with potential UXO presence.

Off-post demilitarization of UXO involves transportation of the UXO to an appropriate Army facility for demilitarization. UXO containing agent that are rendered safe for transport are shipped to an Army facility designed specifically for agent demilitarization. The nearest permitted Army incinerator specializing in demilitarization of HE-filled agent-filled UXO is expected to be the Pueblo Army Depot in Pueblo, Colorado. However, this facility's permit would have to be revised to accept RMA materials. UXO incineration can also be performed at Tooele Army Depot to render the UXO nonhazardous, and all residual streams from the incineration process are controlled and managed by the off-post installation (i.e., Tooele Army Depot).

The Army's current chemical weapons disposal program, which includes Tooele Army Depot, involves robotics and machine disassembly of the chemical weapons under procedures appropriate to each specific munition. The various waste materials from disassembly are incinerated separately as discussed in Section 9.2 of the Technology Descriptions Volume. Transportation requirements are outlined in AMC-R 385-131 (AMC 1987) for HE-filled agent-filled UXO, and by the Department of Transportation (DOT) for munitions transport in general.

4.3.6 Alternative U4a: Detonation (Off-Post Army Facility)

Alternative U4a is a treatment alternative that involves demilitarization of HE-filled UXO at an off-post facility. This alternative was developed for areas that include HE-filled UXO only. The major components of Alternative U4a are the following:

- Geophysical clearance of sites to identify HE-filled UXO prior to excavation
- Excavation of soil with HE-filled UXO, separation of UXO from excavated material, and packaging and transport of the UXO by truck or rail to an existing Army facility
- Detonation of HE-filled UXO at the existing Army facility
- Excavation of contaminated soil (as defined by the RCRA TCLP test on composite samples) and debris in the on-post hazardous waste landfill

A magnetometer or other field screening method is used to identify the locations of UXO prior to excavation. Excavation and UXO removal are conducted as described in Section 4.3.3. The HE-filled UXO are transported to Fort Carson Army Post in Colorado Springs, Colorado for detonation in accordance with AMC-R 385-100 (AMC 1985). Runoff-control measures are implemented as necessary during excavation to minimize erosion. The excavated area is backfilled and regraded. The uppermost 6 inches of soil over the disturbed area are supplemented with conditioners and revegetated in accordance with a refuge management plan.

4.4 ALTERNATIVES FOR THE POTENTIAL AGENT PRESENCE CATEGORY

In the DSA, four alternatives were retained for the Potential Agent Presence Category. These alternatives include a no additional action alternative, a containment alternative, and two treatment alternatives. Soil washing using solvent extraction, which was not evaluated in the DSA, was introduced during the DAA based on promising treatability study results. This exceedance category consists of a single medium group, the Agent Storage Medium Group, which is divided into the North Plants and Toxic Storage Yards subgroups. The five alternatives are applicable to both subgroups. As with UXO, DOD regulations govern the treatment of soil containing agent (AMC-R 385-131) (AMC 1987).

In addition to sites within the Agent Storage Medium Group, agent may be found at other sites at RMA. These include areas within the Basin A, Sewer Systems, Disposal Trenches, Lime Basins, South Plants, and Undifferentiated Medium Groups. Appendix A describes the sites contained within these medium groups as well as the potential areas, depths, and volumes of agent-contaminated soil.

4.4.1 Alternative A1: No Additional Action (Provisions of FFA)

Alternative A1 is a no action alternative. No specific actions are undertaken to address acute chemical hazards associated with potential agent presence. The major components of Alternative A1 are the following:

- No further action beyond the FFA restrictions (EPA et al. 1989) and the existing or planned IRAs

- Monitoring through site reviews to observe site conditions

The provisions of the FFA (EPA et al. 1989) promote protection of human health by prohibiting residential development, consumption of all game or fish taken at RMA, and agricultural activities other than erosion control or those related to remedial activities. No IRAs currently exist or are planned for sites within the Agent Storage Medium Group, although IRAs for structures in North Plants have been planned. Site conditions are monitored as part of the 5-year site review procedure, but no additional soil sampling is conducted.

4.4.2 Alternative A2: Caps/Covers (Soil Cover)

Alternative A2 is a containment alternative that reduces the acute hazards associated with agent-contaminated materials by interrupting exposure pathways. The major components of Alternative A2 are the following:

- Containment of soil potentially containing agent by installing a 4-ft-thick soil cover and vegetation layer that controls potential exposure

- Monitoring through site reviews and maintenance operations to determine effectiveness of the containment systems

Section 4.3.2 discusses the installation of a soil cover under Alternative U2: Caps/Covers (Multilayer Cap). A 4-ft-thick soil cover and a 6-inch-thick reconditioned layer of soil are placed over the potential agent presence areas. The latter is supplemented to facilitate revegetation of the cover. Section 4.3.2 also describes the long-term controls and maintenance requirements of the soil cover.

4.4.3 Alternative A3: Direct Soil Washing (Caustic Solution Washing); Landfill (On-Post Landfill)

Alternative A3 is a chemical treatment alternative for agent-contaminated soil that achieves the 3X treatment level (AMC-R 385-131) (AMC 1987). Figure 4.4-1 provides a schematic of the alternative. The major components of Alternative A3 are the following:

- Field screening with confirmation by laboratory analysis during excavation activities to identify areas containing agent
- Screening and size reduction of the soil
- Separation of remaining oversize material and debris followed by disposal of oversize material in an on-post hazardous waste landfill
- Treatment of agent in the excavated soil through direct soil washing with a caustic solution to neutralize agent compounds
- Treatment of aqueous effluent from solution washing by evaporation/crystallization
- Disposal of the treated soil and the salts from spray drying in the on-post hazardous waste landfill as discussed in Section 4.6.6

Conventional excavation consists of removing soil and debris from its original location using earth-moving equipment such as backhoes, bulldozers, front-end loaders, haul trucks, and scrapers (Figure 4.4-1). The most effective means of removing material from any given site is typically a combination of several types of equipment. Section 4.1 of the Technology Descriptions Volume describes the equipment that can be used to excavate contaminated soil. For excavation in areas potentially contaminated with agent, real-time screening is performed during excavation to ensure protection of site workers.

During excavation, dust emissions are suppressed as described in Section 4.1.1 of the Technology Descriptions Volume. Equipment operators are required to wear appropriate protective clothing, and specific excavation procedures are applied to avoid the accidental release of agent. Runoff-control measures are applied, as necessary, and the excavated area is backfilled, regraded, and revegetated with native grasses.

Caustic washing neutralizes agent in the soil matrix through alkaline hydrolysis. Neutralization does not necessarily destroy all agent present in the materials; therefore, it is classified as a 3X decontamination level of treatment. As discussed in Section 9.3.1 of the Technology Descriptions Volume, a solution of 7.5 percent sodium hydroxide (NaOH) and 2.5 percent hydrogen peroxide (H_2O_2) is used to neutralize agent in soil. The NaOH/H_2O_2 solution achieves the required pH (12) for 3X decontamination. The soil is placed in a pugmill simultaneously with the caustic solution, and the resulting slurry is mixed within the pugmill to ensure contact of the caustic solution with any agent present in the pore spaces of the soil. On a batch basis, the air space in the pugmill is sampled to confirm the sludge has been treated to the 3X level.

Upon discharge from the pugmill, the slurry is allowed to settle, and the excess solution is removed and recycled for use in subsequent washings (with additional NaOH and H_2O_2 to bring it to full strength).

Following settling, the sludge is processed through a dewatering system and then placed in the on-post hazardous waste landfill as described in Section 4.6.6. Liquid removed by the dewatering system is removed by crystallization and the salts and other contaminants recovered through evaporation are landfilled.

4.4.4 Alternative A4: Incineration/Pyrolysis (Rotary Kiln Incineration)

Alternative A4 is a thermal treatment alternative for agent-contaminated soil that achieves the 5X decontamination level (AMC-R 385-131) (AMC 1987). The major components of this alternative are the following:

- Field screening with confirmation by laboratory analysis of soil samples to identify areas containing agent
- Excavation of soil with identified agent presence
- Screening and size reduction of the soil
- Separation of remaining oversize material and debris followed by disposal of oversize material in an on-post hazardous waste landfill

- Treatment of agent in excavated soil by rotary kiln incineration
- Removal and landfilling of particulates and salts from the rotary kiln air pollution control equipment
- Backfilling of treated soil

The screening and excavation of soil with agent is discussed in Section 4.4.3 and described in Section 4.1 of the Technology Descriptions Volume. The rotary kiln incineration system oxidizes or volatilizes all organic waste constituents in the soil matrix for subsequent combustion (oxidation) in the afterburner (Figure 4.4-2). To achieve a 5X level of decontamination, i.e., complete volatilization of all agent constituents (AMC-R 385-131) (AMC 1987), the rotary kiln is operated at a temperature of at least 1,000°F with a soil residence time of 15 minutes. (It should be noted that a treatability study for thermal desorption treatment of agent is currently underway. If this technology is promising, thermal desorption may be substituted for incineration.) Off gas from the rotary kiln is fed to the afterburner for destruction of the VOCs. The afterburner operates at temperatures up to 2,250°F and must be able to withstand the high corrosivity of chlorides and iron compounds. Excess air is added to the afterburner to ensure destruction of at least 99.99 percent of the remaining organics present. The off-gas control system for a rotary kiln incinerator is described in Section 7.2.1 of the Technology Descriptions Volume.

Approximately 10 percent of the solids feed are entrained as particulates in the off-gas stream; however, most particulates are recovered and combined with the treated soil. Approximately 1 percent of the total solids feed are recovered from the scrubber blowdown along with salts from the scrubber (Figure 4.4-2). These residuals are placed in the on-post hazardous waste landfill.

The treated soil is backfilled on site. Since the organic carbon content of the soil is destroyed during rotary kiln incineration, the uppermost 6 inches of soil over the backfilled areas are supplemented with conditioners and revegetated with native grasses in accordance with a refuge management plan.

4.4.5 Alternative A5: Direct Soil Washing (Solvent Extraction); Landfill (On-Post Landfill)

Alternative A5 is a treatment alternative for agent-contaminated soil that achieves the 3X treatment level (AMC-R 385-131) (AMC 1987). The major components of Alternative A5, which was developed during the DAA, are the following:

- Field screening with confirmation by laboratory analysis of soil samples to identify areas containing agent
- Excavation of soil with identified agent presence
- Screening and size reduction of the soil
- Separation of remaining oversize material and debris followed by disposal of oversize material in an on-post hazardous waste landfill
- Treatment of agent in the excavated soil through direct solvent extraction, which utilizes an organic solvent to remove organic contaminants and a caustic solution to adjust pH to a level that neutralizes agent compounds
- Treatment of organic effluent from solvent washing at an off-post treatment and disposal facility
- Disposal of treated soil in the on-post hazardous waste landfill as discussed in Section 4.6.6

Conventional excavation consists of removing soil and debris from its original location using earth-moving equipment such as backhoes, bulldozers, front-end loaders, haul trucks, and scrapers. The most effective means of removing material from any given site is typically a combination of several types of equipment. Section 4.1 of the Technology Descriptions Volume describes the equipment that can be used to excavate contaminated soil. For excavation in areas potentially contaminated with agent, real-time screening is performed both prior to and during excavation to ensure protection of site workers.

During excavation, dust emissions are suppressed as described in Section 4.1.1 of the Technology Descriptions Volume. Equipment operators are required to wear appropriate protective clothing, and specific excavation procedures are applied to avoid the accidental release of agent. Runoff-control measures are applied, as necessary, and the excavated area is backfilled, regraded, and revegetated with native grasses.

Solvent extraction both neutralizes agent through alkaline hydrolysis and removes other organic contaminants in the soil matrix. (A treatability study for this process is currently underway.) Neutralization does not necessarily destroy all agent present in the materials; therefore, it is classified as a 3X decontamination level of treatment. Figure 4.4-3 presents a schematic of the solvent/caustic washing of agent-contaminated soil. As discussed in Section 9.4-1 of the Technology Descriptions Volume, the soil is screened and crushed to size, placed in a reactor, and mixed with a solvent (such as triethylamine) and NaOH mixture. The resulting slurry is then mixed to ensure contact of the caustic solution with any agent present in the pore spaces of the soil. The solution is then removed from the reactor, and another two wash cycles are initiated for a total soil residence time of more than 30 minutes. Since the pH of the solvent washing system is approximately 12, the pH of the treated materials approaches 12 following the three wash cycles. The treated materials are neutralized to lower the pH, and placed in the on-post hazardous waste landfill as described in Section 4.6.6. The equipment used for the solvent/caustic washing of soil is generally the same as that used for solvent extraction, which is described in Section 12.2 of the Technology Descriptions Volume. However, the equipment is modified to withstand the slightly higher pH anticipated in this system as compared to the standard solvent-extraction system. The solvent is regenerated and the product organic solution is sent for off-post disposal.

4.5 ALTERNATIVES FOR THE BIOTA RISK CATEGORY

In the Soil DSA, nine alternatives were retained for the three medium groups (Lake Sediments, Surficial Soil, Ditches/Drainage Areas) in the Biota Risk Category. These alternatives include a no action alternative, a containment alternative, and both direct and in situ treatment alternatives. As discussed in Section 4.2.5, most of the treatment alternatives were eliminated for this category. Therefore, the alternatives developed for this category primarily involve containment (see Table 4.0-1). One new alternative, Alternative B1a: Landfill (On-Post

Landfill); No Additional Action (Provisions of FFA), which involves placing isolated human health exceedances in the on-post hazardous waste landfill and no additional action for the remaining areas, was added in the DAA. Alternative B5: Caps/Covers (Multilayer Cap) was modified as Alternative B5a: Caps/Covers (Multilayer Cap) with Consolidation to include consolidation in Basin A. Alternative B9: In Situ Biological Treatment (Landfarm/Agricultural Practice) was also modified to Alternative B9a: Landfill (On-Post Landfill); In Situ Biological Treatment (Landfarm/Agricultural Practice) to include landfilling of isolated human health exceedances. Section 4.5.9 presents a brief discussion of the alternatives considered for the biota exceedance portions of the Human Health Exceedance Category medium groups. For all biota alternatives, the continuing biota risk evaluation process described in Section 1.4.2.2 will apply to those areas that are not initially remediated and fall within the Area of Dispute or the agreed-upon biota risk areas.

4.5.1 Alternative B1: No Additional Action (Provisions of FFA)

Alternative B1 is a no action alternative that was developed for all three of the medium groups in the Biota Risk Category. The major components of Alternative B1 are the following:

- No further action beyond FFA restrictions (EPA et al. 1989) other than existing or planned IRAs
- Monitoring through annual soil sampling and site reviews to observe natural contaminant attenuation/degradation and potential contaminant migration

Land-use restrictions in the FFA (EPA et al. 1989) promote protection of human health by prohibiting residential development, consumption of all game or fish taken at RMA, and all agricultural activities other than erosion control or those related to remedial activities. The time frame for natural attenuation to remove the potential risks to biota is estimated to be more than 30 years based on the range of half-lives for the primary OCP contaminants detected at these sites (EBASCO 1992a). Contaminant levels are monitored in conjunction with 5-year site reviews to observe natural attenuation and potential contaminant migration. Alternative B1 does not restrict habitat or contain vegetation modifications required to manage wildlife.

Ongoing bio-monitoring conducted by the USFWS and SFS/risk assessment process will be used to determine if any areas where soil posing risk to biota remains in-place require remediation over the long-term. Remedial actions will be determined at such time as they are required but will generally consist of the alternatives identified in Sections 4.5.3 to 4.5.8.

4.5.2 Alternative B1a: Landfill (On-Post Landfill); No Additional Action (Provisions of FFA)

Alternative B1a is a combined containment and no additional action alternative that was developed during the DAA for the Lake Sediments and Surficial Soil Medium Groups. The major components of Alternative B1a are the following:

- Excavation of human health exceedance soil and backfill with on-site borrow material
- Placement of the excavated soil/sediment in the on-post hazardous waste landfill
- No further action for remaining sediment beyond FFA restrictions (EPA et al. 1989) other than existing or planned IRAs
- Long-term operations and maintenance (O&M) of the on-post hazardous waste landfill including cap maintenance, leachate treatment, and monitoring
- Monitoring of remaining soil/sediment through annual sampling and site reviews to observe natural contaminant attenuation/degradation and potential contaminant migration

The human health exceedances are excavated as described in Section 4.1 of the Technology Descriptions Volume. Section 4.6.6 describes the centralized on-post hazardous waste landfill facility, including construction and operation. Groundwater monitoring is conducted as part of the long-term monitoring and maintenance of the landfill. In addition, leachate from the landfill is collected and treated, and the landfill cover is maintained and repaired as needed.

Land-use restrictions in the FFA (EPA et al. 1989) promote protection of human health by prohibiting residential development, consumption of all game or fish taken at RMA, and all agricultural activities other than erosion control or those related to remedial activities. The time frame for natural attenuation to remove the potential risks to biota is estimated at more than 30 years based on the range of half-lives for the primary OCP contaminants detected at these sites

(EBASCO 1992a). Contaminant levels in the remaining soil are monitored to observe natural attenuation and potential contaminant migration, and 5-year site reviews are conducted to document any changes in the site characteristics.

Ongoing bio-monitoring conducted by the USFWS and SFS/risk assessment process will be used to determine if any areas where soil posing risk to biota remains in-place require remediation over the long-term. Remedial actions will be determined at such time as they are required but will generally consist of the alternatives identified in Sections 4.5.3 to 4.5.8.

4.5.3 Alternative B2: Biota Management (Exclusion, Habitat Modification)

Alternative B2 is a no action/institutional controls alternative that was developed for the Ditches/Drainage Areas Medium Group. The major components for Alternative B2 are the following:

- Exclusion of biota through fencing and habitat modification to reduce biota exposure to contaminated soil

- Monitoring through annual soil sampling and site reviews to observe natural contaminant attenuation/degradation and potential contaminant migration

The exclusion of biota from areas of contaminated soil is accomplished through physical barriers and changes to habitat quality. The installation of a 6-ft-high chain-link fence around an area of contaminated soil limits the entry of many mammals and therefore interrupts the exposure pathways. In addition, several types of vegetation are planted in the area that are unappealing to biota and deter the migration of biota into the contaminated area. Section 3.1.1 of the Technology Descriptions Volume describes vegetation that could be used for habitat modification. The revegetation of a contaminated site with less desirable vegetation reduces the use of the site as habitat.

Sampling of contaminated soil is used to detect potential contaminant migration and to observe natural attenuation/degradation of contaminants, and 5-year site reviews are conducted to document the exclusion of wildlife and the natural attenuation of contaminants. The time frame for natural attenuation to remove the potential risks to biota is estimated to be more than 30 years based on the range of half-lives for the primary OCP contaminants detected at these sites (EBASCO 1992a).

Ongoing bio-monitoring conducted by the USFWS and the SFS/risk assessment process will be used to determine if any additional areas require remediation over the long-term. Remedial actions will be determined at such times as they are required but will generally consist of the alternatives identified in Sections 4.5.3 to 4.5.8.

4.5.4 Alternative B3: Landfill (On-Post Landfill)

Alternative B3 is a containment alternative that was developed for the Lake Sediments, Surficial Soil, and Ditches/Drainage Areas Medium Groups. The major components of Alternative B3 are the following:

- Construction of a centralized, on-post hazardous waste landfill facility with multiple landfill cells
- Excavation of soil that may potentially pose a risk to biota (including the soil in Upper Derby Lake)
- Placement of excavated soil in the landfill
- Long-term O&M of the on-post hazardous waste landfill including cap maintenance, leachate treatment, and monitoring.

Section 4.1 of the Technology Descriptions Volume describes the conventional excavation of contaminated soil. The choice of equipment is primarily based on site-specific needs. For example, scrapers may be effectively used to remove surficial soil, but are not applicable to removing contaminated soil from the Ditches/Drainage Areas Medium Group. The excavation or dredging plan developed for biota sites focuses on, to the extent possible, minimizing impacts to biota and maximizing the use of mitigation measures (e.g., determination of the appropriate season to excavate, determination of procedures for relocation of biota prior to excavation).

During excavation, dust-control measures are implemented, in particular for the excavation of widespread areas of the Surficial Soil Medium Group. Once the site is regraded, the soil is reconditioned with fertilizer and then revegetated with native grasses in accordance with a refuge management plan. Runoff-control measures may be needed until the site is fully reclaimed.

Section 4.6.6 describes the centralized on-post landfill facility, including construction and operation. Groundwater monitoring is conducted as part of the long-term monitoring and maintenance of the landfill. In addition, leachate from the landfill is collected and treated, and the landfill cover is maintained and repaired as needed.

Ongoing bio-monitoring conducted by the USFWS and the SFS/risk assessment process will be used to determine if any additional areas require remediation over the long-term. Remedial actions will be determined at such times as they are required but will generally consist of the alternatives identified in Sections 4.5.3 to 4.5.8.

4.5.5 Alternative B5: Caps/Covers (Multilayer Cap)

Alternative B5 is a containment alternative that was developed to contain areas posing risk to biota at the same time adjacent areas with human health exceedances are being contained by a cap. The major components of Alternative B5 are the following:

- Containment of soil that may potentially pose risk to biota by installing a cap/cover or expanding the human health exceedance area cap/cover (multilayer cap)
- Monitoring through 5-year site reviews and maintenance operations to document the effectiveness of the containment system

Section 4.6.14 describes the layers of the multilayer cap, including the construction design requirements. The cap includes layers and controls to limit wildlife exposure and to prevent damage to the containment system. Section 6.4 of the Technology Descriptions Volume discusses the multilayer cap in more detail.

The low-permeability multilayer cap is maintained and inspected annually, and any damage from erosion is repaired. Five-year site reviews are conducted to document the effectiveness of the containment system.

Ongoing bio-monitoring conducted by the USFWS and the SFS/risk assessment process will be used to determine if any additional areas require remediation over the long-term. Remedial actions will be determined at such times as they are required but will generally consist of the alternatives identified in Sections 4.5.3 to 4.5.8.

4.5.6 Alternative B5a: Landfill (On-Post Landfill); Caps/Covers (Multilayer Cap) with Consolidation

Alternative B5a is a containment alternative that was modified for the Ditches/Drainage Areas, Lake Sediments, and Surficial Soils Medium Groups. Human health exceedances, if present, are excavated and landfilled. Instead of capping the soil posing risk to biota in place, the soil is consolidated into Basin A for containment. The major components of Alternative B5a are the following:

- Construction of a centralized, on-post hazardous waste landfill facility with multiple landfill cells
- Excavation of human health exceedance soil and placement in the landfill
- Excavation of soil that may potentially pose a risk to biota (including soil in Upper Derby Lake) and consolidation of excavated soil into Basin A or former Basin F as gradefill prior to installation of a multilayer cap
- Backfill of excavations with clean borrow material
- Monitoring of the Basin A and former Basin F caps through annual groundwater compliance monitoring, 5-year reviews and maintenance operations to document the effectiveness of the system

The biota risk volume is excavated with conventional earth-moving equipment as discussed in Section 4.1 of the Technology Descriptions Volume. During excavation, dust-control measures are implemented. The excavations are backfilled with borrow materials and revegetated with native grasses. Runoff-control measures are implemented as needed during excavation and revegetation.

As discussed in Section 6.4 of the Technology Descriptions Volume, compacted multilayer caps are constructed with design grades that range between 3 and 5 percent both to facilitate runoff and to reduce erosion damage. Therefore, the capping of Basin A requires the installation of approximately 2.5 million cubic yards of fill to achieve design grades. Instead of using borrow materials for gradefill, soil with low levels of contamination is consolidated and used as gradefill. As discussed in Section 3.1.3, the consolidation of soil for containment reduces the areas requiring long-term management and maintenance and increases the areas available for use as habitat. The consolidated soil forms the subgrade for capping, which is then regraded and compacted to minimize subsidence.

Ongoing bio-monitoring conducted by the USFWS and the SFS/risk assessment process will be used to determine if any additional areas require remediation over the long-term. Remedial actions will be determined at such times as they are required but will generally consist of the alternatives identified in Sections 4.5.3 to 4.5.8.

4.5.7 Alternative B9: In Situ Biological Treatment (Landfarm/Agricultural Practice)

Alternative B9 is a treatment alternative that was developed for the Ditches/Drainage Areas Medium Group. The major components of Alternative B9 are the following:

- Treatment of organic compounds in soil that may potentially pose a risk to biota by landfarm/agricultural practice
- Monitoring through annual soil sampling and site reviews to detect potential contaminant migration to subsurface soil and to observe natural contaminant attenuation/degradation

The landfarm/agricultural practice process consists of using landfarming techniques either with farm machinery (ripper, plow, and disk) or a soil stabilizer along with seeding to facilitate stabilization and attenuation of OCPs in surface soil (0- to 1-ft depth interval). As discussed in Section 11.1 of the Technology Descriptions Volume, the pesticides found in surficial soil at other sites have been shown to decrease in concentration over time when subjected to landfarm/agricultural practices. The landfarm technology does not provide intensive treatment of the contaminants present. It does, however, reduce the migration of contaminated dust, limit exposure to surface receptors, and promote the natural attenuation of contaminants.

In this process, a plow with 6- to 8-inch bottoms is used to cover the upper 2 inches of contaminated soil with uncontaminated soil from below the 0- to 2-inch depth interval. (Where hard pan is present, the ground surface must first be ripped.) In the final step, a disk is used to break up and uniformly mix the soil. Fertilizer and mulch are applied, and a mixture of native grasses is seeded (in accordance with a refuge management plan) to facilitate development of a stable final grass stand, aid soil conservation, and prevent dust dispersion.

A number of soil stabilizers that perform soil mixing are currently available. The soil stabilizers can uniformly mix an 8-ft width of soil to a depth of up to 18 inches. They typically come equipped with an internal spray bar through which water or nutrients can be added to the soil during the mixing process. The use of a soil stabilizer requires only one pass to effectively mix the soil. A typical soil stabilizer, at a working speed of 30 ft per minute (fpm), can till approximately 2.6 acres in a 10-hour day.

Long-term monitoring is conducted over the areas treated to observe the OCP levels over time and to observe the potential migration of contaminants to subsurface soil. The time frame for natural attenuation to remove the potential risks to biota is estimated to be more than 30 years based on the range of half-lives for the primary OCP contaminants detected at these sites (EBASCO 1992a). Five-year site reviews are conducted to document the changes in OCP levels.

Ongoing bio-monitoring conducted by the USFWS and the SFS/risk assessment process will be used to determine if any additional areas require remediation over the long-term. Remedial actions will be determined at such times as they are required but will generally consist of the alternatives identified in Sections 4.5.3 to 4.5.8.

4.5.8 Alternative B9a: Landfill (On-Post Landfill); In Situ Biological Treatment (Landfarm/Agricultural Practice)

Alternative B9a is a treatment alternative that was developed for the Surficial Soil Medium Group. The major components of Alternative B9a are the following:

- Construction of a centralized, on-post hazardous waste landfill facility with multiple landfill cells
- Excavation of isolated human health exceedances
- Placement of excavated soil in the landfill and backfill of excavations with borrow material or adjacent potential biota risk soil
- Treatment of organic compounds in remaining soil that may potentially pose a risk to biota by landfarm/agricultural practices
- Long-term O&M of the on-post hazardous waste landfill including cap maintenance, leachate treatment, and monitoring.
- Monitoring through annual soil sampling and site reviews to detect potential contaminant migration to subsurface soil and to observe natural contaminant attenuation/degradation

Section 4.1 of the Technology Descriptions Volume describes the conventional excavation of contaminated soil. The excavation plan developed for biota risk sites focuses on, to the extent possible, minimizing impacts to biota and maximizing the use of mitigation measures (e.g., determination of the appropriate season to excavate, determination of procedures for relocation of biota prior to excavation). During excavation, dust-control measures are implemented as necessary. The excavation is backfilled with on-site borrow material and compacted to prevent future subsidence. The site is then regraded and revegetated with native grasses in accordance with a refuge management plan. Runoff-control measures may be needed until the site is fully reclaimed.

Section 4.6.6 describes the centralized on-post hazardous waste landfill facility, including construction and operation. Groundwater monitoring is conducted as part of the long-term monitoring and maintenance of the landfill. In addition, leachate from the landfill is collected and treated, and the landfill cover is maintained and repaired as needed.

The landfarm/agricultural practices are discussed in Section 4.5.7 and consist of using landfarming techniques either with farm machinery (ripper, plow, and disk) or a soil stabilizer along with seeding to facilitate stabilization and attenuation of OCPs in surface soil (0- to 1-ft depth interval). As discussed in Section 11.1 of the Technology Descriptions Volume, the pesticides found in surficial soil have been shown to decrease in concentration over time when subjected to landfarm/agricultural practices. The landfarm technology does not provide intensive treatment of the contaminants present. It does, however, reduce the migration of contaminated dust, limit exposure to surface receptors, and promote the natural attenuation of contaminants.

Long-term monitoring is conducted over the areas treated to observe the OCP levels over time and to observe the potential migration of contaminants to subsurface soil. The time frame for natural attenuation to remove the potential risks to biota is estimated to be more than 30 years based on the range of half-lives for the primary OCP contaminants detected at these sites (EBASCO 1992a). Five-year site reviews are conducted to document the decrease in OCP levels.

Ongoing bio-monitoring conducted by the USFWS and the SFS/risk assessment process will be used to determine if any additional areas require remediation over the long-term. Remedial actions will be determined at such times as they are required but will generally consist of the alternatives identified in Sections 4.5.3 to 4.5.8.

4.5.9 Biota Alternatives for Human Health Exceedance Category Medium Groups

Most of the biota alternatives described above can also apply to the biota risk portions of some Human Health Exceedance Category medium groups. For example, Alternative B3: Landfill (On-Post Landfill) can be applied to the biota risk portion of the Secondary Basins Subgroup in conjunction with Alternative 3: Landfill (On-Post Landfill).

4.6 ALTERNATIVES FOR THE HUMAN HEALTH EXCEEDANCE CATEGORY

Fourteen alternatives were retained in the DSA for the Human Health Exceedance Category. As discussed in Section 4.2, the alternatives for the Human Health Exceedance Category subgroups were modified to account for consolidation of contaminated soil, treatment of principal threats, and containment of residual contamination. Based on these modifications, a total of 35 alternatives are evaluated for the Human Health Exceedance Category medium groups.

In the DSA, the human health alternatives included generalized agent, UXO, and biota alternatives developed to address potential agent or UXO presence and biota risk areas. In the DAA, specific alternatives were developed for each subgroup in the Human Health Exceedance Category to address the potential presence of agent or UXO and biota risks. These agent, UXO, and biota alternatives are not described in the following sections, but rather in Sections 10 through 19 to avoid confusion.

4.6.1 Alternative 1: No Additional Action (Provisions of FFA)

A no action alternative was developed for all 19 medium groups/subgroups within the Human Health Exceedance Category. The major components of Alternative 1 are the following:

- No further action beyond the FFA restrictions (EPA et al. 1989) and existing or planned IRAs (this alternative includes long-term maintenance of soil covers installed during IRAs)
- Annual soil monitoring and 5-year site reviews to observe natural contaminant attenuation/degradation and potential migration of contaminants
- Annual groundwater compliance monitoring will be conducted to evaluate the long-term protectiveness of the alternative

The provisions of the FFA (EPA et al. 1989) promote protection of human health by prohibiting residential development, consumption of all game or fish taken at RMA, and all agricultural activities other than erosion control or those related to remedial activities. In addition, contaminant levels are monitored and groundwater compliance monitoring is conducted to observe natural contaminant attenuation/degradation and potential contaminant migration. Changes in the site conditions are documented through 5-year site reviews. The time frame for natural attenuation to achieve Human Health PRGs and to remove potential risks to biota is estimated to be more than 30 years based on the range of half-lives for the predominant organic contaminants detected at these sites (EBASCO 1992a).

4.6.2 Alternative 1a: Direct Thermal Desorption (Direct Heating) of Principal Threat Volume; No Additional Action (Provisions of FFA)

Alternative 1a treats the principal threat volume by thermal desorption and initiates no additional action for the remaining soil. This alternative is applicable to the Basin A Medium Group and Former Basin F, Chemical Sewers, South Plants Ditches, and South Plants Balance of Areas Subgroups. The major components of Alternative 1a are the following:

- Excavation of principal threat volume and treatment by direct thermal desorption at a centralized facility as discussed in Section 4.6.25 (Alternative 13a)
- Separation of oversize soil and debris as a pre-treatment step
- Disposal of oversize materials in the on-post hazardous waste hazardous waste landfill
- Disposal of particulates and salts from the scrubber blowdown of the thermal desorption emission control equipment in the on-post hazardous waste landfill and backfill of treated soil
- No further action for remaining soil beyond the FFA restrictions (EPA et al. 1989) and existing or planned IRAs (including long-term maintenance of soil covers installed during IRAs)
- Annual monitoring and 5-year site reviews to observe natural contaminant attenuation/degradation and potential migration of contaminants in remaining soil
- Annual groundwater compliance monitoring will be conducted to evaluate the long-term protectiveness of the alternative

The soil composing the principal threat volume is excavated using conventional earth-moving equipment as discussed in Section 4.1 of the Technology Descriptions Volume. During excavation operations, dust is suppressed and emissions of volatiles and odors are controlled. Former Basin F is excavated inside an enclosure to control vapors as described in detail in

Section 4.1.2 of the Technology Descriptions Volume. The enclosure includes emission control equipment to prevent the buildup of toxic gases inside the enclosure. For Basin A, dewatering is required prior to excavation to allow the excavation of soil near the water table.

The excavated soil is transported to the centralized thermal desorption facility and thermally treated at 300 degrees centigrade (°C). The processing rate is dependent on the moisture content of the solids feed, but is generally about 1,300 BCY/day with a 65-percent on-line factor for the principal threat volume (assuming most of this soil is near saturation). Approximately 1 percent of the solids feed is collected as particulates and salts from the emission control equipment and placed in the on-post hazardous waste landfill. The treated soil is backfilled, but the uppermost 6 inches of soil over the backfilled areas are supplemented with conditioners since the thermal desorption process removes the organic content of soil. The conditioned soil is then revegetated with native grasses in accordance with a refuge management plan.

The provisions of the FFA (EPA et al. 1989) promote protection of human health by prohibiting residential development, consumption of all game or fish taken at RMA, and all agricultural activities other than erosion control or those related to remedial activities. In addition, contaminant levels in the remaining soil are monitored, groundwater compliance monitoring is conducted, and 5-year site reviews are performed to observe natural contaminant attenuation/degradation and potential contaminant migration. The time frame for natural attenuation to achieve Human Health PRGs and to remove potential risks to biota is estimated to be more than 30 years based on the range of half-lives for the predominant organic contaminants detected at these sites (see EBASCO 1992a).

4.6.3 Alternative 1b: Direct Thermal Desorption (Direct Heating) and Direct Solidification/ Stabilization (Cement-Based Solidification) of Principal Threat Volume; No Additional Action (Provisions of FFA)

Alternative 1b involves treating soil containing organic and inorganic contaminants exceeding the principal threat criteria by thermal desorption and solidification/stabilization and by initiating no additional actions for the remaining soil. Alternative 1b is applicable to the South Plants Central Processing Area Subgroup. The major components of Alternative 1b are the following:

- Excavation of principal threat volume and treatment of organics by direct thermal desorption as discussed in Section 4.6.25 (Alternative 13a) and of inorganics by direct solidification/stabilization at a centralized facility as discussed in Section 4.6.23 (Alternative 10)

- Separation of oversize soil and debris as a pre-treatment step followed by disposal of oversize materials in the on-post hazardous waste landfill

- Disposal of particulates and soil from the scrubber blowdown of the thermal desorption emission control equipment in the on-post hazardous waste landfill and backfill of treated soil without inorganic exceedances

- Placement of at least 4 ft of thermally desorbed soil over backfilled solidified soil (as cover to preserve integrity of solidified materials and prevent freeze/thaw damage)

- Long-term monitoring of solidified soil to observe durability and maintenance of overlying cover

- No further action for remaining soil beyond the FFA restrictions (EPA et al. 1989)

- Annual soil monitoring and 5-year site reviews to observe natural contaminant attenuation/degradation and potential migration of contaminants in remaining soil

- Annual groundwater compliance monitoring will be conducted to evaluate the long-term protectiveness of the alternative

The principal threat volume is excavated using conventional earth-moving equipment as described in Section 4.1 of the Technology Descriptions Volume. During excavation operations, dust is suppressed and emissions of volatiles and odors are controlled. Soil containing organic compounds exceeding the principal threat criteria is treated by thermal desorption, while soil with inorganics exceeding the principal threat criteria is treated by direct solidification/stabilization. Both treatment facilities are sited in the vicinity of South Plants.

The soil is thermally desorbed at 300°C and a rate of approximately 1,300 BCY/day with a 65-percent on-line factor (assuming most principal threat soil is near saturation). However, the processing rate is dependent on the moisture content of the solids feed. Approximately 1 percent of the total solids feed is collected as particulates and salts from the emission control equipment. These materials are placed in the on-post hazardous waste landfill. Treated soil without exceedances of the inorganic principal threat criteria is backfilled. Since thermal desorption removes the organic content of soil during processing, the uppermost 6 inches of soil over the backfilled area are supplemented with conditioners and revegetated with native grasses.

Soil with inorganics exceeding the principal threat criteria is solidified by adding cement at a ratio of 0.2 tons/ton of soil. The solidified soil is backfilled on post. At least 4 ft of thermally desorbed soil is placed over the solidified soil to prevent freeze/thaw damage. The durability of the solidified soil is monitored, and the cover is maintained by repairing any damage caused by erosion.

The provisions of the FFA (EPA et al. 1989) promote protection of human health by prohibiting residential development, consumption of all game or fish taken at RMA, and all agricultural activities other than erosion control or related remedial activities. In addition, contaminant levels in the remaining soil are monitored, groundwater compliance monitoring samples are collected, and 5-year site reviews are performed to observe natural contaminant attenuation/degradation and potential contaminant migration. The time frame for natural attenuation to achieve Human Health PRGs and to remove the potential risks to biota is considered to be more than 30 years based on the range of half-lives for the predominant organic contaminants detected at the site (EBASCO 1992a).

4.6.4 Alternative 2: Access Restrictions (Modifications to the FFA)

Alternative 2 is a no action/institutional controls alternative that applies to the Basin F Wastepile, Sanitary/Process Water Sewers, Chemical Sewers, Buried Sediments, and Section 36 Balance of Areas subgroups and the Secondary Basins and Sanitary Landfills medium group. The major components of Alternative 2 are the following:

- Installation of fencing and modifications to the FFA (EPA et al. 1989) to limit human contact with contaminants and habitat modifications to address residual contamination in some sites that may pose a risk to biota

- Annual soil monitoring and 5-year site reviews to observe natural contaminant attenuation/degradation and potential contaminant migration and maintenance of soil covers installed during IRAs

- Annual groundwater compliance monitoring will be conducted to evaluate the long-term protectiveness of the alternative

The exposure of humans to contaminated soil is reduced through both land-use restrictions and modifications to worker practices. As discussed in Section 3.1 of the Technology Descriptions Volume, public education programs are initiated to ensure that RMA visitors and workers are aware of the access restrictions and that they observe the controls. Construction of a 6-ft-high chain-link perimeter fence with posting around each site further reduces direct human contact with contaminated soil as discussed in Section 4.5.3 for biota exclusion (Alternative B2). For the Sewer Systems Medium Group, access is restricted through modifications to worker practices, as described in the FFA (EPA et al. 1989), and the plugging of chemical sewer pipes and sanitary manholes. Biota exclusion measures, consisting of habitat management to reduce biota exposure to contaminants, are discussed in Section 4.5.3.

Soil monitoring and annual groundwater monitoring are used to observe natural attenuation/degradation and detect potential contaminant migration, and 5-year site reviews are used to document the changes to site conditions. The time frame for natural attenuation to achieve Human Health PRGs and to remove potential risks to biota is considered to be more than 30 years based on the range of half-lives for the predominant organic contaminants detected at these sites (see EBASCO 1992a).

4.6.5 Alternative 2a: Direct Thermal Desorption (Direct Heating) of Principal Threat Volume; Access Restrictions (Modifications to the FFA)

Alternative 2a involves institutional controls and direct thermal desorption of the principal threat volumes. This alternative applies to the Former Basin F and Chemical Sewers Subgroup. The major components for Alternative 2a are the following:

- Excavation of principal threat volume and treatment by direct thermal desorption at a centralized facility as discussed in Section 4.6.25 (Alternative 13a)
- Separation of oversize soil and debris as a pre-treatment step followed by disposal of oversize materials in the on-post hazardous waste landfill
- Disposal of particulates and salts from the scrubber blowdown of the thermal desorption emission control equipment in the on-post hazardous waste landfill and backfill of treated soil followed by restoration of existing cap
- Installation of fencing or plugging of sewer lines and initiation of modifications to the FFA (EPA et al. 1989) to limit human contact with contaminants
- Annual soil monitoring and 5-year site reviews to observe natural contaminant attenuation/degradation and potential contaminant migration and maintenance of soil covers installed as part of IRAs
- Annual groundwater compliance monitoring will be conducted to evaluate the long-term protectiveness of the alternative

The soil containing organic contaminants exceeding the principal threat criteria is excavated using conventional earth-moving equipment as discussed in Section 4.1 of the Technology Descriptions Volume. During excavation operations, dust is suppressed and emissions of volatiles and odors are controlled. Former Basin F is excavated inside an enclosure to control vapors as described in detail in Section 4.1.2 of the Technology Descriptions Volume. The enclosure includes emission control equipment to prevent the buildup of toxic gases inside the enclosure.

The excavated soil is transported to the centralized thermal desorption facility and thermally treated at 300°C. The processing rate is dependent on the moisture content of the solids feed, but is generally 2,000 BCY/day with a 65-percent on-line factor for the principal threat volumes (assuming most of this soil is not near saturation). Approximately 1 percent of the total solids feed is collected as particulates and salts from the emission control equipment and placed in the on-post hazardous waste landfill. The treated soil is backfilled, and the existing cap is restored and revegetated. The conditioned soil is then revegetated with native grasses.

The exposure of humans to residual contaminated soil is reduced through both land-use restrictions and modifications to worker practices. Construction of a 6-ft-high chain-link perimeter fence with posting around each site further reduces direct human contact with contaminated soil as discussed in Section 4.5.3 for biota exclusion (Alternative B2). Biota exclusion measures for former Basin F, consisting of habitat management to reduce biota exposure to contaminants, are discussed in Section 4.5.3. For Chemical Sewers Subgroup, access restrictions are achieved through plugging sewer pipe and modifications to worker practices.

Soil monitoring of the balance of areas, annual groundwater compliance monitoring, and 5-year site reviews are used to observe natural attenuation/degradation and detect potential migration of contaminants. The time frame for natural attenuation to achieve Human Health PRGs is estimated to be more than 30 years based on the range of half-lives for the predominant organic contaminants detected at these sites (EBASCO 1992a).

4.6.6 Alternative 3: Landfill (On-Post Landfill)

Alternative 3 is a containment alternative that applies to the Secondary Basins, Sewer Systems, Sanitary Landfills, Buried Sediments/Ditches, and Undifferentiated medium groups and the Shell Trenches, Hex Pit, Buried M-1 Pits, Basin F Wastepile, South Plants Ditches, and South Plants Balance of Areas subgroups. Section 3.1.3 discusses the construction of a centralized hazardous waste landfill to contain up to 5,100,000 BCY of soil and debris. The major components of Alternative 3 are the following:

- Construction of a centralized on-post hazardous waste landfill facility with multiple landfill cells
- Excavation of soil exceeding the Human Health SEC (EBASCO 1994a) and transportation to the on-post hazardous waste landfill

- Placement of excavated soil in the on-post hazardous waste landfill and backfill of excavations with clean borrow material

- Long-term O&M of the on-post hazardous waste landfill including cap maintenance, leachate treatment, and monitoring

Section 4.1 of the Technology Descriptions Volume discusses the conventional excavation of contaminated soil and the choice of specific excavation equipment. During excavation, dust is suppressed and volatile organic and odor emissions are controlled. The Shell Trenches, Hex Pits, Basin F Wastepile, and Buried M-1 Pits Subgroups are excavated inside an enclosure to control vapors as described in Section 4.1.2 of the Technology Descriptions Volume. The enclosure includes emission control equipment to prevent the buildup of toxic gases inside the enclosure and emissions of gases or odors from the enclosure. Materials handling activities are required for these three groups prior to disposal. Specialized excavation equipment and blending of saturated soils are required for the Shell Trenches and Hex Pit. Any saturated materials from the Basin F Wastepile are addressed with a dryer. Dewatering is required for the Shell Trenches and Section 36 Balance of Areas Subgroups prior to excavation to allow the removal of soil near the water table. Following excavation, the site is backfilled with borrow material obtained on post and compacted to prevent future subsidence. The uppermost 6 inches of soil are supplemented with conditioners, regraded, and revegetated with native grasses. Runoff-control measures may be needed until the site is fully reclaimed.

The number of cells to be constructed in the landfill is based on the total amount of contaminated soil that is to be disposed. Section 6.5.2 of the Technology Descriptions Volume details the construction of hazardous waste landfills.

A RCRA hazardous waste landfill cell is constructed with a double-composite liner system consisting of at least two synthetic liners and two low-permeability soil liners. This system also contains leachate collection and leak detection systems. The cover system for the hazardous waste landfill cell is constructed with a synthetic/soil low-permeability barrier, an infiltration drainage system, a gas collection system, and a soil cover layer.

The cover system acts as an impermeable cap above the waste to isolate the contaminated material from the surface environment. Although the material being disposed is compacted as it is placed in the landfill cell, the cap is designed to accommodate any settlement or subsidence within or below the cell and consists of several individual layers that include the following (listed from top to bottom):

- 4-ft-thick upper soil/vegetation layer that includes 6 inches of reconditioned soil to allow revegetation of the cover and prevent freeze/thaw damage to the low-permeability layer
- 1-ft-thick biota barrier layer of cobbles underlain by a geosynthetic filter fabric to prevent intrusion by burrowing animals
- 1-ft-thick drainage layer to intercept water percolating through the upper layers of the cap and transport it out of the cover
- Composite low-permeability layer comprised of a flexible membrane liner (FML) and a 2-ft-thick compacted low-permeability soil cap
- Gas-vent layer constructed of a geonet or granular fill and perforated high-density polyethylene (HDPE) pipe surrounded by a filter fabric blanket

The liner system consists of a double-composite liner that isolates the contaminated soil and leachate from the underlying subsurface environment. An enhanced liner system consisting of a triple composite liner will be used for the disposal of the Basin F Wastepile and Section 36 Lime Basins material. The layers of a composite liner typically consist of a synthetic FML directly underlain by a 3-ft-thick low-permeability soil layer. The synthetic liners must be chemically compatible with the waste contaminants and any leachate generated. Commonly used synthetic liner materials include HDPE, chlorinated polyethylene (CPE), chlorosulfonated polyethylene (CSPE), and polyvinyl chloride (PVC). The low-permeability soil layers are constructed such that the permeability of the compacted soil is less than 1×10^{-7} centimeters per second (cm/sec). The leachate collection and removal system is located inside the cell, directly above the primary liner. The system includes either granular material or a geonet. The leachate is collected in sumps and transported to an on-post groundwater or wastewater treatment facility for treatment. A leak-detection system, constructed similarly to the leachate collection system, is located between the primary composite liner and the secondary composite liner.

Groundwater monitoring is conducted around the landfill, and 24-hour security provided to prevent unwarranted intrusion and to preserve the integrity of the landfill. Monitoring equipment is continuously inspected to ensure reliability. During operation, leachate from the landfill is collected, sampled, and treated on post at one of the existing groundwater treatment facilities. When the landfill is filled to capacity, the area is completely contained with a cap, regraded, revegetated, mowed, and fertilized. The performance of a RCRA-compliant landfill is monitored and maintained for a minimum of 30 years following closure.

4.6.7 Alternative 3a: Direct Thermal Desorption (Direct Heating) of Principal Threat Volume; Landfill (On-Post Landfill)

Alternative 3a combines treatment of the principal threat volume by thermal desorption with containment of the remaining human health exceedance volume in the on-post hazardous waste landfill. This alternative applies to the Chemical Sewers, South Plants Ditches, and South Plants Balance of Areas Subgroups. The major components of Alternative 3a are the following:

- Construction of a centralized on-post hazardous waste landfill facility with multiple landfill cells

- Excavation of principal threat volume and treatment of organic constituents by direct thermal desorption at a centralized facility as discussed in Section 4.6.25 (Alternative 13a)

- Separation of oversize soil and debris as a pre-treatment step followed by disposal of oversize materials in the on-post hazardous waste landfill

- Disposal of particulates and soil from the scrubber blowdown of the thermal desorption emission control equipment and treated soil in the landfill

- Excavation of the remaining soil exceeding the Human Health SEC (EBASCO 1994a) and transportation to the on-post hazardous waste landfill

- Placement of excavated soil in the on-post hazardous waste landfill and backfill of excavations with clean borrow material

- Long-term O&M of the on-post hazardous waste landfill including cap maintenance, leachate treatment, and monitoring

The principal threat volume is excavated using conventional earth-moving equipment as described in Section 4.1 of the Technology Descriptions Volume. During excavation operations, dust is suppressed and emissions of volatiles and odors are controlled. Soil containing organics exceeding the principal threat criteria is treated by thermal desorption at a centralized treatment facility in the vicinity of South Plants.

The soil is thermally desorbed at 300°C at a rate of approximately 1,300 BCY/day with a 65-percent on-line factor for most of the principal threat volume (assuming most of this soil is near saturation). Approximately 1 percent of the total solids feed is collected as particulates and salts from the emission control equipment. These materials are placed in the on-post hazardous waste landfill. Treated soil is also landfilled.

The remaining exceedance volume of soil is excavated using conventional equipment as discussed above. During excavation, dust is suppressed and emissions of volatiles and odors are controlled. Following excavation, the site is backfilled with borrow material obtained on post and compacted to prevent future subsidence. The site is then regraded and revegetated with native grasses. Runoff-control measures are implemented as needed during excavation and revegetation. The centralized landfill facility is as discussed in Section 4.6.6. Groundwater monitoring is conducted as part of the long-term monitoring and maintenance of the landfill. Leachate from the landfill is collected and treated, and the landfill cover is maintained and repaired as needed.

4.6.8 <u>Alternative 3b: Landfill (On-Post Landfill); Caps/Covers (Soil Cover or Multilayer Cap)</u>

Alternative 3b involves excavating and placing the human health exceedance volume (to a depth of 10 ft below ground surface) in the on-post hazardous waste landfill and containing the residual contamination (that is more than 10 ft below ground surface) with a soil cover or multilayer cap.

This alternative applies to the Basin A and Secondary Basins medium groups and Former Basin F, Section 36 Lime Basins, and South Plants Central Processing Area Subgroups. The major components of Alternative 3b are the following:

- Construction of a centralized on-post hazardous waste landfill facility with multiple landfill cells
- Excavation of soil exceeding the Human Health SEC (EBASCO 1994a) and transportation to the on-post hazardous waste landfill
- Placement of excavated soil in the on-post hazardous waste landfill and backfill of excavations with clean borrow material
- Containment of soil with residual contamination by installing a soil cover (Lime Basins and Secondary Basins only) or a multilayer cap (soil posing risk to biota may be consolidated into Basin A and the South Plants Central Processing Area to reduce the volume of gradefill required)
- Long-term O&M of the on-post hazardous waste landfill including cap maintenance, leachate treatment, and monitoring
- Monitoring through 5-year site reviews and maintenance operations to document the effectiveness of the containment system

The human health exceedance volume of soil is excavated using conventional equipment as discussed in Section 4.1 of the Technology Descriptions Volume. During excavation, dust is suppressed and emissions of volatiles and odors are controlled. The Former Basin F is excavated inside an enclosure to control vapors as described in Section 4.1.2 of the Technology Descriptions Document. The enclosure includes emission control equipment to prevent the buildup of toxic gases inside the enclosure and emissions of gases or odors from the enclosure. Dewatering is required for Basin A and Section 36 Lime Basins to allow the removal of soil near the water table. An enhanced liner system is used for material from the Section 36 Lime Basins, as discussed in Section 4.6.6. Following excavation, the site is backfilled with borrow material and compacted to prevent future subsidence. A multilayer cap is then installed to reduce continued migration of residual contamination and interrupt human and biota exposure pathways. The centralized landfill facility is as discussed in Section 4.6.6 and the design of the multilayer cap is as discussed in Section 4.6.14. Groundwater monitoring is conducted as part of the long-term monitoring and maintenance of the landfill. Leachate from the landfill is collected and treated, and the landfill cover is maintained and repaired as needed.

4.6.9 Alternative 3c: Direct Thermal Desorption (Direct Heating) of Principal Threat Volume; Landfill (On-Post Landfill); Caps/Covers (Multilayer Cap)

Alternative 3c involves treating the principal threat volume by thermal desorption, landfilling the remaining human health exceedance volume (to a depth of 10 ft), and containing the residual contamination (i.e., that which is more than 10 ft below ground surface) with a multilayer cap. This alternative applies to the Basin A Medium Group and the Former Basin F Subgroup. The major components of Alternative 3c are the following:

- Construction of a centralized on-post hazardous waste landfill facility with multiple landfill cells

- Excavation of principal threat volume and treatment by direct thermal desorption at a centralized facility as discussed in Section 4.6.25 (Alternative 13a)

- Separation of oversize soil and debris as a pre-treatment step followed by disposal of oversize materials in the on-post hazardous waste landfill

- Disposal of particulates and salts from the scrubber blowdown of the thermal desorption emission control equipment and treated soil into the landfill

- Excavation of the remaining soil exceeding the Human Health SEC (EBASCO 1994a) and transportation to the on-post hazardous waste landfill

- Placement of excavated soil in the on-post hazardous waste landfill and backfill of excavations with clean borrow material

- Containment of soil with residual contamination below 10 ft by installing a multilayer cap (soil posing risk to biota may be consolidated into Basin A to reduce the volume of gradefill required)

- Long-term O&M of the on-post hazardous waste landfill including cap maintenance, leachate treatment, and monitoring

- Monitoring through 5-year site reviews and maintenance operations to document the effectiveness of the containment systems

Soil exceeding the principal threat criteria is excavated using conventional earth-moving equipment as discussed in Section 4.1 of the Technology Descriptions Volume. During excavation operations, dust is suppressed and emissions of volatiles and odors are controlled. The Former Basin F Subgroup is excavated inside an enclosure to control vapors as described in Section 4.1.2 of the Technology Descriptions Document. The enclosure includes emission control equipment to prevent the buildup of toxic gases inside the enclosure and emissions of gases or odors from the enclosure. Overburden soil associated with the Former Basin F IRA is stockpiled on site for use as backfill.

The excavated principal threat volume is transported to the centralized thermal desorption facility and thermally treated at 300°C. The processing rate is dependent on the moisture content of the solids feed, but is generally 2,000 BCY/day with a 65-percent on-line factor for the principal threat volume treated for this alternative (assuming most of this soil is not near saturation). Approximately 1 percent of the total solids feed is collected as particulates and salts from the emission control equipment and placed in the on-post hazardous waste landfill. The treated soil is also landfilled.

The human health exceedance volume of soil is excavated using conventional equipment as discussed above. During excavation, dust is suppressed and emissions of volatiles and odors are controlled. Dewatering is required for Basin A to allow the removal of soil from near the water table. Following excavation, the site is backfilled with borrow material and compacted to prevent future subsidence. A multilayer cap is then installed to reduce continued migration of residual contamination and interrupt human and biota exposure pathways. The centralized landfill facility is as discussed in Section 4.6.6, and the design of the multilayer cap is as discussed in Section 4.6.14. Groundwater monitoring is conducted as part of the long-term monitoring and maintenance of the landfill. Leachate from the landfill is collected and treated, and the landfill cover is maintained and repaired as needed.

4.6.10 Alternative 3d: Direct Thermal Desorption (Direct Heating) and Direct Solidification/Stabilization (Cement-Based Solidification) of Principal Threat Volume; Landfill (On-Post Landfill); Caps/Covers (Multilayer Cap)

Alternative 3d involves treating the principal threat volume by thermal desorption and cement-based solidification, landfilling the human health exceedance volume (to a depth of 5 ft), and containing the residual contamination (i.e., that more than 5 ft below ground surface) with a soil cover. This alternative applies to the South Plants Central Processing Area Subgroup. The major components of Alternative 3d are the following:

- Construction of a centralized on-post hazardous waste landfill facility with multiple landfill cells
- Excavation of principal threat volume and treatment of organics by direct thermal desorption as discussed in Section 4.6.25 (Alternative 13a) and of inorganics by direct solidification/stabilization at a centralized facility as discussed in Section 4.6.23 (Alternative 10)
- Separation of oversize soil and debris as a pre-treatment step followed by disposal of oversize materials in the on-post hazardous waste landfill
- Disposal of particulates and soil from the scrubber blowdown of the thermal desorption emission control equipment and treated soil without inorganic exceedances in the landfill
- Excavation of the remaining soil exceeding the Human Health SEC (EBASCO 1994a) (to a depth of 5 ft) and transportation to the on-post hazardous waste landfill
- Placement of excavated soil in the on-post hazardous waste landfill and backfill of excavations with clean borrow material
- Containment of soil with residual contamination below 5 ft by installing a multilayer cap (soil posing risk to biota may be consolidated into the South Plants Central Processing Area to reduce the volume of gradefill required)
- Long-term O&M of the on-post hazardous waste landfill including cap maintenance, leachate treatment, and monitoring
- Long-term monitoring of solidified soil to observe durability and maintenance of overlying cover
- Annual groundwater compliance monitoring to evaluate the long-term protectiveness of the alternative

- Monitoring through 5-year site reviews and maintenance operations to document the effectiveness of the containment system

The principal threat volume is excavated using conventional earth-moving equipment as described in Section 4.1 of the Technology Descriptions Volume. During excavation operations, dust is suppressed and emissions of volatiles and odors are controlled. Soil containing organics above the principal threat criteria is treated by thermal desorption, while soil with inorganics above the principal threat criteria is treated by direct solidification/stabilization. Both treatment facilities are sited in the vicinity of South Plants.

The soil is thermally desorbed at 300°C at a rate of approximately 1,300 BCY/day with a 65-percent on-line factor for most of the principal threat volume (assuming most of this soil is near saturation). Approximately 1 percent of the total solids feed is collected as particulates and salts from the emission control equipment. These materials are placed in the on-post hazardous waste landfill. Treated soil without inorganic exceedances is landfilled.

Soil exceeding the principal threat criteria for inorganics is solidified by adding cement at a ratio of 0.2 tons/ton of soil. The solidified soil is landfilled on post, which prevents freeze/thaw damage. The landfill cover is maintained by repairing any damage caused by erosion.

The remaining human health exceedance soil is excavated using conventional equipment as discussed above. During excavation, dust is suppressed and emissions of volatiles and odors are controlled. Following excavation, the site is backfilled with borrow material and compacted to prevent future subsidence. A multilayer cap is then installed to reduce the migration of the residual contamination and interrupt human and biota exposure pathways. The centralized landfill facility is as discussed in Section 4.6.6, and the design of the multilayer cap consists of a 4-ft thick soil/vegetation cover overlying a biota barrier. The biota barrier can be constructed with cobbles or crushed concrete. Groundwater monitoring is conducted as part of the long-term monitoring and maintenance of the landfill. Leachate from the landfill is collected and treated, and the landfill cover is maintained and repaired as needed.

4.6.11 Alternative 3e: Access Restrictions (Modifications to FFA); Landfill (On-Post Landfill)

Alternative 3e addresses the plugging of Chemical Sewers in the South Plants Central Processing Area and Complex Trenches (which will then be capped) and landfilling of the remaining sewers located outside these areas. Alternative 3e is applicable to the Chemical Sewers Subgroup. The major components of Alternative 3e are the following:

- Plugging of sewers to limit human exposures to contaminants within the South Plants Central Processing Area and Complex Trenches
- Construction of a centralized on-post hazardous waste landfill facility with multiple landfill cells
- Excavation of the remaining chemical sewers and associated soil that exceeds the Human Health SEC (EBASCO 1994a) and transportation to the on-post hazardous waste landfill
- Placement of excavated soil and sewer debris in the on-post hazardous waste landfill and backfill of excavations with clean borrow material
- Long-term O&M of the on-post hazardous waste landfill including cap maintenance, leachate treatment, and monitoring
- Annual soil and groundwater compliance monitoring and 5-year site reviews to observe natural contaminant attenuation/degradation and potential migration of contaminants in remaining soil

The sewers located outside the South Plants Central Processing Area and Complex Trenches are excavated using conventional equipment as described in Section 4.1 of the Technology Descriptions Volume. During excavation, dust is suppressed and emissions of volatiles and odors are controlled. The excavated sewer debris and associated soil is then placed in the centralized on-post hazardous waste landfill (Section 4.6.6). Groundwater monitoring is conducted as part of the long-term monitoring and maintenance of the landfill. Leachate from the landfill is collected and treated, and annual groundwater monitoring, and the landfill cover is maintained and repaired as needed.

Alternative 3e achieves a reduction in potential exposures to human receptors in combination with capping of the South Plants Central Processing Area and Complex Trenches. Soil monitoring of the balance of areas, annual groundwater compliance monitoring, and 5-year site reviews are used to observe natural attenuation and detect potential migration of contaminants.

4.6.12 Alternative 3f: Landfill (On-Post Landfill); Caps/Covers (Multilayer Cap) with Consolidation

Alternative 3f involves containing the human health exceedance volume (to a depth of 10 ft below ground surface) in the on-post hazardous waste landfill and consolidating soil posing potential risks to biota in Basin A. This alternative applies to the Secondary Basins and Sanitary Landfills Medium Groups and Sand Creek Lateral Subgroup. The major components of Alternative 3f are the following:

- Construction of a centralized on-post hazardous waste landfill facility with multiple landfill cells
- Excavation of soil exceeding the Human Health SEC (EBASCO 1994a) and transportation to the on-post hazardous waste landfill
- Placement of excavated soil in the on-post hazardous waste landfill and backfill of excavations with clean borrow material
- Consolidation of soil posing potential risks to biota into Basin A as gradefill prior to installation of a multilayer cap (Section 4.5.6)
- Long-term O&M of the on-post hazardous waste landfill including cap maintenance, leachate treatment, and monitoring
- Monitoring through 5-year site reviews and maintenance operations to document the effectiveness of the containment system

The human health exceedance volume of soil is excavated using conventional equipment as discussed in Section 4.1 of the Technology Descriptions Volume. During excavation, dust is suppressed and emission of volatiles and odors are controlled. Following excavation, the site is backfilled with borrow material and compacted. The centralized landfill facility is as discussed in Section 4.6.6 and the design of the multilayer cap is discussed in Section 4.6.14. Groundwater monitoring is conducted as part of the long-term monitoring and maintenance of the landfill.

Leachate from the landfill is collected and treated, and the landfill cover is maintained and repaired as needed.

The soil posing a potential risk to biota is excavated with conventional earth-moving equipment as described in Section 4.1 of the Technology Descriptions Volume and consolidated in Basin A as part of Alternative B5a: Caps/Covers (Multilayer Cap) with Consolidation. The consolidated soil is used as gradefill prior to installation of a multilayer cap to achieve the design grade as discussed in Section 4.5.6. The excavations are backfilled with borrow materials and revegetated with native grasses.

4.6.13 Alternative 3g: Landfill (On-Post Landfill); Caps/Covers (Multilayer Cap) with Consolidation; Caps/Covers (Soil Cover)

Alternative 3g involves containing the human health exceedance volume (to a depth of 10 ft below ground surface) in the on-post hazardous waste landfill, consolidating soil posing potential risks to biota in Basin A or the South Plants Central Processing Area, and containing any residual contamination with a soil cover. This alternative applies to the Section 36 Balance of Areas, South Plants Ditches, and South Plants Balance of Areas Subgroups. The major components of Alternative 3g are the following:

- Construction of a centralized on-post hazardous waste landfill facility with multiple landfill cells

- Excavation of soil exceeding the Human Health SEC (EBASCO 1994a) and transportation to the on-post hazardous waste landfill

- Placement of excavated soil in the on-post hazardous waste landfill and backfill of excavations with clean borrow material

- Consolidation of soil posing potential risks to biota into Basin A or the South Plants Central Processing Area as gradefill prior to installation of a multilayer cap (Section 4.5.6)

- Containment of any soil with residual contamination by installing a variable thickness soil cover

- Long-term O&M of the on-post hazardous waste landfill including cap maintenance, leachate treatment, and monitoring

- Monitoring through 5-year site reviews and maintenance operations to document the effectiveness of the containment system

The human health exceedance volume of soil is excavated using conventional equipment as discussed in Section 4.1 of the Technology Descriptions Volume. During excavation, dust is suppressed and emission of volatiles and odors are controlled. Dewatering is required for Section 36 Balance of Areas to allow the removal of soil near the water table. Following excavation, the site is backfilled with borrow material and compacted to prevent future subsidence. The centralized landfill facility is as discussed in Section 4.6.6. Groundwater monitoring is conducted as part of the long-term monitoring and maintenance of the landfill. Leachate from the landfill is collected and treated, and the landfill cover is maintained and repaired as needed.

The soil posing a potential risk to biota is excavated with conventional earth-moving equipment as described in Section 4.1 of the Technology Descriptions Volume and consolidated in Basin A and the South Plants Central Processing Area as part of Alternative B5a: Caps/Covers with Consolidation. The consolidated soil is used as gradefill prior to installation of a multilayer cap to achieve the design grade as discussed in Section 4.5.6.

Following the excavation activities, a variable thickness soil cover is installed. The thickness of the soil cover installed over the former human health exceedance area is 2 ft (Section 36 Balance Areas) or 3 ft (South Plants Ditches and Balance of Areas), and the soil cover over the former area posing a potential risk to biota is 1 ft thick. The soil cover is maintained through inspections and any damage caused by erosion is repaired. Five-year site reviews are conducted to document the effectiveness of the containment system.

4.6.14 Alternative 5: Caps/Covers (Multilayer Cap); Vertical Barriers (Slurry Walls)

Alternative 5 is a containment alternative that is applicable to the Complex Trenches, Hex Pit, and Buried M-1 Pits Subgroups. The major components of Alternative 5 are the following:

- Containment of soil exceeding the Human Health SEC (EBASCO 1994a) through installation of a multilayer cap
- Construction of a slurry wall to contain contaminants and control migration of contaminated groundwater
- Annual groundwater compliance monitoring to evaluate the long-term protectiveness of the alternative
- Monitoring through 5-year site reviews and maintenance operations to determine the effectiveness of the containment systems

The multilayer cap consists of three primary layers. For the Complex Trenches, it is assumed that this cap is RCRA-equivalent, and it will meet the performance criteria to be developed by the Parties prior to the remedial design. From top to bottom, the multilayer cap consists of the following:

- 4-ft-thick soil/vegetation layer consisting of clean borrow material capable of supporting vegetation, including 6 inches of reconditioned soil that acts to promote growth, minimize erosion, and promote drainage
- 1-ft-thick biota barrier layer made up of crushed concrete or cobbles to protect the underlying low-permeability layer from burrowing animals
- 2-ft-thick compacted low-permeability soil layer

Section 6.2 of the Technology Descriptions Volume discusses the multilayer cap in more detail. To prevent ponding of rainwater due to irregularities in the top layer of the cap, it is constructed with a slope of 3 to 5 percent. Native grasses used for revegetation are selected to impede erosion and to allow surface runoff from major storm events as well as to discourage burrowing animals from using the area for habitat.

The biota barrier consists of a 1-ft-thick layer of crushed concrete or cobbles to prevent animals from burrowing into the lower layers of the cap. Over time, soil from the overlying soil layer infiltrates and fills the voids, but the effectiveness of neither layer is compromised.

The final layer of the multilayer cap is the low-permeability soil layer, which is constructed such that the hydraulic conductivity of the unit is no greater than 1×10^{-7} cm/sec. This layer provides long-term minimization of infiltration into the contaminated soil unit. The compacted layer is 2 ft thick and is constructed as specified by EPA guidelines for hazardous waste caps. The layer is installed as a series of 6-inch lifts to allow any localized inconsistencies in one lift to be "sealed" by another.

Slurry walls are installed around the sites in conjunction with the placement of a multilayer cap to form an isolation cell around the contaminated soil. Installation of the slurry wall prior to the soil cap allows the compacted soil layer to be "keyed" into the top of the slurry wall. The installation of a slurry wall entails the excavation of a trench with a backhoe, extended-reach backhoe, or a clamshell as discussed in Section 6.3.1 of the Technology Descriptions Volume. A slurry of bentonite and water is pumped into the trench to prevent the walls of the trench from collapsing. The fill material, consisting of a soil and bentonite mixture, is then placed into the slurry-filled trench. In general, the soil excavated from the trench is amended with bentonite and used as slurry wall backfill; however, in some instances the excavated soil is used as gradefill for the cap, and clean borrow material is used as slurry-wall backfill. The ratio of bentonite to water, as well as the specifications for the mixture of soil and bentonite for the fill material, is based on laboratory-scale engineering and compatibility testing. The soil used in the soil-bentonite backfill generally should be well graded with a large percentage of fine-grained materials.

To control groundwater migration, a groundwater removal system is installed in conjunction with the slurry wall to maintain a reduced hydraulic head and ensure that groundwater moves from the outside of the slurry wall system to the inside. The groundwater removal system is designed, based on site-specific conditions, to be flexible in meeting increased or decreased pumping demands and to ensure that the required hydraulic gradient may be established and maintained.

The long-term maintenance of the low-permeability multilayer cap consists of mowing the vegetative cover and repairing damage caused by erosion. Five-year site reviews and annual groundwater compliance monitoring are conducted to document the effectiveness of the containment system. The water removed from the dewatering system is pumped to the CERCLA Wastewater Treatment Plant or a groundwater treatment system.

4.6.15 Alternative 5a: Caps/Covers (Multilayer Cap); Vertical Barriers (Slurry Walls) with Modifications to Existing System

Alternative 5a is a containment alternative that is applicable to the Shell Trenches Subgroup. The major components of Alternative 5a are the following:

- Containment of soil exceeding the Human Health SEC (EBASCO 1994a) by modifying the existing soil cover from the IRA
- Construction of a slurry wall to augment the existing vertical barrier
- Annual groundwater compliance monitoring to evaluate long-term protectiveness of the alternative
- Monitoring through 5-year site reviews and annual groundwater sampling, and maintenance operations to document the effectiveness of the containment systems

The existing soil cover constructed during the IRA is augmented by installing a low-permeability multilayer cap to improve the long-term performance of the existing cover. It is assumed that this cap is RCRA-equivalent, which will meet performance criteria to be developed by the Parties prior to the remedial design. Section 4.6.14 provides a discussion of a multilayer cap. The modified multilayer cap consists of the same layers as described in Section 4.6.14, except that the uppermost 2 ft of the existing soil cover are removed, stockpiled, and incorporated into the soil/vegetation layer. Section 4.6.14 also describes the installation of the slurry wall, operation of the dewatering system, and long-term monitoring and maintenance activities.

4.6.16 Alternative 6: Caps/Covers (Multilayer Cap)

Alternative 6 is a containment alternative that was developed for the Basin A, Secondary Basins, Sanitary Landfills, South Plants, Buried Sediments/Ditches, and Undifferentiated medium groups and Former Basin F and Section 36 Lime Basins subgroups. The major components of Alternative 6 are the following:

- Installation of backfill materials as gradefill to achieve design grades
- Containment of soil exceeding the Human Health SEC (EBASCO 1994a) through installation of a multilayer cap (soil posing risk to biota may be consolidated into Basin A and the South Plants Central Processing Area to reduce the volume of gradefill required)
- Monitoring through 5-year site reviews and maintenance operations to document the effectiveness of the containment systems
- Annual groundwater compliance monitoring will be conducted to evaluate the long-term protectiveness of the alternative

The low-permeability multilayer cap is designed and constructed as described in Section 4.6.14. For Basin A, the 1-ft-thick biota barrier is replaced with a 6-inch-thick layer of concrete. For the South Plants Central Processing Area, the 2-ft-thick compacted low-permeability soil layer is omitted. The cap is maintained and inspected annually, and any damage caused by erosion is repaired. Five-year site reviews and annual groundwater compliance monitoring are conducted to document the effectiveness of the containment system.

4.6.17 Alternative 6a: Direct Thermal Desorption (Direct Heating) and Direct Solidification/ Stabilization (Cement-Based Solidification) of Principal Threat Volume; Caps/Covers (Multilayer Cap)

Alternative 6a combines containment and treatment of soil above the principal threat criteria and was evaluated for the South Plants Central Processing Area Subgroup. Alternative 6a treats the organic principal threat volume by thermal desorption and the inorganic principal threat volume by cement-based solidification; the remaining human health exceedance volume is contained by a multilayer cap. The major components of Alternative 6a are the following:

- Excavation of principal threat volume and treatment of organics by direct thermal desorption as discussed in Section 4.6.25 (Alternative 13a) and of inorganics by direct solidification/stabilization at a centralized facility as discussed in Section 4.6.23 (Alternative 10)

- Separation of oversize soil and debris as a pre-treatment step followed by disposal of oversize materials in the on-post hazardous waste landfill

- Disposal of particulates and salts from the scrubber blowdown of the thermal desorption emission control equipment in the hazardous waste landfill and backfill of treated soil

- Containment of treated soil and remaining soil exceeding the Human Health SEC (EBASCO 1994a) by installing a multilayer cap (soil posing risk to biota may be consolidated into the South Plants Central Processing Area to reduce the volume of gradefill required)

- Long-term monitoring of solidified soil to observe durability and maintenance of overlying cover

- Monitoring through 5-year site reviews and maintenance operations to document the effectiveness of the containment system

- Annual groundwater compliance monitoring will be conducted to evaluate the long-term protectiveness of the alternative

The soil comprising the principal threat volume is excavated using conventional earth-moving equipment as discussed in Section 4.1 of the Technology Descriptions Volume. During excavation operations, dust is suppressed and emissions of volatiles and odors are controlled.

Soil containing organics exceeding principal threat criteria is processed at 300°C at a rate of approximately 1,300 BCY/day with a 65-percent on-line factor (most principal threat soil is near saturation). Approximately 1 percent of the total solids feed is collected as particulates and salts from the emission control equipment. These materials are placed in the on-post hazardous waste landfill. Treated soil without inorganic exceedances of the principal threat criteria is backfilled.

Soil with inorganics above the principal threat criteria is solidified by adding cement at a ratio of 0.2 tons/ton of soil as discussed in Section 4.6.23. The solidified soil is backfilled on post, but solidification results in a volume increase of nearly 40 percent. The solidified soil is placed below the multilayer cap to prevent damage from freeze/thaw conditions.

A multilayer cap is then constructed over the entire area as described in Section 4.6.14. The multilayer cap is regularly inspected and any damage caused by erosion is repaired. Five-year site reviews and annual groundwater compliance monitoring are conducted to document the effectiveness of the containment system.

4.6.18 Alternative 6b: In Situ Solidification/Stabilization (Silica/Proprietary Agent Solidification) of Principal Threat Volume; Caps/Covers (Multilayer Cap)

Alternative 6b combines containment and treatment processes and was evaluated for the Former Basin F Subgroup. Alternative 6b treats the principal threat volume by in situ solidification/ stabilization with the remaining exceedance volume contained by a multilayer cap. The major components of Alternative 6b are the following:

- Treatment of principal threat volume through in situ silica/proprietary agent based solidification/ stabilization

- Containment of treated soil and remaining soil exceeding human health SEC through the installation of a multilayer cap

Soil volumes exceeding the principal threat criteria are treated by in situ solidification as described in Section 4.6.31; however, a proprietary agent/silicate binder is used instead of cement to minimize the generation of VOCs and ammonia during treatment. The solidification process increases volume of the treated soil. Based on the required binder ratio, the expansion may range between 10 and 25 percent. Post-treatment may involve recontouring the expanded soil in place prior to installing the multilayer cap. A multilayer cap is then installed over the entire area as described in Section 4.6.14. It is assumed that this cap is RCRA-equivalent, and it will meet performance criteria to be developed by the Parties prior to the remedial design. The clay/soil cap is maintained through inspections and any damage caused by erosion is repaired. Five-year site reviews and annual groundwater monitoring are conducted to document the effectiveness of the containment system.

4.6.19 Alternative 6c: Direct Thermal Desorption (Direct Heating) of Principal Threat Volume; Caps/Covers (Multilayer Cap)

Alternative 6c combines containment and treatment processes and was evaluated for the Basin A Medium Group and Former Basin F, South Plants Ditches, and South Plants Balance of Areas subgroups. Alternative 6c treats the principal threat volume by thermal desorption; the remaining human health exceedance volume is contained by a multilayer cap. The major components of Alternative 6c are the following:

- Excavation of principal threat volume and treatment by direct thermal desorption at a centralized facility as discussed in Section 4.6.25 (Alternative 13a)
- Separation of oversize soil and debris as a pre-treatment step followed by disposal of oversize materials in the on-post hazardous waste landfill
- Disposal of particulates and salts from the scrubber blowdown of the thermal desorption emission control equipment in the hazardous waste landfill and backfill of treated soil
- Containment of treated soil and remaining soil exceeding the Human Health SEC (EBASCO 1994a) through installation of a multilayer cap (soil posing risk to biota may be consolidated into Basin A to reduce the volume of gradefill required)
- Monitoring through 5-year site reviews and maintenance operations to document the effectiveness of the containment system
- Annual groundwater compliance monitoring will be conducted to evaluate the long-term protectiveness of the alternative.

The soil comprising the principal threat volume is excavated using conventional earth-moving equipment as discussed in Section 4.1 of the Technology Descriptions Volume. During excavation operations, dust is suppressed and emissions of volatiles and odors are controlled. The Former Basin F Subgroup is excavated inside an enclosure to control vapors as described in Section 4.1.2 of the Technology Descriptions Volume. The enclosure includes emission control equipment to prevent the buildup of toxic gases inside the enclosure and emissions of gases or odors from the enclosure.

The excavated principal threat soil is transported to the centralized thermal desorption facility and thermally treated at 300°C. The processing rate is dependent on the moisture content of the solids feed, but is generally 2,000 BCY/day with a 65-percent on-line factor for the principal threat volumes addressed by this alternative (assuming most of the soil is not near saturation). Approximately 1 percent of the total solids feed is collected as particulates and salts from the emission equipment and placed in the on-post hazardous waste landfill.

A multilayer cap is then installed over the whole area as described in Section 4.6.14. The multilayer cap is inspected annually and any damage caused by erosion is repaired. Five-year site reviews and annual groundwater compliance monitoring are conducted to document the effectiveness of the containment system.

4.6.20 <u>Alternative 6d: Caps/Covers (Composite Cap)</u>

Alternative 6d is a containment alternative that was developed for the Basin F Wastepile Subgroup. The major components of Alternative 6d are the following:

- Containment of the Basin F Wastepile soil through installation of a composite cap
- Monitoring through 5-year site reviews and maintenance operations to document the effectiveness of the containment system and to verify the collection and treatment of leachate from the wastepile
- Annual groundwater compliance monitoring will be conducted to evaluate the long-term protectiveness of the alternative

A composite cap is placed over the Basin F Wastepile to augment the existing cover on the wastepile. The cap consists of a gas vent layer, low-permeability geosynthetic clay liner, geomembrane, biota barrier, and soil cover layers. Section 6.4 of the Technology Descriptions Volume provides a detailed description of the composite cap. The installation of the composite cap on the Basin F Wastepile interrupts exposure pathways and reduces the generation of leachate by reducing infiltration; however, continued collection and treatment of leachate is required until the wastepile is dewatered. The cap is inspected and maintained annually and any damage caused by erosion is repaired.

4.6.21 Alternative 8a: Direct Soil Washing (Solvent Washing)

Alternative 8a is a treatment alternative that is applicable to the Basin F Wastepile and Chemical Sewers Subgroups. It differs from Alternative 8b in that these subgroups do not require solidification of inorganic exceedances. The major components of Alternative 8a are the following:

- Excavation of soil exceeding the Human Health SEC (EBASCO 1994a)
- Screening and size reduction of the soil
- Separation of remaining oversize materials and debris followed by disposal of oversize material in the on-post hazardous waste landfill
- Treatment of organics in excavated soil through direct solvent washing
- Off-post treatment and disposal of the effluent from solvent washing
- Backfilling of treated soil

The specific technology described below was selected as a representative process option, based on the results of the pilot-scale treatability study performed at RMA, for the purpose of conceptual design and costing. If other more effective solvent washing technologies become available prior to remediation, these may be substituted.

Conventional earth-moving equipment, as described in Section 4.1 of the Technology Descriptions Volume, is used to excavate soil. During excavation operations, dust is suppressed and emissions of volatiles and odors are controlled. The Basin F Wastepile Subgroup is excavated inside an enclosure to control vapors as described in Section 4.1.2 of the Technology Descriptions Document. The enclosure includes emission control equipment to prevent the buildup of toxic gases inside the enclosure and emissions of gases or odors from the enclosure. Excavated soil is screened to remove debris and oversize materials. The oversize material is fed to a size-reduction unit as described in Section 7.1.1 of the Technology Descriptions Volume, then back into the feed stream. The maximum size of the feed material is 0.5 inches in diameter.

The feed materials are mixed and agitated with refrigerated solvent and NaOH in a washer/dryer mixing vessel. As the solvent breaks the organics/water/solids bonds in the waste, the solids are released and settle to the bottom of the vessel. The solvent/water mixture is removed and decanted. Decanted solvent is sent to a stripping column where the contaminants are separated from the solvent. The concentrated contaminants are sent for disposal off post and the solvent is recycled for use in the washer/dryer mixing vessel. The water is sent to another stripping column to remove any residual solvent. Several extractions are necessary to obtain the desired removal efficiencies. Once the contaminants are removed, feed materials are adjusted back to neutral pH and product water is added back to the treated soil to re-moisten it to pre-treatment levels. Following treatment, the treated soil is backfilled and the uppermost 6 inches of soil are supplemented with conditioners. Treated soil from the Basin F Wastepile is landfilled and the area is backfilled with clean borrow. The area is subsequently revegetated with native grasses. Figure 4.6-1 provides a schematic of the solvent washing process.

4.6.22 Alternative 8b: Direct Soil Washing (Solvent Washing); Direct Solidification/ Stabilization (Cement-Based Solidification); Caps/Covers (Multilayer Cap)

Alternative 8b is a treatment alternative that is applicable to the Basin A Medium Group. It differs from Alternative 8a in that it includes solidification/stabilization of inorganic exceedances after solvent washing treatment of the human health exceedance volumes to a depth of 10 ft. The treated soil and remaining residual contamination (i.e., that more than 10 ft below ground surface) are contained with a multilayer cap. The major components of Alternative 8b are the following:

- Excavation of soil exceeding the Human Health SEC (EBASCO 1994a)
- Screening and size reduction of the soil
- Separation of remaining oversize materials and debris followed by disposal of oversize material in the on-post hazardous waste landfill
- Treatment of organic contaminants in excavated soil through direct solvent washing
- Off-post treatment and disposal of the organic effluent from solvent washing

- Treatment of inorganic exceedances in excavated soil through direct cement-based solidification

- Backfill of treated soil from solvent washing and solidification

- Monitoring to observe durability of the solidified soil

- Containment of treated soil and soil with residual contamination below 10 ft through the installation of a multilayer cap (soil posing risk to biota may be consolidated into Basin A to reduce the volume of gradefill required)

- Monitoring through 5-year site reviews and maintenance operations to document the effectiveness of the containment system

Conventional earth-moving equipment, as described in Section 4.1 of the Technology Descriptions Volume, is used to excavate soil. During excavation operations, dust is suppressed and emissions of volatiles and odors are controlled. Excavated soil is screened to remove debris and oversize materials. The oversize material is fed to a size-reduction unit as described in Section 7.1.1 of the Technology Descriptions Volume, then back into the feed stream. The maximum size of the feed material is 0.5 inches in diameter. The feed is then mixed and agitated with refrigerated solvent and NaOH in a washer/dryer mixer vessel as described in Section 4.6.21.

Following solvent extraction, soil with inorganics exceeding the Human Health SEC (EBASCO 1994a) is solidified by adding cement at a ratio of 0.2 tons/ton of soil as discussed in Section 4.6.23. Figure 4.6-2 presents a schematic of the soil washing and solidification/stabilization process. The solidified soil is backfilled, but solidification results in a volume increase of approximately 38 percent. At least 4 ft of treated soil are placed over the solidified soil to prevent damage from freeze/thaw stresses. The durability of the solidified soil is monitored, and the cover is maintained by repairing any damage caused by erosion.

Following treatment, the treated soil is backfilled to the site and compacted. A multilayer cap is then installed to reduce the migration of the residual contamination and interrupt exposure pathways. The design of multilayer caps is discussed in Section 4.6.14.

4.6.23 Alternative 10: Direct Solidification/Stabilization (Cement-Based Solidification)

Alternative 10 is a treatment alternative that is applicable to the Buried M-1 Pits and Burial Trenches Subgroups. The major components of Alternative 10 are the following:

- Excavation of soil exceeding the Human Health SEC (EBASCO 1994a)
- Separation of oversize soil and any debris as a pre-treatment step followed by disposal of oversize material in the on-post hazardous waste landfill
- Treatment of excavated soil by direct cement-based solidification, placement of solidified soil in the on-post landfill, or backfill of the solidified soil along with the installation of a soil cover
- Monitoring to observe durability of the solidified soil

Conventional earth-moving equipment, as described in Section 4.1 of the Technology Descriptions Volume, is used to excavate soil exceeding the Human Health SEC (EBASCO 1994a). During excavation operations, dust is suppressed and emissions of volatiles and odors are controlled. The M-1 Pits are excavated under an enclosure to control vapors as described in Section 4.1.2 of the Technology Descriptions Volume. The enclosure includes emission control equipment to prevent the buildup of toxic gases inside the enclosure and emission of gases or odors from the enclosure.

The solidification process starts by mixing the contaminated soil with Portland cement as discussed in Section 10.1 of the Technology Descriptions Volume. A variety of aluminum silicate compounds form during the hydration process and bind the soil particles and contaminants into the crystalline lattice of the cement matrix. The final product varies from a granular, soil-like material to a cohesive solid, depending on the amount of binder added and the contaminants present in the soil. As hydration proceeds and the crystallinity of the matrix increases, the porosity and internal surface area decrease. The final product is much less permeable than the contaminated soil, and the contaminants are physically incorporated (or sometimes chemically bonded) to the cement matrix. The overall effect is to inhibit the leaching of contaminants from the solidified/stabilized mass. Figure 4.6-3 presents a schematic of the direct Solidification/Stabilization process for Alternative 10.

Solidification requires equipment for chemical storage, materials handling, materials mixing, and materials control. Dry binder ingredients, such as Portland cement, fly ash, and lime, are usually delivered in bulk transport trailers and stored in elevated metal storage silos. Liquid ingredients, such as hydrated calcium silicates, calcium hydroxides, and calcium-aluminum-silicates, are delivered in both bulk and drummed shipments and are stored in tanks or buildings. Storage tanks and buildings may require protection from extreme heat or cold for year-round operations.

Binder ratios and additive levels are determined on a site- and soil-specific basis. As discussed in Section 10.1 of the Technology Descriptions Volume, preliminary results from the treatability studies conducted by the U.S. Army Corps of Engineers Waterways Experimental Station (WES 1995) indicate that a binder-to-soil ratio of 0.2 tons/ton of soil (weight basis) is generally optimum for RMA soil. A volume increase usually accompanies the solidification process. In most instances, the volume of the final mixture is nearly 40 percent greater than the original volume of contaminated soil.

Solidified soil is either backfilled in the original excavation (with a soil cover providing weather protection for the treated material) or it is placed in the on-post landfill. If the configuration of the site or depth of the excavation precludes backfilling all of the processed material, the excess soil is placed in the on-post hazardous waste landfill. In this case, the solidified materials are placed in forms and allowed to cure for a few days, and then removed and the "monoliths" placed in the landfill.

4.6.24 Alternative 13: Direct Thermal Desorption (Direct Heating); Direct Solidification/ Stabilization (Cement-Based Solidification)

Alternative 13 is a treatment alternative that is applicable to the South Plants Balance of Areas and Sand Creek Lateral subgroups. The major components of Alternative 13 are the following:

- Excavation of soil exceeding the Human Health SEC (EBASCO 1994a)
- Separation of oversize soil and any debris as a pre-treatment step followed by disposal of oversize material in the on-post hazardous waste landfill
- Treatment of organics in excavated soil through direct thermal desorption
- Disposal of particulates and salts from the scrubber blowdown of the thermal desorption emission control equipment in the on-post landfill
- Treatment of inorganic exceedances in excavated soil through direct cement-based solidification
- Backfill of treated soil from thermal desorption and solidification
- Monitoring to observe durability of the solidified soil

Conventional earth-moving equipment, as described in Section 4.1 of the Technology Descriptions Volume, is used to excavate soil. During excavation operations, dust is suppressed and emissions of volatiles and odors are controlled.

For direct thermal desorption, the soil is transported to the centralized thermal desorber where it is prepared as feedstock for the thermal desorber. Typically, large objects (greater than 1.5 to 2.0 inches) are screened from the feedstock and disposed in the on-post hazardous waste landfill. The centralized thermal desorption facility requires two inclined, direct-fired rotary dryers (52 ft long and 10 ft in diameter) operating under induced draft at 300°C as discussed in Section 7.1.1 of the Technology Descriptions Volume. The total soil processing rate, with a moisture content of 20 percent, is 1,300 BCY/day, with an overall soil residence time of 50 minutes. With a moisture content of 10 percent, the processing rate is increased to 2,000 BCY/day with a 65-percent on-line factor. Figure 4.6-4 presents a schematic of this alternative.

As described in Section 7.1.1 of the Technology Descriptions Volume, off gas from the desorber passes through a cyclone separator before entering the secondary combustion chamber (SCC). The particulates removed by the cyclone are recombined with the treated soil or are treated separately to immobilize the metals. Organic contaminants in the cyclone off gas are destroyed in the SCC at an operating temperature of 1,200°C and a residence time of 2.5 seconds. Off-gas treatment involves the removal of the acid gases formed by oxidation reactions in the SCC and the removal of the particulates carried over from the cyclone separator. Other off-gas system equipment consists of a spray tower for adiabatic gas cooling and a baghouse for particulate removal. A caustic quench step is added to remove acid gases.

Soil with inorganics above the Human Health SEC (EBASCO 1994a) is solidified by adding cement at a ratio of 0.2 tons/ton of soil as discussed in Section 4.6.23. The solidified soil is backfilled on post, but solidification results in a volume increase of nearly 40 percent. Four feet of thermally desorbed soil are placed over the solidified soil to prevent damage from freeze/thaw stresses. The durability of the solidified soil is monitored, and the cover is maintained by repairing any damage caused by erosion. The uppermost 6 inches of soil over the backfilled area are supplemented with conditioners and revegetated with native grasses.

4.6.25 Alternative 13a: Direct Thermal Desorption (Direct Heating)

Alternative 13a is a treatment alternative that is applicable to the Secondary Basins Medium Group and the Chemical Sewers, South Plants Ditches, Buried Sediments, and Section 36 Balance of Areas subgroups. It differs from Alternative 13 in that these sites do not require solidification of inorganic exceedances. The major components of Alternative 13a are the following:

- Excavation of soil exceeding the Human Health SEC (EBASCO 1994a)
- Separation of oversize soil and any debris as a pre-treatment step followed by disposal of oversize material in the on-post hazardous waste landfill
- Treatment of organic contaminants in excavated soil through direct thermal desorption
- Treatment of particulates and inorganic contaminants in off gas

- Disposal of particulates and salts from the scrubber blowdown of the thermal desorption emission control equipment in the on-post landfill

- Backfilling of treated soil

Conventional earth-moving equipment, as described in Section 4.1 of the Technology Descriptions Volume, is used to excavate soil. During excavation operations, dust is suppressed and emissions of volatiles and odors are controlled. Dewatering is required for the Section 36 Balance of Areas Subgroups to allow the excavation of soil near the water table. Direct thermal desorption volatilizes organic contaminants from excavated soil and subsequently destroys the volatilized organics in a combustion chamber. Figure 4.6-5 is a schematic of this alternative. The centralized facility operates at 300°C as discussed in Section 7.1.1 of the Technology Descriptions Volume. The solids processing rate varies from 1,300 to 2,000 BCY/day with a 65-percent on-line factor based on the moisture content of the soil.

Approximately 1 percent of the total solids feed is collected as particulates and salts from the emission control equipment and placed in the on-post hazardous waste landfill. Treated soil is backfilled. Since thermal desorption removes the organic content of soil during processing, the uppermost 6 inches of soil over the backfilled area are supplemented with conditioners and revegetated with native grasses.

4.6.26 Alternative 13b: Direct Thermal Desorption (Direct Heating); Landfill (On-Post Landfill)

Alternative 13b is a treatment alternative that is applicable to the Basin F Wastepile Subgroup and the Sanitary Landfills Medium Group. The Sanitary Landfills Medium Group is addressed by this alternative because the debris from the site cannot be effectively solidified to address inorganic exceedances; therefore, it must be landfilled to control potential contaminant migration. The major components of Alternative 13b are the following:

- Excavation of soil exceeding the Human Health SEC (EBASCO 1994a)

- Separation of oversize soil and any debris as a pre-treatment step followed by disposal of oversize material in the on-post hazardous landfill
- Treatment of organic contaminants in excavated soil through direct thermal desorption
- Treatment of inorganic contaminants s and particulates in off gas
- Disposal of particulates and salts from the scrubber blowdown of the thermal desorption emission control equipment in the on-post landfill
- Disposal of treated soil and debris in the on-post hazardous waste landfill
- Backfill of sites with borrow material
- Monitoring of landfill

Conventional earth-moving equipment, as described in Section 4.1 of the Technology Descriptions Volume, is used to excavate soil. During excavation operations, dust is suppressed and emissions of volatiles and odors are controlled. The Basin F Wastepile Subgroup is excavated inside an enclosure to control vapors as described in Section 4.1.2 of the Technology Descriptions Volume. The enclosure includes emission control equipment to prevent the buildup of toxic gases inside the enclosure and emission of gases or odors from the enclosure.

The direct thermal desorption equipment operates at a temperature of 300°C, as discussed in Section 7.1.1 of the Technology Descriptions Volume. Its throughput varies from 1,300 to 2,000 BCY/day, depending on the moisture content of the solids feed, with a 65-percent on-line factor. All of the treated soil, including the particulates collected from the emission control equipment, are placed in the on-post hazardous waste landfill.

Excavated soil from the Sanitary Landfills Medium Group that contain inorganic exceedances is not treated by direct solidification/stabilization because the large amounts of debris present in this soil would necessitate intensive pre-treatment and materials separation prior to treatment. Therefore, these materials are placed directly into the on-post landfill, as discussed in Section 4.6.6, following thermal treatment.

4.6.27 Alternative 13c: Direct Thermal Desorption (Direct Heating); Caps/Covers (Multilayer Cap)

Alternative 13c is a treatment alternative that is applicable to the Former Basin F Subgroup. This alternative was developed to address containment of treated soil and residual contamination in soil at a depth of more than 10 ft. Under this alternative, contaminant migration is reduced and human and biota exposure pathways are interrupted. The major components of Alternative 13c are the following:

- Excavation of soil exceeding the Human Health SEC (EBASCO 1994a)
- Separation of oversize soil and any debris as a pre-treatment step followed by disposal of oversize material in the on-post hazardous waste landfill
- Treatment of organic contaminants in excavated soil through direct thermal desorption
- Disposal of particulates and salts from the scrubber blowdown of the thermal desorption emission control equipment in the on-post landfill
- Backfill of treated soil
- Containment of treated soil residual contamination below 10 ft by installing a multilayer cap
- Monitoring through 5-year site reviews and maintenance operations to document the effectiveness of the containment system

Conventional earth-moving equipment, as described in Section 4.1 of the Technology Descriptions Volume, is used to excavate soil. During excavation operations, dust is suppressed and emissions of volatiles and odors are controlled. The Former Basin F Subgroup is excavated inside an enclosure to control vapors as described Section 4.1.2 of the Technology Descriptions Volume. The enclosure includes emission control equipment to prevent the buildup of toxic gases inside the enclosure and emissions of gases or odors from the enclosure.

As discussed in Section 7.1.1 of the Technology Descriptions Volume, the centralized thermal desorption facility operates at 300°C. The solids processing rate is generally 2,000 BCY/day with a 65-percent on-line factor based on the moisture content of the soil. Approximately 1 percent of the total solids feed is collected as particulates and salts from the emission control equipment and placed in the on-post hazardous waste landfill. Treated soil is backfilled.

Residual contamination and the treated soil are contained through installation of a multilayer cap as described in Section 4.6.14. The multilayer cap is inspected annually and any damage caused by erosion is repaired. Five-year site reviews are conducted to document the effectiveness of the containment system.

4.6.28 Alternative 13d: Direct Thermal Desorption (Direct Heating); Direct Solidification/ Stabilization (Cement-Based Solidification); Caps/Covers (Multilayer Cap)

Alternative 13d is a combination of treatment and containment that is applicable to the Basin A Medium Group and the Section 36 Lime Basins and the South Plants Central Processing Area subgroups. The major components of Alternative 13d are the following:

- Excavation of soil exceeding the Human Health SEC (EBASCO 1994a)
- Separation of oversize soil and any debris as a pre-treatment step followed by disposal of oversize material in the on-post hazardous waste landfill
- Treatment of organic contaminants in excavated soil through direct thermal desorption
- Disposal of particulates and salts from the scrubber blowdown of the thermal desorption emission control equipment in the on-post landfill
- Treatment of inorganic exceedances in excavated soil through direct cement-based solidification
- Backfill of treated soil from thermal desorption and solidification
- Containment of the treated soil and residual contamination at a depth of more than 10 ft through installation of a multilayer cap (soil posing risk to biota may be consolidated into Basin A and the South Plants Central Processing Area to reduce the volume of gradefill required)
- Monitoring through 5-year site reviews and maintenance operations to document the effectiveness of the containment system
- Monitoring to observe durability of the solidified soil

Conventional earth-moving equipment, as described in Section 4.1 of the Technology Descriptions Volume, is used to excavate soil. During excavation operations, dust is suppressed and emissions of volatiles and odors are controlled. Dewatering is required for the Basin A Medium Group and the Section 36 Lime Basins Subgroup to allow the excavation of soil near the water table.

As discussed in Section 7.1.1 of the Technology Descriptions Volume, the centralized facility operates at 300°C. The solids processing rate is generally 1,300 BCY/day with a 65-percent on-line factor based on the moisture content of the soil. Approximately 1 percent of the total solids feed is collected as particulates and salts from the emission control equipment and placed in the on-post hazardous waste landfill. Treated soil is backfilled.

Soil with inorganics exceeding the Human Health SEC (EBASCO 1994a) is solidified by adding cement at a ratio of 0.2 tons/ton of soil as discussed in Section 4.6.23. The solidified soil is backfilled on post, but solidification results in a volume increase of nearly 40 percent. The solidified soil is placed below the multilayer cap to prevent damage from freeze/thaw stresses.

To contain the residual contamination, a multilayer cap is installed as described in Section 4.6.14. The multilayer cap is inspected annually and any damage caused by erosion is repaired. Five-year site reviews are conducted to document the effectiveness of the containment system.

4.6.29 Alternative 14: Incineration/Pyrolysis (Rotary Kiln); Landfill (On-Post Landfill)

Alternative 14 is a treatment alternative that is applicable to the Disposal Trenches Medium Group. The major components of Alternative 14 are the following:

- Excavation of soil and debris exceeding Human Health SEC (EBASCO 1994a) from disposal trenches
- Separation of any oversize debris as a pre-treatment step followed by disposal of oversize debris in the on-post hazardous waste landfill
- Treatment of organic contaminants in excavated soil through rotary kiln incineration

- Placement of treated soil as well as particulates and salts from the scrubber blowdown in the on-post hazardous waste landfill and backfill of excavations with borrow materials
- Long-term O&M of the on-post hazardous waste landfill including cap maintenance, leachate treatment, and groundwater monitoring

Specialized earth-moving equipment, as described in Section 4.1 of the Technology Descriptions Volume, is used to excavate soil. During excavation operations, dust is suppressed and emissions of volatiles and odors are controlled. The disposal trenches are excavated inside an enclosure to control vapors as described in detail in Section 4.1.2 of the Technology Descriptions Volume. The enclosure includes emission control equipment to prevent the buildup of toxic gases inside the enclosure and emissions of gases or odors from the enclosure. Dewatering is required to allow the excavation of soil near the water table.

The soil and debris are excavated using specialized equipment and moved to the central processing area where they are prepared as feedstock. Typically, objects larger than 1.5 to 2.0 inches are screened from the feedstock and rejected as oversize. Debris is sized so that it is no larger than 1 ft long by 1 ft wide, and all rebar is removed from concrete. Oversize and separated debris is landfilled.

The incinerator is a inclined, direct-fired rotary kiln operating under induced draft at a discharge temperature of 760°C. Because the soil discharges from the incinerator at a higher temperature than it would from a thermal desorber (300°C), fuel requirements for incineration are higher per ton of soil processed. The resulting higher volume of flue gas forces an increase in the diameter of the rotary kiln incinerator in order to maintain the same design-space velocity, and it also forces an increase in the sizing of the off-gas treatment system for the same soil processing rate. The overall soil residence time is 66 minutes. Figure 4.6-6 presents a schematic of rotary kiln incineration for Alternative 14.

As with thermal desorption, off gas from the incinerator passes through a cyclone separator before entering the SCC. Residual organic contaminants in the cyclone off gas are destroyed in the SCC at an operating temperature of 1,200°C and a residence time of 2.5 seconds. As discussed in Section 7.2.1 of the Technology Descriptions Volume, the off-gas treatment sequence following the SCC uses a spray tower for adiabatic gas cooling, a baghouse for particulate removal, and a venturi scrubber for additional particulate removal. A caustic quench step is added to remove acid gases.

During incineration, natural organic material is burned out of the soil matrix. The clay and silt fractions tend to disappear as the smaller particles form sand-sized aggregates and the pH of the soil increases with the loss of hydroxyl groups from the clay minerals and the conversion of carbonate minerals to their oxide forms. Since metal oxides tend to be more soluble than the carbonates, incineration tends to increase the extractability of metal constituents in treated soil over the extractability of metals in untreated soil. The residual from the process, an ash-like substance, is landfilled.

The inorganic exceedance volumes from this medium group are not treated by direct solidification/stabilization following rotary kiln incineration because the large amounts of debris present in this soil would necessitate intensive pre-treatment and materials separation prior to solidification/stabilization. Therefore, these materials are placed directly into the on-post hazardous waste landfill (Section 4.6.6) following thermal treatment.

4.6.30 Alternative 17: In Situ Physical/Chemical Treatment (Soil Flushing); In Situ Thermal Treatment (Surface Soil Heating)

Alternative 17 is a treatment alternative that was developed for the Basin A Medium Group. Surficial soil containing organics (primarily OCPs) exceeding the Human Health SEC (EBASCO 1994a) is first treated using surface soil heating. In situ soil flushing is then used to remove other contaminants in both surficial and subsurface soil within the human health exceedance volume. The major components of Alternative 17 are the following:

- Treatment of organic contaminants in surficial soil above the Human Health SEC (EBASCO 1994a) through in situ surface soil heating

- Treatment of inorganic and organic contaminants in subsurface and surficial soil through in situ physical/chemical treatment

- Monitoring during treatment to document contaminant reduction and potential migration of contaminants

- Annual groundwater compliance monitoring will be conducted to evaluate the long-term protectiveness of this alternative

Surface soil heating thermally desorbs organic contaminants at soil temperatures of 250°C using a radiant heat source applied at the surface. The desorbed organic vapors are then collected at the surface and drawn into an off-gas treatment system.

As discussed in Section 12.1 of the Technology Descriptions Volume, soil flushing is an in situ treatment technology designed to remove contaminants from soil by passing extractant solutions through the soil. In this alternative, the flushing solution is ponded over the soil area to be treated. As the flushing solution percolates through the treatment zone, it mobilizes contaminants from the soil matrix and carries the mobilized contaminants through the soil profile to the water table. The solution and contaminants are then collected in downgradient recovery wells at the Basin A Neck IRA and pumped to the Basin A Neck groundwater treatment system. The Basin A Neck IRA recovery and treatment systems require expansion if this alternative is selected. Costs to expand the system are included in the estimated costs for this alternative. This alternative must be closely coordinated with groundwater remedial alternatives for the Basin A Plume Group, and annual groundwater monitoring will be conducted.

Surfactants improve the ability of an aqueous flushing solution to mobilize strongly adsorbed, low-solubility compounds. However, interactions between surfactants, soil media, contaminants, and microbial populations can lead to problems caused by loss of permeability resulting from enhanced microbial growth or expansion of clays. Surfactants may be lost within the soil or groundwater environment through adsorption on solid surfaces, absorption by partitioning into free-phase contaminants, or biodegradation. Complete removal of surfactants from the environment may not be possible, and surfactant recovery from the waste stream can be difficult.

4.6.31 Alternative 19: In Situ Thermal Treatment (Microwave Heating); In Situ Solidification/Stabilization (Cement-Based Solidification)

Alternative 19 is a treatment alternative that was developed for the Buried M-1 Pits and South Plants Balance of Areas Subgroups. This alternative removes organic contaminants using in situ RF/microwave heating and solidifies inorganic contaminants using in situ cement-based solidification. The major components of Alternative 19 are the following:

- Treatment of soil exceeding the Human Health SEC (EBASCO 1994a) for organic contaminants through in situ RF/microwave heating

- Treatment of organic contaminants in off gases from the in situ thermal treatment process through catalytic oxidation and of liquid sidestream at the thermal desorption facility

- Treatment of soil with inorganic exceedances through in situ cement-based solidification

- Monitor following treatment to document contaminant reduction and to observe durability of the solidified soil

- Annual groundwater compliance monitoring will be conducted to evaluate the long-term protectiveness of the alternative

The RF/microwave heating process involves heating the soil until organic contamination is volatilized as discussed in Section 8.2.1 of the Technology Descriptions Volume. The process equipment includes an RF generator, a vapor collection system, and a vapor treatment system. In general, the proposed full-scale module design treats a soil block that is 100 ft long by 48 ft wide and 10 ft deep.

RF/microwave heating is implemented by inserting electrodes in the ground and heating the soil to volatilize organic contaminants. The depth of the electrodes defines the depth of soil to be treated. As the soil is heated to 250°C, volatilized contaminants and steam are collected from the soil through the perforated electrodes, which serve as vacuum-extraction vents, and drawn into the vapor collection system. The off gases are treated by catalytic oxidation in the vapor treatment system. Depending upon the concentration of the organic contaminants in the collected gases entering the oxidizer, additional fuel may have to be added to the oxidizer. The vent gases are scrubbed to remove hydrochloric acid formed during oxidation and then quenched.

Post-treatment of the soil after RF/microwave heating is required. Due to the heating of the soil matrix, revegetation is necessary to restore the site to its original condition. The soil organic content has to be supplemented with fertilizers and humic material to effectively maintain a vegetative cover.

Soil exceeding the Human Health SEC (EBASCO 1994a) for inorganics is treated by in situ cement-based solidification. The major difference between direct and in situ solidification is the absence of the excavation and backfill steps required by direct processes. The mixing equipment is based on powerful drilling rigs rather than cement batch plants; the former are available from specialty foundation and cut-off wall construction vendors. In this instance, the mixing equipment is moved through the volume of soil to be remediated. The equipment can drill as deep as 150 ft. Each type of specialized auger is supported by cement slurry storage and transfer equipment, and the binder ingredients are metered into the hollow-stem auger or kelly bar and injected into the soil column. (A specialized auger comes equipped with a shroud that can be used for vapor collection if volatile contaminants are expected.) In situ cement-based solidification uses the same cement/soil ratio as direct cement-based solidification (Section 4.6.23), but consumes more binder for two reasons. First, the drilling pattern necessarily incorporates some amount of overlap. Second, it is difficult to monitor the amount of binder needed for in situ mixing. Estimates of quantities needed must therefore err on the high side.

The solidification process increases the volume of the treated soil. Based on the required binder ratio of 0.2 tons/ton of soil, the expansion may range between 10 and 25 percent. Post-treatment may involve recontouring the expanded soil in place, or removing the excess volume to be consolidated in Basin A or disposed in the on-post hazardous waste landfill.

4.6.32 Alternative 19a: In Situ Thermal Treatment (RF/Microwave Heating)

Alternative 19a is a treatment alternative that was developed for the Secondary Basins Medium Group and the Buried Sediments and Section 36 Balance of Areas subgroups. The major components of Alternative 19a are the following:

- Treatment of soil exceeding the Human Health SEC (EBASCO 1994a) for organic contaminants through in situ RF/microwave heating

- Treatment of organic contaminants in off gases from the in situ thermal treatment process through catalytic oxidation and treatment of liquid sidestream at the thermal desorption facility

RF/microwave heating, as described in Section 4.6.31, treats organics exceeding the Human Health SEC (EBASCO 1994a). The soil is heated to 250°C, and vapors are collected and treated. This alternative removes organic contaminants using in situ heating and differs from Alternative 19 in that these sites do not require solidification/stabilization treatment of inorganic exceedance volumes.

4.6.33 Alternative 19b: In Situ Thermal Treatment (RF/Microwave Heating); In Situ Solidification/Stabilization (Cement-Based Solidification); Caps/Covers (Multilayer Cap)

Alternative 19b is a treatment alternative that was developed for the Basin A Medium Group and Section 36 Lime Basins and South Plants Central Processing Area subgroup. This alternative removes organic contaminants using in situ RF/microwave heating and solidifies inorganic contaminants using in situ cement-based solidification. The treated soil and residual contamination at depths more than 10 ft below ground surface are contained through installation of a multilayer cap, thereby reducing residual contaminant migration and interrupting human and biota exposure pathways. The major components of Alternative 19b are the following:

- Treatment of soil exceeding the Human Health SEC (EBASCO 1994a) for organic contaminants through in situ RF/microwave heating

- Treatment of organic contaminants in off gases from the in situ thermal treatment process through catalytic oxidation and treatment of liquid sidestream at the thermal desorption facility

- Treatment of soil with inorganic exceedances through in situ cement-based solidification

- Containment of treated soil and residual contamination by installing a multilayer cap (soil posing risk to biota may be consolidated into Basin A and the South Plants Central Processing Area to reduce the volume of gradefill required)

- Monitoring following treatment to document contaminant reduction and to observe durability of the solidified soil

- Monitoring through 5-year site reviews and maintenance operations to document the effectiveness of the containment system

- Annual groundwater compliance monitoring will be conducted to evaluate the long-term protectiveness of the alternative

The RF/microwave heating process involves the desorption and collection of organic compounds through the placement of electrodes into a grid of boreholes as discussed in Section 8.2 of the Technology Descriptions Volume and Section 4.6.31. Soil exceeding the Human Health SEC (EBASCO 1994a) for inorganics is treated by in situ cement-based solidification, which is described in Section 4.6.31.

The solidification process increases the volume of the treated soil. Based on the required binder ratio of 0.2 tons/ton of soil, the expansion may range between 10 and 25 percent. Post-treatment may involve recontouring the expanded soil in place, or removing the excess volume to Basin A for consolidation or to the on-post hazardous waste landfill.

To contain residual contamination, a multilayer cap is installed as described in Section 4.6.14. The multilayer cap is inspected annually and any damage caused by erosion is repaired. Five-year site reviews and annual groundwater compliance monitoring are conducted to document the effectiveness of the containment system.

4.6.34 Alternative 19c: In Situ Thermal Treatment (RF/Microwave Heating); Caps/Covers (Multilayer Cap)

Alternative 19c is a treatment alternative developed for the Former Basin F Subgroup. The treated soil and residual contamination at depths more than 10 ft below ground surface are contained by installing a multilayer cap, which reduces residual contaminant migration and interrupts human and biota exposure pathways. The major components of Alternative 19d are the following:

- Treatment of soil exceeding the Human Health SEC (EBASCO 1994a) for organic contaminants through in situ RF/microwave heating

- Treatment of organic contaminants in off gases from the in situ thermal treatment process through catalytic oxidation and treatment of liquid sidestream at the thermal desorption facility

- Containment of treated soil and residual contamination below 10 ft by installing a multilayer cap

- Monitoring through 5-year site reviews and maintenance operations to document the effectiveness of the containment system

RF/microwave heating, as described in Section 4.6.31, treats organics exceeding the Human Health SEC (EBASCO 1994a). The soil is heated to 250°C, and vapors are collected and treated. This alternative removes organic contaminants using in situ heating and differs from Alternative 19 in that this subgroup does not require solidification/stabilization treatment for inorganic exceedances, and from Alternative 19a because it does require a cap to contain residual contamination.

The multilayer cap is designed and constructed as described in Section 4.6.14. The multilayer cap is inspected annually and any damage caused by erosion is repaired. Five-year site reviews are conducted to document the effectiveness of the containment system.

4.6.35 Alternative 21: In Situ Thermal Treatment (In Situ Vitrification)

Alternative 21 is a treatment alternative specifically developed for the Buried M-1 Pits Subgroup. In situ vitrification is applicable to high levels of mixed organic and inorganic contamination and is only cost effective when it is used to treat limited volumes of soil. These attributes are directly applicable to soil in this subgroup. The major components of Alternative 21 are the following:

- Treatment of soil exceeding the Human Health SEC (EBASCO 1994a) for organic and inorganic contaminants through in situ vitrification
- Treatment of organic and volatile inorganic contaminants contained in off gases from vitrification
- Backfill over vitrified materials to bring to grade
- Monitoring through sampling and site reviews to observe durability of vitrified soil

As discussed in Section 8.3 of the Technology Descriptions Volume, in situ vitrification uses electrical energy to melt soil and sludges for the purpose of thermally treating organic and immobilizing inorganic contaminants present within the treatment volume. Most in situ vitrification applications involve melting the natural soil; however, other naturally occurring or process residual chemicals may be addressed during treatment. Organic and volatile inorganic contaminants that are not destroyed by pyrolysis during the vitrification process are driven out of the soil, collected, and treated in a vapor treatment system. In situ vitrification equipment consists of the electrode array, power source, off-gas hood, and vapor treatment system. In situ vitrification is currently being developed by Geosafe Corporation. The technology has progressed through numerous tests and demonstrations from bench to pilot scale; however, only a few full-scale treatment operations have been performed.

Geosafe has designed a full-scale system capable of treating an area with dimensions of 30 ft by 30 ft and a maximum depth of 30 ft. During operation, in situ vitrification is able to process 4 to 6 tons of soil/hour and requires 0.3 to 0.5 Kilowatts (kW) per pound of soil. The full-scale process takes place at temperatures ranging from 1,600°C to 2,000°C.

The processing area is covered by an octagonal-shaped off-gas collection hood that is 55 ft wide. Flow of air through the hood is controlled to maintain a lower pressure relative to atmospheric pressure. Since the process occurs at temperatures well above combustion minimums, air is injected under the hood to ensure excess oxygen is available for combustion of pyrolysis byproducts and organic vapors. The off gases, combustion products, and air are drawn from the hood via an induced draft blower into the off-gas treatment system.

The off-gas treatment system includes quenching, pH-controlled scrubbing, demisting, heating (temperature and dew point control), particulate filtration, and granular activated carbon (GAC) adsorption components. Section 8.3 of the Technology Descriptions Volume discusses the offgas control equipment for in situ vitrification.

Preparation of the treatment site is required. Groundwater in the soil treatment zone slows the vitrification process since the process requires that this water be vaporized prior to the melt progressing downward. Therefore, a sheet-pile wall and dewatering wells may be installed to cut off groundwater flow into the area during in situ vitrification. Any vegetative growth and any surface debris is also cleared from the site. Site restoration activities include backfilling the disturbed area with clean soil, regrading the surface as necessary, removing the sheet piles, and revegetating the area with native grasses. A soil volume reduction of 28 percent is anticipated from in situ vitrification.

4.6.36 Alternative 22: In Situ Solidification/Stabilization (Cement-Based Solidification or Silica/Proprietary Agent-Based Solidification)

Alternative 22 is an in situ treatment alternative that is applicable to the Buried M-1 Pits and Hex Pits Subgroups. The major components of Alternative 22 are the following:

- Treatment of soil with inorganic exceedances through in situ cement-based solidification or treatment of soil with organic exceedances through in situ silica/proprietary agent-based solidification

- Monitoring following treatment to observe durability of the solidified soil

- Annual groundwater compliance monitoring will be conducted to evaluate the long-term protectiveness of the alternative

Soil volumes exceeding the Human Health SEC (EBASCO 1994a) for inorganics are treated by in situ cement-based solidification as described in Section 4.6.31. Soil volumes containing organic exceedances are treated in the same manner; however, a proprietary agent/silicate binder is used instead of cement. The solidification process increases volume of the treated soil. Based on the required binder ratio of 0.2 tons/ton of soil, the expansion may range between 10 and 25 percent. Post-treatment may involve recontouring the expanded soil in place, or removing the excess volume to Basin A for consolidation or to the on-post hazardous waste landfill.

	Alternative Name	Alternative Description
U1:	No Additional Action (Provisions of FFA)	Provisions of the FFA and the existing or planned IRAs; monitor site conditions.
U2:	Caps/Covers (Multilayer Cap)	Geophysical clearance; contain potential UXO area; cover includes 4-ft-thick soil cover and vegetation layers that control potential exposure and prevent damage to containment system; monitor effectiveness of system.
U3:	Detonation (On-Post Detonation) Incineration/Pyrolysis (Rotary Kiln Incineration)	Excavate potential UXO identified by geophysical clearance; separate UXO from excavated material; dispose excavated materials/debris in on-post landfill; incinerate agent-filled UXO; and detonate HE-filled UXO on post.
U3a:	Detonation (On-Post Detonation)	Excavate potential HE-filled UXO identified by geophysical clearance; separate UXO from excavated material; dispose excavated materials/debris in on-post landfill; detonate HE-filled UXO on post.
U4:	Detonation (Off-Post Army Facility); Incineration/Pyrolysis (Off-Post Incineration)	Excavate potential UXO identified by geophysical clearance; separate UXO from excavated material; dispose excavated materials/debris in on-post landfill; prepare UXO for transportation to an existing off-post Army facility; incinerate agent-filled UXO; and detonate HE-filled UXO at off-post Army facility.
U4a:	Detonation (Off-Post Army Facility)	Excavate potential HE-filled UXO identified by geophysical clearance; separate UXO from excavated material; dispose excavated materials/debris in on-post landfill; prepare UXO for transportation to an existing off-post Army facility; detonate HE-filled UXO at off-post Army facility.
A1:	No Additional Action (Provisions of FFA)	Provisions of the FFA and the existing or planned IRAs; monitor site conditions.
A2:	Caps/Covers (Soil Cover)	Contain potential agent area; cover includes 4-ft thick soil cover and vegetation layers that control potential exposure and prevent damage to containment system; monitor effectiveness of system.
A3:	Direct Soil Washing (Caustic Solution Washing); Landfill (On-Post Landfill)	Identify soil containing agent during excavation; materials handling and sizing; soil washing with caustic; treat aqueous effluent by evaporation/crystallization; dispose treated soil and salts in on-post landfill.
A4:	Incineration/Pyrolysis (Rotary Kiln Incineration)	Identify soil containing agent; excavate soil with agent; materials handling and sizing; incinerate agent-contaminated soil; capture particulates and treat volatile organic contaminants in off gas; backfill treated soil; dispose particulates from off gas in on-post landfill.
A5:	Direct Soil Washing (Solvent Extraction); Landfill (On-Post Landfill)	Identify soil containing agent; excavate soil with agent; perform materials handling and sizing; use caustic/solvent washing to degrade agent; treat organic effluent off post; dispose treated soil in landfill.
B1:	No Additional Action (Provisions of FFA)	Provisions of the FFA and the existing or planned IRAs; monitor natural attenuation/degradation and potential migration; defer to USFWS for future remedial actions.

Alternative Name		Alternative Description
B1a:	Landfill (On-Post Landfill); No Additional Action (Provisions of FFA)	Excavate human health exceedances; transport soil to landfill; place soil in landfill; provisions of FFA and the existing or planned IRAs for balance of area; monitor natural attenuation/degradation and potential migration for balance of area; defer to USFWS for additional remedial actions.
B2:	Biota Management (Exclusion, Habitat Modification)	Exclude biota using physical barriers and habitat modification; monitor natural attenuation/degradation and potential migration; defer to USFWS for additional remedial actions.
B3:	Landfill (On-Post Landfill)	Construct on-post landfill; excavate soil; transport soil to landfill; place soil in landfill; perform operation, maintenance, and monitoring of landfill; revegetate excavated area; defer to USFWS for additional remedial actions.
B5:	Caps/Covers (Multilayer Cap)	Contain biota risk area; cap/cover includes compacted low-permeability soil, biota barrier, and cover soil/vegetation layers that limit potential wildlife exposure and prevent damage to containment system; monitor effectiveness of system; defer to USFWS for additional remedial actions.
B5a:	Landfill (On-Post Landfill); Caps/Covers (Multilayer Cap) with Consolidation	Excavate human health exceedances; transport soil to landfill; place soil in landfill; consolidate biota risk volume into Basin A or Former Basin F; cap/cover includes compacted low-permeability soil, biota barrier, and cover soil/vegetation layers that limit potential exposure and prevent damage to containment system; cover biota excavation area with one ft of soil and revegetate; monitor effectiveness of system; defer to USFWS for additional remedial actions.
B9:	In Situ Biological Treatment (Landfarm/Agricultural Practice)	Prepare and clear site; treat biota risk area by landfarm/agricultural practice; monitor natural attenuation/degradation and potential migration; defer to USFWS for additional remedial actions.
B9a:	Landfill (On-Post Landfill); In Situ Biological Treatment (Landfarm/Agricultural Practice)	Construct on-post landfill; excavate human health exceedances; transport soil to landfill; place soil in landfill; backfill excavations with borrow soil; treat biota risk area by landfarm/agricultural practice; perform operation, maintenance, and monitoring of landfill; monitor natural attenuation/degradation and potential migration; defer to USFWS for additional remedial actions.
1:	No Additional Action (Provisions of FFA)	Provisions of the FFA and the existing or planned IRAs; monitor natural attenuation/degradation and potential migration; conduct annual groundwater monitoring.
1a:	Direct Thermal Desorption (Direct Heating) of Principal Threat Volume; No Additional Action (Provisions of FFA)	Excavate and treat principal threat volume by direct thermal desorption (Alternative 13a) and backfill; perform materials handling and sizing; dispose oversize debris and particulates in landfill; provisions of the FFA and the existing or planned IRAs for balance of area; monitor natural attenuation/degradation and potential migration for balance of area; conduct annual groundwater monitoring.

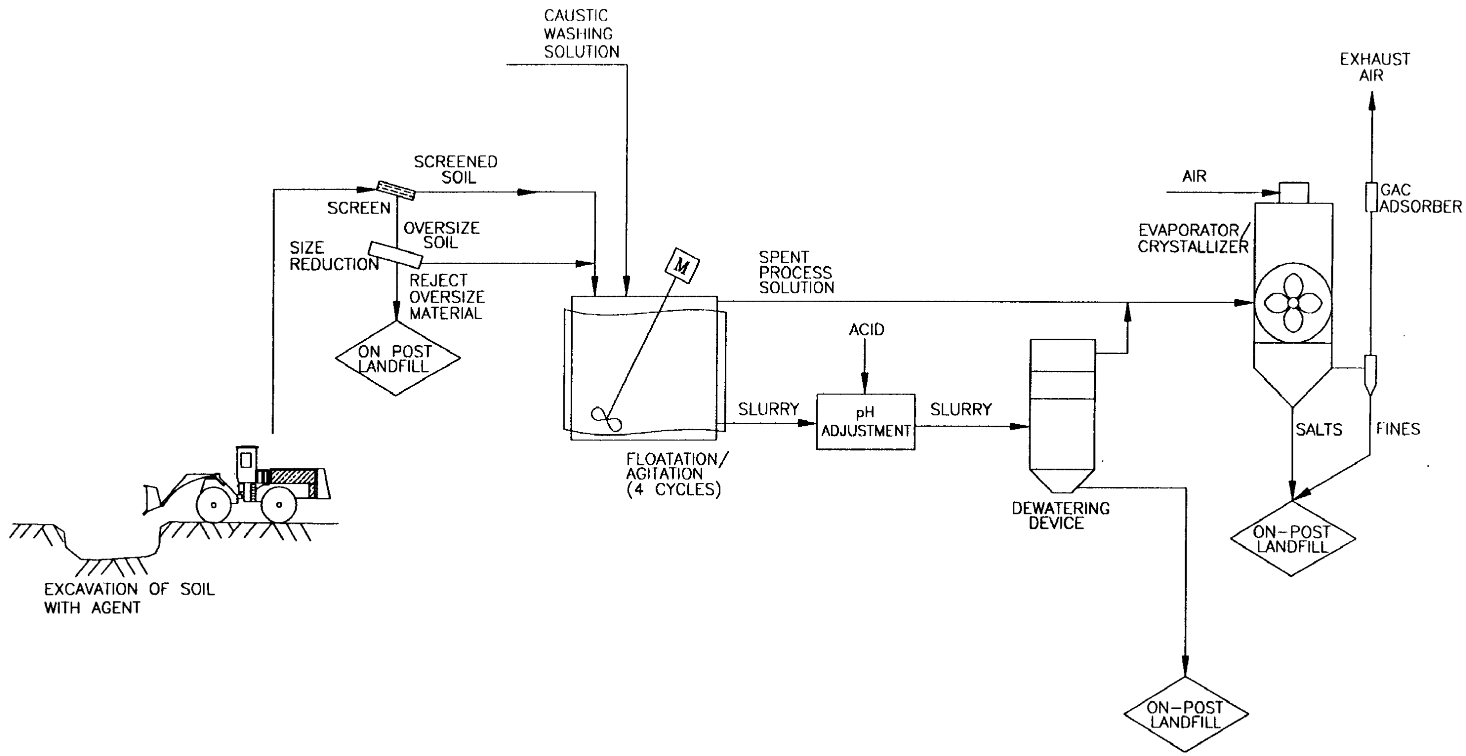
	Alternative Name	Alternative Description
1b:	Direct Thermal Desorption (Direct Heating) and Direct Solidification/Stabilization (Cement-Based Solidification) of Principal Threat Volume; No Additional Action (Provisions of FFA)	Excavate principal threat volume; treat organic risks by direct thermal desorption (Alternative 13a) and backfill; treat inorganic exceedances by direct solidification/stabilization (Alternative 10); perform materials handling and sizing; dispose oversize materials and particulates in landfill; backfill solidified soil under 4-ft-thick layer of other backfill; provisions of FFA and the existing or planned IRAs; monitor natural attenuation/degradation and potential migration for remaining balance of area; conduct annual groundwater monitoring.
2:	Access Restrictions (Modifications to FFA)	Install site access restrictions (fencing and modifications to FFA); monitor natural attenuation/degradation and potential migration; conduct annual groundwater monitoring.
2a:	Direct Thermal Desorption (Direct Heating) of Principal Threat Volume; Access Restrictions (Modifications to FFA)	Excavate and treat principal threat volume by direct thermal desorption (Alternative 13a); and backfill materials handling and sizing; dispose oversize materials and particulates in on-post landfill; install site access restrictions (fencing or plugging and modifications to FFA) for balance of area; monitor natural attenuation/degradation and potential migration for balance of area; conduct annual groundwater monitoring.
3:	Landfill (On-Post Landfill)	Construct on-post landfill; excavate human health exceedance volume soil; place soil in landfill; backfill excavations with borrow soil; perform operation, maintenance, and monitoring of landfill.
3a:	Direct Thermal Desorption (Direct Heating) of Principal Threat Volume; Landfill (On-Post Landfill)	Construction of on-post landfill; excavate principal threat volume and treat using direct thermal desorption (Alternative 13a); landfill treated soil; perform materials handling and sizing; dispose oversize materials and particulates in landfill; excavate remaining human health exceedance volume soil; place remaining soil in landfill; backfill excavations with borrow soil; perform operation, maintenance, and monitoring of landfill.
3b:	Landfill (On-Post Landfill); Caps/Covers (Soil Cover or Multilayer Cap)	Construct on-post landfill; excavate human health exceedance volume soil; place soil in landfill; backfill excavations with borrow soil; contain residual contamination using cap/cover; perform operation, maintenance, and monitoring of landfill and cap/cover.
3c:	Direct Thermal Desorption (Direct Heating) of Principal Threat Volume; Landfill (On-Post Landfill); Caps/Covers (Multilayer Cap)	Construct on-post landfill; excavate and treat principal threat volume by direct thermal desorption (Alternative 13a) and landfill; perform materials handling and sizing; dispose oversize materials and particulates in on-post landfill; excavate remaining human health exceedance volume soil; place remaining soil in landfill; backfill excavations with borrow soil; contain residual contamination using cap/cover; perform operation, maintenance, and monitoring of landfill and cap/cover.

Alternative Name		Alternative Description
3d:	Direct Thermal Desorption (Direct Heating) and Direct Solidification/Stabilization (Cement-Based Solidification) of Principal Threat Volume; Landfill (On-Post Landfill); Caps/Covers (Multilayer cap)	Construct on-post landfill; excavate principal threat volume; treat organic exceedances by direct thermal desorption (Alternative 13a) and treat inorganic exceedances by direct solidification/stabilization (Alternative 10) and dispose treated soil in landfill; perform materials handling and sizing; dispose oversize materials and particulates in landfill; excavate remaining human health exceedance volume soil; place remaining soil in landfill; backfill excavations with borrow soil; contain residual contamination using cap/cover; perform operation, maintenance, and monitoring of landfill and cap/cover.
3e:	Access Restrictions (Modifications to FFA); Landfill (On-Post Landfill)	Site access restrictions and modifications to FFA including sewer plugging in central portion of South Plants and Complex Trenches; construct on-post landfill; excavate remaining sewers and human health exceedance volume soil; place remaining soil in landfill; backfill excavations with borrow soil; perform operation, maintenance, and monitoring of landfill; monitor natural attenuation/degradation and potential migration; conduct annual groundwater monitoring.
3f:	Landfill (On-Post Landfill); Caps/Covers (Multilayer Cap) with Consolidation	Construct on-post landfill; excavate human health exceedance volume soil; place soil in landfill; backfill excavations with borrow soil; consolidate soil posing risk to biota into Basin A prior to capping; backfill excavations with borrow soil; perform operation, maintenance, and monitoring of landfill.
3g:	Landfill (On-Post Landfill); Caps/Covers (Multilayer Cap) with Consolidation; Cap/Covers (Soil Cover)	Construct on-post landfill; excavate human health exceedance volume soil; place soil in landfill; backfill excavations with borrow soil; consolidate soil posing risk to biota into Basin A and South Plants Control Processing Area prior to capping; perform operation, maintenance and monitoring of landfill; install 1-3 ft thick soil cover; perform maintenance and monitoring of cover.
5:	Caps/Covers (Multilayer Cap); Vertical Barriers (Slurry Walls)	Contain human health exceedance area; cap/cover includes compacted low-permeability soil, biota barrier, and cover soil/vegetation layers that control potential exposure and prevent damage to containment system; construct slurry wall; monitor effectiveness of system; conduct annual groundwater monitoring.
5a:	Caps/Covers (Multilayer Cap); Vertical Barriers (Slurry Walls) with Modifications to Existing System	Install additional compacted low-permeability soil, biota barrier, and soil cover/vegetation layers to augment existing cap; construct slurry wall to augment existing system and improve long-term performance; monitor effectiveness of system; conduct annual groundwater monitoring.
6:	Caps/Covers (Multilayer Cap)	Contain human health exceedance area; cap/cover includes compacted low-permeability soil, biota barrier, and cover soil/vegetation layers that control potential exposure and prevent damage to containment system; monitor effectiveness of system; conduct annual groundwater monitoring.

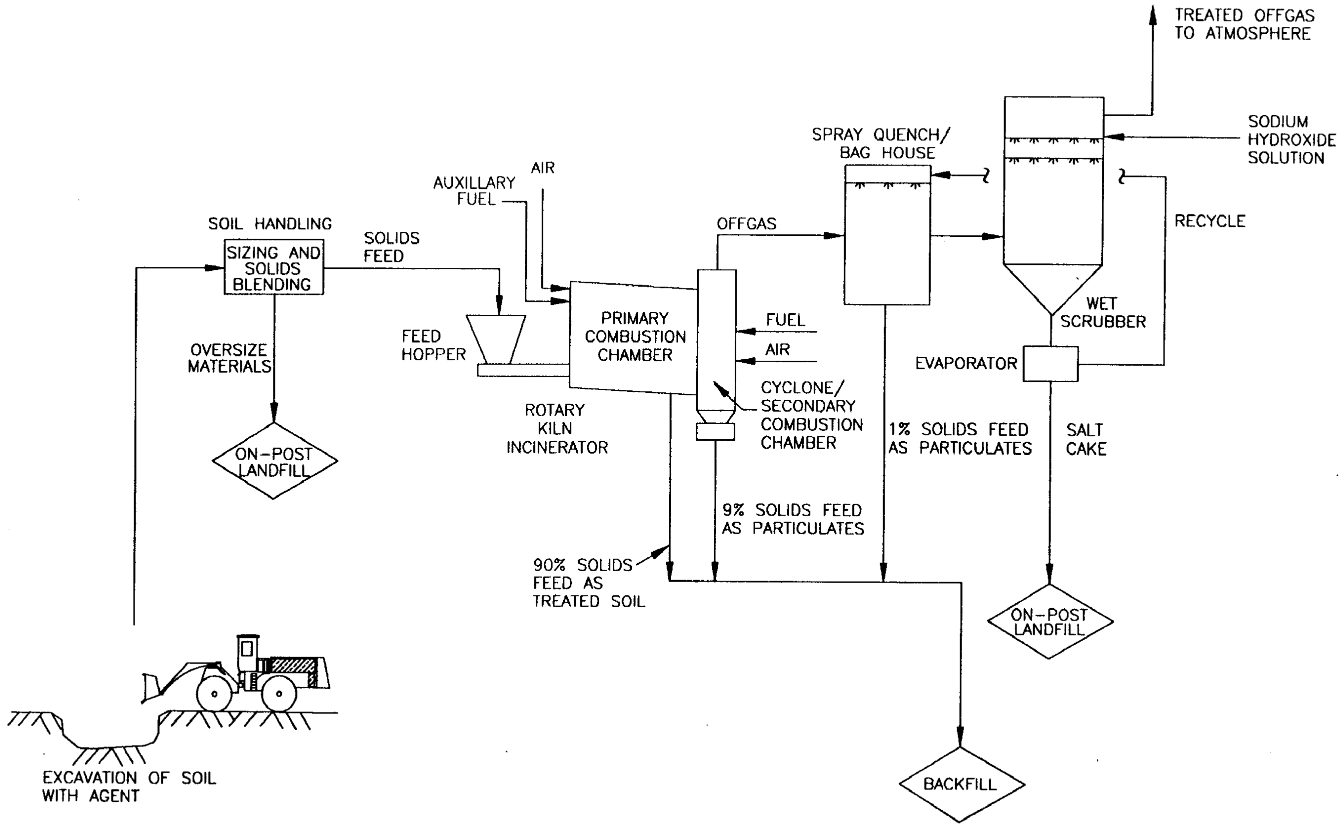
	Alternative Name	Alternative Description
6a:	Direct Thermal Desorption (Direct Heating) and Direct Solidification/Stabilization (Cement-Based Solidification) of Principal Threat Volume; Caps/Covers (Multilayer Cap)	Excavate principal threat volume and treat organic exceedances by direct thermal desorption (Alternative 13a) and inorganic exceedances by direct solidification/stabilization (Alternative 10); perform materials handling and sizing; dispose oversize material and particulates in on-post landfill; backfill treated soil; contain human health exceedance area using cap/cover; perform operation, maintenance, and monitoring of landfill and cap/cover; conduct annual groundwater monitoring.
6b:	In Situ Solidification/Stabilization (Silica/Proprietary Agent Solidification) Principal Threat Volume; Caps/Covers (Multilayer Cap)	Treat principal threat volume by in situ solidification/stabilization; contain human health exceedance area by installing a cap/cover; perform maintenance and monitoring of cap/cover; conduct annual groundwater monitoring.
6c:	Direct Thermal Desorption (Direct Heating) of Principal Threat Volume; Caps/Covers (Multilayer Cap)	Excavate and treat principal threat volume by direct thermal desorption (Alternative 13a and backfill); perform materials handling and sizing; dispose oversize material and particulates in on-post landfill; contain human health exceedance area using multilayer cap; perform operation, maintenance, and monitoring of landfill and cap/cover; conduct annual groundwater monitoring.
6d:	Caps/Covers (Composite Cap)	Contain Basin F Wastepile; cap/cover includes compacted clay layer, flexible membrane liner, biota barrier, and cover soil/vegetative layers that improve long-term performance of wastepile; monitor effectiveness of system; conduct annual groundwater monitoring.
8a:	Direct Soil Washing (Solvent Washing)	Excavate human health exceedance volume; perform materials handling and sizing; treat organics using direct solvent washing; treat concentrated organic contaminants (effluent) off post; backfill treated soil (or landfill treated soil for Basin F Wastepile).
8b:	Direct Soil Washing (Solvent Washing); Direct Solidification/Stabilization (Cement-Based Solidification); Caps/Covers (Multilayer Cap)	Excavate human health exceedance volume; perform materials handling and sizing; treat organics using direct solvent washing; treat concentrated organic contaminants (effluent) off post; direct cement-based solidification of inorganic volume; backfill treated and solidified soil in excavations; cover solidified materials with 4 ft of treated soil; contain residual contamination using cap/cover; monitor solidified soil; maintain cap/cover.
10:	Direct Solidification/ Stabilization (Cement-Based Solidification)	Excavate human health exceedance volume; perform materials handling and sizing; direct cement-based solidification of soil; landfill solidified soil or backfill solidified soil in excavations and install a 4-ft-thick cover; dispose oversize material and particulates in landfill; monitor solidified soil.

Alternative Name		Alternative Description
13:	Direct Thermal Desorption (Direct Heating); Direct Solidification/Stabilization (Cement-Based Solidification)	Excavate human health exceedance volume; perform materials handling and sizing; direct thermal desorption of organic volume; capture particulates and treat volatile inorganic contaminants in off gas; dispose particulates from off gas in on-post landfill; direct cement-based solidification of inorganic volume; backfill treated soil in excavation with solidified soil beneath 4-ft-thick cover of treated soil; monitor solidified soil; perform operation, maintenance, and monitoring of landfill.
13a:	Direct Thermal Desorption (Direct Heating)	Excavate human health exceedance volume; perform materials handling and sizing; direct thermal desorption of organic volume and backfill; capture particulates and treat volatile inorganic contaminants in off gas; dispose particulates from off gas in on-post landfill; perform operation, maintenance, and monitoring of landfill.
13b:	Direct Thermal Desorption (Direct Heating); Landfill (On-Post Landfill)	Excavate human health exceedance volume; perform materials handling and sizing; direct thermal desorption of organic volume; capture particulates and treat volatile inorganic contaminants in off gas; dispose particulates from off gas, treated soil and inorganic volume in on-post landfill; backfill excavation with borrow soil; perform operation, maintenance, and monitoring of landfill.
13c:	Direct Thermal Desorption (Direct Heating); Caps/Covers (Multilayer Cap)	Excavate human health exceedance volume; perform materials handling and sizing; direct thermal desorption of organic volume and backfill; capture particulates and treat volatile inorganic contaminants in off gas; dispose particulates from off gas in on-post landfill; contain treated soil and residual contamination using cap/cover; perform operation, maintenance, and monitoring of landfill and cap/cover.
13d:	Direct Thermal Desorption (Direct Heating); Direct Solidification/Stabilization (Cement-Based Solidification); Caps/Covers (Multilayer Cap)	Excavate human health exceedance volume; perform materials handling and sizing; direct thermal desorption of organic volume; capture particulates and treat volatile inorganic contaminants in off gas; dispose particulates from off gas in on-post landfill; direct cement-based solidification of inorganic volume; backfill treated soil in excavation; contain treated soil and residual contamination using cap/cover; perform operation, maintenance, and monitoring of landfill and cap/cover.
14:	Incineration/Pyrolysis (Rotary Kiln); Landfill (On-Post Landfill)	Excavate human health exceedance volume; perform materials handling and sizing; rotary kiln incinerate organic volume; treat particulates and treat volatile inorganic contaminants in off gas; dispose treated material in on-post landfill; backfill excavation with borrow soil; perform operation, maintenance, and monitoring of landfill.
17:	In Situ Physical/Chemical Treatment (Soil Flushing); In Situ Thermal Treatment (Surface Soil Heating)	Clear and prepare site; in situ surface soil heating of organics in human health exceedance volume in surficial soil; treat off gases from in situ heating; in situ soil flushing of inorganics and organics in subsurface and surficial soil exceedance volume; monitor contaminant reduction and potential migration; conduct annual groundwater monitoring.

Alternative Name		Alternative Description
19:	In Situ Thermal Treatment (Radio Frequency/Microwave Heating); In Situ Solidification/Stabilization (Cement-Based Solidification)	Clear and prepare site; in situ radio frequency/microwave heating of organics in human health exceedance volume; treat off gases from in situ heating; in situ cement-based solidification of inorganics in exceedance volume; monitor solidified soil; conduct annual groundwater monitoring.
19a:	In Situ Thermal Treatment (Radio Frequency/Microwave Heating)	Clear and prepare site; in situ radio frequency/microwave heating of organics in human health exceedance volume; treat off gases from in situ heating.
19b:	In Situ Thermal Treatment (Radio Frequency/Microwave Heating); In Situ Solidification/Stabilization (Cement-Based Solidification); Caps/Covers (Multilayer Cap)	Clear and prepare site; in situ radio frequency/microwave heating of organics in human health exceedance volume; treat off gases from in situ heating; in situ cement-based solidification of inorganics in exceedance volume; contain treated soil and residual contamination using cap/cover; monitor solidified soil; maintain cap/cover; conduct annual groundwater monitoring.
19c:	In Situ Thermal Treatment (Radio Frequency/Microwave Heating); Caps/Covers (Multilayer Cap)	Clear and prepare site; in situ radio frequency/microwave heating of organics in human health exceedance volume; treat off gases from in situ heating; contain treated soil and residual contamination using cap/cover; maintain cap/cover.
21:	In Situ Thermal Treatment (In Situ Vitrification)	Clear and prepare site; in situ vitrification of human health exceedance volume for organics and inorganics; treat off gases from in situ vitrification; backfill over vitrified materials to bring to grade; monitor vitrified soil; conduct annual groundwater monitoring.
22:	In Situ Solidification/ Stabilization (Cement-Based Solidification or Silica/Proprietary Agent-Based Solidification)	In situ cement-based solidification of inorganics in exceedance volume; in situ silica/proprietary agent-based solidification of organic exceedances; monitor solidified soil; conduct annual groundwater monitoring.

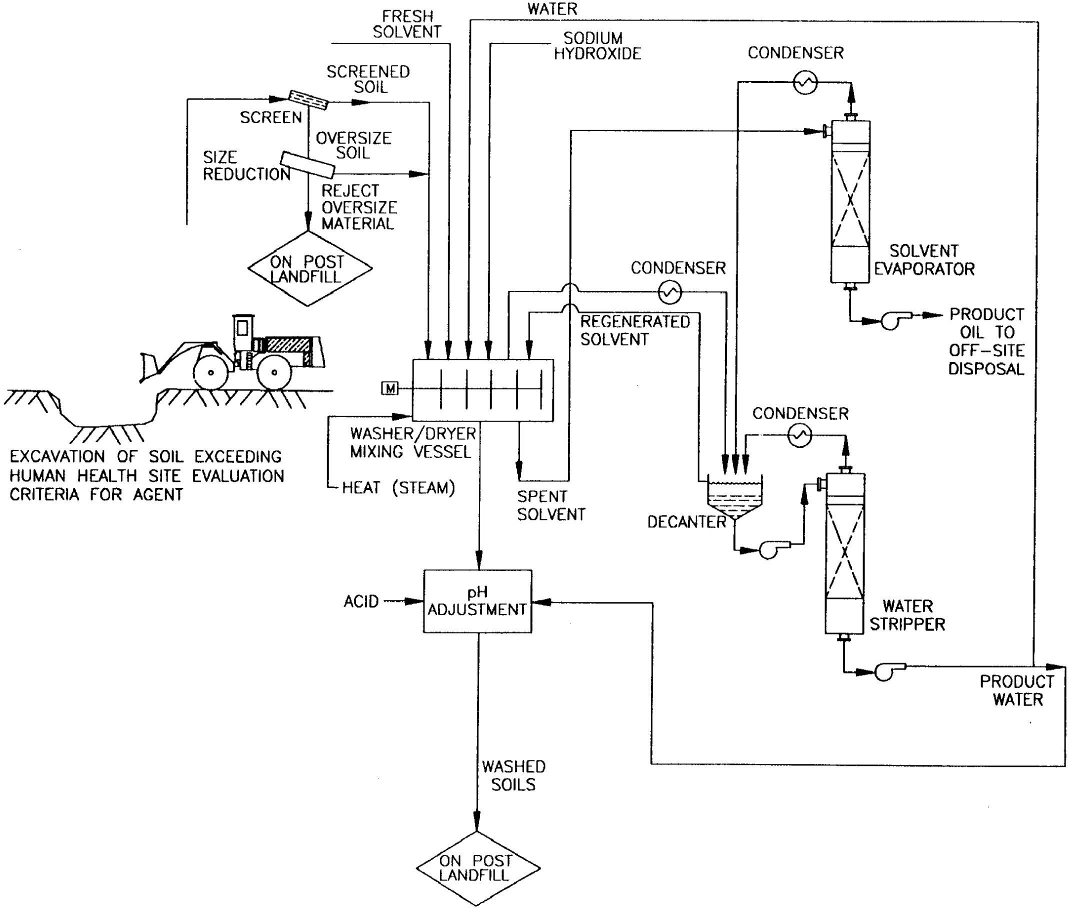


Prepared for: U.S. Army Program Manager for Rocky Mountain Arsenal	FIGURE 4.4-1 Alternative A3 Direct Soil Washing (Caustic Solution Washing); Landfill	Prepared by: Foster Wheeler Environmental Corporation

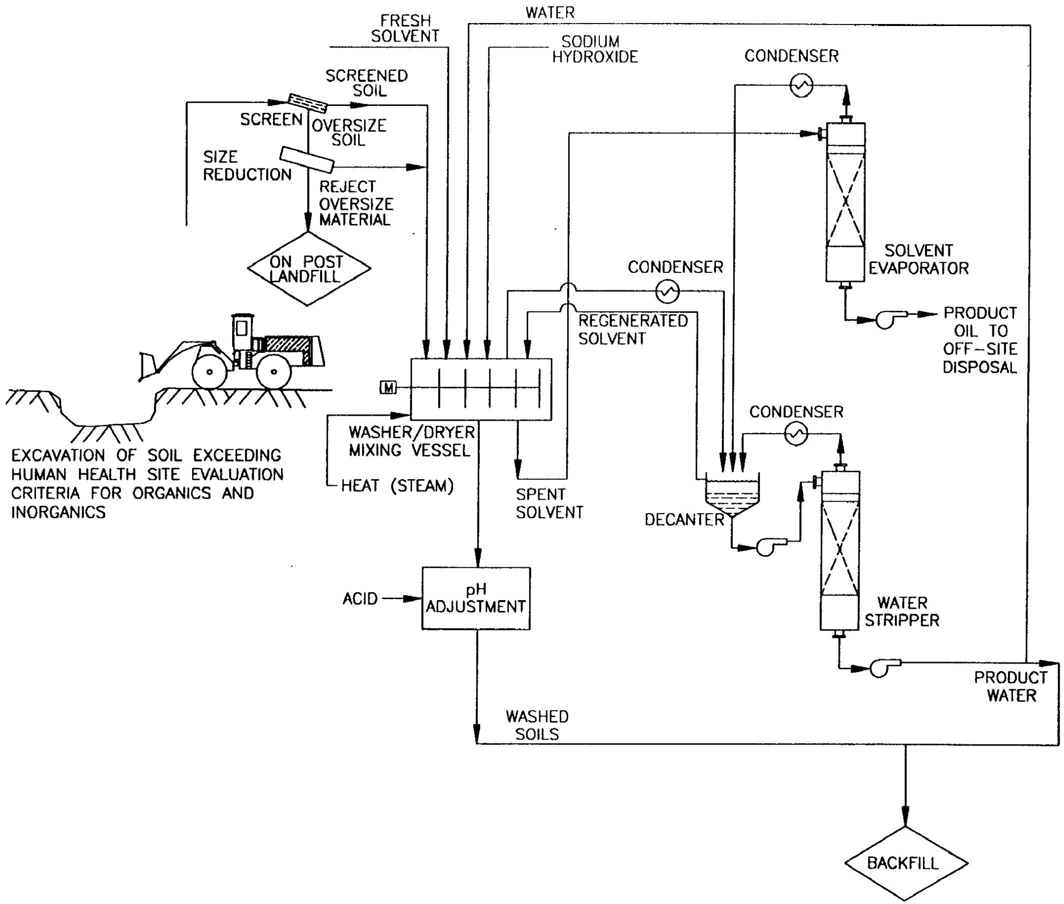


SOURCE: Figure 7.2-1, Technology Descriptions Volume

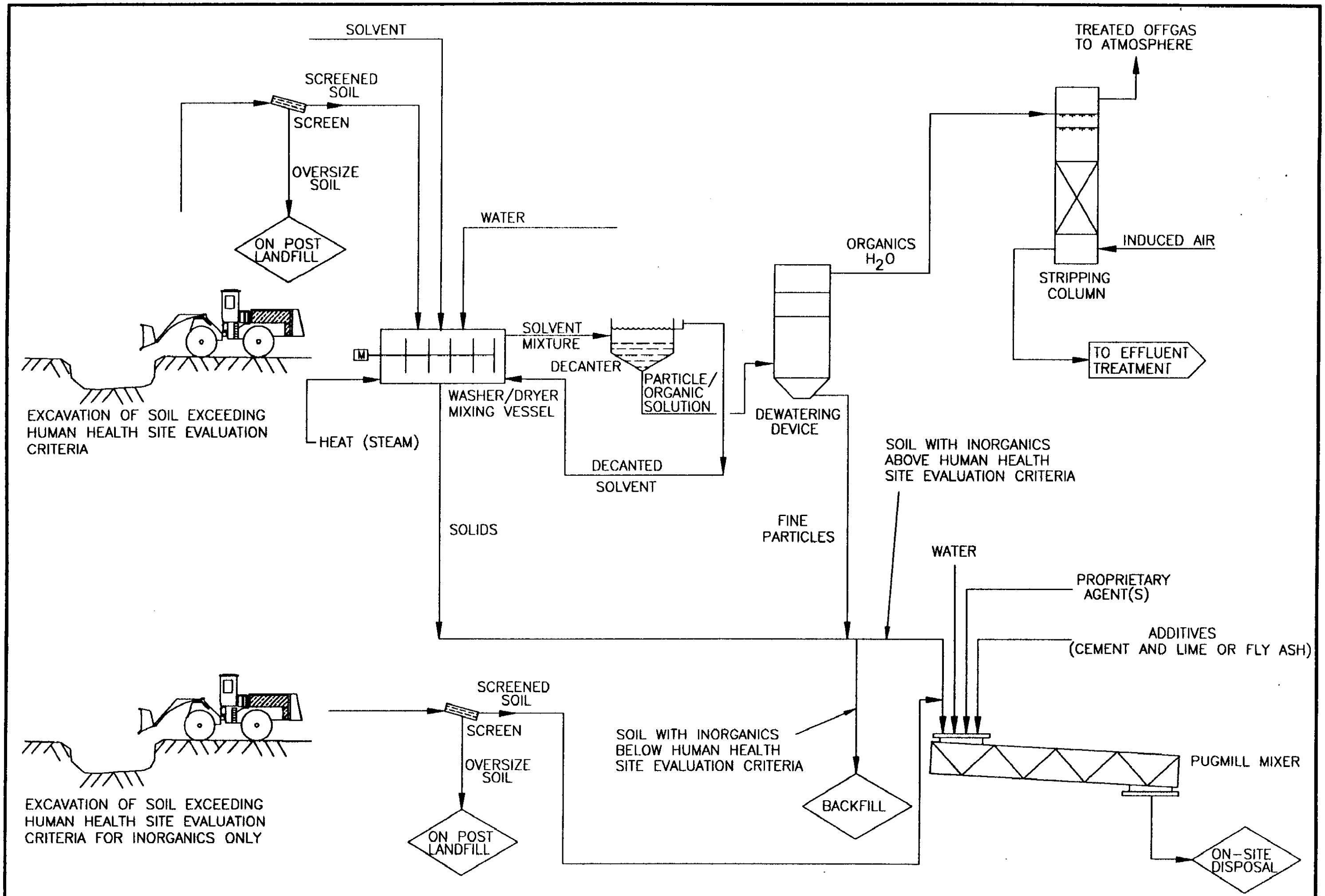
Prepared for: U.S. Army Program Manager for Rocky Mountain Arsenal	FIGURE 4.4-2 Alternative A4 Incineration/Pyrolysis	Prepared by: Foster Wheeler Environmental Corporation



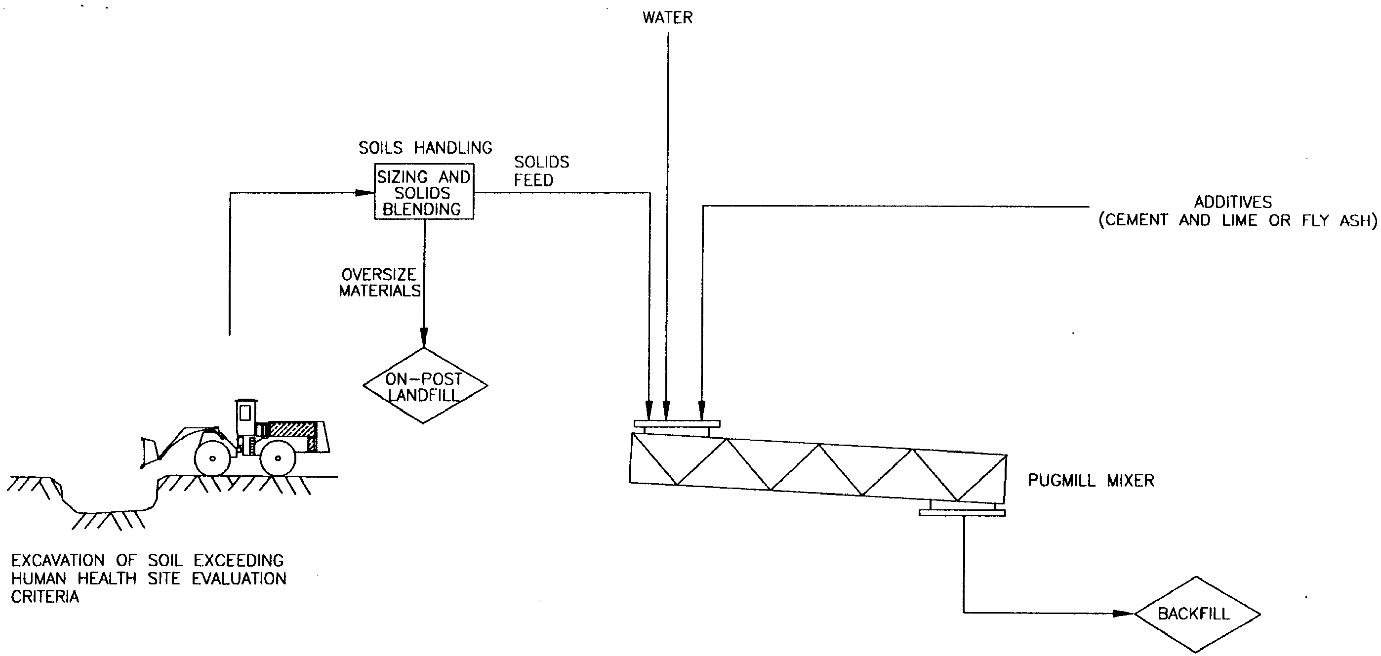
Prepared for: Office for the Program Manager for Rocky Mountain Arsenal	FIGURE 4.4-3 Alternative A5 Soil Washing (Solvent Caustic Washing); Landfill	Prepared by: Foster Wheeler Environmental Corporation



Prepared for: Office for the Program Manager for Rocky Mountain Arsenal	FIGURE 4.6-1 Alternative 8a Soil Washing (Solvent Washing)	Prepared by: Foster Wheeler Environmental Corporation

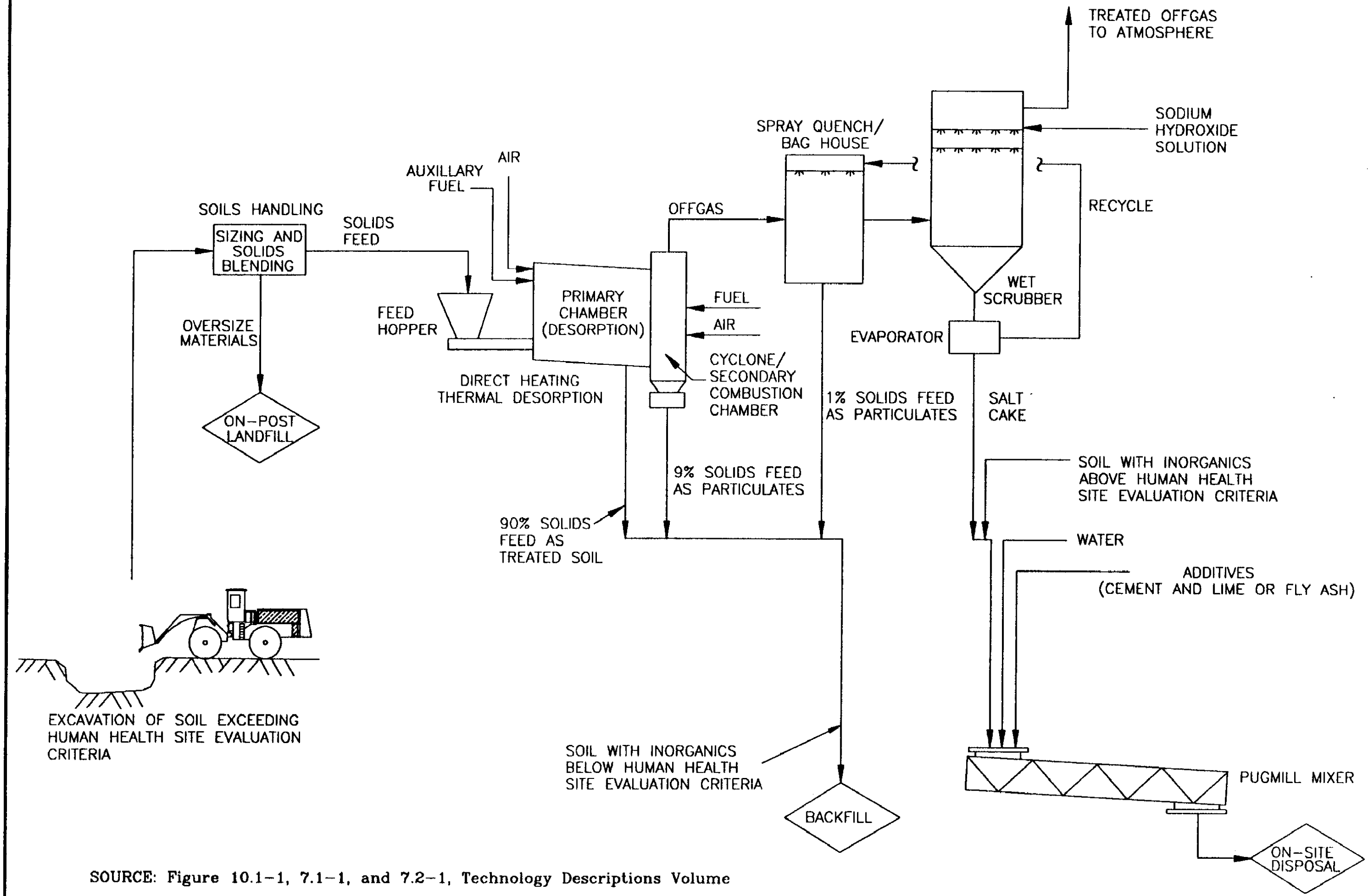


Prepared for:	FIGURE 4.6-2	Prepared by:
Office for the Program Manager for Rocky Mountain Arsenal	Alternative 8b Soil Washing: (Solvent Washing) Direct Solidification/Stabilization	Foster Wheeler Environmental Corporation



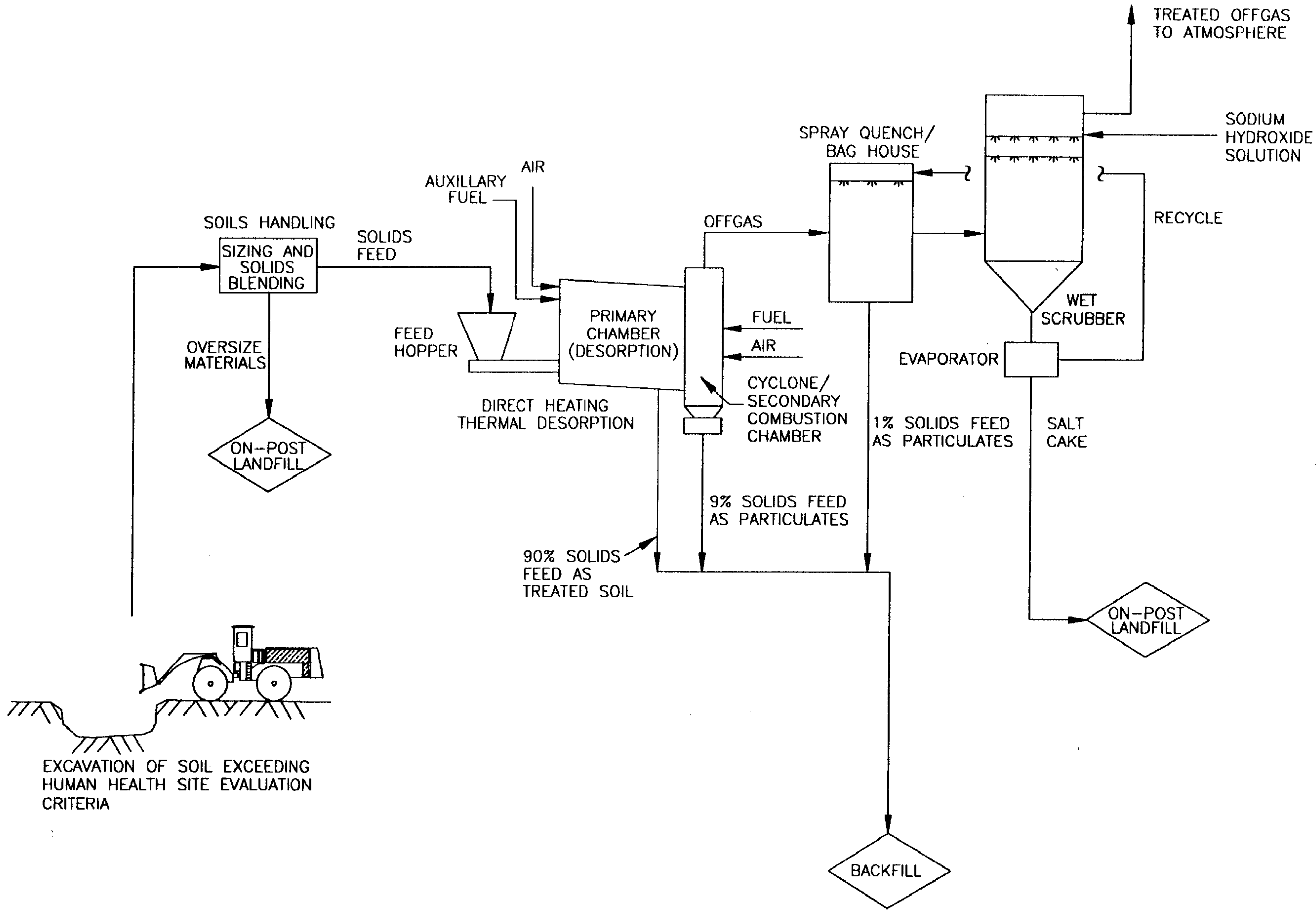
SOURCE: Figure 10.1-1, Technology Descriptions Volume

Prepared for: U.S. Army Program Manager for Rocky Mountain Arsenal	FIGURE 4.6-3 Alternative 10 Direct Solidification/Stabilization	Prepared by: Foster Wheeler Environmental Corporation



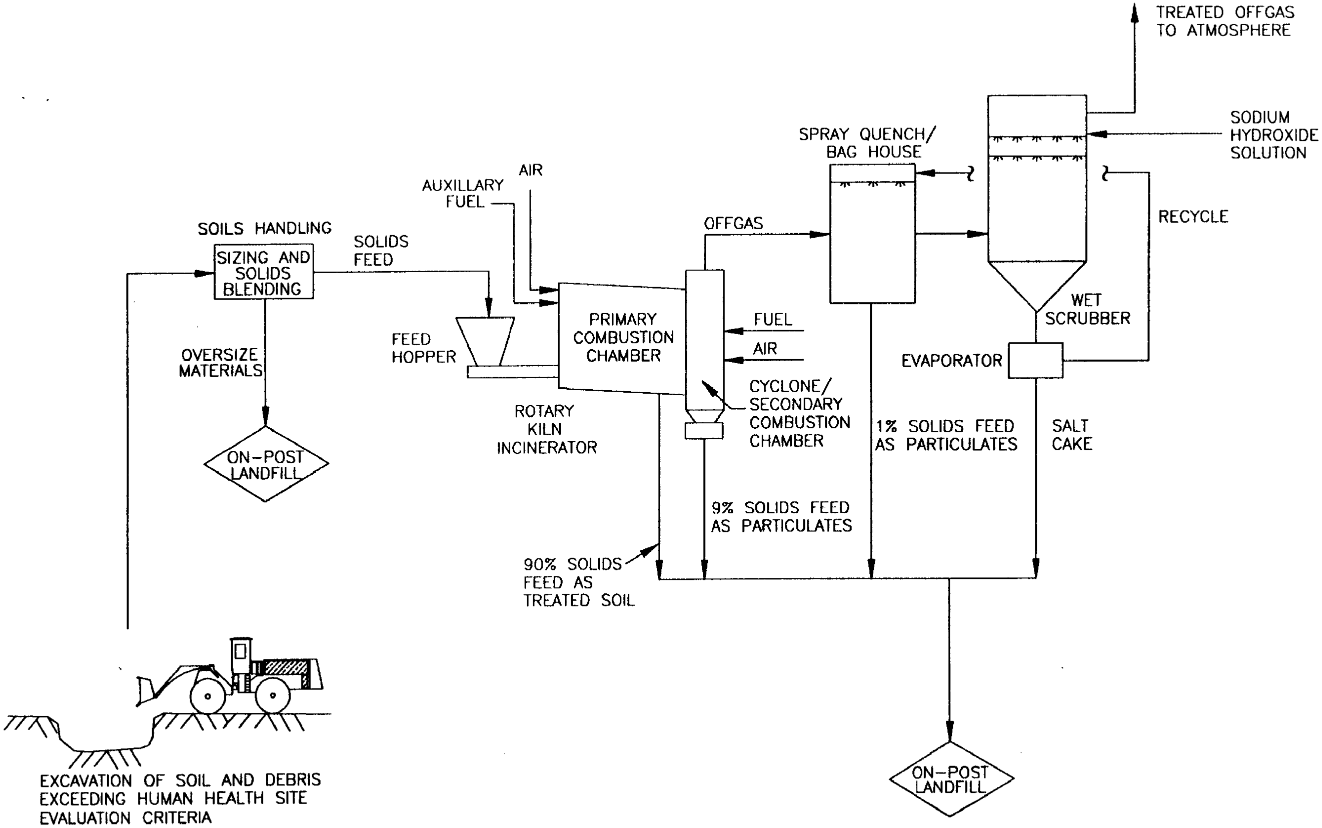
SOURCE: Figure 10.1-1, 7.1-1, and 7.2-1, Technology Descriptions Volume

Prepared for: U.S Army Program Manager for Rocky Mountain Arsenal	FIGURE 4.6-4 Alternative 13 Direct Thermal Desorption; Direct Solidification/Stabilization	Prepared by: Foster Wheeler Environmental Corporation



SOURCE: Figure 7.1-1 and 7.2-1, Technology Descriptions Volume

Prepared for: U.S. Army Program Manager for Rocky Mountain Arsenal	FIGURE 4.6-5 Alternative 13a Direct Thermal Desorption	Prepared by: Foster Wheeler Environmental Corporation



SOURCE: Figure 7.2-1, Technology Descriptions Volume

Prepared for: U.S. Army Program Manager for Rocky Mountain Arsenal	FIGURE 4.6-6 Alternative 14 Incineration/Pyrolysis; Landfill	Prepared by: Foster Wheeler Environmental Corporation

Section 5

5.0 DETAILED ANALYSIS OF ALTERNATIVES FOR THE MUNITIONS TESTING MEDIUM GROUP

The Munitions Testing Medium Group consists of eight sites that were grouped based on similar site histories and the potential presence of UXO. These sites, predominantly located in the eastern portions of RMA, were used for the testing and destruction of nonchemical munitions. The sites typically contain slag, debris, and potential UXO in the upper 1 ft of soil, and therefore represent potential physical hazards. One of the sites (ESA-4a) was an impact area for mortars and may contain HE-filled UXO at depths to 6 ft. There are no human health exceedances present within this medium group. Areas posing potential risk to biota in this medium group are either removed as part of the UXO/debris remediation or are addressed through continued monitoring as described in Section 1.4.2.2. Figure 5.0-1 shows the locations of the sites comprising this medium group.

During the DSA (EBASCO 1992b), alternatives were developed and screened based only on the general characteristics of the medium group. During the DAA, the characteristics of the medium group—including site configuration and potential presence of UXO—were evaluated to determine whether any modifications to the range of retained alternatives from the DSA would be appropriate, but none were required. Accordingly, individual subgroups were not developed for these sites, and the retained DSA alternatives apply to the Munitions Testing Medium Group as a whole.

The following sections present the characteristics of this medium group (Table 5.0-1), an evaluation of the retained alternatives against the DAA criteria listed in the NCP (EPA 1990a), and the selection of alternatives, based on comparative analysis, that was considered in the development of the sitewide alternatives (Section 20).

In addition to the Munitions Testing Medium Group, UXO may be found at other sites at RMA including those in the Basin A, Disposal Trenches, South Plants, and Undifferentiated Medium Groups. In these medium groups, however, areas with potential agent presence generally overlap areas with human health exceedance volumes. In these instances, UXO are addressed as part of the human health or biota alternatives.

5.1 MEDIUM GROUP CHARACTERISTICS

The Munitions Testing Medium Group consists of sites CSA-2c (Munitions Testing Area), CSA-2d (Incinerator NN 3601), ESA-1a (Section 19 Surface Burn), ESA-1b (Section 20 Surface Burn), ESA-1c (Section 29 Surface Burn), ESA-1d (Section 30 Surface Burn), ESA-4a (Impact Area), and ESA-4b (Demolition Area). These sites, primarily located in the Eastern Study Area, were used to test or destroy munitions. Table 5.1-1 presents a summary of detections for samples taken at sites in this medium group. None of the samples exceed the Human Health SEC (EBASCO 1994a). Agent-filled munitions are not expected to be found at these sites based on the site histories (EBASCO 1992a).

UXO may potentially be found at all the sites in this medium group. The potential UXO exceedance area for this medium group is 270,000 square yards (SY) (Table 5.0-1). The UXO are expected to occur in the 0- to 1-ft depth interval except at site ESA-4a, where they may occur at depths up to 6 ft. Assuming that 0.1 percent of this total soil volume actually contains UXO, the volume of soil with UXO is estimated at 450 BCY for this medium group. The volume of metallic debris and associated soil anticipated for this medium group is up to 89,000 BCY based on the depth of debris identified at these sites during the RI program (0- to 1-ft depth interval). This near-surface debris is addressed under the alternatives for this medium group. Volume and area calculations for this medium group are summarized in Appendix A.

The UXO exceedance volume does not affect the quality of the groundwater or surface water, nor does it affect any structures. The sites within the Munitions Testing Medium Group contain weedy forbs or areas of disturbed vegetation. Under most of the alternatives developed for this medium group, the surface debris is removed and the areas disturbed during remedial actions are revegetated in accordance with a refuge management plan. In most instances, the overall habitat is improved, which should offset the short-term loss of habitat resulting from remedial actions.

5.2 EVALUATION OF ALTERNATIVES

The four alternatives developed for the Munitions Testing Medium Group vary in approach from no action to treatment. The following subsections present a description of each alternative and an evaluation of the alternative against the DAA criteria listed in the NCP (EPA 1990a).

5.2.1 Alternative U1: No Additional Action

Alternative U1: No Additional Action (Provisions of FFA) applies to 270,000 SY of potential UXO presence area in the Munitions Testing Medium Group. No action is taken under this alternative to reduce potential human exposure to UXO or to any soil that might pose a risk to biota. Five-year site reviews are required to assess the status of UXO left in place.

The following discussion presents a detailed evaluation of this alternative against the DAA criteria listed in the NCP (EPA 1990a). For purposes of comparison, Table 5.2-1 summarizes the evaluation of all alternatives developed for this medium group.

5.2.1.1 Overall Protection of Human Health and the Environment

This alternative does not achieve Human Health or Biota RAOs since soil with potential UXO and potential risk to biota remains in place and no controls are implemented. There are no unacceptable impacts on groundwater, surface water, or air quality.

5.2.1.2 Compliance with ARARs

This alternative complies with action- and location-specific ARARs since site reviews are conducted and sites in the Munitions Testing Medium Group are not located in wetlands or a 100-year flood plain. The alternative also complies with provisions of the FFA (EPA et al. 1989). However, if areas with potential UXO presence are released from Army control before clearance activities can be conducted, institutional controls, at a minimum fences and signs, are required to control site access (AMC-R 385-131) (AMC 1987). (ARARs are listed in Appendix A of the Technology Descriptions Volume).

5.2.1.3 Long-Term Effectiveness and Permanence

The residual risk for human exposure is high due to the anticipated volume of soil that potentially contains UXO; the debris remaining on site potentially poses a risk to biota. The existing habitat is neither impacted nor improved by this alternative.

5.2.1.4 Reduction in TMV

There is no reduction in TMV since no soil is treated or contained. A total of 270,000 SY of soil with potential UXO remains.

5.2.1.5 Short-Term Effectiveness

Risks to workers and the community in the short term are not significant since soil is not disturbed. In addition, there are no environmental impacts since the existing habitat is not affected and there are no unacceptable impacts on surface water, groundwater, or air quality. RAOs for this alternative are not achieved since soil with potential UXO remains on site.

5.2.1.6 Implementability

This alternative is technically and administratively feasible to implement. Site reviews are conducted every 5 years, but monitoring is not required.

5.2.1.7 Present Worth Cost

The total estimated present worth cost is $80,000 and includes only long-term O&M costs associated with site reviews. Table B1.1-U1 details the costing for this alternative.

5.2.2 Alternative U2: Caps/Covers

Alternative U2: Caps/Covers (Multilayer Cap) addresses 270,000 SY of area with potential for presence of UXO through containment. A surface sweep is conducted using geophysics or other methods to ensure that the surface sweeps conducted in the RI did not leave UXO undetected in the near-surface soil. If any UXO are identified, they would be addressed as described in Alternative U4a: Detonation (Off-Post Army Facility) (based on the small quantity expected).

Prior to installing the soil cover, the area is crowned with 490,000 BCY of fill to facilitate surface-water runoff. The area is then covered with a 4-ft-thick layer of common fill, which includes 6 inches of reconditioned soil, and revegetated in accordance with a refuge management plan. The soil cover provides a physical barrier to protect human and biota receptors from directly contacting potential UXO and the munitions debris. The fill materials are excavated from an on-post borrow area, and installation of the cover takes less than 1 year to complete. Maintenance activities ensure the continued integrity of the soil cover.

The following discussion presents a detailed evaluation of this alternative against the DAA criteria listed in the NCP (EPA 1990a). For purposes of comparison, Table 5.2-1 summarizes the evaluation of all alternatives for this medium group.

5.2.2.1 Overall Protection of Human Health and the Environment

This alternative achieves Human Health and Biota RAOs through containment with a soil cover. Human exposure pathways to soil that potentially contain UXO are interrupted by the soil cover layers. There are no unacceptable impacts on groundwater, surface water, or air quality.

5.2.2.2 Compliance with ARARs

This alternative complies with action-specific ARARs regarding construction of a soil cover and monitoring of the contained material. Sites in the Munitions Testing Medium Group are not located in wetlands or a 100-year flood plain, thus complying with location-specific ARARs. This alternative also complies with provisions of the FFA (EPA et al. 1989). Soil potentially containing UXO is contained and so is not subjected to Army regulations governing the demilitarization of UXO. However, certified UXO removal might be required in order to release these sites to another federal agency. (ARARs are listed in Appendix A of the Technology Descriptions Volume.)

5.2.2.3 Long-Term Effectiveness and Permanence

The residual risk associated with this alternative is low since the 270,000 SY of soil that potentially contain UXO are contained by a soil cover. There is high confidence in that the engineering controls will prevent exposure and that monitoring and maintenance will ensure the integrity of the cover. Site reviews are also required to ensure the integrity of the cover. The overall habitat quality for the site is improved through revegetation.

5.2.2.4 Reduction in TMV

The exposure pathways are interrupted by the soil cover. No materials are treated.

5.2.2.5 Short-Term Effectiveness

This alternative entails low short-term risks as no intrusive activities are conducted. Personal protective equipment (PPE) and safe work practices protect workers from physical and chemical risks during UXO screening and cover installation. Dust controls (i.e., water sprays) are adequate for addressing uncontaminated fugitive dust released during the construction of the cap. Odor/vapor emissions are not anticipated. Construction activities only minimally impact the environment, but borrow areas must be disturbed for the gradefill and capping materials, which results in an overall moderate impact to the environment. Installation of the 270,000-SY soil cover is feasible within 1 year.

5.2.2.6 Implementability

The alternative is technically feasible because the cover can be constructed within the required time frame and reliably operated and maintained thereafter. Additional remedial actions can be easily undertaken for soil left in place, although the cover adds to the overall site volume. The alternative is administratively feasible since the substantive requirements of soil cover design and operating regulations are easily achieved. Equipment, specialists, and materials are readily available for installation of the soil cover.

5.2.2.7 Present Worth Cost

The total estimated present worth cost is $9,640,000, including $9,330,000 and $315,000 for operating and long-term costs, respectively. Table B1.1-U2 details the costing for this alternative. There is a low level of uncertainty associated with the cost of this alternative because the materials required to construct the cap are available on post and the area to be capped is known (i.e., the uncertainty commonly associated with excavation does not exist).

5.2.3 Alternative U3a: Detonation

Alternative U3a: Detonation (On-Post Detonation) addresses the 450 BCY of soil estimated to contain HE-filled UXO through demilitarization. UXO are specially packaged and transported to on-post facilities for detonation. The initial steps in the process are to identify UXO in the munitions area using geophysics or other methods (to identify magnetic sources) and excavate the soil containing UXO using specialized techniques. The HE-filled UXO are taken to the closest on-post site for detonation and the debris remaining after detonation are collected by conventional earth-moving equipment and landfilled on post. Any UXO not considered safe for removal and transportation to the detonation area are packed in explosives and detonated in place. The debris is collected and landfilled on post.

Once the UXO have been removed from the site, the uppermost 1 ft of soil sitewide (270,000 SY) is removed to collect any remaining debris. Toxic characteristic leaching procedure (TCLP) samples (approximately 2 per acre) will be collected to identify soils that should be landfilled with the munitions debris. This soil/debris volume (up to 89,000 BCY) is transported to the on-post hazardous waste landfill. A layer of reconditioned soil is placed over the excavated areas and revegetated with native grasses. The on-post landfill takes 1 year to construct and is fenced to restrict wildlife access. Long-term activities after landfill closure include maintenance, leachate collection and treatment, and groundwater monitoring.

The following discussion presents a detailed evaluation of this alternative against the DAA criteria listed in the NCP (EPA 1990a). For purposes of comparison, Table 5.2-1 summarizes the evaluation of all alternatives developed for this medium group.

5.2.3.1 Overall Protection of Human Health and the Environment

This alternative achieves Human Health and Biota RAOs through treatment of UXO on post and containment of debris and associated contaminated soil in an on-post hazardous waste landfill. There are no unacceptable impacts on groundwater, surface water, or air quality, but the removal of UXO and the on-post detonation present a high short-term risk.

5.2.3.2 Compliance with ARARs

This alternative complies with action-specific ARARs including state regulations on landfill siting, design, and operation. Endangered species are impacted. Neither the landfill nor the sites in the Munitions Testing Medium Group and the landfill are located in wetlands or a 100-year flood plain, thus complying with location-specific ARARs. Disposal in the landfill does not trigger LDRs since the landfill is a CAMU (as defined in Section 1.4). This alternative also complies with the provisions of the FFA (EPA et al. 1989) and Army Materiel Command regulations (AMC-R 385-131) (AMC 1987) regarding UXO demilitarization. (ARARs are listed in Appendix A of the Technology Descriptions Volume.)

5.2.3.3 Long-Term Effectiveness and Permanence

A residual risk does not exist at the Munitions Testing Medium Group sites since any identified UXO are demilitarized and up to 89,000 BCY of soil/debris are removed and landfilled. There is high confidence in the landfill engineering controls. Monitoring of the landfill is required, but there are no expected difficulties associated with monitoring or maintaining the landfill. The existing habitat at the site is improved by revegetation; however, the habitat at the landfill is eliminated.

5.2.3.4 Reduction in TMV

The exposure pathways are interrupted through the containment of up to 89,000 BCY of soil/debris in an on-post landfill, but the materials are not treated. Any identified HE-filled UXO are detonated on post. TMV reduction by detonation is irreversible for HE-filled UXO. Metallic debris from the on-post detonation of UXO are landfilled.

5.2.3.5 Short-Term Effectiveness

This alternative entails high short-term risks associated with UXO clearance, excavation, transportation, and on-post demilitarization of UXO. These risks are reduced through engineering controls and PPE, but cannot be completely removed. Even with engineering controls such as water sprays (to control dust) or high berms (to protect against explosive hazards), the short-term risks associated with on-post detonation of UXO cannot be completely eliminated. There are minimal impacts to the environment. The time frame until RAOs are achieved is 2 years: 1 year for detonation of the estimated 450 BCY of soil with UXO and containment of up to 89,000 BCY of soil/debris after 1 year for construction of the landfill.

5.2.3.6 Implementability

This alternative exhibits a low level of administrative feasibility based on the concerns of adequately controlling the detonation of UXO as part of on-post demilitarization (despite strict compliance with Army regulations governing UXO demilitarization). The alternative is technically feasible and can be implemented within the required time frame and reliably operated and maintained thereafter with periodic landfill-cell monitoring. Additional remedial actions for the landfilled materials would require removal of the landfill cover. The landfill portion of the alternative is administratively feasible since the substantive requirements of landfill siting, design, and operating regulations are achieved. Equipment, specialists, and materials are readily available for construction of the landfill, and the landfill technology has been well demonstrated at full scale.

5.2.3.7 Present Worth Cost

The total present worth cost is $5,480,000 including $2,340,000, $3,080,000, and $63,000 for capital, operating, and long-term costs, respectively. Table B.1.1-U3a details the costing for this alternative. A large degree of uncertainty regarding the clearance of UXO and landfilling of contaminated soil exists because there is an unknown quantity of UXO and soil that would fail the TCLP at each site.

5.2.4 Alternative U4a: Detonation

Alternative U4a: Detonation (Off-Post Army Facility) provides for the off-post treatment of the 450 BCY of soil estimated to contain UXO. UXO is removed and specially packaged on post and then transported to an off-post Army facility specifically designed for UXO demilitarization.

The initial step in the process is to identify UXO in the munitions area using geophysics or other methods and to carefully excavate the soil containing HE-filled UXO. HE-filled UXO rendered safe for transport are shipped by truck or rail to Fort Carson in Colorado Springs, Colorado for demilitarization. The Army's Explosive Ordnance Detail or a contractor to the U.S. Army Corps of Engineers, Huntsville Division is responsible for all handling, packaging, and transportation of UXO. Any HE-filled UXO not considered safe for transport is handled in accordance with the procedures outlined in Section 5.2.3.

Once the UXO has been removed from the site, the uppermost 1 ft of soil sitewide (270,000 SY) is removed to collect any remaining debris. TCLP samples (approximately 2 per acre) will be collected to identify soils that should be landfilled along with the munitions debris. This soil/debris (up to 89,000 BCY) is transported to the on-post hazardous waste landfill. A layer of reconditioned soil is placed on the excavated areas and revegetated with native grasses. The on-post landfill takes 1 year to construct and is fenced to restrict wildlife access. Long-term activities after landfill closure include maintenance, leachate collection and treatment, and groundwater monitoring.

The following discussion presents a detailed evaluation of this alternative against the DAA criteria listed in the NCP (EPA 1990a). For purposes of comparison, Table 5.2-1 summarizes the evaluation of all alternatives developed for this medium group.

5.2.4.1 Overall Protection of Human Health and the Environment

This alternative achieves Human Health and Biota RAOs through treatment of UXO off post and containment of soil/debris in an on-post landfill. There are no impacts on groundwater, surface water, or air quality, but removal and off-post transportation of UXO does pose a significant short-term risk.

5.2.4.2 Compliance with ARARs

This alternative complies with action-specific ARARs, including state regulations on the transportation of explosives, as well as landfill design and operation. Endangered species are not impacted. Location-specific ARARs are also met since neither the landfill nor sites in the Munitions Testing Medium Group are located in wetlands or a 100-year flood plain. Disposal in the landfill does not trigger LDRs since the landfill is a CAMU (as defined in Section 1.4). This alternative also complies with provisions of the FFA (EPA et al. 1989) and Army Materiel Command regulations (AMC-R 385-131) (AMC 1987) regarding UXO transport and demilitarization. (ARARs are listed in Appendix A of the Technology Descriptions Volume.)

5.2.4.3 Long-Term Effectiveness and Permanence

A residual risk at the site does not exist since any identified UXO (approximately 450 BCY of soil with HE-filled UXO) are excavated and detonated off post, and up to 89,000 BCY of soil/debris are removed and landfilled. There is high confidence in the engineering controls for the landfill, and there are no expected difficulties associated with landfill maintenance. Landfill-cell monitoring is required. The existing habitat quality at the site is improved by revegetation of the disturbed area; however, at the landfill it is eliminated.

5.2.4.4 Reduction in TMV

The exposure pathways are interrupted through the containment of up to 89,000 BCY of untreated soil/debris in an on-post landfill, but the materials are not treated. The estimated 450 BCY of soil with HE-filled UXO are detonated off post. TMV reduction by detonation is irreversible for HE-filled UXO. There are no treatment residuals associated with the off-post detonation of UXO.

5.2.4.5 Short-Term Effectiveness

This alternative entails high short-term risks to workers and community associated with UXO clearance, excavation, transportation, and off-post demilitarization of UXO. These risks are reduced through dust controls, such as water spraying, and personal protective equipment. However, the risks cannot be completely removed. For example, risks associated with off-post transportation of UXO cannot be completely eliminated, but are significantly reduced by following Army transportation regulations. There are minimal impacts to the environment. The time frame until RAOs are achieved is 2 years: 1 year for detonation of 450 BCY of soil with UXO and containment of up to 89,000 BCY of soil/debris after 1 year for construction of the landfill.

5.2.4.6 Implementability

The alternative is technically feasible and can be implemented within the required time frame and reliably operated and maintained thereafter. Additional remedial actions for the landfilled materials require removal of the landfill cover. The alternative is administratively feasible since the substantive requirements associated with the transportation of the explosives and the landfill siting, design, and operating regulations are achieved. Several Army facilities (including Fort Carson, Colorado) are available for demilitarization of HE-filled UXO. Equipment, specialists, and materials are readily available for the construction of the landfill and transportation of UXO, and landfills have been well demonstrated at full scale.

5.2.4.7 Present Worth Cost

The total present worth cost is $5,480,000 including $2,340,000, $3,080,000, and $63,000 for capital, operating, and long-term costs, respectively. Table B.1.1-U4a details the costing for this alternative. A large degree of uncertainty regarding the clearance of UXO and landfilling of contaminated soil exists because there is an unknown quantity of UXO and soil that would fail the TCLP at each site.

5.3 COMPARATIVE ANALYSIS OF ALTERNATIVES

There are 450 BCY of soil in the Munitions Testing Medium Group that are expected to contain UXO, primarily in the 0- to 1-ft depth interval. Up to 89,000 BCY of soil are anticipated to contain metallic debris from the testing and destruction of munitions. Agent-filled munitions are not expected to be found in this medium group based on site histories.

Sites within this medium group contain weedy forbs or areas of disturbed vegetation. Alternatives that disrupt habitat include revegetation and restoration following remediation; however, significant habitat impacts are not anticipated.

The evaluation of which alternatives should be used in developing sitewide remediation options must include consideration of the physical hazards and long-term risks involved in leaving UXO in place versus the short-term risks to site workers and the general public from excavation and detonation operations. Risks to site workers and the general public can be minimized with appropriate safety equipment and procedures, although it is difficult to control all short-term risks during on-post detonation of UXO. Table 5.2-1 summarizes this evaluation.

Alternative U1: No Additional Action does not address potential physical hazards associated with UXO and so does not achieve RAOs; it is therefore eliminated from further consideration. The three remaining alternatives achieve RAOs and meet the two EPA threshold criteria for the DAA: they are protective of human health and the environment and comply with action- and location-specific ARARs. These three alternatives, however, differ in how well they meet the five balancing criteria.

The containment alternative, Alternative U2: Caps/Covers (Multilayer Cover), does not remove and destroy UXO, but does interrupt exposure pathways. This alternative entails the creation of a borrow area for gradefill and construction activities. Although installing a cover does not entail the short-term risks associated with UXO removal, the higher costs and habitat impacts associated with this amount of earthwork does not offset the lower costs, but higher short-term risks, of removing HE-filled UXO (if any are identified during clearance operations). In addition, certified clearance may be required if these sites are transferred to another federal agency.

The other two alternatives both address the removal of UXO similarly, and both comply with the Army regulations for the management of UXO. Alternative U4a: Detonation (Off-Post Army Facility) differs from Alternative U3a: Detonation (On-Post Detonation) in that the off-post treatment lowers risk to site workers, although the risks related to off-post transportation cannot be completely eliminated. Furthermore, the detonation of UXO at an off-post facility may be more acceptable to the community due to the perceived risks associated with on-post detonation. The small estimated volume of UXO increases the feasibility of off-post transportation and decreases the magnitude of transportation risks.

Alternative U4a is more protective since the UXO are removed and treated at a lower risk to workers. This alternative uses existing facilities, may be more acceptable to the community, and complies with Army regulations for UXO demilitarization. However, Alternative U3a may be required for unstable UXO or if off-post disposal is not feasible. The costs for Alternative U3a and U4a are similar based on the small volume of anticipated UXO and the landfilling of up to 90,000 BCY of debris or contaminated soil under both alternatives.

Consequently, Alternative U4a: Detonation (Off-Post Army Facility) was retained to represent the Munitions Testing Medium Group in the development of the sitewide alternatives.

Table 5.0-1 Characteristics of the Munitions Testing Medium Group

Characteristic	Munitions Testing Medium Group
<u>Contaminants of Concern</u>	
Human Health	none
Biota*	none
<u>Exceedance Area (SY)</u>	
Total	0
Human Health	0
Biota*	0
Potential Agent	not applicable
Potential UXO	270,000
<u>Exceedance Volume (BCY)</u>	
Total	0
Human Health	0
Organic	0
Inorganic	0
Principal Threat	0
Biota*	0
Potential Agent	not applicable
Potential UXO	450
<u>Depth of Contamination (ft)</u>	
Human Health	not applicable
Biota*	not applicable

* Any soil that may present risks to biota in this medium group will be removed as part of UXO/debris remediation or addressed through continued monitoring (Section 1.4.2.2).

Table 5.1-1 Frequency of Detections for Munitions Testing Medium Group

	Total Samples	BCRL		CRL-SEC(1)		Acute-HH SEC(2)		HH SEC-Pr. Threat(2)		>Pr. Threat(2)	
	Analyzed	Number	%	Number	%	Number	%	Number	%	Number	%
Aldrin	145	143	98.6%	2	1.4%	0	0.0%	0	0.0%	0	0.0%
Benzene	10	10	100.0%	0	0.0%	--	--	0	0.0%	0	0.0%
Carbon Tetrachloride	10	10	100.0%	0	0.0%	--	--	0	0.0%	0	0.0%
Chlordane	145	145	100.0%	0	0.0%	0	0.0%	0	0.0%	0	0.0%
Chlorobenzene	9	9	100.0%	0	0.0%	--	--	0	0.0%	0	0.0%
Chloroform	10	10	100.0%	0	0.0%	--	--	0	0.0%	0	0.0%
p,p,DDE	145	145	100.0%	0	0.0%	--	--	0	0.0%	0	0.0%
p,p,DDT	145	144	99.3%	1	0.7%	0	0.0%	0	0.0%	0	0.0%
Dibromochloropropane	126	126	100.0%	0	0.0%	--	--	0	0.0%	0	0.0%
1,2-Dichloroethane	10	10	100.0%	0	0.0%	--	--	0	0.0%	0	0.0%
1,1-Dichloroethene	5	5	100.0%	0	0.0%	--	--	0	0.0%	0	0.0%
Dicyclopentadiene	141	141	100.0%	0	0.0%	--	--	0	0.0%	0	0.0%
Dieldrin	145	142	97.9%	3	2.1%	0	0.0%	0	0.0%	0	0.0%
Endrin	145	144	99.3%	1	0.7%	0	0.0%	0	0.0%	0	0.0%
Hexachlorocyclopentadiene	145	145	100.0%	0	0.0%	--	--	0	0.0%	0	0.0%
Isodrin	145	145	100.0%	0	0.0%	--	--	0	0.0%	0	0.0%
Methylene Chloride	8	6	75.0%	2	25.0%	--	--	0	0.0%	0	0.0%
Tetrachloroethane	5	5	100.0%	0	0.0%	--	--	0	0.0%	0	0.0%
Tetrachloroethylene	10	10	100.0%	0	0.0%	--	--	0	0.0%	0	0.0%
Toluene	10	10	100.0%	0	0.0%	--	--	0	0.0%	0	0.0%
Trichloroethylene	10	10	100.0%	0	0.0%	--	--	0	0.0%	0	0.0%
Arsenic	133	113	85.0%	20	15.0%	0	0.0%	0	0.0%	0	0.0%
Cadmium	127	111	87.4%	16	12.6%	0	0.0%	0	0.0%	0	0.0%
Chromium	127	14	11.0%	113	89.0%	--	--	0	0.0%	0	0.0%
Lead	127	92	72.4%	35	27.6%	--	--	0	0.0%	0	0.0%
Mercury	141	122	86.5%	19	13.5%	0	0.0%	0	0.0%	0	0.0%

(1) SEC limits for this interval are based on chronic HH SEC, or where appropriate, acute risk-based criteria for the 0- to 1-ft depth interval.

(2) Table 1.4-1 presents acute criteria, HH SEC, and principal threat criteria.

-- not applicable

Table 5.2-1 Comparative Analysis of Alternatives for the Munitions Testing Medium Group

Criteria		Alternative U1: No Additional Action	Alternative U2: Caps/Covers	Alternative U3a: Detonation (On Post)	Alternative U4a: Detonation (Off Post)
1.	Overall protection of human health and the environment	Not Protective: Does not achieve Human Health or Biota RAOs; no cross media impacts	Protective: Achieves Human Health and Biota RAOs: no cross-media impacts	Protective: Achieves Human Health and Biota RAOs; no cross-media impacts; high short-term risks for on-post detonation	Protective: Achieves Human Health and Biota RAOs; no cross-media impacts; some short-term transportation risk
2.	Compliance with ARARs	Does not comply with Army regulations for control of UXO	Complies	Complies	Complies
3.	Long-term effectiveness and permanence	High Residual Risk: potential hazard for UXO remains	Low Residual Risk; exposure pathways interrupted but potential hazard for UXO remains	No Residual Risk: identified UXO, metallic debris and contaminated soil removed	No Residual Risk: identified UXO, metallic debris and contaminated soil removed
4.	Reduction in TMV	No reduction in TMV	Exposure pathways interrupted	Any UXO identified are destroyed, irreversible TMV reduction, metallic debris and contaminated soil contained, mobility reduced	Any UXO identified are destroyed, irreversible TMV reduction, metallic debris and contaminated soil contained, mobility reduced
5.	Short-term effectiveness	No risk to workers or environmental impacts	Low risk to workers during UXO screening; moderate environmental impact at borrow area; RAOs achieved in 1 year	High risk to workers and community during clearance excavation, transport, and on-post detonation; RAOs achieved in 2 years	High risk to workers and community during UXO removal and transportation; Army transportation procedures reduce risk; RAOs achieved in 2 years
6.	Implementability	No implementation required; 5-year site reviews required	Feasible: No difficulties for construction or maintenance	Technically Feasible: On-post detonation may not be administratively feasible due to difficulties in controlling detonation	Feasible: Army facilities and specialists available
7.	Present Worth Costs	Capital—0 Operating—0 Long-term—$80,000 Total—$80,000	Capital—0 Operating—$9,330,000 Long-term—$315,000 Total—$9,640,000	Capital—$2,340,000 Operating—$3,080,000 Long-term—$63,000 Total—$5,480,000	Capital—$2,340,000 Operating—$3,080,000 Long-term—$63,000 Total—$5,480,000
Summary		Not Retained: Does not achieve RAOs; potential hazard for UXO remains	Not Retained: High cost for cover based on required fill volumes does not offset lower short-term risks	Not Retained; Some UXO may have to be detonated on post because of safety concerns at a higher risk	Retained: More protective; UXO removed and detonated at lower risk to workers and the community

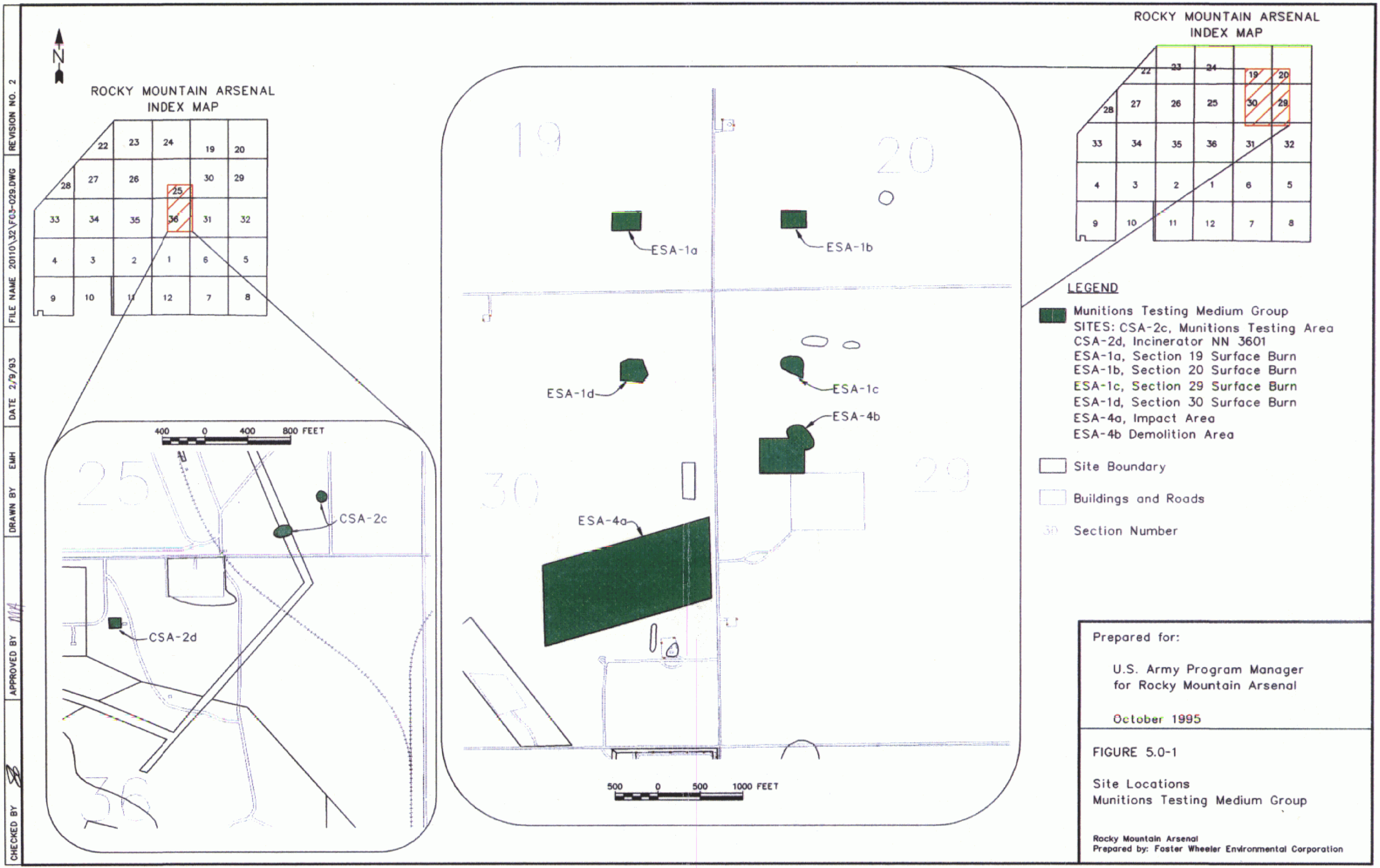


FIGURE 5.0-1
Site Locations
Munitions Testing Medium Group

Section 6

6.0 DETAILED ANALYSIS OF ALTERNATIVES FOR THE AGENT STORAGE MEDIUM GROUP

The Agent Storage Medium Group consists of 15 sites that were grouped together based on similar site histories and uses. They are considered exceedance sites based on the potential presence of Army chemical agent, although some of the sites also contain COCs exceeding Human Health SEC and potentially posing risk to biota. The sites in this medium group include former agent storage areas located in the eastern portion of RMA, ditches in the vicinity of the agent storage areas, and the North Plants GB manufacturing area. The potential presence of agent was evaluated at these sites during the Soil Volume Refinement Program (EBASCO 1994b) by drilling borings and screening soil samples from the borings. None of the samples encountered agent. Although agent has not been detected at these sites, they are presumed to potentially contain agent within the uppermost 5 to 10 ft of soil based on historical usage or based on the presence of agent breakdown products. Based on the site type and contamination pattern within this depth range, the sites within this medium group were divided into two subgroups, the North Plants Subgroup and the Toxic Storage Yards Subgroup. Figure 6.0-1 shows the locations of the sites in the North Plants Subgroup and Figure 6.0-2 shows those within the Toxic Storage Yards Subgroup.

The human health exceedance contaminant in this medium group is arsenic only. In addition, OCPs and mercury were found at levels that potentially pose risk to biota: The RISR identifies the sites within the North Plants Subgroup as potential sources of groundwater contamination (EBASCO 1992a). Table 6.0-1 presents the characteristics of this medium group, including COCs and exceedance volumes. Appendix A of Volume IV presents a summary of exceedance volumes and area calculations.

In the DSA (EBASCO 1992b), alternatives were developed and screened based on the general characteristics of the medium group as a whole. In the DAA, the retained alternatives were reviewed to ensure that they apply to each subgroup. The characteristics of each subgroup—including contaminants and concentrations, site configuration, depth of contamination, and potential presence of agent—were evaluated to determine whether any modifications to alternatives would be appropriate. One modification was made to the alternatives retained from the DSA for the North Plants Subgroup, and a new alternative was added for both subgroups based on treatability studies for solvent washing.

The following sections present the characteristics of each subgroup, an evaluation of the retained alternatives against the DAA criteria listed in the NCP (EPA 1990a), and the selection of alternatives for each subgroup, based on a comparative analysis, that was considered in the development of the sitewide alternatives (Section 20).

In addition to the Agent Storage Medium Group, agent may be found at other sites at RMA. These include areas within the Basin A, Sewer Systems, Disposal Trenches, Lime Basins, South Plants, and Undifferentiated Medium Groups. Appendix A of Volume IV describes the sites contained within these medium groups as well as the potential areas, depths, and volumes of agent-contaminated soil.

6.1 NORTH PLANTS SUBGROUP CHARACTERISTICS

The North Plants Subgroup is composed of sites NPSA-3 (GB Manufacturing Area), NPSA-5 (Special Weapons Plant), NPSA-6 (Underground Spill Area), the soil surrounding and beneath Building 1601 (GB and Bomb Plant), Building 1606 (Cluster Assembly Building), and Building 1607 (Warehouse) (Figure 6.0-1). These sites potentially contain agent based on historical use or based on the presence of agent breakdown products. In addition, these sites contain isolated human health exceedances in approximately 220 BCY of soil (330 SY) and contaminants at concentrations that potentially pose a risk to biota in 17,000 BCY (50,000 SY) (Figure 6.1-1).

Table 6.1-1 provides a summary of contaminants, concentrations, and the corresponding exceedance values for the subgroup. Table 6.1-2 presents the frequency of detections for contaminants that are above the Human Health SEC (EBASCO 1994a). Arsenic is the only contaminant that exceeds the Human Health SEC for this subgroup; it only occurred in two isolated samples.

The North Plants Subgroup sites were identified as historical sources of groundwater contamination in the RISR (EBASCO 1992a); however, these sites are not expected to be significant as ongoing sources of contamination to groundwater plumes based on the levels of contamination detected in soil. A groundwater plume, which originates in North Plants and migrates to the north, is being collected and treated at the North Boundary Containment System. The Water DAA is evaluating several remedial alternatives for this plume as part of the North Boundary Plume Group. Although the North Boundary Containment System might be positively impacted by the remediation of soil in the North Plants Subgroup, it is unlikely that the boundary system could be abandoned due to the contaminant mass already present in the aquifer.

Areas with potential agent presence in the North Plants Subgroup may be located below existing structures at RMA. Alternatives for these structures are being analyzed in the Structures DAA. Most of the structures in North Plants will be demolished in accordance with the chemical agent treaties and the structures preferred alternative as discussed in Section 3.1 of the Structures DAA. The treatment of soil beneath these structures requires the removal of structural debris following demolition. In the capping alternatives described below, the structural debris is disposed in the on-post hazardous waste landfill following demolition of the structures (Section 6.2.2).

The sites within the North Plants Subgroup contain areas of disturbed vegetation. Most of the alternatives developed for this subgroup call for the revegetation of the disturbed areas with native grasses in accordance with a refuge management plan. Therefore, the overall habitat is improved, which should offset the short-term loss of habitat resulting from remedial actions.

6.2 NORTH PLANTS SUBGROUP EVALUATION OF ALTERNATIVES

The five alternatives for the North Plants Subgroup include no action, containment, and treatment approaches. During the DAA, a new alternative involving solvent washing was added to address agent contamination. This alternative was added based on results achieved for the removal of OCPs in a pilot-scale treatability study at RMA. This process makes use of a caustic solution as part of the solvent extraction that effectively neutralizes agent compounds. The following subsections present a description of each alternative and an evaluation of the alternative against the DAA criteria listed in the NCP (EPA 1990a).

6.2.1 Alternative A1: No Additional Action

Alternative A1: No Additional Action (Provisions of FFA) applies to an area of 28,000 SY of the North Plants Subgroup beneath which agent potentially occurs and 50,000 SY of soil posing potential risk to biota. No action is taken under this alternative to reduce potential exposure to agent. The soil with isolated human health exceedance volumes of arsenic and potential risks to biota remains in place. Since no action is taken for the soil, there is no impact on the evaluation of structures alternatives. Five-year reviews and soil and groundwater monitoring are required to assess the status of potential agent and other COCs remaining in these sites.

The following discussion presents a detailed evaluation of this alternative against the DAA criteria listed in the NCP (EPA 1990a). For purposes of comparison, Table 6.2-1 summarizes the evaluation of all alternatives developed for the subgroup.

6.2.1.1 Overall Protection of Human Health and the Environment

This alternative does not achieve RAOs since soil with potential agent and isolated human health exceedances remain and no controls are implemented. Potential impacts to groundwater are not reduced.

6.2.1.2 Compliance with ARARs

This alternative complies with action- and location-specific ARARs because long-term monitoring and site reviews are conducted and North Plants is not located in wetlands or a 100-year flood plain. The alternative also complies with provisions of the FFA (EPA et al. 1989). This alternative does not achieve Army regulations regarding control of agent-contaminated materials. (ARARs are listed in Appendix A of the Technology Descriptions Volume.)

6.2.1.3 Long-Term Effectiveness and Permanence

Although soil potentially containing agent, as well as low levels of isolated human health exceedances remain in place, the residual risk is low. Site reviews and groundwater and soil monitoring are required. The existing habitat is not improved by this alternative.

6.2.1.4 Reduction in TMV

There is no reduction in TMV except by natural attenuation since soil with potential agent, isolated human health exceedances, and potential risk to biota remains in place.

6.2.1.5 Short-Term Effectiveness

RAOs are not achieved since soil with potential agent, isolated human health exceedances and potentially posing risk to biota remains. This alternative does not pose risk to workers and the community during remedial actions since no actions are taken. No measures are taken to address the potential for continued migration of contaminants to the groundwater. The existing habitat is not changed by remedial actions.

6.2.1.6 Implementability

The alternative is technically and administratively feasible. No action is required, but soil monitoring and site reviews are required.

6.2.1.7 Cost

The total present worth is cost $82,600 and includes only long-term O&M costs associated with monitoring and site reviews. Table B2.1-A1 details the costing for this alternative. The cost uncertainty relative to monitoring and site reviews is low.

6.2.2 Alternative A2: Caps/Covers

Alternative A2: Caps/Covers (Soil Cover) involves placing a 50,000-SY soil cover over areas with potential agent presence, isolated human health exceedances, soil posing potential risk to biota. The soil subgrade is compacted before any cover materials are installed, and the area receiving the soil cover is crowned with 43,000 BCY of fill to facilitate surface-water runoff.

The structural debris from the demolition of North Plants buildings is removed. As described in Section 6.1 of the Technology Descriptions Volume, the area is then covered by a 4-ft-thick soil/vegetation layer that includes 6 inches of reconditioned soil. The reconditioned soil layer is then revegetated with native grasses. The soil/vegetation layer acts as a physical barrier to protect human and biota receptors from directly contacting soil with potential agent presence. The fill material is excavated from an on-post borrow area. The covering operations take less than 1 year to complete. Long-term maintenance activities ensure the continued integrity of the soil cover.

The following discussion presents a detailed evaluation of this alternative against the DAA criteria listed in the NCP (EPA 1990a). For purposes of comparison, Table 6.2-1 summarizes the evaluation of all alternatives developed for this subgroup.

6.2.2.1 Overall Protection of Human Health and the Environment

This alternative achieves RAOs through containment. Human and biota exposure are interrupted by the soil cover layers, and potential groundwater impacts are also reduced.

6.2.2.2 Compliance with ARARs

This alternative complies with action-specific ARARs regarding construction of soil cover layers and monitoring of contained material. Sites in the North Plants Subgroup are not located in wetlands or a 100-year flood plain, thus complying with location-specific ARARs. This alternative also complies with the provisions of the FFA (EPA et al. 1989), and is not subject to Army regulations regarding agent demilitarization since any soil with agent is contained. (ARARs are listed in Appendix A of the Technology Descriptions volume.)

6.2.2.3 Long-Term Effectiveness and Permanence

The residual risk associated with this alternative is minimal. There is high confidence in engineering controls that are used to monitor and maintain the soil cover. Site reviews, groundwater monitoring, erosion-control activities, and maintenance of the soil/vegetation layer are also required. The overall habitat quality for the subgroup is improved through revegetation, although the types of vegetation placed at the site and the maintenance activities performed there are designed to discourage burrowing animals from using the covered area as habitat. The potential for migration of contaminants to groundwater is reduced.

6.2.2.4 Reduction in TMV

Exposure pathways are interrupted and mobility of contaminants is reduced through the installation of a 50,000-SY soil cover. The reduction in contaminant mobility and protection from hazards are only reversible should the cover degrade or leak. There are no treatment residuals associated with this alternative.

6.2.2.5 Short-Term Effectiveness

This alternative presents minimal short-term risks to workers and the community since no intrusive activities are conducted. Personal protective equipment protects workers during cover installation, and uncontaminated fugitive dust (associated with the installation of a cover) that may affect the community is controlled through water sprays. Odor/vapor emissions are not anticipated. There are minimal impacts to the existing habitat. Migration of the contaminants to groundwater is reduced. Installation of the soil cover is feasible within 1 year after the removal of structures.

6.2.2.6 Implementability

The alternative is technically feasible; it can be constructed within the required time frame and reliably operated and maintained thereafter. Additional remedial actions can be easily undertaken for soil left in place, although the cover adds to the overall site volume. The alternative is administratively feasible since the substantive requirements of soil cover design and construction regulations are achieved. Equipment, specialists, and materials are readily available for construction of the soil cover. Soil covers are well demonstrated at full scale.

6.2.2.7 Cost

The total present worth cost is $1,300,000, including $1,170,000 and $129,000 for operating and long-term costs, respectively. Table B2.1-A2 details the costing for this alternative. There is a low level of uncertainty associated with the cost of this alternative since the materials required to construct the cover are available on post and the area to be contained is relatively well defined (i.e., the uncertainty commonly associated with excavation does not exist).

6.2.3 Alternative A3: Direct Soil Washing; Landfill

Alternative A3: Direct Soil Washing (Caustic Solution Washing); Landfill (On-Post Landfill) in conjunction with Alternative B5: Caps/Covers (Multilayer Cap) addresses agent-contaminated soil anticipated to be found in the North Plants Subgroup through the process of caustic washing. Approximately 220 BCY of soil with human health exceedances is excavated and landfilled, and a soil cover is placed over soil with a potential risk to biota. Caustic solution washing is a physical/chemical treatment process option in which agent-contaminated soil is excavated and then neutralized in caustic wash fluids in an aboveground unit. The caustic washing process is performed in four cycles to achieve an Army decontamination level of 3X (Section 4.4.3), a level that indicates that the soil has been surface-decontaminated (AMC-R 385-131) (Army 1987). The treated soil is separated from the wash water and placed in the on-post hazardous waste landfill.

The North Plants structures are demolished in accordance with the chemical agent treaties and the structures preferred alternative, and the resulting debris disposed in the hazardous waste landfilling with the human health exceedances. As the 220 BCY of human health exceedance is excavated, it is screened for agent using real-time monitoring of samples. If agent is detected in the field, the samples are sent to the RMA laboratory for verification. Any agent-contaminated soil is then transported to the on-post caustic solution washing unit as described in Section 4.4.3. Any abandoned utilities encountered during excavation are removed and consolidated with the structural debris. The excavated human health exceedance soil in which agent was not detected is transported to the on-post hazardous waste landfill. The excavated areas are backfilled with fill material obtained from an on-post borrow area. A 2-ft-thick soil cover is placed over soil posing a potential risk to biota and the footprint of the North Plants processing area (total area 160,000 SY) as shown in Figure 6.2-1. The uppermost 6 inches of soil of the soil cover and backfill are reconditioned and revegetated with native grasses. The borrow area is also revegetated with native grasses, thereby restoring the value of the habitat.

The soil identified as containing agent is placed in the washing unit and mixed with a 7.5-percent solution of sodium hydroxide (NaOH) and 2.5 percent hydrogen peroxide (H_2O_2) at a ratio of 5:1 solution/soil for at least 30 minutes. Two waste streams are generated, the washed soil and the caustic solution. Caustic solution washing consists of multiple wash cycles, with air space monitoring after each cycle used to determine if additional cycles are required. Additional NaOH and H_2O_2 are added to bring the solution to full strength for each successive wash cycle, thereby reducing the volumes of caustic solution to treat. The capacity of the unit allows each wash cycle to treat approximately 6 BCY of agent-contaminated soil. The spent caustic is evaporated by evaporation/crystallization and the resulting salts are transported to the on-post hazardous waste landfill along with the treated soil. The on-post hazardous waste landfill requires 1 year to construct and is fenced to prevent wildlife from entering the area. The landfill requires long-term maintenance and monitoring after closure.

The following discussion presents a detailed evaluation of this alternative against the DAA criteria listed in the NCP (EPA 1990a). For purposes of comparison, Table 6.2-1 summarizes the evaluation of all alternatives developed for this subgroup.

6.2.3.1 Overall Protection of Human Health and the Environment

This alternative achieves RAOs through treatment and containment. Agent-contaminated soil is treated to remove agent and then contained in an on-post landfill, thus preventing exposure. Soil with isolated human health exceedances (220 BCY) is contained in an on-post landfill. Soil with potential risk to biota and the North Plants processing area (160,000 SY) is contained by a soil cover. Potential groundwater impacts are also reduced. There are significant short-term impacts associated with agent clearance and the excavation of contaminated soil, although the extent of excavation is limited.

6.2.3.2 Compliance with ARARs

This alternative complies with action specific ARARs including state regulations on air emission sources and landfill siting, design, and operation. Endangered species are not impacted. Sites in the North Plants Subgroup, the caustic washing facility, and the landfill are not located in wetlands or a 100-year flood plain, thus complying with location-specific ARARs. This alternative also complies with the provisions of the FFA (EPA et al. 1989) and Army Materiel Command regulations (AMC-R 385-131) regarding agent demilitarization. (ARARs are listed in Appendix A of the Technology Descriptions Volume.)

6.2.3.3 Long-Term Effectiveness and Permanence

The residual risk is minimal since soil with agent is treated by caustic washing, and the treated soil, along with 220 BCY of untreated soil, are placed in an on-post landfill. There is high confidence in the engineering controls for the landfill, and there are no expected difficulties associated with landfill maintenance, although landfill-cell monitoring is required. Soil with a potential risk to biota is covered, and the existing habitat at the site is improved by revegetation; however, habitat at the landfill is eliminated.

6.2.3.4 Reduction in TMV

Soil containing agent is identified, treated by caustic solution washing to remove the agent, and then landfilled. TMV reduction by caustic solution washing is irreversible. Exposure pathways for 220 BCY of untreated human health exceedance soil are interrupted and mobility of contaminants is reduced through containment in the landfill. The exposure pathway for soil posing a potential risk to biota is reduced through the installation of a soil cover. Reduction of contaminant mobility is only reversible should the engineering controls for the landfill or soil cover fail. Treatment residuals from caustic solution washing include salts, which are landfilled on post along with the treated soil.

6.2.3.5 Short-Term Effectiveness

This alternative presents significant short-term risks associated with agent clearance, excavation, transportation, treatment, and landfilling of contaminated soil. These risks are reduced through engineering controls and use of PPE, but they cannot be completely removed. Engineering controls for dust (such as water sprays) or vapors/odors (such as daily covers, tarps, or foams) are initiated to reduce short-term risks; however, the adequacy of these controls has not yet been fully demonstrated, and the possibility exists for vapor/odor emissions during excavation in spite of these controls. There are minimal impacts to the existing habitat, and potential migration of the contaminants to the groundwater is reduced. The time frame until RAOs are achieved is 2 years: landfilling of 220 BCY of soil is feasible within 1 year after 1 year for construction of the landfill. The construction of the caustic solution washing system takes 1 year. The soil cover can be constructed in 1 year after removal of structures.

6.2.3.6 Implementability

The alternative is technically feasible and can be implemented within the required time frame and reliably operated and maintained thereafter. The agent-contaminated soil is excavated at variable rates and frequencies, resulting in batch-type operations of the caustic solution washing system. Landfill-cell monitoring and maintenance is required, and additional remedial actions require removal of the landfill cover. The soil cover requires maintenance. Demolition of structures and removal of structural debris are also required. The alternative is administratively feasible since the substantive requirements of the caustic treatment unit and landfill siting, design, and operating regulations are achieved. Equipment, specialists, and materials are readily available for soil cover construction, construction of the landfill, and the landfill technology has been well demonstrated at full scale. Although caustic washing is not well demonstrated at full scale, the associated equipment is well demonstrated and widely available.

6.2.3.7 Cost

The total present worth cost is $1,520,000 including $24,000, $1,320,000, and $172,000 for capital, operating, and long-term costs, respectively. Table B2.1-A3 details the costing for this alternative. Some cost uncertainty relative to identifying the presence of agent as well as the extent and depth of contamination exists; however, the magnitude of this uncertainty is small based on the small volume of soil estimated to be involved.

6.2.4 <u>Alternative A4: Incineration/Pyrolysis</u>

Alternative A4: Incineration/Pyrolysis (Rotary Kiln Incineration) in conjunction with Alternative 3: Landfill (On Post Landfill) and Alternative B5: Caps/Covers (Multilayer Cap) treats agent-contaminated soil through on-post incineration and addresses soil with potential risk to biota by the placement of a soil cover. This alternative achieves the 5X criterion for materials containing agent as discussed in Section 4.4.4. The North Plants structures are demolished in accordance with the chemical agent treaties, and the resulting debris removed to allow access to the soil potentially containing agent. Areas with the potential presence of agent are screened using a drilling program to identify agent-contaminated soil. Soil samples collected during drilling are screened by field analytical methods for agent and sent to the RMA laboratory for verification. The soil identified as containing agent is excavated and transported to the rotary kiln incinerator. Any abandoned utilities encountered during excavation are removed and consolidated with the structural debris.

The centralized incineration facility is constructed in the northeast corner of Section 2. The facility requires approximately 2 years for construction and testing. The incinerator has a throughput of approximately 470 BCY/day and a total solids residence time of 66 minutes at 760°C. Section 4.6.29 discusses emission controls for incinerator off-gases. The treated soil is backfilled. Following screening for agent, the 220 BCY of human health exceedance volume, less any soil identified with agent, is excavated and placed in the on-post landfill along with the particulates from the scrubber blowdown, which constitute an estimated 1 percent of the solids feed. The excavations are backfilled with borrow material from an on-post borrow area. A 2-ft soil cover is placed over 50,000 SY of soil with potential risk to biota. The uppermost 6 inches of backfill and of the soil cover are reconditioned and revegetated with native grasses.

The following discussion presents a detailed evaluation of this alternative against the DAA criteria listed in the NCP (EPA 1990a). For purposes of comparison, Table 6.2-1 summarizes the evaluation of all alternatives developed for this subgroup.

6.2.4.1 Overall Protection of Human Health and the Environment

This alternative achieves RAOs through treatment. Agent-contaminated soil is treated and backfilled. Soil with isolated human health exceedances and blowdown solids are placed in an on-post landfill. Soil with potential risk to biota is contained by a soil cover. Containment interrupts exposure pathways and reduces migration of contaminants to groundwater. There are significant short-term impacts associated with agent clearance and the excavation of contaminated soil.

6.2.4.2 Compliance with ARARs

This alternative complies with action specific ARARs, including state regulations on air emissions sources and landfill design and operation. Endangered species are not impacted. Location-specific ARARs are met as sites in the North Plants Subgroup, incinerator, and the landfill are not located in wetlands or a 100-year flood plain. In addition to the ARARs, this alternative complies with provisions of the FFA (EPA et al. 1989) and Army Materiel Command regulations (AMC-R 385-131) (AMC 1987) regarding agent demilitarization. (ARARs are listed in Appendix A of the Technology Descriptions Volume.)

6.2.4.3 Long-Term Effectiveness and Permanence

The residual risk is minimal since agent-contaminated soil is incinerated and 220 BCY of untreated human health exceedance soil are placed in an on-post landfill. The exposure pathway is reduced for 50,000 SY of soil with potential risk to biota. There is high confidence in the engineering controls used for the landfill, and there are no expected difficulties associated with landfill maintenance. Landfill-cell monitoring is required. Following installation of the soil cover, the existing habitat at the site is improved by revegetation; however, habitat at the landfill is eliminated.

6.2.4.4 Reduction in TMV

Incineration irreversibly removes agent contamination from the soil. Exposure pathways are interrupted through containment of 220 BCY of untreated soil and blowdown solids in an on-post landfill. The reduction in mobility for this volume is only reversible should the landfill fail.

6.2.4.5 Short-Term Effectiveness

This alternative presents significant short-term risks associated with agent clearance, excavation, transportation, incineration, and landfilling of contaminated soil. These risks are reduced through engineering controls and use of personal protective equipment, but they cannot be completely removed. Engineering controls for dust (such as water sprays) or vapors/odors (such as daily covers, tarps, or foams) are initiated to reduce short-term risks; however, the adequacy of these controls has not yet been fully demonstrated, and the possibility exists for vapor/odor emissions during excavation in spite of these controls. In addition, the preparation of the feedstock prior to incineration presents short-term risks, although the materials handling is conducted in an enclosed building to control dust and vapors/odors. The emissions from the incinerator contain low but acceptable levels of some contaminants, although the off-gas control system for the incinerator is designed to achieve air quality standards. Environmental impacts are minimal and the potential for migration of contaminants to groundwater is minimized. The time frame for completion of the alternative is 3 years. Incineration of the small volume of agent-contaminated soil is feasible within 1 year after 2 years for construction of the incineration facility. Containment of 220 BCY is feasible within 1 year after 1 year for construction of the landfill. The soil cover can be constructed within 1 year after the removal of structures.

6.2.4.6 Implementability

The alternative is technically feasible and can be implemented within the required time frame and reliably operated and maintained thereafter. Operation of the incinerator, which requires a constant feed rate, may be restricted by the batch excavation of soil. Additional remedial actions require removal of the landfill cover and the landfill cells require monitoring. Demolition of structures and removal of debris is required. Administrative difficulties associated with demonstrating compliance with permits and O&M regulations for incineration may lead to delays, and it may be difficult to implement this alternative due to the poor public perceptions regarding the safety of incineration. Equipment, specialists, and materials are readily available for the construction of the soil cover and landfill and design and construction of the incinerator. Landfills and incinerators have been well demonstrated at full scale.

6.2.4.7 Cost

The total present worth cost is $792,000 including $13,000, $668,000, and $101,000 for capital, operating, and long-term costs, respectively. Table B2.1-A4 details the costing for this alternative. Some cost uncertainty relative to identifying the presence of agent and the extent and depth of contamination exists; however, the magnitude of this uncertainty is small based on the small volume of soil estimated to be involved. In addition, there is a high level of uncertainty relative to maintaining the assumed on-line percentage of the incinerator. Possible delays in implementation and variations in agent concentrations in the soil feed may lead to increased treatment costs.

The cost estimate for incineration is based on treating several hundred thousand bank cubic yards of contaminated soil on a continuous basis. The treatment of the small volume of agent-contaminated soil requires operating the equipment on a batch basis, which would substantially increase the unit cost of the incinerator were it not being used to treat other materials.

6.2.5 Alternative A5: Direct Soil Washing: Landfill

Alternative A5: Direct Soil Washing (Solvent Extraction); Landfill (On-Post Landfill) in conjunction with Alternative 3: Landfill and Alternative: B5 Caps/Covers (Multilayer Cap) addresses the agent-contaminated soil in the North Plants Subgroup through the process of solvent extraction with a caustic solution. The human health exceedance volume is excavated and contained in a landfill and the soil posing a potential risk to biota is contained by a soil cover. Solvent extraction is a physical/chemical treatment process option in which agent-contaminated soil is excavated, mixed with a caustic solution to adjust the pH and degrade agent, agitated with an organic solvent to extract any other organic contaminants, and then separated from the wash solvent. Most of the solvent is recycled, and the waste solvent containing the extracted contaminants is disposed off post. The caustic solution washing portion of solvent extraction achieves an Army decontamination level of 3X (Section 4.4.5), which indicates that the soil has been surface-decontaminated (AMC-R 385-131) (AMC 1987). Once treatment is achieved, the treated soil is adjusted back to neutral pH and placed in the on-post landfill. Approximately 1 to 2 gallons of waste solvent containing concentrated contaminants is expected to be generated for each cubic yard of soil treated.

The North Plants structures are demolished in accordance with the chemical agent treaties and the structures preferred alternative, and the resulting debris removed to allow access to the soil potentially containing agent. This soil is screened for agent using real-time monitoring of samples collected from boreholes. Agent presence is verified by analysis at the RMA laboratory. The agent-contaminated soil is then excavated and transported to the on-post solvent washing unit as described in Section 4.4.5. Any abandoned utilities encountered during excavation are removed and consolidated with the structural debris. The 220 BCY of soil with isolated human health exceedances are excavated and placed in the on-post hazardous waste landfill along with the treated soil. The on-post hazardous waste landfill requires 1 year to construct and is fenced to restrict wildlife access. The landfill requires long-term (30-year) maintenance and monitoring after closure. The soil posing potential risk to biota is contained by a 2-ft soil cover. The excavated areas are backfilled with fill material obtained from an on-post borrow area. The uppermost 6 inches of backfill soil and of the soil cover are reconditioned and revegetated with native grasses. The borrow area is also revegetated with native grasses, thereby restoring the value of the habitat.

The following discussion presents a detailed evaluation of this alternative against the DAA criteria listed in the NCP (EPA 1990a). For purposes of comparison, Table 6.2-1 summarizes the evaluation of all alternatives developed for this subgroup.

6.2.5.1 Overall Protection of Human Health and the Environment

This alternative achieves RAOs through treatment of agent-contaminated soil followed by containment of the treated soil and soil with isolated human health exceedances in an on-post landfill. Soil posing potential risk to biota is contained by a soil cover. Groundwater impacts are reduced. There are significant short-term impacts associated with agent-clearance activities and the excavation of contaminated soil.

6.2.5.2 Compliance with ARARs

This alternative complies with action specific ARARs including state regulations on air emission sources and landfill siting, design, and operation. Endangered species are not impacted. Sites in the North Plants Subgroup, the solvent washing facility, and the landfill are not located in wetlands or a 100-year flood plain, thus complying with location-specific ARARs. This alternative also complies with the provisions of the FFA (EPA et al. 1989) and Army Materiel Command regulations (AMC-R 385-131) (AMC 1987) regarding agent demilitarization. (ARARs are listed in Appendix A of the Technology Descriptions Volume.)

6.2.5.3 Long-Term Effectiveness and Permanence

The residual risks are minimal since agent-contaminated soil is treated and then placed, along with 220 BCY of untreated soil, in an on-post landfill. A 50,000-SY soil cover reduces exposure to soil posing potential risk to biota. There is high confidence in the engineering controls used for the landfill and soil cover, and there are no expected difficulties associated with landfill maintenance, although landfill-cell monitoring is required. The existing habitat at the site is improved by revegetation; however, habitat at the landfill is eliminated.

6.2.5.4 Reduction in TMV

Soil washing irreversibly removes agent contamination from the soil. Exposure pathways for the untreated soil are interrupted, and mobility of the contaminants is reduced through containment in the landfill. Reduction of mobility is only reversible should the landfill fail. Approximately 1 to 2 gallons of residual liquid for each cubic yard of agent-contaminated soil is sent off-post for treatment.

6.2.5.5 Short-Term Effectiveness

This alternative presents significant short-term risks associated with agent clearance, excavation, transportation, treatment, and landfilling of contaminated soil. These risks are reduced through engineering controls and use of personal protective equipment, but they cannot be completely removed. Engineering controls for dust (such as water sprays) or vapors/odors (such as daily covers, tarps, or foams) are initiated to reduce short-term risks; however, the adequacy of these controls has not yet been fully demonstrated, and the possibility exists for vapor/odor emissions during excavation in spite of these controls. In addition, the preparation of the feedstock prior to solvent extraction presents short-term risks, although the materials handing is conducted in an enclosed building to control dust and vapors/odors. There are minimal impacts to the existing habitat, and the potential for migration of the contaminants to the groundwater is reduced. The time frame until RAOs are achieved is 2 years: solvent extraction of the small amount of agent-contaminated soil is feasible within 2 years, and landfilling of 220 BCY of soil is feasible within 1 year after 1 year for construction of the landfill. The soil cover can be constructed within 1 year after removal of structures.

6.2.5.6 Implementability

This alternative is very difficult to implement. Although commercial solvent extraction units are available, the technology has not yet been demonstrated at the scale required for RMA, and performance data are not available to document the effectiveness of the technology on agent-contaminated soil. Demolition of structures and removal of structural debris is also required. The landfill portion can be implemented within the required time frame and reliably operated and maintained thereafter with periodic landfill-cell monitoring. Additional remedial actions will require removal of the landfill cover.

The alternative is administratively feasible since the substantive requirements of the direct treatment unit and landfill siting, design, and operating regulations are achieved. Limited vendor sources are available for the solvent extraction unit. Equipment, specialists, and materials are readily available for construction of the soil cover and landfill, and landfill technology has been well demonstrated at full scale.

6.2.5.7 Cost

The total present worth cost is $841,000 including $11,000, $722,000, and $108,000 for capital, operating, and long-term costs, respectively. Table B2.1-A5 details costing for this alternative. Some cost uncertainty relative to evaluating the presence of agent and identifying the extent and depth of contamination; however, the magnitude of this uncertainty is small based on the small volume of soil estimated to be involved. In addition, there is a high level of uncertainty relative to achieving the estimated on-line percentage for solvent extraction since operating data are not available at the necessary scale. The potential for delays associated with maintenance and from variations in contaminant levels in the feedstock also adds to the cost uncertainty.

The cost estimate for solvent extraction is based on treating hundreds of thousands cubic yards of contaminated soil on a continuous basis. The treatment of the small volume of agent-contaminated soil requires operating the equipment on a batch basis, which would substantially increase the unit cost of the equipment were it not used to treat other materials.

6.3 COMPARATIVE ANALYSIS OF ALTERNATIVES

Agent is expected to be found in a small volume of soil in sites in the North Plants Subgroup. These sites are suspected to potentially contain agent based on historical usage or the presence of agent breakdown products. Isolated detections of arsenic above the Human Health SEC in two samples (Table 6.1-2) account for 220 BCY of human health exceedance volume. Contaminants potentially pose risk to biota over on an area of 50,000 SY. Sites in this subgroup contain areas of disturbed vegetation. Areas disturbed by remedial actions are to be revegetated after remediation to restore and improve the habitat.

Evaluation of alternatives for this subgroup must consider whether the long-term risks associated with leaving potential agent contamination in place outweigh the short-term risks associated with excavating and treating the soil. In general alternatives that leave untreated soil in place include long-term groundwater compliance monitoring to evaluate the potential migration of contaminants. Risk to site workers can be minimized with appropriate health and safety equipment and procedures.

Alternative 1: No Additional Action does not achieve Human Health RAOs since the potential for exposure to agent and arsenic remains. This alternative is eliminated from further consideration. The four remaining alternatives achieve RAOs and meet the two DAA threshold criteria—protection of human health and the environment and compliance with action-specific and location-specific ARARs—although they differ in how well they meet the five balancing criteria (Table 6.2-1)

Alternative A2: Caps/Covers provides low long-term residual risks without incurring short-term risks. This option also interrupts human and biota exposure pathways and reduces the impacts on groundwater. There are no treatment residuals associated with this alternative. This technology is well demonstrated and has a cost comparable to Alternative A3 (1,320,000); however, it leaves agent contaminated and human health soil in place and is therefore less protective. As a result, this alternative was eliminated from further consideration.

Alternative A3: Direct Soil Washing; Landfill involves limited excavation and treatment prior to landfilling of agent-contaminated soil and human health exceedance soil. Soil posing a potential risk to biota and the footprint of the North Plants processing area are covered with 2 feet of soil. This alternative has a comparatively low cost of $1,520,000. A drawback of the alternative includes the hazards of agent clearance, although the excavation is limited. A caustic solution washing system would need to be designed and constructed, but equipment is readily available. This alternative is retained for further consideration.

Alternative A5: Direct Soil Washing; Landfill involves limited excavation and treatment of agent-contaminated soil through solvent extraction prior to landfilling the treated soil. Human health exceedance soil is landfilled and soil posing potential risk to biota is contained by a soil cover. This alternative has several disadvantages. Treatment residuals include 1 to 2 gallons of solvent for every cubic yard treated; these residuals will ultimately require off-post treatment. The alternative also entails short-term risks from excavation and agent clearance. This alternative is not cost effective unless solvent extraction is retained for human health exceedances from other sites. The treatment of the small volume of agent-contaminated soil requires operating the equipment on a batch basis, which would substantially increase the unit cost. For these reasons, this alternative was not retained for further consideration.

Alternative A4: Incineration/Pyrolysis involves thermal treatment of agent contamination; the alternative does not require landfilling the treated soil. Administrative difficulties associated with demonstrating compliance with permits and operating and maintenance regulations for incineration may lead to delays, and it may be difficult to implement this alternative due to the public perceptions regarding the safety of incineration. This alternative entails short-term risks during excavation and agent clearance. The treatment of the small volume of agent-contaminated soil requires operating the equipment on a batch basis, which would substantially increase the unit cost. This alternative is not cost effective unless incineration is retained for human health exceedances. Accordingly, this alternative was not retained since it has limited administrative feasibility based on public concerns.

The alternatives retained for the remediation of the structures on the site incorporate demolition in accordance with the chemical agent treaties and the structures preferred alternative. The resulting debris may be treated and landfilled, or consolidated, following demolition. Whichever alternative is chosen, the structural debris is removed prior to soil incineration (see Plate 3.0-1 in the Structures DAA). There are no soil/water interactions for the North Plants Subgroup.

Consequently, the alternative that was retained to represent the North Plants Subgroup in the development of the sitewide alternatives (Section 20) is the following:

- Alternative A3: Direct Soil Washing; Landfill (in conjunction with Alternative B5: Caps/Covers [Multilayer Cap])

6.4 TOXIC STORAGE YARDS SUBGROUP CHARACTERISTICS

The Toxic Storage Yards Subgroup consists of sites ESA-3a (Section 5 Storage Yard), ESA-3b (Section 6 Old Storage Yard), ESA-3c (Section 31 New Storage Yard), ESA-3d (Section 31 Toxic Yard Plots), ESA-3e (VX Demilitarization Pad), ESA-3f (Rail Loading Area), ESA-3g (Open Storage Area), ESA-3h (Open Storage Area), and ESA-3i (Toxic Storage Plots Ditch) (Figure 6.0-2). The sites in this subgroup can be further identified as the Old Toxic Storage Yards (ESA-3a and ESA-3b) and the New Toxic Storage Yards (remainder of the sites). These sites are located in the Eastern Study Area, and were identified as potentially containing agent in the RISR (EBASCO 1992a) based on historical usage or based on the presence of agent breakdown products. It should be noted, however, that approximately 100 borings were drilled in these sites (largely in the New Toxic Storage Yards) to screen for the presence of agent during the Soil Volume Refinement Program (EBASCO 1994b) and no agent was detected. As a result, only the Old Toxic Storage Yard sites were retained as potential agent presence areas.

Soil in the Toxic Storage Yards Subgroup contains several isolated human health exceedances of CLC2A at depths ranging from 0 to 6 ft below ground surface. Table 6.4-1 provides a summary of contaminants, concentrations, and the corresponding exceedance values for the subgroup. Table 6.4-2 presents the frequency of detections for contaminants above the Human Health SEC. CLC2A exceeds the Human Health SEC in four samples at concentrations ranging from 80 to 134 ppm, and arsenic exceeds the Human Health SEC (EBASCO 1994a) in five samples at concentrations ranging from 450 to 4,000 ppm. Figure 6.4-1 shows the locations of these isolated human health exceedances (2,700 BCY). Areas of the Toxic Storage Yards Subgroup could be used as low permeability or structural borrow fill as described in the Feasibility Study Soil Volume Refinement Program, Geotechnical Sampling in the New Toxic Storage Yard, Section 31, RMA (Foster Wheeler Environmental 1995). This subgroup contains approximately 130,000 SY of soil in the Old Toxic Storage Yard with the potential for agent contamination (Table 6.0-1).

Sites in the Toxic Storage Yards Subgroup have not been identified as historical sources of groundwater or surface-water contamination. Although several concrete pads are present within the subgroup, the remediation of contaminated soil in the Toxic Storage Yards is not impacted by the presence of these structures since they are for the most part located outside the potential agent presence area.

The sites within the Toxic Storage Yards Subgroup contain weedy forbs. In most of the alternatives developed for this medium group, the areas disturbed during remedial actions are revegetated with native grasses in accordance with a refuge management plan, thereby improving the overall habitat. The short-term loss of habitat resulting from remedial actions is offset by overall habitat improvement. Two of the sites within this subgroup (sites ESA-3a and ESA-3b) are located within the Bald Eagle Management Area. Therefore, any remedial actions for these sites must be coordinated with USFWS to ensure that the disturbance of habitat is minimized.

6.5 TOXIC STORAGE YARDS SUBGROUP EVALUATION OF ALTERNATIVES

The five alternatives for the Toxic Storage Yards Subgroup include no action, containment, and treatment approaches. During the DAA, a new alternative involving solvent extraction was added to address agent contamination. This alternative was added based on results achieved for the removal of OCPs in a pilot-scale treatability study at RMA. This process makes use of a caustic solution as part of the solvent extraction process that effectively neutralizes agent compounds. The following subsections present a description of each alternative and an evaluation of the alternative against the DAA criteria listed in the NCP (EPA 1990a).

6.5.1 Alternative A1: No Additional Action

Alternative A1: No Additional Action (Provisions of FFA) applies to 130,000 SY of the Toxic Storage Yards Subgroup that potentially contain agent. No action is taken under this alternative to reduce potential exposure to agent and soil with isolated human health exceedances remains in place. Five-year reviews are required to assess the status of potential agent and other COCs remaining in these sites.

The following discussion presents a detailed evaluation of this alternative against the DAA criteria listed in the NCP (EPA 1990a). For purposes of comparison, Table 6.5-1 summarizes the evaluation of all alternatives developed for this subgroup.

6.5.1.1 Overall Protection of Human Health and the Environment

This alternative does not achieve RAOs since soil with potential agent and isolated human health exceedances remains and no controls are implemented. There are no impacts on surface-water or groundwater quality.

6.5.1.2 Compliance with ARARs

This alternative complies with action- and location-specific ARARs as long-term monitoring and site reviews are conducted and sites in the Toxic Storage Yards Subgroup are not located in wetlands or a 100-year flood plain. The alternative complies with provisions of the (EPA et al.

1989) FFA, but does not achieve Army regulations regarding the control of agent-contaminated materials. (ARARs are listed in Appendix A of the Technology Descriptions Volume.)

6.5.1.3 Long-Term Effectiveness and Permanence

Although agent-contaminated soil remains in place, as does soil with human health exceedances, residual risk is low. Site reviews and soil monitoring are required. The existing habitat is not changed by this remedial alternative.

6.5.1.4 Reduction in TMV

There is no reduction in TMV since no soil is treated or contained. A total of 270,000 SY of soil with potential agent and human health exceedances remain in place.

6.5.1.5 Short-Term Effectiveness

RAOs are not achieved since soil with potential agent and isolated human health exceedances remains. This alternative does not pose risk to workers and the community during remedial actions since no actions are taken. The existing habitat is not changed by remedial actions.

6.5.1.6 Implementability

The alternative is technically and administratively feasible. Monitoring services and site reviews are required.

6.5.1.7 Cost

The total present worth cost is $82,600 and includes only long-term O&M costs associated with long-term monitoring and site reviews. Table B2.2-A1 details costing for this alternative. The cost uncertainty relative to monitoring and site reviews is low.

6.5.2 <u>Alternative A2: Caps/Covers</u>

Alternative A2: Caps/Covers (Soil Cover) involves placing a soil cover over 130,000 SY of soil with potential agent presence and isolated human health exceedances, and an additional 140,000 SY of soil within the New Toxic Storage Yards. The soil subgrade is compacted before any cover materials are installed, and the area receiving the soil cover is crowned with 360,000 BCY of fill to facilitate surface-water runoff. The area is covered by 4 ft of fill (which includes 6 inches of reconditioned soil) and is then revegetated. The soil/vegetation cover provides a physical barrier to protect human and biota receptors from directly contacting soil with potential agent presence. The fill material is excavated from an on-post borrow area. The covering operations require less than 1 year to complete, and long-term maintenance activities ensure the continued integrity of the soil cover.

The following discussion presents a detailed evaluation of this alternative against the DAA criteria listed in the NCP (EPA 1990a). For purposes of comparison, Table 6.5-1 summarizes the evaluation of all alternatives developed for this subgroup.

6.5.2.1 Overall Protection of Human Health and Environment

This alternative achieves RAOs since soil potentially containing agent and other contamination is contained by a soil cover to prevent exposure. Groundwater impacts are reduced through placement of the soil cover.

6.5.2.2 Compliance with ARARs

This alternative complies with action-specific ARARs regarding construction of a soil cover layer and monitoring of the contained material. Endangered species are not impacted. Location-specific ARARs are met as sites in the Toxic Storage Yards Subgroup are not located in wetlands or a 100-year flood plain. This alternative is not subject to Army regulations pertaining to demilitarization since any soil with agent is contained; it does, however, comply with the provisions of the FFA (EPA et al. 1989). (ARARs are listed in Appendix A of the Technology Descriptions Volume.)

6.5.2.3 Long-Term Effectiveness and Permanence

The residual risk is minimal since 130,000 SY of soil with potential agent presence are contained through installation of a soil cover. There is high confidence in the engineering controls used for the soil cover. Long-term monitoring and site reviews are required for the soil cover, as are erosion-control activities and maintenance of the soil/vegetation layer. The overall habitat quality for the site is improved through revegetation of disturbed areas, although the types of vegetation placed at the site and the maintenance activities performed there are designed to discourage burrowing animals from using the covered area as habitat.

6.5.2.4 Reduction in TMV

Human and biota exposure pathways are interrupted and the mobility of the contaminants is reduced through installation of a 270,000-SY soil cover. Reduction of contaminant mobility through containment is only reversible should the cover degrade or leak. There are no treatment residuals associated with this alternative.

6.5.2.5 Short-Term Effectiveness

This alternative presents minimal short-term risks to workers and the community since no intrusive activities are conducted. Personal protective equipment adequately protects workers during cover installation, and uncontaminated fugitive dust associated with the installation of a cover is controlled by water sprays. Vapor emissions are not anticipated. Impacts to the habitat are minimal. The time frame for completion of the alternative is 1 year.

6.5.2.6 Implementability

The alternative is technically feasible and can be implemented within the required time frame and reliably operated and maintained thereafter. Additional remedial actions are easily undertaken for soil left in place, although the cap adds to the overall site volume. The alternative is administratively feasible since the requirements of the cap design and construction regulations are achieved. Materials, specialists, and equipment are readily available, and soil covers are well demonstrated at full scale.

6.5.2.7 Cost

The total present worth cost is $5,750,000, including $5,560,000 and $192,000 for operating and long-term costs, respectively. Table B2.2-A2 details the costing for this alternative. There is a low level of uncertainty associated with the cost of this alternative since the materials required to construct the cover are available on post and the area to be contained is well defined (i.e., the uncertainty commonly associated with excavation does not exist).

6.5.3 Alternative A3: Direct Soil Washing; Landfill

Alternative A3: Direct Soil Washing (Caustic Solution Washing); Landfill (On-Post Landfill) addresses agent-contaminated soil in the Toxic Storage Yards Subgroup through the process of caustic solution washing as discussed in Section 6.2.3 and landfills the human health exceedance volume. The New Toxic Storage Yards are used as a borrow area for both low-permeability soil and structural fill. As a result, the risks potentially posed at the sites are further reduced. Depending on the refuge management plan's goals, the borrow area may be restored and revegetated as a wetland.

Caustic solution washing is a physical/chemical treatment process option in which agent-contaminated soil is excavated, mixed with caustic wash fluids in an aboveground unit to degrade the agent, and then separated from the wash water. The process of caustic washing of the agent-contaminated soil is performed in batches to achieve a decontamination level of 3X (Section 4.4.3), a level that indicates that the soil has been surface-decontaminated (AMC-R 385-131) (AMC 1987). The treatment level is documented through air monitoring in the mixing unit. The treated soil is placed in the on-post hazardous waste landfill.

During excavation of the human health exceedance volume (2,700 BCY) and preparation of the borrow areas, real-time monitoring is conducted to screen for agent. Agent presence is verified by analysis at the RMA laboratory. The agent-contaminated soil is then transported to the on-post caustic solution washing unit as described in Section 4.4.3. The treated soil and the remaining human health exceedance volume are landfilled. The borrow area within the New Toxic Storage Yards may be converted into a wetland or it may be revegetated with native grasses depending on what the USFWS determines in the refuge management plan.

The following discussion presents a detailed evaluation of this alternative against the DAA criteria listed in the NCP (EPA 1990a). For purposes of comparison, Table 6.5-1 summarizes the evaluation of all alternatives developed for this subgroup.

6.5.3.1 Overall Protection of Human Health and the Environment

This alternative achieves RAOs through treatment of agent-contaminated soil and containment of treated soil and isolated human health exceedances in an on-post landfill. There are significant short-term impacts associated with agent clearance and the excavation of contaminated soil, although the extent of excavation is limited. There are no impacts on surface-water or groundwater quality.

6.5.3.2 Compliance with ARARs

This alternative complies with action specific ARARs including state regulations on air emission sources and landfill siting, design, and operation. Endangered species are not impacted. Sites in the Toxic Storage Yards Subgroup, the caustic solution washing facility, and the landfill are not located in wetlands or a 100-year flood plain, thus complying with location-specific ARARs. Disposal in the landfill does not trigger LDRs since the landfill is a CAMU (as defined in Section 1.4). This alternative also complies with the provisions of the FFA and Army Materiel Command regulations (AMC-R 385-131) (Army 1987) regarding agent demilitarization. (ARARs are listed in Appendix A of the Technology Descriptions Volume.)

6.5.3.3 Long-Term Effectiveness and Permanence

The residual risk at the site is minimal since soil with agent is treated by caustic washing, and the treated soil and 2,700 BCY of untreated soil are contained in an on-post landfill. There is high confidence in the engineering controls for the landfill, and there are no expected difficulties associated with landfill maintenance, although landfill-cell monitoring is required. The existing habitat at the site is improved by revegetation following the removal of borrow materials; however, habitat at the landfill is eliminated.

6.5.3.4 Reduction in TMV

Soil washing irreversibly removes agent contamination from the soil. Exposure pathways for 2,700 BCY of untreated soil are interrupted, and mobility of the contaminants is reduced through containment in the landfill. Reduction of mobility is only reversible should the landfill fail. Treatment residuals include salts, which are landfilled on post along with the treated soil.

6.5.3.5 Short-Term Effectiveness

This alternative involves significant short-term risks associated with agent clearance, excavation, transportation, treatment, and landfilling of contaminated soil. These risks are reduced through engineering controls and use of personal protective equipment, but they cannot be completely removed. Engineering controls for dust (such as water sprays) or vapor/odor (such as daily covers, tarps, or foams) are initiated to reduce short-term risks; however, the adequacy of these controls has not been fully demonstrated, and the possibility exists for vapor/odor emissions during excavation in spite of these controls. There are also impacts on habitat during the development of the borrow area. The time frame until RAOs are achieved is 2 years. Landfilling of 2,700 BCY of soil is feasible within 1 year after 1 year for construction of the landfill. The construction of the caustic washing system takes 1 year.

6.5.3.6 Implementability

The alternative is technically feasible and can be implemented within the required time frame and reliably operated and maintained thereafter with periodic landfill-cell monitoring. Caustic solution washing is a batch process that is well suited for excavation of agent-contaminated soil at variable rates and frequencies. Additional remedial actions require removal of the landfill cover. The alternative is administratively feasible since the substantive requirements of the caustic washing unit and landfill siting, design, and operating regulations are achieved. Equipment, specialists, and materials are readily available for construction of the landfill, and the landfill technology has been well demonstrated at full scale. Although caustic solution washing is not well demonstrated at full scale, the equipment is well demonstrated and widely available.

6.5.3.7 Cost

The total present worth cost is $770,000 including $134,000, $634,000, and $2,000 for capital, operating, and long-term costs, respectively. Table B2.2-A3 details the costing for this alternative. A large cost uncertainty relative to identifying the agent-contaminated soil, as well as the extent and depth of contamination, exists.

6.5.4 Alternative A4: Incineration/Pyrolysis

Alternative A4: Incineration/Pyrolysis (Rotary Kiln Incineration) treats 220 BCY of agent-contaminated soil through on-post incineration. This alternative achieves the 5X criterion for materials containing agent as discussed in Section 4.4.4. Areas with the potential presence of agent (130,000 SY) are screened using a drilling program to identify soil containing agent. Soil samples or pore gas samples collected during drilling are screened by real-time field analytical methods for agent and suspected positive samples sent to the RMA laboratory for verification. The soil identified as containing agent is excavated and transported to the rotary kiln incinerator as described in Section 6.2.4. The particulates from the scrubber blowdown, which constitute an estimated 1 percent of the solids feed, along with 2,700 BCY of soil with isolated human health exceedances, are placed in the on-post landfill. The New Toxic Storage Yards are used as a borrow area for both low-permeability soil and structural fill. As a result, the risks potentially posed at the sites are further reduced. The borrow area is revegetated with native grasses or converted to a wetland, depending on the refuge management plan.

The following discussion presents a detailed evaluation of this alternative against the DAA criteria listed in the NCP (EPA 1990a). For purposes of comparison, Table 6.5-1 summarizes the evaluation of all alternatives developed for the subgroup.

6.5.4.1 Overall Protection of Human Health and the Environment

This alternative achieves Human Health RAOs through treatment and containment. Agent-contaminated soil is treated by incineration and backfilled. Blowdown solids and 2,700 BCY of untreated soil are placed in an on-post landfill. There are significant short-term impacts associated with agent clearance and the excavation of contaminated soil. There are no impacts on surface-water or groundwater quality.

6.5.4.2 Compliance with ARARs

This alternative complies with action specific ARARs including state regulations on air emissions sources, landfill siting, design, and operation. Endangered species are not impacted. Location-specific ARARs are met as sites in the Toxic Storage Yards Subgroup, incinerator, and the landfill are not located in wetlands or a 100-year flood plain. Disposal in the landfill does not trigger LDRs since the landfill is a CAMU (as defined in Section 1.4). This alternative also complies with provisions of the FFA (EPA et al. 1989) and Army Materiel Command regulations (AMC-R 385-131) (AMC 1987) regarding agent demilitarization. (ARARs are listed in Appendix A of the Technology Descriptions Volume.)

6.5.4.3 Long-Term Effectiveness and Permanence

The residual risk is minimal since agent-contaminated soil is incinerated and 2,700 BCY of untreated soil are contained in an on-post landfill. There is high confidence in the engineering controls for the landfill. Landfill-cell monitoring, site reviews, and landfill maintenance are required. The existing habitat at the site is improved by revegetation; however, habitat at the landfill is eliminated.

6.5.4.4 Reduction in TMV

Incineration irreversibly removes agent contamination from the soil. Exposure pathways for untreated soil are interrupted, and the mobility of the contaminants is reduced through containment in the landfill. The blowdown solids and soil with human health exceedances and with potential risk biota are landfilled. Reduction of mobility in this volume is only reversible should the landfill fail.

6.5.4.5 Short-Term Effectiveness

This alternative entails significant short-term risks associated with agent clearance, excavation, transportation, treatment, and landfilling of contaminated soil. These risks are reduced through engineering controls and use of personal protective equipment, but they cannot be completely eliminated. Engineering controls for dust (such as water sprays) or vapors/odors (such as daily covers, tarps, or foams) are initiated to reduce short-term risks; however, the adequacy of these controls has not yet been fully demonstrated, and the possibility exists for vapor/odor emissions during excavation in spite of these controls. In addition, the preparation of the feedstock prior to incineration presents short-term risks, although the materials handling is conducted in an enclosed building to control dust and vapors/odors, and the emissions from the incinerator contain low but acceptable levels of some contaminants, although the off-gas control system for the incinerator is designed to achieve air quality standards. Some environmental impacts exist during the development of the borrow area. The time frame for completion of the alternative is 3 years. Incineration of the small volume of contaminated soil is feasible within 1 year after 2 years for construction of the incineration facility, and containment of 2,700 BCY is feasible within 1 year after 1 year for construction of the landfill.

6.5.4.6 Implementability

The alternative is technically feasible and can be implemented within the required time frame and reliably operated and maintained thereafter. Additional remedial actions require removal of the landfill cover. Landfill-cell monitoring, landfill maintenance, and site reviews are required. Administrative difficulties associated with demonstrating compliance with permits and operating and maintenance regulations for the incinerator may lead to delays, and it may be difficult to implement this alternative due to the perceptions regarding the safety of incineration. Equipment, specialists, and materials are readily available for the construction of the landfill and design and construction of the incinerator. Landfills and incinerators have been well demonstrated at full scale.

6.5.4.7 Cost

The total present worth cost is $1,910,000 including $67,000, $1,840,000, and $2,000 for capital, operating, and long-term costs, respectively. Table B2.2-A4 details the costing for this alternative. A cost uncertainty relative to identifying the extent and depth of contamination and evaluating the presence of agent exists; however, the magnitude of this uncertainty is relatively small based on the small volume of soil to be excavated. In addition, there is a high level of uncertainty relative to maintaining the estimated on-line percentage. Possible delays in implementation and variations in contaminant levels in the soil feed may also increase treatment costs.

The cost estimate for incineration is based on treating several hundred thousand bank cubic yards of contaminated soil on a continuous basis. The treatment of the small volume of agent-contaminated soil requires operating the equipment on a batch basis, which would substantially increase the unit cost were incineration not selected for other medium groups.

6.5.5 Alternative A5: Direct Soil Washing; Landfill

Alternative A5: Direct Soil Washing (Solvent Extraction); Landfill (On-Post Landfill) addresses the 220 BCY of agent-contaminated soil in the Toxic Storage Yards Subgroup through the process of solvent extraction with a caustic solution. Solvent extraction is a physical/chemical treatment process option in which agent-contaminated soil is excavated, mixed with a caustic solution to adjust the pH which degrades agent, agitated with an organic solvent to extract any other organic contaminants, and then separated from the wash solvent. Most of the solvent is recycled, and the waste solvent containing the contaminants is disposed off post. The process of solvent extraction of the agent-contaminated soil is presented in Section 6.2.5. The treated soil is placed in the on-post hazardous waste landfill.

The first step is to screen the suspected areas (130,000 SY) for agent-contaminated soil, which is accomplished using real-time monitoring of samples collected from boreholes. Agent presence is verified by analysis at the RMA laboratory. The agent-contaminated soil is then excavated and transported to the on-post solvent extraction unit as described in Section 4.4.5. The New Toxic Storage Yards are used as a borrow area for both low-permeability soil and structural fill. As a result, the risks potentially posed at the sites are further reduced. The soil in the borrow area is reconditioned and revegetated with native grasses, or converted to a wetland, thereby restoring the value of the habitat.

The 2,700 BCY of soil with isolated human health exceedances are excavated and placed in the on-post hazardous waste landfill along with the treated soil. The on-post hazardous waste landfill requires 1 year to construct and is fenced to restrict wildlife access. The landfill requires long-term (30-year) maintenance and monitoring after closure.

The following discussion presents a detailed evaluation of this alternative against the DAA criteria listed in the NCP (EPA 1990a). For purposes of comparison, Table 6.5-1 summarizes the evaluation of all alternatives developed for this subgroup.

6.5.5.1 Overall Protection of Human Health and the Environment

This alternative achieves RAOs through treatment of agent-contaminated soil and containment of the treated soil and 2,700 BCY of untreated soil in an on-post landfill. There are significant short-term impacts associated with agent clearance and the excavation of contaminated soil. There are no impacts on surface-water or groundwater quality.

6.5.5.2 Compliance with ARARs

This alternative complies with action specific ARARs including state regulations on air emission sources and landfill siting, design, and operation. Endangered species are not impacted. Sites in the Toxic Storage Yards Subgroup, solvent extraction facility, and landfill are not located in wetlands or a 100-year flood plain, thus complying with location-specific ARARs. Disposal in the landfill does not trigger LDRs since the landfill is a CAMU (as defined in Section 1.4). This alternative also complies with the provisions of the FFA (EPA et al. 1989) and Army Materiel Command regulations (AMC-R 385-131) (AMC 1987) regarding agent demilitarization. (ARARs are listed in Appendix A of the Technology Descriptions Volume.)

6.5.5.3 Long-Term Effectiveness and Permanence

The residual risks are minimal since agent-contaminated soil is treated and the treated soil and 2,700 BCY of untreated soil are placed in an on-post landfill. There is high confidence in the engineering controls used for the landfill, and there are no expected difficulties associated with landfill maintenance, although landfill-cell monitoring, maintenance, and site reviews are required.

The existing habitat at the site is improved by revegetation following the removal of borrow materials; however, habitat at the landfill is eliminated.

6.5.5.4 Reduction in TMV

Soil washing irreversibly removes agent contamination from the soil. Exposure pathways for untreated soil are interrupted, and mobility of contaminants is reduced through containment in the landfill. Reduction of mobility for this volume is only reversible should the landfill fail. For each cubic yard of agent-contaminated soil that is treated, approximately 1 to 2 gallons of residual solvent is sent off site for disposal.

6.5.5.5 Short-Term Effectiveness

This alternative entails significant short-term risks associated with agent clearance, excavation, transportation, treatment, and landfilling of contaminated soil. These risks are reduced through engineering controls and use of personal protective equipment, but they cannot be completely removed. Engineering controls for dust (such as water sprays) or vapors/odors (such as daily covers, tarps, or foams) are initiated to reduce short-term risks; however, the adequacy of these controls has not yet been fully demonstrated, and the possibility exists for vapor/odor emissions during excavation in spite of these controls. In addition, the preparation of the feedstock prior to solvent extraction presents short-term risks, although the materials handing is conducted in an enclosed building to control dust and vapors/odors. There are some impacts to the environment due to the development of the borrow area. The time frame until RAOs are achieved is 3 years: solvent extraction of the small amount of agent-contaminated soil is feasible within 2 years, and landfilling of 2,700 BCY of soil is feasible within 1 year after 1 year for construction of the landfill.

6.5.5.6 Implementability

This alternative is very difficult to implement because, although commercial solvent extraction units are available, the technology has not yet been demonstrated at the scale required for RMA. Performance data are not available to document the effectiveness of the technology for treating agent-contaminated soil. The landfill portion can be implemented within the required time frame and reliably operated and maintained thereafter with periodic landfill-cell monitoring. Additional remedial actions require removal of landfill cover. The alternative is administratively feasible since the substantive requirements of the solvent extraction unit and landfill siting, design, and operating regulations are achieved. Limited vendor sources are available for the solvent extraction unit. Equipment, specialists, and materials are readily available for construction of the landfill, and the landfill technology has been well demonstrated at full scale.

6.5.5.7 Cost

The total present worth cost is $2,050,000 including $88,000, $1,960,000, and $2,000 for capital, operating, and long-term costs, respectively. Table B2.2-A5 details costing for this alternative. A cost uncertainty relative to identifying the extent and depth of contamination and evaluating the presence of agent exists. In addition, there is a high level of uncertainty relative to achieving the estimated on-line percentage since operating data are not available at the necessary scale. The potential for delays associated with maintenance and from variations in contaminant levels in the soil feed also adds to the cost uncertainty.

The cost estimate for solvent extraction is based on treating hundreds of thousands cubic yards of contaminated soil on a continuous basis. The treatment of the small volume of agent-contaminated soil requires operating the equipment on a batch basis, which would substantially increase the unit cost of this alternative were solvent extraction not selected for other medium groups.

6.6 COMPARATIVE ANALYSIS OF ALTERNATIVES

Agent is expected to be found in 220 BCY of soil in sites in the Toxic Storage Yards Subgroup. These sites are suspected to potentially contain agent based on historical usage or the presence of agent breakdown products. Four isolated detections of CLC2A and five detections of arsenic above the Human Health SEC (EBASCO 1994a) isolated in three areas account for 2,700 BCY of human health exceedance volume. The presence of agent was not confirmed in the Soil Volume Refinement Program (EBASCO 1994b). Soil posing potential risk to biota is not specifically addressed because this soil is part of the surficial soil medium group adjacent to the defined Toxic Storage Yard Sites, and this soil may be used as borrow material.

Areas disturbed by remedial actions are to be revegetated after remediation to restore and improve the habitat. The two sites in this subgroup that are within the Bald Eagle Management Area are considered sensitive habitat, so remedial actions for these sites must be coordinated with USFWS to ensure that habitat disturbance is minimized.

Evaluation of alternatives for this subgroup must consider whether the long-term risks associated with leaving potential agent contamination in place outweigh the short-term risks to site workers and to biota in sensitive habitats. Risks to site workers can be minimized with appropriate health and safety equipment and procedures.

Alternative 1: No Additional Action (Provisions of FFA) does not protect human health and was eliminated from further consideration since soil potentially contaminated with agent remains in place. The four remaining alternatives achieve RAOs and meet the two DAA threshold criteria—protection of human health and the environment and compliance with action-specific and location-specific ARARs.

Alternative A2: Caps/Covers presents low long-term residual risks without incurring short-term risks. This option also interrupts exposure pathways, reduces impacts on groundwater, and produces no treatment residuals. This technology is well demonstrated, but its high cost ($5,750,000) indicates that this alternative is not cost effective. As a result, this alternative was eliminated from further consideration.

Alternative A3: Direct Soil Washing (Caustic Solution Washing); Landfill (On Post Landfill) involves the limited excavation and treatment of agent-contaminated soil prior to landfilling at a comparatively low cost of $770,000. A drawback of the alternative includes the hazards of agent clearance, although the excavation is limited. A caustic washing system would have to be designed and constructed, but equipment is readily available. The New Toxic Storage Yards are used as a borrow area for both low-permeability soil and structural fill. As a result, the risks potentially posed at the sites are further reduced. This alternative is retained for further consideration.

Alternative A5: Direct Soil Washing Landfill involves limited excavation and treatment of agent-contaminated soil prior to landfilling the treated soil. This alternative has several disadvantages. First, treatment residuals, an estimated 1 to 2 gallons of solvent for every cubic yard treated, require off-post treatment. Second, the alternative presents short-term risks to workers from excavation and agent-clearance activities. Third, the treatment of the small volume of agent-contaminated soil requires operating the equipment on a batch basis, which would substantially increase the unit cost. For these reasons, this alternative was not retained for further consideration.

Alternative A4: Incineration/Pyrolysis addresses agent contamination through thermal treatment and does not require landfilling of treated soil. Administrative difficulties associated with demonstrating compliance with permits and operating and maintenance regulations for the incinerator may lead to delays, and it may be difficult to implement this alternative due to the poor public perceptions regarding the safety of incineration. This alternative entails short-term risks to workers during excavation and agent-clearance activities. The treatment of the small volume of agent-contaminated soil requires operating the equipment on a batch basis, which would substantially increase the unit cost. Accordingly, this alternative was not retained since it is has limited administrative feasibility based on public concerns.

Consequently, the alternative that was retained to represent the Toxic Storage Yards Subgroup in the development of the sitewide alternatives (Section 20) is the following:

- Alternative A3: Direct Soil Washing (Caustic Solution Washing); Landfill (On Post Landfill)

Table 6.0-1 Characteristics of the Agent Storage Medium Group[1]

Characteristic	North Plants Subgroup	Toxic Storage Yards Subgroup
Contaminants of Concern		
Human Health	As	CLC2A, As
Biota	OCPs	none (within human health)
Exceedance Area (SY)		
Total	50,000	1,800
Human Health	330	1,800
Principal Threat	0	0
Biota	50,000	0
Potential Agent	28,000	130,000
Potential UXO	not applicable	not applicable
Exceedance Volume (BCY)		
Total	--	2,700
Human Health	220	2,700
Organic	0	2,400
Inorganic	220	310
Principal Threat	0	0
Biota	17,000	0
Potential Agent	61	220
Potential UXO	not applicable	not applicable
Depth of Contamination (ft)		
Human Health	0-1	0-6
Biota	not applicable	not applicable

1 Any soil that may present risks to biota in this medium group will be addressed through continued monitoring (Section 3)

Table 6.1-1 Summary of Contaminant Concentrations for the North Plants Subgroup

Contaminants of Concern	Range of Concentrations[1] (ppm)	Average Concentration[1] (ppm)	Human Health SEC (ppm)	Human Health Principal Threat Criteria (ppm)	Human Health Acute Criteria (ppm)
Human Health Exceedance Volume					
Arsenic	312–10,000	2,800	420	4,200	270
Biota Volume					
Dieldrin	0.01–2.9	0.25	41	410	3.7
Endrin	0.003–0.09	0.02	230	230,000	56
Arsenic	2.8–260	33.5	420	4,200	270
Mercury	0.05–2.9	0.5	570	570	82

1 Based on concentrations of contaminants of concern above SEC within the human health exceedance volume and on concentrations within the potential biota risk area for the biota volume.

Table 6.1-2 Frequency of Detections for North Plants Subgroup

	Total Samples Analyzed	BCRL Number	BCRL %	CRL-SEC(1) Number	CRL-SEC(1) %	Acute-HH SEC(2) Number	Acute-HH SEC(2) %	HH SEC-Pr. Threat(2) Number	HH SEC-Pr. Threat(2) %	>Pr. Threat(2) Number	>Pr. Threat(2) %
Aldrin	127	117	92.1%	10	7.9%	0	0.0%	0	0.0%	0	0.0%
Benzene	61	55	90.2%	6	9.8%	--	--	0	0.0%	0	0.0%
Carbon Tetrachloride	55	54	98.2%	0	0.0%	--	--	1	1.8%	0	0.0%
Chlordane	124	88	71.0%	36	29.0%	0	0.0%	0	0.0%	0	0.0%
Chloroacetic Acid	95	94	98.9%	1	1.1%	--	--	0	0.0%	0	0.0%
Chlorobenzene	55	54	98.2%	1	1.8%	--	--	0	0.0%	0	0.0%
Chloroform	55	54	98.2%	1	1.8%	--	--	0	0.0%	0	0.0%
p,p,DDE	127	124	97.6%	3	2.4%	--	--	0	0.0%	0	0.0%
p,p,DDT	127	117	92.1%	10	7.9%	0	0.0%	0	0.0%	0	0.0%
Dibromochloropropane	113	113	100.0%	0	0.0%	--	--	0	0.0%	0	0.0%
1,2-Dichloroethane	55	54	98.2%	1	1.8%	--	--	0	0.0%	0	0.0%
1,1-Dichloroethene	14	13	92.9%	[illegible]	0.0%	--	--	1	7.1%	0	0.0%
Dicyclopentadiene	113	113	100.0%	0	0.0%	--	--	0	0.0%	0	0.0%
Dieldrin	127	106	83.5%	21	16.5%	0	0.0%	0	0.0%	0	0.0%
Endrin	127	114	89.8%	13	10.2%	0	0.0%	0	0.0%	0	0.0%
Hexachlorocyclopentadiene	121	121	100.0%	0	0.0%	--	--	0	0.0%	0	0.0%
Isodrin	127	125	98.4%	2	1.6%	--	--	0	0.0%	0	0.0%
Methylene Chloride	53	53	100.0%	0	0.0%	--	--	0	0.0%	0	0.0%
Tetrachloroethylene	55	53	96.4%	2	3.6%	--	--	0	0.0%	0	0.0%
Toluene	59	59	100.0%	0	0.0%	--	--	0	0.0%	0	0.0%
Trichloroethylene	55	54	98.2%	1	1.8%	--	--	0	0.0%	0	0.0%
Arsenic	110	50	45.5%	54	49.1%	2	1.8%	2	1.8%	2	1.8%
Cadmium	93	80	86.0%	13	14.0%	0	0.0%	0	0.0%	0	0.0%
Chromium	93	1	1.1%	92	98.9%	--	--	0	0.0%	0	0.0%
Lead	93	26	28.0%	67	72.0%	--	--	0	0.0%	0	0.0%
Mercury	89	65	73.0%	24	27.0%	0	0.0%	0	0.0%	0	0.0%

(1) SEC limits for this interval are based on chronic HH SEC, or where appropriate, acute risk-based criteria for the 0- to 1-ft depth interval.

(2) Table 1.4-1 presents acute criteria, HH SEC, and principal threat criteria.

-- not applicable

Table 6.2-1 Comparative Analysis of Alternatives for the North Plants Subgroup

Criteria	Alternative A1: No Additional Action	Alternative A2: Caps/Covers	Alternative A3: Direct Soil Washing; Landfill	Alternative A4: Incineration/Pyrolysis	Alternative A5: Direct Soil Washing; Landfill
1. Overall protection of human health and the environment	Not Protective: Does not achieve RAOs, impacts to groundwater not reduced	Protective: Achieves RAOs through containment; groundwater impacts reduced	Protective: RAOs achieved through treatment and containment; ground water impacts reduced	Protective: RAOs achieved through treatment and containment; ground water impacts reduced	Protective: RAOs achieved through treatment and containment; ground water impacts reduced
2. Compliance with ARARs	Does not comply with Army regulations regarding the control of agent-contaminated materials	Complies	Complies	Complies	Complies
3. Long-term effectiveness and permanence	Low Residual Risk	Minimal Residual Risk: Containment provides protection	Minimal Residual Risk: All contaminated soil removed and treated and/or contained	Minimal Residual Risk: All contaminated soil removed and treated and/or contained	Minimal Residual Risk: All contaminated soil removed and treated and/or contained
4. Reduction in TMV	No reduction in TMV except by natural attenuation	Mobility reduced through containment	Soil washing eliminates TMV for agent-contaminated soil; mobility reduced for remainder through containment	Incineration eliminates TMV for agent-contaminated soil; mobility reduced for remainder through containment	Soil washing eliminates TMV for agent-contaminated soil; mobility reduced for remainder through containment; treatment residuals include 1 to 2 gallons of liquid for each cubic yard treated
5. Short-term effectiveness	RAOs not achieved; no implementation required	Minimal Short-Term Risk; no intrusive activity; RAOs achieved in 1 year	Significant short-term risk associated with excavation, transport, and treatment of contaminated soil; RAOs achieved in 2 years	Significant short-term risk associated with excavation, transport, and treatment of contaminated soil RAOs achieved in 3 years	Significant short-term risk associated with excavation, transport, and treatment of contaminated soil; RAOs achieved in 2 years
6. Implementability	Feasible	Feasible	Soil washing not demonstrated at scale required for RMA, but equipment available; feasible	Limited administrative feasibility associated with poor public perception of incineration	Solvent washing not demonstrated at scale required for RMA and for Army agent; not feasible
7. Present worth costs	Capital—$0 Operating—$0 Long-term—$82,600 Total—$82,600	Capital—$0 Operating—$1,170,000 Long-term—$129,000 Total—$1,300,000	Capital—$24,000 Operating—$1,320,000 Long-term—$172,000 Total—$1,520,000	Capital—$13,000 Operating—$678,000 Long-term—$101,000 Total—$792,000	Capital—$11,000 Operating—$722,000 Long-term—$108,000 Total—$841,000
Summary	Not Retained: Not protective of human health and the environment	Not Retained; less protective than A3 but same cost	Retained: Protection provided through treatment and containment	Not Retained: Limited feasibility	Not Retained: Large volume of treatment residuals that must be treated off post; not demonstrated

Table 6.4-1 Summary of Contaminant Concentrations for the Toxic Storage Yards Subgroup

Contaminants of Concern	Range of Concentrations[1] (ppm)	Average Concentration[1] (ppm)	Human Health SEC (ppm)	Human Health Principal Threat Criteria (ppm)	Human Health Acute Criteria (ppm)
<u>Human Health Exceedance Volume</u>					
CLC2A	80–134	115	77	77	3,900
Arsenic	270–4,000	1,600	420	4,200	270
<u>Biota Volume</u>					
Arsenic	BCRL–140	3.6	420	4,200	270
Mercury	BCRL–30	0.15			82

[1] Based on concentrations of contaminants of concern above SEC within the human health exceedance volume and on concentrations within the potential biota risk area for the biota volume.

Table 6.4-2 Frequency of Detections for Toxic Storage Yards Subgroup

	Total Samples	BCRL		CRL-SEC(1)		Acute-HH SEC(2)		HH SEC-Pr. Threat(2)		>Pr. Threat(2)	
	Analyzed	Number	%	Number	%	Number	%	Number	%	Number	%
Aldrin	295	292	99.0%	3	1.0%	0	0.0%	0	0.0%	0	0.0%
Benzene	108	105	97.2%	3	2.8%	--	--	0	0.0%	0	0.0%
Carbon Tetrachloride	108	108	100.0%	0	0.0%	--	--	0	0.0%	0	0.0%
Chlordane	288	260	90.3%	28	9.7%	0	0.0%	0	0.0%	0	0.0%
Chloroacetic Acid	601	586	97.5%	11	1.8%	--	--	4	0.7%	0	0.0%
Chlorobenzene	108	107	99.1%	1	0.9%	--	--	0	0.0%	0	0.0%
Chloroform	108	108	100.0%	0	0.0%	--	--	0	0.0%	0	0.0%
p,p,DDE	295	295	100.0%	0	0.0%	--	--	0	0.0%	0	0.0%
p,p,DDT	295	294	99.7%	1	0.3%	0	0.0%	0	0.0%	0	0.0%
Dibromochloropropane	315	315	100.0%	0	0.0%	--	--	0	0.0%	0	0.0%
1,2-Dichloroethane	108	108	100.0%	0	0.0%	--	--	0	0.0%	0	0.0%
1,1-Dichloroethene	63	63	100.0%	0	0.0%	--	--	0	0.0%	0	0.0%
Dicyclopentadiene	311	311	100.0%	0	0.0%	--	--	0	0.0%	0	0.0%
Dieldrin	295	286	96.9%	9	3.1%	0	0.0%	0	0.0%	0	0.0%
Endrin	296	295	99.7%	1	0.3%	0	0.0%	0	0.0%	0	0.0%
Hexachlorocyclopentadiene	326	326	100.0%	0	0.0%	--	--	0	0.0%	0	0.0%
Isodrin	295	295	100.0%	0	0.0%	--	--	0	0.0%	0	0.0%
Methylene Chloride	107	103	96.3%	4	3.7%	--	--	0	0.0%	0	0.0%
Tetrachloroethane	61	61	100.0%	0	0.0%	--	--	0	0.0%	0	0.0%
Tetrachloroethylene	108	106	98.1%	2	1.9%	--	--	0	0.0%	0	0.0%
Toluene	107	102	95.3%	5	4.7%	--	--	0	0.0%	0	0.0%
Trichloroethylene	108	105	97.2%	3	2.8%	--	--	0	0.0%	0	0.0%
Arsenic	657	137	20.9%	515	78.4%	0	0.0%	5	0.8%	0	0.0%
Cadmium	235	224	95.3%	11	4.7%	0	0.0%	0	0.0%	0	0.0%
Chromium	235	12	5.1%	222	94.5%	--	--	1	0.4%	0	0.0%
Lead	235	80	34.0%	155	66.0%	--	--	0	0.0%	0	0.0%
Mercury	633	618	97.6%	14	2.2%	1	0.2%	0	0.0%	0	0.0%

(1) SEC limits for this interval are based on chronic HH SEC, or where appropriate, acute risk-based criteria for the 0- to 1-ft depth interval.
(2) Table 1.4-1 presents acute criteria, HH SEC, and principal threat criteria.
-- not applicable

Table 6 Comparative Analysis of Alternatives for the Toxic Stora 'ards Subgroup

Criteria	Alternative A1: No Additional Action	Alternative A2: Caps/Covers	Alternative A3: Direct Soil Washing; Landfill	Alternative A4: Incineration/Pyrolysis	Alternative A5: Soil Direct Soil Washing; Landfill
1. Overall protection of human health and the environment	Not Protective: Does not achieve RAOs, impacts to groundwater not reduced	Protective: Achieves RAOs through containment; groundwater impacts reduced	Protective: RAOs achieved through treatment and containment; no groundwater impacts	Protective: RAOs achieved through treatment and containment; no groundwater impacts	Protective: RAOs achieved through treatment and containment; no groundwater impacts
2. Compliance with ARARs	Does not comply with Army regulations regarding the control of agent-contaminated materials	Complies	Complies	Complies	Complies
3. Long-term effectiveness and permanence	Low Residual Risk	Minimal Residual Risk: Containment provides protection	Minimal Residual Risk: All contaminated soil removed and treated and/or contained	Minimal Residual Risk: All contaminated soil removed and treated and/or contained	Minimal Residual Risk: All contaminated soil removed and treated and/or contained
4. Reduction in TMV	No reduction in TMV except by natural attenuation	Mobility reduced through containment	Soil washing eliminates TMV for agent-contaminated soil; mobility reduced for remainder through containment	Incineration eliminates TMV for agent-contaminated soil; mobility reduced for remainder through containment	Soil washing eliminates TMV for agent-contaminated soil; mobility reduced for remainder through containment; treatment residuals include 1 to 2 gallons of liquid for each cubic yard treated
5. Short-term effectiveness	RAOs not achieved	Minimal short-term risk; no intrusive activity; RAOs achieved in 1 year	Significant short-term risk associated with excavation, transport, and treatment of contaminated soil; RAOs achieved in 2 years	Significant short-term risk associated with excavation, transport, and treatment of contaminated soil; RAOs achieved in 3 years	Significant short-term risk associated with excavation, transport, and treatment of contaminated soil; RAOs achieved in 3 years
6. Implementability	No Implementation Required	Feasible	Soil washing not demonstrated at scale required for RMA, but equipment available; feasible	Limited administrative feasibility associated with poor public perception of incineration	Solvent washing not demonstrated at scale required for RMA or for Army agent
7. Present worth costs	Capital—$0 Operating—$0 Long-term—$82,600 Total—$82,600	Capital—$0 Operating—$5,560,000 Long-term—$192,000 Total—$5,750,000	Capital—$134,000 Operating—$634,000 Long-term—$2,000 Total—$770,000	Capital—$67,000 Operating—$1,840,000 Long-term—$2,000 Total—$1,910,000	Capital—$88,000 Operating—$1,960,000 Long-term—$2,000 Total—$2,050,000
Summary	Not Retained: Not protective of human health and the environment	Not Retained: Not cost effective	Retained: Protection provided through treatment and containment	Not Retained: Limited in feasibility	Not Retained: Large volume of treatment residuals that must be treated off post; not demonstrated

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ROCKY MOUNTAIN ARSENAL
INDEX MAP

LEGEND

North Plants Subgroup
SITES: NPSA-3, GB Manufacturing Area
NPSA-5, Special Weapons Plant
NPSA-6, Underground Spill Area
Building 1601, GB and Bomb Plant
Building 1606, Cluster Assembly Building
Building 1607, Warehouse

Site Boundary

Buildings and Roads

25 Section Number

300 0 300 600 FEET

Prepared for:

U.S. Army Program Manager
for Rocky Mountain Arsenal

October 1995

FIGURE 6.0-1

Site Locations
North Plants Subgroup

Rocky Mountain Arsenal.
Prepared by: Foster Wheeler Environmental Corporation

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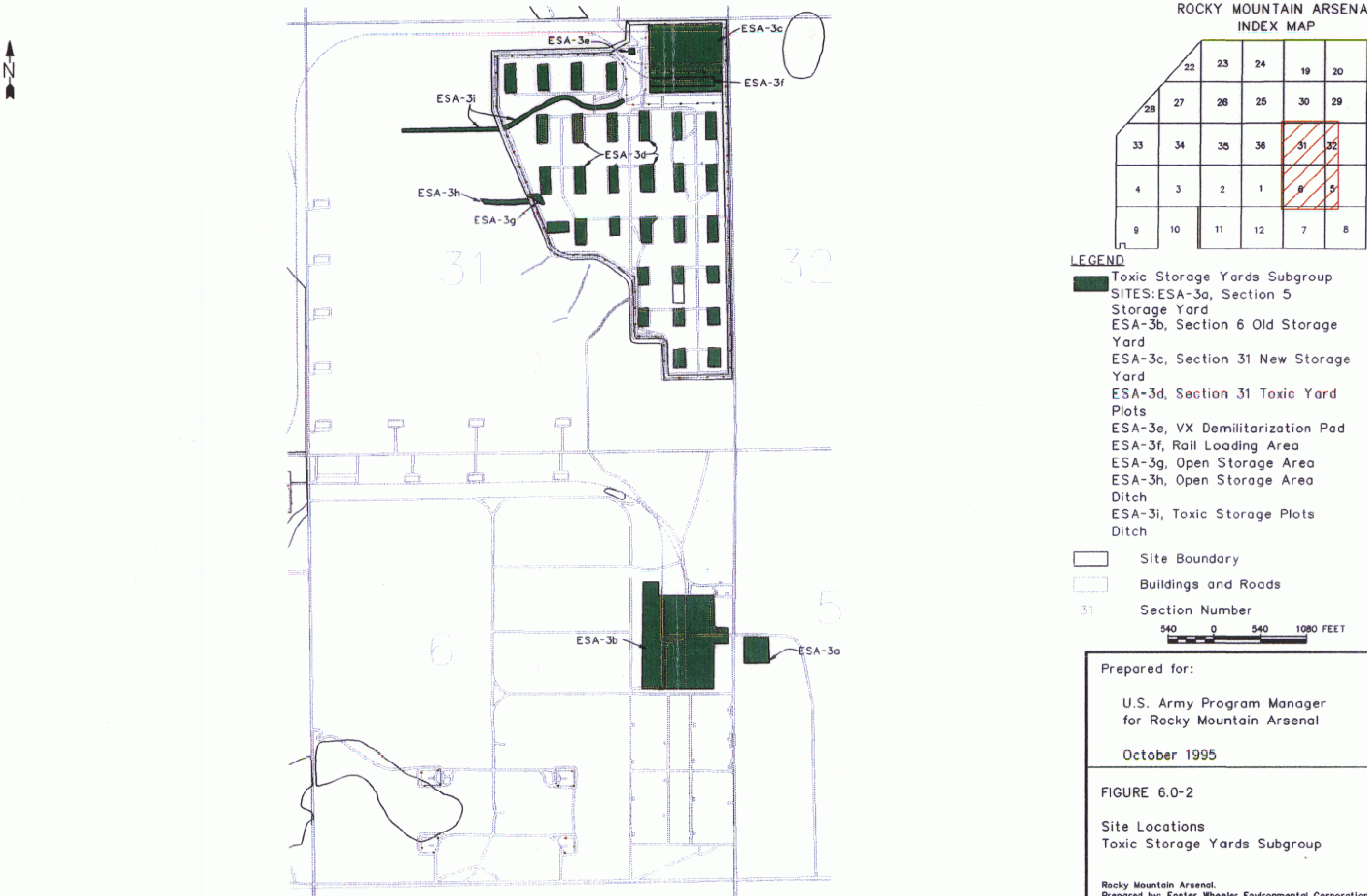

Prepared for:

U.S. Army Program Manager
for Rocky Mountain Arsenal

October 1995

FIGURE 6.0-2

Site Locations
Toxic Storage Yards Subgroup

Rocky Mountain Arsenal.
Prepared by: Foster Wheeler Environmental Corporation

Prepared for:

U.S. Army Program Manager
for Rocky Mountain Arsenal

October 1995

FIGURE 6.1-1

Exceedance Areas
North Plants Subgroup

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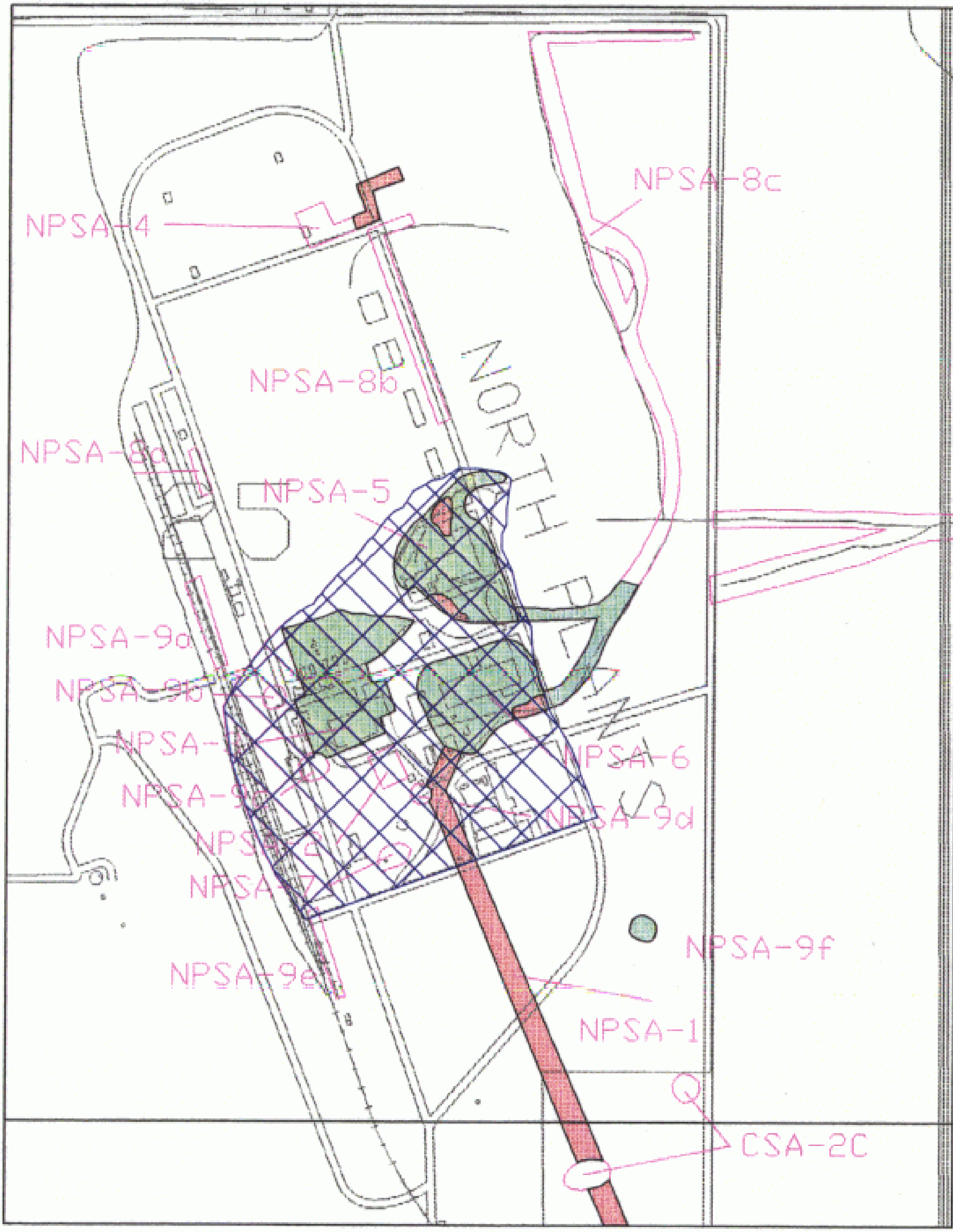

Legend

Human Health Exceedance Area

Excess Biota Risk Area (excluding surficial soil)

2 Foot Soil Cover Area

SAR Site and ID

31 Section Number

Section Line

Drainage

Road

Railroad

0 300 600
Scale in Feet

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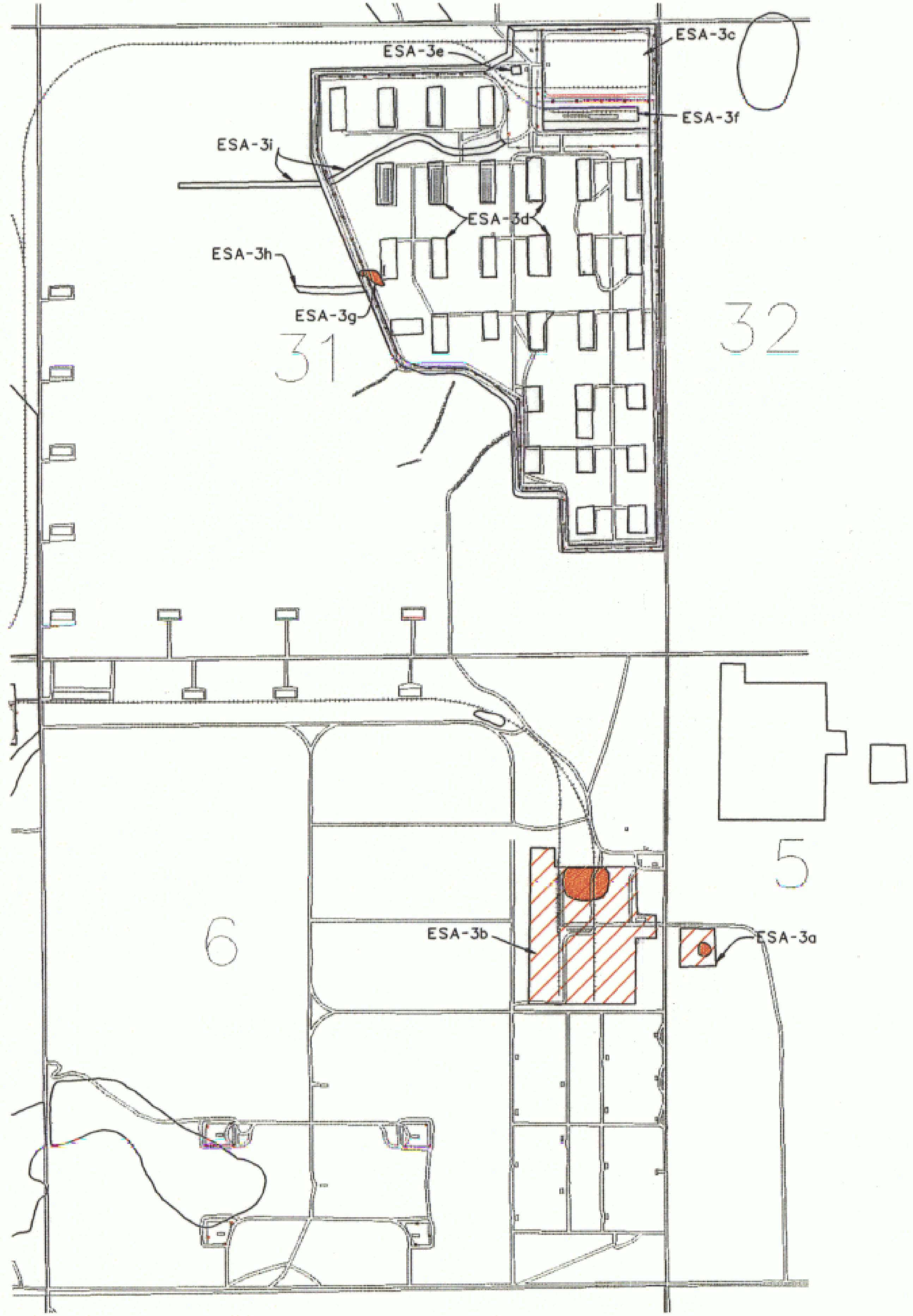
U.S. Army Program Manager
for Rocky Mountain Arsenal

Prepared October 1995

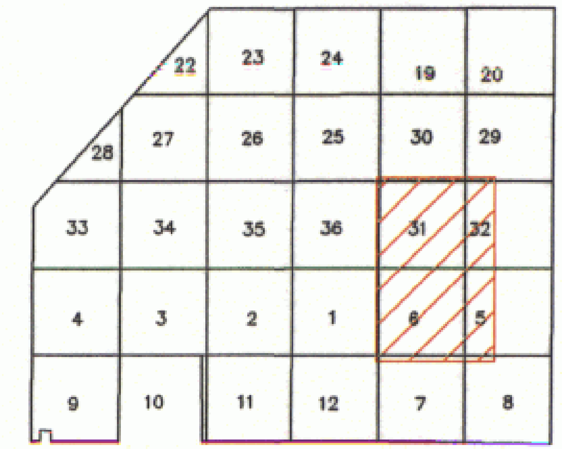
Figure 6.2-1

Soil Cover Areas
North Plants Subgroup

Rocky Mountain Arsenal
Prepared by: Foster Wheeler Environmental Corp.



ROCKY MOUNTAIN ARSENAL
INDEX MAP



LEGEND

- Human Health Exceedance Area
- Potential Agent Presesence Area
- Site Boundary
- Buildings and Roads
- 31 Section Number

540 0 540 1080 FEET

Prepared for:

U.S. Army Program Manager
for Rocky Mountain Arsenal

October 1995

FIGURE 6.4-1

Exceedance Areas
Toxic Storage Yards Subgroup

Rocky Mountain Arsenal.
Prepared by: Foster Wheeler Environmental Corporation

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Section 7

7.0 DETAILED ANALYSIS OF ALTERNATIVES FOR THE LAKE SEDIMENTS MEDIUM GROUP

The Lake Sediments Medium Group includes four lakes located in the southern portion of RMA and sediments from the North Bog (Figure 7.1-1). These sites were grouped together based on similar contamination patterns within the lakes and physical properties of the lake-bed sediments. Isolated exceedances of Human Health SEC (EBASCO 1994a) for acute exposure and levels of contaminants that potentially pose a risk to biota occur in Upper Derby Lake, which is dry and so can be managed as soil rather than sediment. Lower Derby Lake contains isolated human health exceedances. The IEA/RC report (EBASCO 1994a) indicates that contaminant concentrations in the sediment cannot be related to the measured body boundary in aquatic biota based on the available toxicological and contaminant data. Ultimately, however, soils from shoreline and surrounding upland areas are the source of contamination found in RMA lake sediments and waters, so biota contamination through the aquatic food chains is attributable to soil contamination in the vicinity of the lakes. There are no areas in the other lakes that exceed the Human Health SEC (EBASCO 1994a) or pose any potential risk to biota.

The COCs posing a potential risk to biota in this medium group are mainly OCPs. The concentrations of these COCs are below the certified reporting limits (CRLs) in the majority of the samples collected. Human health exceedances of chlordane, aldrin, and chromium were also detected, but only at isolated locations in Upper and Lower Derby Lakes. It has been suggested that the lake sediments within this medium group are potential sources of surface-water contamination based upon the direct contact of contaminated sediments with surface water (EBASCO 1992a). In addition, runoff from South Plants leads to some contamination of surface water. Furthermore, this medium group has not shown to be a source of contamination to groundwater. Table 7.0-1 presents the characteristics of this medium group, including exceedance volumes and COCs.

In the DSA (EBASCO 1992b), alternatives were developed and screened based on the general characteristics of the medium group. In the DAA, individual subgroups were not developed for the five sites, so the retained alternatives apply to the Lake Sediments Medium Group as a whole. The characteristics of the sites in this group—including contaminant types and contaminant concentrations, site configuration, and depth of contamination—were evaluated to determine whether any changes to the range of alternatives retained in the DSA (EBASCO 1992b) were appropriate. Based on this evaluation, two modifications were made to the retained alternatives. First, water is currently not being allowed to pond in Upper Derby Lake. The potential increase in risk to terrestrial biota that is a result of this action is addressed in the DAA by treating this volume as distinct from the aquatic sediments. Second, alternatives that consist of the in situ treatment of aquatic sediments were removed because the destruction of aquatic habitat they would entail and because risk to aquatic biota could not be derived based on the available toxicological and contaminant-distribution data. However, monitoring activities will be conducted for aquatic sediments.

The following sections present the characteristics of the medium group, an evaluation of the retained alternatives against the DAA criteria listed in the NCP (EPA 1990a), and the selection of alternatives, based on a comparative analysis, that was considered in the development of the sitewide alternatives (Section 20).

7.1 MEDIUM GROUP CHARACTERISTICS

The Lake Sediments Medium Group is composed of sites NCSA-7 (North Bog), SSA-1b (Upper Derby Lake), SSA-1c (Lower Derby Lake), SSA-1e (Lake Ladora), and SSA-5b (Havana/Peoria Street Ponds) (Figure 7.1-1). The water from Upper and Lower Derby lakes and Lake Ladora was formerly used as process/coolant water for South Plants. These sites contain sediments contaminated by the influx of suspended solid- or dissolved-phase contaminants transported to the lakes by groundwater or surface water. Upper and Lower Derby lakes contain contamination that poses a potential risk to humans, and Upper Derby Lake alone poses potential risk to biota; therefore, the alternatives in this section focus on these lakes.

Table 7.1-1 provides a summary of contaminants, concentrations within the exceedance volume, and the corresponding exceedance values for the medium group. Table 7.1-2 summarizes the frequency of detections for samples taken at sites within the medium group. As shown by these tables, several samples contained chlordane, aldrin, or chromium at concentrations exceeding the Human Health SEC (EBASCO 1994a) or Acute Risk Criteria. These exceedances are generally located near the inlets of the lakes in wetland areas. Contaminants posing a potential risk to biota in Upper Derby Lake consist of OCPs at low concentrations.

Figure 7.1-1 presents locations of the areas that pose potential risk to biota as well as those areas that exceed the Human Health SEC (EBASCO 1994a). Approximately 19,000 BCY of contaminated soil are contained in the isolated human health exceedance areas. Although these areas were determined to be human health exceedance areas based on elevated levels of chlordane, the areas also contain the highest levels of most Biota COCs. An estimated additional 49,000 BCY poses a potential risk to biota in Upper Derby Lake (Table 7.0-1). Appendix A in Volume IV presents a summary of the exceedance volume and area calculations.

The lakes in this medium group represent a potential source of groundwater and surface-water contamination due to the proximity of the contaminated sediments to both aqueous media. However, groundwater plumes have not been identified as originating from these sites, and surface-water contamination appears to be a result of runoff from South Plants rather than contact with contaminated sediments. As such, the contaminated sediments do not appear to be impacting groundwater or surface-water quality.

The sites in the Lake Sediments Medium Group provide aquatic and wetland habitats, and with the exception of site NCSA-7, the sites are also located within the Bald Eagle Management Area. Therefore, the evaluation of alternatives for this medium group must consider the impacts of alternatives on the habitat within these sites. The areas disturbed during remedial actions are to be restored to the existing aquatic and wetland habitats, but only over the course of several years.

7.2 EVALUATION OF ALTERNATIVES

The four alternatives for the Lake Sediments Medium Group vary in approach from no action to containment. For this medium group, the major modification to the retained DSA (EBASCO 1992b) alternatives was made in relation to the lack of a demonstrated pathway between contaminated sediment and aquatic biota. In the DSA (EBASCO 1992b), Alternative B6: Direct Thermal Desorption (Direct Heating), and B10: In Situ Biological Treatment (Aerobic Biodegradation) addressed the removal or in situ treatment of aquatic lake sediments. Based on risk evaluations performed during the IEA/RC (EBASCO 1994a), however, risk to aquatic biota from lake sediments could not be derived based on the available toxicological and contaminant-distribution data. Accordingly, these two alternatives were eliminated. Alternative B3: Landfill (On-Post Landfill) is modified to address only sediment posing risk to biota from Upper Derby Lake, since the sediment is dry and can be managed as soil. In addition, two new alternatives were added to address the isolated human health exceedances in Lower and Upper Derby lakes and the soil in Upper Derby Lake that potentially poses risks to biota. These two new alternatives are modifications to the no action alternative. The first new alternative (B1a: Landfill; No Additional Action) involves landfilling this soil. The second new alternative (B5a: Caps/Covers [Multilayer Cap] With Consolidation) involves excavating the soil posing a potential risk to biota and consolidating under a cap/cover in Basin A and excavating and landfilling the human health exceedance soil. In both cases, monitoring activities are conducted for the aquatic sediments to ensure they continue to pose no risk to aquatic biota.

The following subsections present a description of each alternative and an evaluation of the alternative against the DAA criteria for the NCP (EPA 1990a).

7.2.1 Alternative B1: No Additional Action

Alternative B1: No Additional Action (Provisions of FFA) applies to the aquatic lake sediments in this medium group. Soil that poses a potential risk to biota (19,000 BCY) and isolated human health exceedances (19,000 BCY) remain in place, and no action is taken to reduce exposure pathways. Long-term monitoring of soil and aquatic sediments left in place is conducted (an average of 17 samples per year) and 5-year site reviews are conducted to assess natural attenuation/degradation and the potential migration of contaminants and to ensure that the sediments continue to pose no risk to aquatic biota. Ongoing biomonitoring conducted by the USFWS, in addition to the SFS/Risk Assessment process, will be used to determine if any areas where lake sediments remain in place require remediation over the long term. Additional remedial actions taken for this medium group will be determined at such time as they are required.

The following discussion presents a detailed evaluation of this alternative against the DAA criteria listed in the NCP (EPA 1990a). For purposes of comparison, Table 7.2-1 summarizes the evaluation of all alternatives developed for this medium group.

7.2.1.1 Overall Protection of Human Health and the Environment

This alternative does not achieve Human Health or Biota RAOs since untreated soil remains in place; however, this alternative does not disturb the aquatic and wetland habitats that would be significantly impacted by intrusive remedial activities. Natural attenuation is the only process by which the long-term reduction in toxicity of contaminants can be achieved. There are no impacts to surface water or groundwater.

7.2.1.2 Compliance with ARARs

This alternative complies with action-specific ARARs as long-term monitoring and site reviews are conducted; however, it does not comply with location-specific ARARs since sites in the Lake Sediments Medium Group are located in wetlands. The alternative complies with provisions of the FFA (EPA et al. 1989). (ARARs are listed in Appendix A of the Technology Descriptions Volume.)

7.2.1.3 Long-Term Effectiveness and Permanence

The residual risk for human health and biota exposure is low because the contaminant concentrations are low. Site reviews and soil monitoring are required. The aquatic and wetland habitat are not impacted.

7.2.1.4 Reduction in TMV

There is no reduction in TMV except by natural attenuation. The 38,000 BCY of untreated soil remain in place, potentially posing a risk to biota.

7.2.1.5 Short-Term Effectiveness

RAOs are not achieved since soil with isolated human health exceedances and soil that may pose a potential risk to biota remain in place. There are no risks to workers or the surrounding community associated with disturbance of the area since there is no action; consequently, there are no environmental impacts. The time frame to achieve RAOs is greater than 30 years since natural attenuation is the only process by which contaminant reduction can be achieved.

7.2.1.6 Implementability

The alternative is technically and administratively feasible. Monitoring services are readily available.

7.2.1.7 Cost

The total present worth cost of this alternative is $817,000 and includes only long-term O&M costs associated with long-term maintenance and site reviews. Table B3.1-B1 details the costing for this alternative.

7.2.2 Alternative B1a: Landfill; No Additional Action

Alternative B1a: Landfill (On-Post Landfill); No Additional Action (Provisions of FFA) involves excavating the 19,000 BCY of human health exceedance soil from Upper and Lower Derby Lakes and placing it in the centralized on-post hazardous waste landfill. The area excavated is limited in extent and is backfilled with reconditioned borrow soil and revegetated with wetland species. The landfill contains multiple cells and requires 1 year for the construction of the first cell and associated support facilities. Fences are installed at the landfill to exclude biota. Containment of untreated soil in the landfill requires leachate collection and treatment, groundwater monitoring, and long-term maintenance of the landfill cover.

The soil posing potential risk to biota and aquatic sediments in the other lakes is left in place under the no-action component of the alternative. This area is monitored over the long term (an average of 17 samples per year) and 5-year site reviews are conducted both to assess natural attenuation/degradation and the potential migration of contaminants and to ensure that the sediments continue to pose no risk to aquatic biota. Ongoing biomonitoring conducted by the USFWS, in addition to the SFS/Risk Assessment process, will be used to determine if any areas where lake sediments remain in place require remediation over the long term. Additional remedial actions taken for this medium group will be determined at such time as they are required.

The following discussion presents a detailed evaluation of this alternative against the DAA criteria listed in the NCP (EPA 1990a). For purposes of comparison, Table 7.2-1 summarizes the evaluation of all alternatives developed for this medium group.

7.2.2.1 Overall Protection of Human Health and the Environment

This alternative achieves Human Health and RAOs since human health exceedance soil is excavated and transported to the centralized on-post hazardous waste landfill for containment. Soil posing potential risk to biota remains in place. There are no impacts on surface water or groundwater, and the short-term impacts on habitat can be addressed through engineering controls and revegetation.

7.2.2.2 Compliance with ARARs

This alternative complies with action-specific ARARs, including state regulations on landfill siting, design, and operation, as well as impacts on endangered species. This alternative does not comply with location-specific ARARs because wetland areas are disturbed to excavate the human health exceedances. However, the wetlands are restored after excavation, so this impact is ultimately mitigated. Disposal in the landfill does not trigger LDRs since the landfill is a CAMU (as defined in Section 1.4). This alternative complies with the provisions of the FFA (EPA et al. 1989). (ARARs are listed in Appendix A of the Technology Descriptions Volume.)

7.2.2.3 Long-Term Effectiveness and Permanence

The residual risk is minimal because the 19,000 BCY of untreated soil that contain contamination exceeding Human Health SEC (EBASCO 1994a) is removed and contained in the centralized on-post landfill. There is high confidence in the engineering controls used for the landfill, and there are no difficulties expected to be associated with landfill maintenance. Landfill-cell monitoring, soil monitoring, and 5-year site reviews are required. The wetlands habitat is restored after the excavation.

7.2.2.4 Reduction in TMV

Exposure pathways are interrupted and the mobility of contaminants reduced through containment of 19,000 BCY of human health exceedance volume in the landfill, but TMV is reversible should the landfill design fail. Soil posing potential risk to biota remains in place. There are no treatment residuals associated with the alternative.

7.2.2.5 Short-Term Effectiveness

This alternative involves some minor short-term risks associated with excavation, transportation, and landfilling of contaminated soil. These risks are addressed by personal protective equipment and dust controls such as water sprays. In addition, this alternative requires the disturbance of wetland habitat, although these areas are revegetated. The time frame to achieve RAOs is 2 years based on landfilling 19,000 BCY in less than 1 year after 1 year for construction of the landfill.

7.2.2.6 Implementability

The alternative is technically feasible because the alternative can be implemented within the required time frame and reliably operated and maintained thereafter with periodic landfill-cell monitoring. Additional remedial actions require removal of the landfill cover. The alternative is administratively feasible since the substantive requirements for Subtitle C landfill siting, design, and operations are achieved. Equipment, specialists, and materials (including clay) are readily available for construction of the landfill, and landfills are well demonstrated at full scale. Wetlands are restored after excavation.

7.2.2.7 Cost

The total present worth cost is $2,910,000 including $503,000, $1,580,000, and $831,000 for capital, operating, and long-term costs, respectively. Table B3.1-B1a details the costing for this alternative. A cost uncertainty relative to identifying the extent and depth of contamination exists; however, the magnitude of this uncertainty is small based on the small volume of soil involved and the shallow depth of the excavation.

7.2.3 <u>Alternative B3: Landfill</u>

Alternative B3: Landfill (On-Post Landfill) involves excavating the 19,000 BCY of human health exceedances from Upper and Lower Derby Lakes and the 19,000 BCY that pose potential risk to biota from Upper Derby Lake and placing them in the centralized on-post hazardous waste landfill. The area excavated is limited in extent and is backfilled with reconditioned borrow soil and revegetated with wetland species. The landfill contains multiple cells and requires 1 year for the construction of the first cell and associated support facilities. Fences are installed at the landfill to exclude biota. Containment of untreated soil in the landfill requires leachate collection and treatment, groundwater monitoring, and long-term maintenance of the landfill cover.

The aquatic sediments in the other lakes are left in place and the area is monitored over the long term (an average of 17 samples per year). Five-year site reviews are conducted both to assess natural attenuation/degradation and the potential migration of contaminants and to ensure that the remaining sediments do not pose a risk to aquatic biota.

The following discussion presents a detailed evaluation of this alternative against the DAA criteria listed in the NCP (EPA 1990a). For purposes of comparison, Table 7.2-1 summarizes the evaluation of all alternatives developed for this medium group.

7.2.3.1 Overall Protection of Human Health and the Environment

This alternative achieves Human Health and Biota RAOs since human health exceedance soil and soil that poses potential risk to biota is excavated and transported to the centralized on-post landfill facility for containment. There are no impacts on surface water or groundwater, and the short-term impacts on habitat can be addressed through engineering controls and revegetation.

7.2.3.2 Compliance with ARARs

This alternative complies with action-specific ARARs, including state regulations on landfill siting, design, and operation, as well as impacts on endangered species. This alternative does not comply with location-specific ARARs because wetland areas are disturbed to excavate the human health exceedances and the volume that poses potential risk to biota. However, the wetlands are restored after excavation, so this impact is ultimately mitigated. Disposal in the landfill does not trigger LDRs since the landfill is a CAMU (as defined in Section 1.4). This alternative complies with the provisions of the FFA (EPA et al. 1989). (ARARs are listed in Appendix A of the Technology Descriptions Volume.)

7.2.3.3 Long-Term Effectiveness and Permanence

The residual risk is minimal because the 19,000 BCY of untreated soil that contain contamination exceeding Human Health SEC (EBASCO 1994a) and the 19,000 BCY that potentially pose risk to biota are removed and contained in the centralized on-post hazardous waste landfill. There is high confidence in the engineering controls used for the landfill, and there are no difficulties expected to be associated with landfill maintenance. Landfill cell monitoring and 5-year site reviews are required. The wetlands habitat is restored after the excavation.

7.2.3.4 Reduction in TMV

Exposure pathways are interrupted and the mobility of contaminants reduced through containment of 19,000 BCY of human health exceedance volume and soil with potential risk to biota (19,000 BCY) in the landfill, but TMV is reversible should the landfill design fail. There are no treatment residuals associated with the alternative.

7.2.3.5 Short-Term Effectiveness

This alternative involves some minor short-term risks associated with excavation, transportation, and landfilling of contaminated soil. These risks are addressed by PPE and dust controls such as water sprays. In addition, this alternative requires the disturbance of wetlands habitat, although these areas are revegetated. The time frame to achieve RAOs is 2 years based on landfilling 38,000 BCY in less than 1 year after 1 year for construction of the landfill.

7.2.3.6 Implementability

The alternative is technically feasible because the alternative can be implemented within the required time frame and reliably operated and maintained thereafter with periodic landfill-cell monitoring. Additional remedial actions require removal of the landfill cover. The alternative is administratively feasible since the substantive requirements for Subtitle C landfill siting, design, and operations regulations are achieved. Equipment, specialists, and materials (including clay) are readily available for construction or the landfills, and landfills are well demonstrated at full scale. Wetlands are restored after excavation.

7.2.3.7 Cost

The total present worth cost is $4,240,000, including $988,000, $2,450,000, and $805,000 for capital, operating, and long-term costs, respectively. Table B3.1-B3 details the costing for this alternative. A cost uncertainty relative to identifying the extent and depth of contamination exists; however, the magnitude of this uncertainty is small based on the small volume of soil involved and the shallow depth of the excavation.

7.2.4 Alternative B5a: Landfill; Caps/Covers with Consolidation

Alternative B5a: Landfill; Caps/Covers (Multilayer Cap) with Consolidation includes excavating the isolated human health exceedance volume of 19,000 BCY and placing it in the centralized on-post hazardous waste landfill. The area excavated is limited in extent and is backfilled with reconditioned borrow soil and revegetated with wetland species. The landfill facility contains multiple cells and requires 1 year for the construction of the first cell and associated support facilities. Fences are installed at the landfill to exclude biota. Containment of untreated soil in the landfill requires leachate collection and treatment, groundwater monitoring, and long-term maintenance of the landfill cover. The 19,000 BCY of soil in Upper Derby Lake that poses potential risk to biota is excavated and transported to Basin A, consolidated as gradefill over the more highly contaminated soil present in the basin, and contained with a multilayer cap. The excavation is backfilled with reconditioned borrow soil to facilitate restoration of the wetlands, and backfilled areas are further restored by planting wetland vegetation. As discussed in Section 10.2.5, the containment of Basin A requires approximately 2,500,000 BCY of gradefill to achieve the design grade for the cap. Consolidation of 19,000 BCY of soil posing potential risk to biota from the Lake Sediments Medium Group removes the highest levels of contamination from the lakes and helps meet the need for gradefill in Basin A.

The aquatic sediments in the other lakes are left in place and the area is monitored over the long term (an average of 17 samples per year). Five-year site reviews are conducted both to assess natural attenuation/degradation and the potential migration of contaminants and to ensure that the sediments continue not to pose a risk to aquatic biota. Ongoing biomonitoring conducted by the USFWS, in addition to the SFS/Risk Assessment process, will be used to determine if any areas where lake sediments remain in place require remediation over the long term. Additional remedial actions taken for this medium group will be determined at such time as they are required.

The following discussion presents a detailed evaluation of this alternative against the DAA criteria listed in the NCP (EPA 1990a). For purposes of comparison, Table 7.2-1 summarizes the evaluation of all alternatives developed for this medium group.

7.2.4.1 Overall Protection of Human Health and the Environment

This alternative achieves Human Health and Biota RAOs since human health exceedance soil is excavated and contained in the on-post landfill, and soil that poses potential risk to biota is excavated and consolidated in Basin A for containment with a multilayer cap. There are no impacts to surface water or groundwater, and the short-term impacts on the habitat can be addressed through engineering controls and revegetation.

7.2.4.2 Compliance with ARARs

This alternative complies with action-specific ARARs regarding the construction of soil covers, the monitoring of contained material, and state regulations on landfill siting, design, and operation as well as impacts on endangered species. This alternative does not comply with location-specific ARARs because wetland areas are disturbed to excavate the human health exceedances and the volume that poses potential risk to biota. However, the wetlands are restored after excavation, so this impact is ultimately mitigated. Disposal in the landfill does not trigger LDRs since the landfill is a CAMU (as defined in Section 1.4). Consolidation to Basin A does not trigger LDRs since Upper Derby Lake does not contain hazardous waste (based on historical records and TCLP results). Materials within the consolidation volume may be landfilled based on visual observations such as soil stains or newly-discovered evidence of contamination; this landfill volume will be part of the 150,000 CY contingent volume. This alternative complies with the provisions of the FFA (EPA et al. 1989). (ARARs are listed in Appendix A of the Technology Descriptions Volume.)

7.2.4.3 Long-Term Effectiveness and Permanence

The residual risk is minimal because the entire 38,000 BCY of soil (including human health exceedance soil and soil that poses a potential risk to biota), are excavated and contained in the on-post landfill or consolidated and contained in Basin A with a multilayer cap. There is high confidence in engineering controls used for the landfill and multilayer cap in Basin A, although long-term monitoring and 5-year site reviews are required. The wetlands habitat in Upper and Lower Derby lakes is restored after the limited excavation, and the remaining aquatic habitat is not impacted by the remedial alternative. Long-term sampling of the aquatic sediments is conducted to ensure the sediments continue not to pose a risk to aquatic biota.

7.2.4.4 Reduction in TMV

Exposure pathways are interrupted and the mobility of contaminants reduced through removal of 38,000 BCY of soil from the site and containment either in the landfill or by the Basin A cap. TMV is only reversible should the Basin A cap degrade or leak or the landfill design fail. There is no reduction in contaminant volume or mobility except by natural attenuation for the remaining sediments, which do not pose a risk to aquatic biota. There are no treatment residuals associated with the alternative.

7.2.4.5 Short-Term Effectiveness

This alternative entails some minor short-term risks associated with excavation, transportation, landfilling, and consolidation of contaminated soil. These risks are addressed through PPE and dust controls such as water sprays. In addition, although this alternative requires the disturbance of wetland habitat, the total area disturbed is limited in extent and is ultimately revegetated. The time frame to achieve RAOs is 2 years for landfilling 19,000 BCY and 1 year for consolidating 19,000 BCY into Basin A.

7.2.4.6 Implementability

The alternative is technically feasible because it can be implemented within the required time frame and reliably operated and maintained thereafter. Additional remedial actions can be easily undertaken if the cap/cover in Basin A is removed. Periodic landfill monitoring is required. The substantive requirements of landfill siting, design, and operating regulations and capping are achieved. Equipment, specialists, and materials are readily available for the construction of the landfill and the consolidation and multilayer cap construction. Multilayer caps and landfills are well demonstrated at full scale. Wetlands at the inlets are restored after excavation.

7.2.4.7 Cost

The total present worth cost is $3,650,000, including $486,000, $2,380,000 and $792,000 for capital, operating, and long-term costs, respectively. Table B3.1-B5a details the costing for this alternative. A cost uncertainty relative to identifying the extent and depth of contamination exists; however, the magnitude of this uncertainty is small based on the small volume of soil involved and the shallow depth of the excavation.

7.3 COMPARATIVE ANALYSIS OF ALTERNATIVES

The majority of soil and sediments in the Lake Sediments Medium Group do not represent a risk to aquatic biota. The average levels of OCPs in the volume that poses a potential risk to biota are less than 1 ppm (Table 7.1-1), which is substantially lower than the Human Health SEC (EBASCO 1994a). Approximately 19,000 BCY of isolated human health exceedances for chlordane and chromium occur in the sediments. The isolated chlordane exceedances occur in wetlands areas near the inlet of Upper Derby Lake, where concentrations of other OCPs (10 to 50 ppm) are also higher than in the remainder of the area, and in Lower Derby Lake. In addition, the soil in Upper Derby Lake potentially poses a risk to terrestrial biota since water is not being allowed to pond in the lakebed. The human health exceedance areas and the area where biota potentially are at risk in Upper Derby Lake are treated as distinct from the aquatic sediments under the alternatives for this medium group since no pathway has been demonstrated between the sediments and aquatic wildlife.

The Lake Sediments Medium Group provides aquatic and wetland habitat with low levels of contamination. The removal of the isolated human health exceedances and the area where biota face potential risk in Upper Derby Lake requires the restoration of wetlands. The excavation of soil requires habitat mitigation measures since wetlands habitat would be highly disturbed or even possibly eliminated during removal operations. Personal protective equipment and site controls protect site workers and the community during remedial actions.

Alternative B1: No Additional Action does not achieve Human Health or Biota RAOs and is eliminated from further consideration. Alternative B1a achieves Human Health RAOs, and the two remaining alternatives achieve both Human Health and Biota RAOs since the aquatic sediments do not pose risks to aquatic biota based on the evaluation of risks in the Final IEA/RC (EBASCO 1994a).

Alternatives B1a, B3, and B5a all include the excavation of the 19,000 BCY of human health exceedance volume and containment of the soil in the on-post landfill. The alternatives vary in addressing the soil in Upper Derby Lake that poses a potential risk to biota. In Alternative B1a: Landfill; No Action, soil with a potential risk to biota in Upper Derby Lake remains in place. Alternative B3: Landfill and Alternative B5a: Landfill; Caps/Covers with Consolidation address the soil with potential risk to biota through excavation and containment in a landfill or consolidation under the Basin A cap, respectively.

Consequently, these three alternatives were retained to represent the Lake Sediments Medium Group in the development of the sitewide alternatives (Section 20):

- Alternative B1a: Landfill (On-Post Landfill); No Additional Action (Provisions of FFA)
- Alternative B3: Landfill (On-Post Landfill)
- Alternative B5a: Landfill (On-Post Landfill); Caps/Covers (Multilayer Cap) With Consolidation

Table 7.0-1 Characteristics of the Lake Sediments Medium Group

Characteristic	Lake Sediments Medium Group
<u>Contaminants of Concern</u>	
Human Health	OCPs
Biota[2]	OCPs, Hg
<u>Exceedance Area (SY)</u>	
Total	100,000
Human Health	45,000
Principal Threat	0
Biota[2]	57,000
Potential Agent	not applicable
Potential UXO	not applicable
<u>Exceedance Volume (BCY)</u>	
Total	38,000
Human Health[1]	19,000
Organic	19,000
Inorganic	0
Principal Threat	0
Biota[2]	19,000
Potential Agent	not applicable
Potential UXO	not applicable
<u>Depth of Contamination (ft)</u>	
Human Health[1]	0-5
Biota[2]	0-1

1 Human health exceedances are isolated detections. Human health exceedance area/volume does not reflect isolated detection in Lower Derby Lake Sediments.

2 Biota COCs and exceedance area/volume within the biota risk management area are as defined in Section 1. Any additional biota exceedances will be addressed through continued monitoring.

Table 7.1-1 Summary of Concentrations for the Lake Sediments Medium Group

Contaminants of Concern	Range of Concentrations[1] (ppm)	Average Concentration[1] (ppm)	Human Health SEC (ppm)	Human Health Principal Threat Criteria (ppm)	Human Health Acute Criteria (ppm)
Human Health Exceedance Volume					
Aldrin	BCRL–31	11.8	71	720	3.8
Dieldrin	BCRL–3.4	0.7	41	410	3.7
Chlordane	BCRL–57	1.8	55	3,700	12
Biota Volume					
Aldrin	BCRL–2.7	0.060	71	720	3.8
Dieldrin	BCRL–2.9	0.069	41	410	3.7
p,p,DDE	BCRL–3.0	0.018	1,250	12,500	--
p,p,DDT	BCRL–3.0	0.35	410	13,500	14
Mercury	BCRL–17	0.71	570	570,000	82
Chlordane	BCRL–9.3	0.056	55	3,700	12
Arsenic	BCRL–16	0.069	420	4,200	270

1 Based on modeled concentrations within human health exceedance volume or potential biota risk area.

	Total Samples Analyzed	BCRL		CRL-SEC(1)		Acute-HH SEC(2)		HH SEC-Pr. Threat(2)		>Pr. Threat(2)	
		Number	%	Number	%	Number	%	Number	%	Number	%
Aldrin	482	345	71.6%	132	27.4%	5	1.0%	0	0.0%	0	0.0%
Benzene	111	111	100.0%	0	0.0%	--	--	0	0.0%	0	0.0%
Carbon Tetrachloride	130	128	98.5%	2	1.5%	--	--	0	0.0%	0	0.0%
Chlordane	472	445	94.3%	26	5.5%	0	0.0%	1	0.2%	0	0.0%
Chloroacetic Acid	8	8	100.0%	0	0.0%	--	--	0	0.0%	0	0.0%
Chlorobenzene	130	130	100.0%	0	0.0%	--	--	0	0.0%	0	0.0%
Chloroform	130	130	100.0%	0	0.0%	--	--	0	0.0%	0	0.0%
p,p,DDE	484	416	86.0%	68	14.0%	--	--	0	0.0%	0	0.0%
p,p,DDT	469	416	88.7%	53	11.3%	0	0.0%	0	0.0%	0	0.0%
Dibromochloropropane	415	366	88.2%	49	11.8%	--	--	0	0.0%	0	0.0%
1,2-Dichloroethane	130	130	100.0%	0	0.0%	--	--	0	0.0%	0	0.0%
1,1-Dichloroethene	66	66	100.0%	0	0.0%	--	--	0	0.0%	0	0.0%
Dicyclopentadiene	223	223	100.0%	0	0.0%	--	--	0	0.0%	0	0.0%
Dieldrin	481	355	73.8%	125	26.0%	1	0.2%	0	0.0%	0	0.0%
Endrin	485	455	93.8%	30	6.2%	0	0.0%	0	0.0%	0	0.0%
Hexachlorocyclopentadiene	432	419	97.0%	13	3.0%	--	--	0	0.0%	0	0.0%
Isodrin	483	437	90.5%	46	9.5%	--	--	0	0.0%	0	0.0%
Methylene Chloride	122	106	86.9%	16	13.1%	--	--	0	0.0%	0	0.0%
Tetrachloroethane	28	28	100.0%	0	0.0%	--	--	0	0.0%	0	0.0%
Tetrachloroethylene	130	129	99.2%	1	0.8%	--	--	0	0.0%	0	0.0%
Toluene	114	112	98.2%	2	1.8%	--	--	0	0.0%	0	0.0%
Trichloroethylene	130	130	100.0%	0	0.0%	--	--	0	0.0%	0	0.0%
Arsenic	236	215	91.1%	21	8.9%	0	0.0%	0	0.0%	0	0.0%
Cadmium	280	272	97.1%	8	2.9%	0	0.0%	0	0.0%	0	0.0%
Chromium (3)	280	50	17.9%	229	81.8%	--	--	1	0.4%	0	0.0%
Lead	280	133	47.5%	147	52.5%	--	--	0	0.0%	0	0.0%
Mercury	333	219	65.8%	114	34.2%	0	0.0%	0	0.0%	0	0.0%

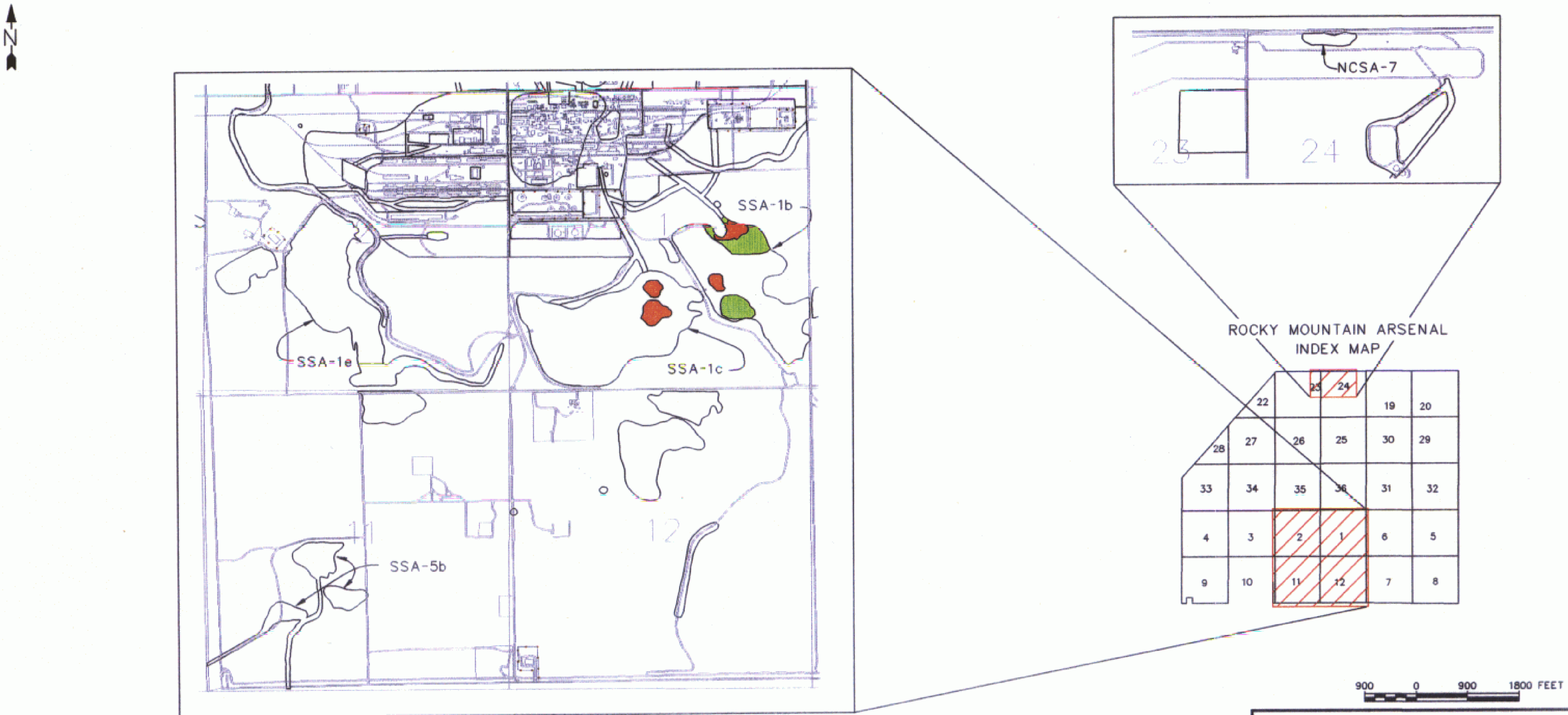
(1) *SEC limits for this interval are based on chronic HH SEC, or where appropriate, acute risk-based criteria for the 0- to 1-ft depth interval.*

(2) Table 1.4-1 presents acute criteria, HH SEC, and principal threat criteria.

(3) Present in aquatic sediments in LowerDerby Lake and not adressed in current alternatives.

-- not applicable

Criteria	Alternative B1: No Additional Action	Alternative B1a: Landfill; No Additional Action	Alternative B3: Landfill	Alternative B5a: Landfill; Caps/Covers with Consolidation
1. Overall protection of human health and the environment	Does not achieve Human Health or Biota RAOs, but does not disturb aquatic and wetland habitat; no groundwater impacts	Protective: Achieves Human Health RAOs; no groundwater impacts	Protective: Achieves Human Health and Biota RAOs; no groundwater impacts	Protective: Achieves Human Health and Biota RAOs; no groundwater impacts
2. Compliance with ARARs	Not in compliance with location-specific ARARs because exceedance areas are in wetlands	Noncompliance with location-specific ARARs (excavation of wetlands) mitigated by habitat restoration	Noncompliance with location-specific ARARs (excavation of wetlands) mitigated by habitat restoration	Noncompliance with location-specific ARARs (excavation of wetlands) mitigated by habitat restoration
3. Long-term effectiveness and permanence	Low Residual Risk; low concentrations	Minimal Residual Risk: Human health exceedance soil removed and contained	Minimal Residual Risk: contaminated soil removed and contained	Minimal Residual Risk: contaminated soil removed and contained
4. Reduction in TMV	No reduction in TMV except by natural attenuation	Mobility reduced for human health exceedance by containment; TMV reduction by attenuation only for the remaining 19,000 BCY	Mobility of contaminants reduced by containment	Mobility of contaminants reduced by containment
5. Short-term effectiveness	No disturbance of habitat because no action taken	Minor risk to workers and community during excavation and transport of relatively small volume of contaminated soil is adequately mitigated; RAOs achieved in 2 years	Minor risk to workers and community during excavation and transport of relatively small volume of contaminated soil is adequately mitigated; RAOs achieved in 2 years	Minor risk to workers and community during excavation and transport of relatively small volume of contaminated soil is adequately mitigated; RAOs achieved in 2 years
6. Implementability	Feasible	Feasible: no difficulties anticipated	Feasible: no difficulties anticipated	Feasible; no difficulties anticipated
7. Present Worth Costs	Capital—$0 Operating—$0 Long-term—$817,000 Total—$817,000	Capital—$503,000 Operating—$1,580,000 Long-term—$831,000 Total—$2,910,000	Capital—$988,000 Operating—$2,450,000 Long-term—$805,000 Total—$4,240,000	Capital—$486,000 Operating—$2,380,000 Long-term—$792,000 Total—$3,650,000
Summary	Not Retained: Not protective of human health and the environment	Retained: RAOs achieved through containment	Retained: RAOs achieved through containment	Retained: RAOs achieved through containment



LEGEND

Potential Biota Risk Area

Human Health Exceedance Area

Site Boundary

Buildings and Roads

Section Number

Sites:
NCSA-7, North Bog
SSA-1b, Upper Derby Lake
SSA-1c, Lower Derby Lake
SSA-1e, Lake Ladora
SSA-5b, Havanna/Peoria Street Ponds

Prepared for:

U.S. Army Program Manager
for Rocky Mountain Arsenal

October 1995

FIGURE 7.1-1

Exceedance Areas
Lake Sediments Medium Group

Rocky Mountain Arsenal.
Prepared by: Foster Wheeler Environmental Corporation

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CHECKED BY

Section 8

8.0 DETAILED ANALYSIS OF ALTERNATIVES FOR THE SURFICIAL SOIL MEDIUM GROUP

The Surficial Soil Medium Group is composed of several areas outside the boundaries of the sites identified in the RI Site Assessment Reports (SARs). The areas that comprise this medium group are located primarily in the central sections of RMA, with one (site NCSA-4b) located adjacent to former Basin F, one (the Rifle Range) located west of the Rod and Gun Club Pond in Section 12, and one (the Pistol Range) located in Section 19. The latter two sites were intended to be remediated as an interim action prior to the ROD. However, they have been included in the DAA and will be addressed as part of the surficial soil medium group. Areas outside of the SAR sites were defined based on a surficial soil survey conducted to assess the potential for windblown contamination as discussed in the RISR (EBASCO 1992a), and based on the Rifle and Pistol Range clearance project. These areas were grouped together based on the potential risks they pose to biota and the surficial nature of contamination. Sampling results indicate that soil in this medium group generally does not pose a risk to human health. However, soil in the Rifle and Pistol Range failed the RCRA TCLP test.

The COCs present in this medium group are OCPs and lead (in the Rifle and Pistol Range). They are present at concentrations that generally only pose potential risk to biota. In addition, there are several locations, primarily adjacent to Basin F, where dieldrin was detected above the Human Health SEC (EBASCO 1994a). Areas within this medium group are not potential sources of groundwater or surface-water contamination. Table 8.0-1 presents the characteristics of this medium group, including exceedance volumes and COCs, and Appendix A presents a summary of volume and area calculations.

In the DSA (EBASCO 1992b), alternatives were developed and screened based on the general characteristics of the medium group. In the DAA, individual subgroups were not developed for the sites, so the retained alternatives apply to the Surficial Soil Medium Group as a whole, including site NCSA-4b. The characteristics of this medium group—including contaminant types and concentrations, site configuration, and depth of contamination—were evaluated to determine whether any changes to the retained alternatives for this medium group were appropriate. As discussed in Section 4.2.5, thermal treatment was eliminated from consideration and two alternatives were added to address the human health exceedance areas.

The following sections present the characteristics of the medium group, an evaluation of the retained alternatives against the DAA criteria listed in the NCP (EPA 1990a), and the selection of alternatives, based on a comparative analysis, that was considered in the development of the sitewide alternatives (Section 20).

8.1 MEDIUM GROUP CHARACTERISTICS

The Surficial Soil Medium Group is composed of areas of surficial-soil contamination outside the boundaries of the SAR sites (Figure 8.1-1). These areas contain soil that was, in general, contaminated by windblown dust. Soil sampling at locations within this medium group was generally limited to the uppermost 2 inches of soil. Site NCSA-4b encompasses an area of contaminated soil adjacent to the former Basin F that also resulted predominantly from windblown contamination. The Pistol and Rifle Ranges contain lead contamination that is a residual of target practice in these areas.

Table 8.1-1 provides a summary of contaminants, concentrations, and corresponding exceedance values for the medium group. Table 8.1-2 summarizes the frequency of detections for soil samples taken in this medium group. Figure 8.1-1 identifies the location of human health exceedances, which comprise 87,000 BCY of contaminated soil (less than 2 percent of the total volume of this medium group). The majority of the human health exceedances (81,000 BCY) is located southeast of former Basin F (Site NCSA-3).

A single detection of dieldrin at 920 ppm, a concentration that exceeds the principal threat criteria (10^{-3} excess cancer risk, HI of 1,000), occurred in a sample from this area. This isolated exceedance is not treated separately from the medium group based on the impracticality of identifying and addressing an area defined by a single sample. Instead, the alternatives for the Surficial Soil Medium Group were modified to include containment of the entire human health exceedance volume (87,000 BCY). Figure 8.1-1 also indicates the locations of two other isolated

Human Health exceedance areas outside the SAR areas. These exceedance areas are a result of three isolated detections of dieldrin, each of which exceeds the Human Health SEC (EBASCO 1994a) of 3.7 ppm (acute exposure). The concentrations of these samples were 4.4 ppm and 5.5 ppm. Figure 8.1-1 also indicates the location of the Pistol and Rifle Range, which contains a total of 1,200 BCY and 1,100 BCY, respectively, of lead-contaminated soil.

OCPs were detected at levels that potentially pose risk to biota; however, the concentrations are relatively low. The area that poses potential risk to biota, which was defined according to the process described in Section 1.4.2.2, amounts to approximately 1,350,000 SY. This represents 450,000 BCY of contaminated soil (not including the 87,000 BCY of human health exceedance volume) based on an assumed 1-ft-thick interval of contamination. Table 8.0-1 summarizes the volumes for the medium group.

This medium group does not impact groundwater quality, and the alternatives evaluated do not require the demolition or removal of structures. The area that poses potential risk to biota does contain several structures, but remediation of the soil beneath the structures is not required based on historical usage and depth of contamination.

The Surficial Soil Medium Group exhibits vegetation ranging from weedy forbs to native grasses. Some of the areas are located within prairie dog colonies, and other areas are located within the Bald Eagle Management Area. Therefore, the evaluation of alternatives for this medium group must consider the impacts that alternatives might have on the habitat at RMA. Areas disturbed during remediation are to be revegetated with native grasses in accordance with a refuge management plan, but the ultimate success of the restoration process and time required to achieve it are not well defined.

8.2 EVALUATION OF ALTERNATIVES

The five alternatives for the Surficial Soil Medium Group vary in approach from no action to treatment. As discussed in Section 4.2.5, alternatives that address areas potentially posing risk to biota through thermal treatment were removed from consideration. The elimination of

Alternative B11: In Situ Thermal Treatment (Surface Soil Heating) is based on the changes in risk-based levels for human health and biota (and therefore changes in exceedance volumes) between the DSA and DAA. One new alternative was added to address the human health exceedances as a modification to the no additional action alternative. Alternative B1a: Landfill; No Additional Action addresses these isolated exceedances through landfilling. In addition, monitoring activities are conducted in the remaining areas. Also, Alternative B5a: Caps/Covers with Consolidation was added to evaluate consolidating the soil posing risk to biota into Basin A as gradefill prior to capping the basin. Finally, Alternative B9a: In Situ Biological Treatment was modified to involve landfilling the human health exceedances. The following subsections present a description of each alternative and an evaluation of the alternative against the DAA criteria listed in the NCP (EPA 1990a).

8.2.1 Alternative B1: No Additional Action

Alternative B1: No Additional Action (Provisions of FFA) applies to 1,600,000 SY contained in the Surficial Soil Medium Group. This area encompasses approximately 450,000 BCY of soil that poses potential risk to biota and 87,000 BCY of human health exceedance volume.

Under this alternative, no action is taken to limit biota or human exposure to COCs. The contaminated soil is left in place, and no controls are implemented. Long-term monitoring of untreated soil is conducted (an average of 19 samples per year), and 5-year reviews are conducted to assess natural attenuation/degradation and potential migration of contaminants.

Ongoing biomonitoring conducted by the USFWS, in addition to the SFS/Risk Assessment process, will be used to determine if any areas where contamination remains in place require remediation over the long term. Additional remedial actions taken for this medium group will be determined at such time as they are required.

The following discussion presents a detailed evaluation of this alternative against the DAA criteria listed in the NCP (EPA 1990a). For purposes of comparison, Table 8.2-1 summarizes the evaluation of all alternatives developed for this medium group.

8.2.1.1 Overall Protection of Human Health and the Environment

This alternative does not achieve Human Health or Biota RAOs since untreated soil remains and no controls are implemented. However, the concentrations of contaminants in surficial soil are relatively low, and this alternative does not disturb the existing habitat. Long-term reduction in the toxicity of contaminants is only achieved through natural attenuation/degradation. There are no short-term impacts on groundwater, surface water, or air quality.

8.2.1.2 Compliance with ARARs

This alternative generally complies with action- and location-specific ARARs since long-term monitoring and site reviews are conducted and since the areas encompassing this medium group are not located in wetlands or a 100-year flood plain. However, soil containing lead above the RCRA TCLP limit remains in place in the Pistol and Rifle Ranges. The alternative complies with provisions of the FFA. (ARARs are listed in Appendix A of the Technology Descriptions Volume.)

8.2.1.3 Long-Term Effectiveness and Permanence

The residual risk is low since the concentrations of OCPs are very low (the average concentration is 0.11 ppm) over the widespread area posing risk to biota and the lead-contamination is in isolated areas. Nonetheless, these concentrations exceed Human Health SEC in several areas. The existing habitat is not impacted by intrusive remedial action. Since no controls are implemented, site reviews and soil monitoring are required.

8.2.1.4 Reduction in TMV

There is no reduction in TMV except by natural attenuation/degradation. The 540,000 BCY of untreated soil remain, including 87,000 BCY of human health exceedance.

8.2.1.5 Short-Term Effectiveness

RAOs are not achieved since soil with human health exceedances and contamination that may pose a risk to biota remain on site. There are no risks to workers or the surrounding community associated with disturbing the area since there is no action. The time frame for this alternative to eliminate risks to biota is greater than 30 years since natural attenuation/degradation is the only process by which contaminants can be reduced.

8.2.1.6 Implementability

The alternative is technically and administratively feasible. Monitoring services are readily available.

8.2.1.7 Cost

The total present worth cost is $970,000, and includes only long-term O&M costs associated with long-term monitoring and site reviews. Table B3.2-B1 details the costing for this alternative.

8.2.2 Alternative B1a: Landfill; No Additional Action

Alternative B1b: Landfill (On-Post Landfill); No Additional Action (Provisions of FFA) addresses soil in the Surficial Soil Medium Group in two ways. The human health exceedance volume of 87,000 BCY is excavated and transported to a centralized on-post landfill, and areas with potential risk to biota are left in place. The landfill has a capacity for multiple cells as discussed in Section 4.6.6, and requires 1 year for construction of the first cell and associated support facilities. The landfill cover is revegetated after installation and fencing is installed to exclude biota and to prevent damage to the system. The landfill cover requires long-term monitoring and maintenance. Long-term maintenance activities include collecting and treating leachate and monitoring potential leachate migration from the landfill.

The human health exceedance area excavations are regraded, and the soil is supplemented with conditioners and revegetated with native grasses to restore habitat. The potential biota risk volume of 450,000 BCY is left in place under the no action component of the alternative. This area is monitored over the long term (an average of 19 samples per year), and 5-year site reviews are conducted to assess natural attenuation/degradation and potential migration of contaminants. Ongoing biomonitoring conducted by the USFWS, in addition to the SFS/Risk Assessment process will be used to determine if any areas where contamination remains in place require remediation over the long term. Additional remedial actions taken for this medium group will be determined at such time as they are required.

The following discussion presents a detailed evaluation of this alternative against the DAA criteria listed in the NCP (EPA 1990a). For purposes of comparison, Table 8.2-1 summarizes the evaluation of all alternatives developed for this medium group.

8.2.2.1 Overall Protection of Human Health and the Environment

This alternative achieves Human Health RAOs because soil contaminants exceeding the Human Health SEC are contained in a lined on-post landfill. Biota RAOs are not achieved since soil with low levels of contamination, which may pose a potential risk to biota, is left in place; however, the disturbance of the existing habitat over a widespread area is avoided. There are no impacts on groundwater, surface water, or air quality.

8.2.2.2 Compliance with ARARs

This alternative complies with action-specific ARARs, including state regulations on landfill siting, design, and operation, as well as impacts on endangered species. Sites in the Surficial Soil Medium Group and the landfill are not located in wetlands or a 100-year flood plain, thus complying with location-specific ARARs. Disposal in the landfill does not trigger LDRs since the landfill is a CAMU (as defined in Section 1.4). This alternative also complies with provisions of the FFA (EPA et al. 1989). (ARARs are listed in Appendix A of the Technology Descriptions Volume.)

8.2.2.3 Long-Term Effectiveness and Permanence

The residual risk is low because the human health exceedance volume is removed and contained and levels of contamination in the remaining soil are low. There is high confidence in the reliability of the landfill engineering controls, and there are no difficulties associated with landfill maintenance. The isolated locations where human health exceedance soil is excavated are revegetated, and the remaining habitat is not impacted.

8.2.2.4 Reduction in TMV

The mobility of the contaminants and exposure pathways are eliminated for the human health exceedance soil (87,000 BCY) so long as the integrity of the landfill is maintained. There is no reduction in TMV for the low levels of contamination that remain (450,000 BCY) except by natural attenuation/degradation. There are no treatment residuals.

8.2.2.5 Short-Term Effectiveness

This alternative entails minor short-term risks associated with excavation, transportation, and landfilling of contaminated soil. These risks are addressed through use of PPE and dust controls such as water sprays. The environmental impacts are minimal since habitat is restored in the limited areas of excavation. The time frame for completion of the landfill is 2 years, including 1 year for construction of the landfill cell and associated support facilities. The time frame for this alternative to eliminate risks to biota is greater than 30 years since natural attenuation/degradation is the only mechanism by which contaminant reduction can be achieved.

8.2.2.6 Implementability

The alternative is technically feasible. It can be implemented within the required time frame and reliably operated and maintained thereafter with periodic landfill cell monitoring. Additional future remedial actions require removal of the landfill cover. The substantive requirements associated with landfill siting, design, and operating regulations are achieved. The landfill technology has been well demonstrated at full scale, and equipment, specialists, and materials are readily available for construction.

8.2.2.7 Cost

The total present worth cost for this alternative is $5,390,000 including $2,260,000, $2,870,000, and $200,000 for capital, operating, and long-term costs, respectively. Table B3.2-B1a details the costing for this alternative. The cost uncertainty is small based on the shallow depth of the excavation.

8.2.3 Alternative B3: Landfill

Alternative B3: Landfill (On-Post Landfill) involves excavating 450,000 BCY of soil that potentially poses a risk to biota and 87,000 BCY of soil with human health exceedances and disposing of it in an on-post landfill. The landfill facility has a capacity for multiple cells and requires 1 year for construction of the first cell and associated support facilities. The soil beneath the 1,600,000-SY excavated area is reconditioned and revegetated, thus restoring the habitat at the site. Long-term activities required for the containment of untreated soil in the landfill include leachate collection and treatment, monitoring of potential leachate migration, revegetation and maintenance of the landfill cover, and fencing to exclude biota. Ongoing biomonitoring conducted by the USFWS, in addition to the SFS/Risk Assessment process, will be used to determine if any other areas require remediation, monitoring, or site reviews over the long term. Additional remedial actions taken for this medium group will be determined at such time as they are required.

The following discussion presents a detailed evaluation of this alternative against the DAA criteria listed in the NCP (EPA 1990a). For purposes of comparison, Table 8.2-1 summarizes the evaluation for all alternatives developed for this medium group.

8.2.3.1 Overall Protection of Human Health and the Environment

This alternative achieves Human Health and Biota RAOs as contaminated soil is contained in an on-post landfill, thus preventing human and biota exposure. However, there are short-term impacts on habitat over a large excavation area (1,600,000 SY). There are no impacts on groundwater or surface-water quality. The impacts on air quality from excavating large areas of surficial soil are reduced through water sprays.

8.2.3.2 Compliance with ARARs

This alternative complies with action-specific ARARs, including state regulations on landfill siting, design, and operation. Endangered species are not impacted. This alternative also complies with location-specific ARARs since the on-post landfill and the area encompassing this medium group are not located in wetlands or a 100-year flood plain. Disposal in the landfill does not trigger LDRs since the landfill is a CAMU (as defined in Section 1.4). This alternative complies with the provisions of the FFA (EPA et al. 1989). (ARARs are listed in Appendix A of the Technology Descriptions Volume.)

8.2.3.3 Long-Term Effectiveness and Permanence

The residual risk is minimal and the alternative achieves PRGs at the site because 540,000 BCY of untreated soil are contained in an on-post landfill. There is high confidence in the engineering controls for the landfill. There are no difficulties associated with the landfill maintenance, although landfill-cell monitoring is required. The alternative entails significant impacts to habitat over a large area, and habitat is eliminated in the area of the on-post landfill. The excavated areas are revegetated.

8.2.3.4 Reduction in TMV

Exposure pathways are interrupted and mobility of contaminants is reduced through the containment of 540,000 BCY in the on-post landfill. Reduction of mobility is only reversible should the landfill fail. There are no treatment residuals associated with this alternative.

8.2.3.5 Short-Term Effectiveness

In the short term, the alternative involves risk to workers and the surrounding community from fugitive dust generated during excavation activities. These risks are mitigated by PPE for workers and water sprays to control fugitive dust. The time frame for completion of the alternative is 3 years: 2 years for excavation and transport after 1 year for construction of the landfill.

8.2.3.6 Implementability

The alternative is technically feasible. Any additional remedial actions require removal of the landfill cover. Equipment, specialists, and materials (including clay) are readily available for landfill construction, and landfills have been demonstrated at full scale. The substantive requirements of Subtitle C landfill siting, design, and operating regulations are achieved.

8.2.3.7 Cost

The total present worth cost is $27,000,000 including $13,700,000, $12,800,000, and $537,000 for capital, operating, and long-term costs, respectively. Table B3.2-B3 details the costing for this alternative. The excavation of contaminated soil entails a relatively low cost uncertainty because of the shallow depth involved and the contiguous nature of the contaminated soil.

8.2.4 Alternative B5a: Landfill; Caps/Covers with Consolidation

Alternative B5a: Landfill (On-Post Landfill); Caps/Covers (Multilayer Cap) with Consolidation addresses soil in the Surficial Soil Medium Group in two ways. The human health exceedance volume of 87,000 BCY is excavated and placed in a centralized on-post hazardous waste landfill (Section 4.6.6). Less contaminated soil which potentially poses a risk to biota is transported to Basin A, Former Basin F, or South Plants, consolidated as gradefill over the more highly contaminated soil present in these sites, and contained with a multilayer cap (Section 4.6.14 discusses multilayer caps in detail). The excavation is backfilled and revegetated to facilitate restoration of habitat.

Construction of the first cell of the multiple-cell landfill and associated facilities takes 1 year. The landfill area is revegetated following installation of the cover and fencing. The landfill requires annual monitoring, long-term cover maintenance, leachate collection and treatment, and groundwater monitoring. As discussed in Sections 10, 11, and 17, the capping of Basin A, Former Basin F, and South Plants requires a large amount of gradefill to achieve the design grade of 3 to 5 percent. Consolidation of 450,000 BCY of soil with biota exceedances from the Surficial Soil Medium Group helps meet the requirement for gradefill to achieve the design grades while reducing the overall impact on the large borrow area on RMA (compared to a landfilling alternative).

Soil below the excavations is supplemented with conditioners to promote the growth of vegetation. Site remediation is completed by revegetation with native grasses.

The following discussion presents a detailed evaluation of this alternative against the DAA criteria listed in the NCP (EPA 1990a). For purposes of comparison, Table 8.2-1 summarizes the evaluation of all alternatives developed for this medium group.

8.2.4.1 Overall Protection of Human Health and the Environment

This alternative is protective of human health and the environment. RAOs are achieved because contaminated soil is excavated and contained. There are no impacts on groundwater, surface-water, or air quality. However, there are short-term impacts on habitat over a large excavation area (1,600,000 SY). Ongoing biomonitoring conducted by the USFWS and the SFS/Risk Assessment Process will be used to determine if any other areas require remediation, monitoring, or site reviews over the long term. Additional remedial actions taken for this medium group will be determined at such time as they are required.

8.2.4.2 Compliance with ARARs

This alternative complies with action-specific ARARs that apply to state regulations on landfill siting, design, and operation, the construction of covers and the monitoring of contained material. The Surficial Soil Medium Group, Basins A and F, South Plants, and the landfill are not located within wetlands or a 100-year flood plain, thus complying with location-specific ARARs as well. Disposal in the landfill does not trigger LDRs since the landfill is a CAMU, and consolidation to Basin A does not trigger LDRs since all sites in this medium group are located within the on-post AOC (as defined in Section 1.4). Materials within the consolidation volume may be landfilled based on visual observations such as soil stains, barrels, or newly-discovered evidence of contamination; this landfill volume will be part of the 150,000 CY contingent volume. The alternative also complies with provisions of the FFA (EPA et al. 1989) and regulations pertaining to endangered species protection. (ARARs are listed in Appendix A of the Technology Descriptions Volume).

8.2.4.3 Long-Term Effectiveness and Permanence

Soil that exceeds the Human Health SEC (EBASCO 1994a) or potentially poses risk to biota is removed from the site, so residual risk at the site is low. Long-term groundwater monitoring and site reviews are required as part of the consolidation alternative in Basins A and F and South Plants, but the controls are adequate and there is high confidence in the design and controls for the cap. There is also high confidence in the engineering controls for the landfill and there are no expected difficulties associated with landfill maintenance, although landfill-cell monitoring is required. The alternative entails significant impacts to habitat over a large area, and habitat is eliminated in the area of the on-post landfill. The excavated areas are revegetated.

8.2.4.4 Reduction in TMV

Mobility is reduced by containment in the landfill and consolidation and containment in Basins A and F and South Plants. Mobility reduction is irreversible so long as the integrity of the landfill and the Basin A and F and South Plants caps are maintained. Since no materials are treated, the toxicity and volume are reduced only by natural attenuation. There are no treatment residuals since there is no treatment.

8.2.4.5 Short-Term Effectiveness

This alternative entails risk to workers and the community during the excavation, transportation, and consolidation of contaminated soil. These risks are mitigated by PPE for workers and water sprays to control fugitive dust. Vapor emissions are not anticipated. The time frame until RAOs are achieved is 3 years, including the 2 years required to move the contaminated soil to Basins A and F and South Plants and the landfill, following 1 year for the construction of the landfill.

8.2.4.6 Implementability

This alternative is technically feasible and has been well demonstrated at full scale. The alternative can be implemented within the required time frame and reliably maintained thereafter. Additional remedial actions are easily undertaken, but the cap adds to the overall site volume in Basins A and F and South Plants. The alternative is administratively feasible because it meets the design requirements and construction regulations. Materials, specialists, and equipment are readily available.

8.2.4.7 Cost

The total present worth cost is $13,600,000 including $2,260,000, 11,100,000, and $266,000 for capital, operating and long-term costs, respectively. Table B3.2-B5 details the costing for this alternative. The cost uncertainty is small based on the shallow depth of the excavation.

8.2.5 Alternative B9a: In Situ Biological Treatment; Landfill

Alternative B9a: In Situ Biological Treatment (Landfarm/Agricultural Practice); Landfill (On-Post Landfill) applies to the 1,600,000 SY of soil that potentially poses a risk to biota. The human health exceedances (87,000 BCY) are excavated and landfilled as discussed in Alternative B1a: Landfill; No Additional Action. For the areas posing potential risk to biota (1,350,000 SY), this alternative consists of mimicking agricultural practices through tilling, seeding, mulching, and fertilizing. As has been shown in many studies of agricultural soil, the concentrations of OCPs such as dieldrin and aldrin decrease over time when subjected to agricultural practices. In addition to decreasing contaminant concentration, this alternative minimizes the potential for exposures to contaminated surficial soil. Impacts on habitat are minimized by performing these activities in a phased manner such that revegetation of disturbed areas can take place as tilling is being performed elsewhere.

The tilling and mixing of the soil is accomplished with traditional farm equipment or with a soil-mixing device similar to those commonly used for damaged roadbed reclamation. Depending on the specific equipment used, the depth of remediation ranges from the surface (0 to 2 inches) to 12 to 18 inches in depth. Plant and grass species chosen for reseeding are based on an evaluation of desired habitat. Since treatment takes place in situ and the mechanisms of agricultural practices combined with natural degradation processes are not fully understood, long-term monitoring is required until contaminant concentrations do not represent potential risks to biota. Monitoring consists of collecting an average of 19 soil samples per year. Five-year site reviews are performed to review the effectiveness of the alternative.

Ongoing biomonitoring conducted by the USFWS, in addition to the SFS/Risk Assessment process, will be used to determine if any areas where contamination remains in place require remediation over the long term. Additional remedial actions taken for this medium group will be determined at such time as they are required.

The following discussion presents a detailed evaluation of this alternative against the DAA criteria listed in the NCP (EPA 1990a). For purposes of comparison, Table 8.2-1 summarizes the evaluation of all alternatives developed for this medium group.

8.2.5.1 Overall Protection of Human Health and the Environment

This alternative achieves Human Health and Biota RAOs through landfilling of human health exceedances and significantly reducing the risk to biota over a large area through agricultural practices. However, agricultural practices do not completely remove risks to biota, and the process results in short-term destruction of habitat. There are no impacts on groundwater, surface water, or air quality.

8.2.5.2 Compliance with ARARs

This alternative complies with action-specific ARARs, including state regulations on landfill siting, design, and operation. Endangered species are not impacted. This medium group and the landfill are not located in wetlands or a 100-year flood plain, thus complying with location-specific ARARs. Disposal in the landfill does not trigger LDRs since the landfill is a CAMU (as defined in Section 1.4). This alternative complies with provisions of the FFA (EPA et al. 1989). (ARARs are listed in Appendix A of the Technology Descriptions Volume.)

8.2.5.3 Long-Term Effectiveness and Permanence

The residual risk is low because the isolated human health exceedances are landfilled and the contamination remaining in the soil after agricultural practices is very low. The level of confidence in the landfill engineering controls is high, and there are no difficulties associated with landfill maintenance. Long-term monitoring and site reviews are required since a low residual risk to biota exists. The existing habitat is disturbed by landfilling the isolated human health exceedances and performing landfarming/agricultural practices over a large area. The disturbed areas, however, are revegetated to restore habitat value.

8.2.5.4 Reduction in TMV

The mobility of the contaminants and the exposure pathways are eliminated for the human health exceedance volume so long as the integrity of the landfill is maintained. Landfarm/agricultural practices irreversibly reduce the TMV over 1,350,000 SY of surficial soil. There is residual risk to biota following agricultural practices.

8.2.5.5 Short-Term Effectiveness

This alternative presents minor short-term risks to site workers and the community and major environmental impacts from implementing agricultural practices over a large area. The risks associated with fugitive dust are reduced through water sprays, and the disturbed areas are revegetated to restore the habitat. However, the success of revegetation and habitat restoration over a large area in a short period of time is not well demonstrated, and there is a potential for continued habitat impacts over an extended period. The alternative also involves short-term risks associated with excavation, transportation, and landfilling of contaminated soil. These risks are addressed through use of PPE and dust controls such as water sprays. The time frame until RAOs are achieved is a minimum of 5 years (based on the time frame for treating the 1,350,000 SY), but the time frame could be longer if the alternative is performed in a phased manner to reduce widespread habitat impacts.

8.2.5.6 Implementability

The landfill portion of the alternative is technically feasible and can be implemented within the required time frame and reliably operated and maintained thereafter with periodic landfill-cell monitoring. Additional future remedial actions require removal of the landfill cover. The substantive requirements associated with landfill siting, design, and operation regulations are achieved. The landfill technology has been well demonstrated at full scale, and equipment, specialists, and materials are readily available for construction. The agricultural-practices component of this alternative is technically feasible, and the required equipment is readily available. The administrative feasibility of this alternative is difficult based on questions regarding the variability in contaminant concentration reductions, and the residual risk to biota following agricultural practices.

8.2.5.7 Cost

The total present worth cost is $5,860,000, including $2,260,000, $3,380,000, and $221,000 for capital, operating, and long-term costs, respectively. Table B3.2-B9a details the costing for this alternative. This alternative involves some uncertainties related to the extent of contamination and the risk reduction offered by agricultural practices.

8.3 COMPARATIVE ANALYSIS OF ALTERNATIVES

The Surficial Soil Medium Group consists of 450,000 BCY of soil that poses a potential risk to biota in the uppermost 1 ft of soil, and 87,000 BCY of human health exceedance soil. The majority of the human health exceedances are located in the Basin F Exterior site. The exceedance volume also includes soil in the Pistol and Rifle Ranges, and two isolated exceedances located in areas outside of SAR sites. The contamination primarily consists of OCPs, attributed to windblown dust and lead in the Pistol and Rifle Ranges. The risk to human health and biota is low since the average OCP concentrations are relatively low (Table 8.1-1).

This medium group consists of vegetation that varies from weedy forbs to native grasses and includes areas within prairie dog colonies and the Bald Eagle Management Area. The selection of alternatives to be retained for consideration must consider the impacts of remediation on habitat. Areas disturbed during remediation are to be revegetated to restore habitat value.

Alternative B1: No Additional Action is not protective of human health or biota as untreated soil with human health exceedances remains if no controls are implemented. This alternative was eliminated from further consideration as part of the sitewide alternatives. The four remaining alternatives achieve Human Health RAOs and meet the two DAA threshold criteria: protection of human health and the environment and compliance with action-specific and location-specific

ARARs for the DAA. The alternatives are distinguished, however, by how well they satisfy the five balancing criteria (Table 8.2-1).

Alternatives B1a and B5a both remove the human health exceedances for containment elsewhere on RMA. The advantage of Alternative B1a is that the human health exceedances are removed thus reducing the overall risk to biota by addressing the highest levels of contamination without disturbing large areas of habitat, as Alternative B5a does. The short-term impacts associated with excavation of the human health exceedance areas are adequately addressed, and the residual risks are low based on the low concentration of contamination remaining in the soil. Alternative B5a involves the consolidation of soil with low levels of contamination in Basins A and F and South Plants; and this entails a higher cost and higher short-term impact than Alternative B1a. However, Alternative B5a reduces the volume of gradefill required for Basins A and F and South Plants. Both of these alternatives are considered cost effective and were retained for the development of sitewide alternatives.

Alternative B3: Landfill requires the excavation of 540,000 BCY of soil over a large area. Like Alternatives B5a, this alternative involves significant short-term environmental impacts because the excavation and transportation activities impact the habitat over a large area. These impacts can be reduced by phasing the activities, but they cannot be eliminated. In addition, the cost of this alternative ($27,000,000) is higher than that of the other alternatives for this medium group. As a result, this alternative was not retained for further consideration.

Alternative B9a: In Situ Biological Treatment; Landfill has the lowest cost ($5,860,000) of the three alternatives involving implementing an action over the entire area that poses potential risk to biota. This alternative involves the same short-term impacts from fugitive dust and environmental impacts as do Alternatives B3 and B5a; however, the level of the impact is less for agricultural practices. This alternative does not completely eliminate risks to biota, but it does significantly reduce the risks to biota as compared to no action.

Consequently, the three alternatives that were retained to represent the Surficial Soil Medium Group in the development of the sitewide alternatives (Section 20) are the following:

- Alternative B1a: Landfill (On-Post Landfill); No Additional Action (Provisions of FFA)
- Alternative B5a: Landfill (On-Post Landfill); Caps/Covers (Multilayer Cap) with Consolidation
- Alternative B9a: In Situ Biological Treatment (Landfarm/Agricultural Practice); Landfill (On-Post Landfill)

Ongoing biomonitoring conducted by the USFWS and the SFS/Risk Assessment Process will be used to determine if any other areas require remediation, monitoring, or site reviews over the long term. Additional remedial actions taken for this medium group will be determined at such time as they are required.

Table 8.0-1 Characteristics of the Surficial Soil Medium Group

Characteristic	Surficial Soils Medium Group
Contaminants of Concern	
Human Health	OCPs, Pb
Biota	OCPs
Exceedance Area (SY)	
Total	1,600,000
Human Health	260,000
Principal Threat	4,500
Biota	1,350,000
Potential Agent	not applicable
Potential UXO	not applicable
Exceedance Volume (BCY)	
Total	540,000
Human Health	87,000
Organic	85,000
Inorganic	2,300
Principal Threat	1,500
Biota	450,000
Potential Agent	not applicable
Potential UXO	not applicable
Depth of Contamination (ft)	0–1
Human Health	0–1
Biota	

Table 8.1-1 Summary of Concentrations for the Surficial Soil Medium Group

Contaminants of Concern	Range of Concentrations[1] (ppm)	Average Concentration[1] (ppm)	Human Health SEC (ppm)	Human Health Principal Threat Criteria (ppm)	Human Health Acute Criteria (ppm)
Human Health Exceedance Volume					
Aldrin	0.048–390	17	71	720	3.8
Dieldrin	0.001–560	27	41	410	3.7
Lead[2]	--	--	2,200	not applicable	not applicable
Biota Volume					
Aldrin	BCRL–3.0	0.016	71	720	
Dieldrin	BCRL–3.5	0.057	41	410	
Endrin	BCRL–13	0.039	230	230,000	

1 Based on modeled concentrations within the human health exceedance volume or potential biota risk area.
2 Lead contaminated soil from the firing ranges included in human health exceedance volume; these sites not modeled.

Table 8.1-2 Frequency of Detections for Surficial Soil Medium Group

	Total Samples	BCRL		CRL-SEC(1)		Acute-HH SEC(2)		HH SEC-Pr. Threat(2)		>Pr. Threat(2)	
	Analyzed	Number	%	Number	%	Number	%	Number	%	Number	%
Aldrin	3065	2608	85.1%	451	14.7%	5	0.2%	1	0.0%	0	0.0%
Benzene	590	584	99.0%	6	1.0%	--	--	0	0.0%	0	0.0%
Carbon Tetrachloride	572	571	99.8%	1	0.2%	--	--	0	0.0%	0	0.0%
Chlordane	2954	2818	95.4%	136	4.6%	0	0.0%	0	0.0%	0	0.0%
Chloroacetic Acid	192	191	99.5%	1	0.5%	--	--	0	0.0%	0	0.0%
Chlorobenzene	571	570	99.8%	1	0.2%	--	--	0	0.0%	0	0.0%
Chloroform	572	571	99.8%	1	0.2%	--	--	0	0.0%	0	0.0%
p,p,DDE	3026	2935	97.0%	91	3.0%	--	--	0	0.0%	0	0.0%
p,p,DDT	3006	2693	89.6%	313	10.4%	0	0.0%	0	0.0%	0	0.0%
Dibromochloropropane	2956	2944	99.6%	12	0.4%	--	--	0	0.0%	0	0.0%
1,2-Dichloroethane	572	572	100.0%	0	0.0%	--	--	0	0.0%	0	0.0%
1,1-Dichloroethene	215	215	100.0%	0	0.0%	--	--	0	0.0%	0	0.0%
Dicyclopentadiene	2463	2463	100.0%	0	0.0%	--	--	0	0.0%	0	0.0%
Dieldrin	3073	2330	75.8%	721	23.5%	17	0.6%	3	0.1%	2	0.1%
Endrin	3055	2702	88.4%	352	11.5%	1	0.0%	0	0.0%	0	0.0%
Hexachlorocyclopentadiene	2920	2899	99.3%	21	0.7%	--	--	0	0.0%	0	0.0%
Isodrin	3035	2871	94.6%	164	5.4%	--	--	0	0.0%	0	0.0%
Methylene Chloride	545	518	95.0%	27	5.0%	--	--	0	0.0%	0	0.0%
Tetrachloroethane	219	218	99.5%	1	0.5%	--	--	0	0.0%	0	0.0%
Tetrachloroethylene	572	570	99.7%	2	0.3%	--	--	0	0.0%	0	0.0%
Toluene	591	586	99.2%	5	0.8%	--	--	0	0.0%	0	0.0%
Trichloroethylene	572	571	99.8%	1	0.2%	--	--	0	0.0%	0	0.0%
Arsenic	2599	2052	79.0%	547	21.0%	0	0.0%	0	0.0%	0	0.0%
Cadmium	2112	2037	96.4%	75	3.6%	0	0.0%	0	0.0%	0	0.0%
Chromium	2079	462	22.2%	1613	77.6%	--	--	4	0.2%	0	0.0%
Lead	2090	1322	63.3%	768	36.7%	--	--	0	0.0%	0	0.0%
Mercury	2556	2431	95.1%	125	4.9%	0	0.0%	0	0.0%	0	0.0%

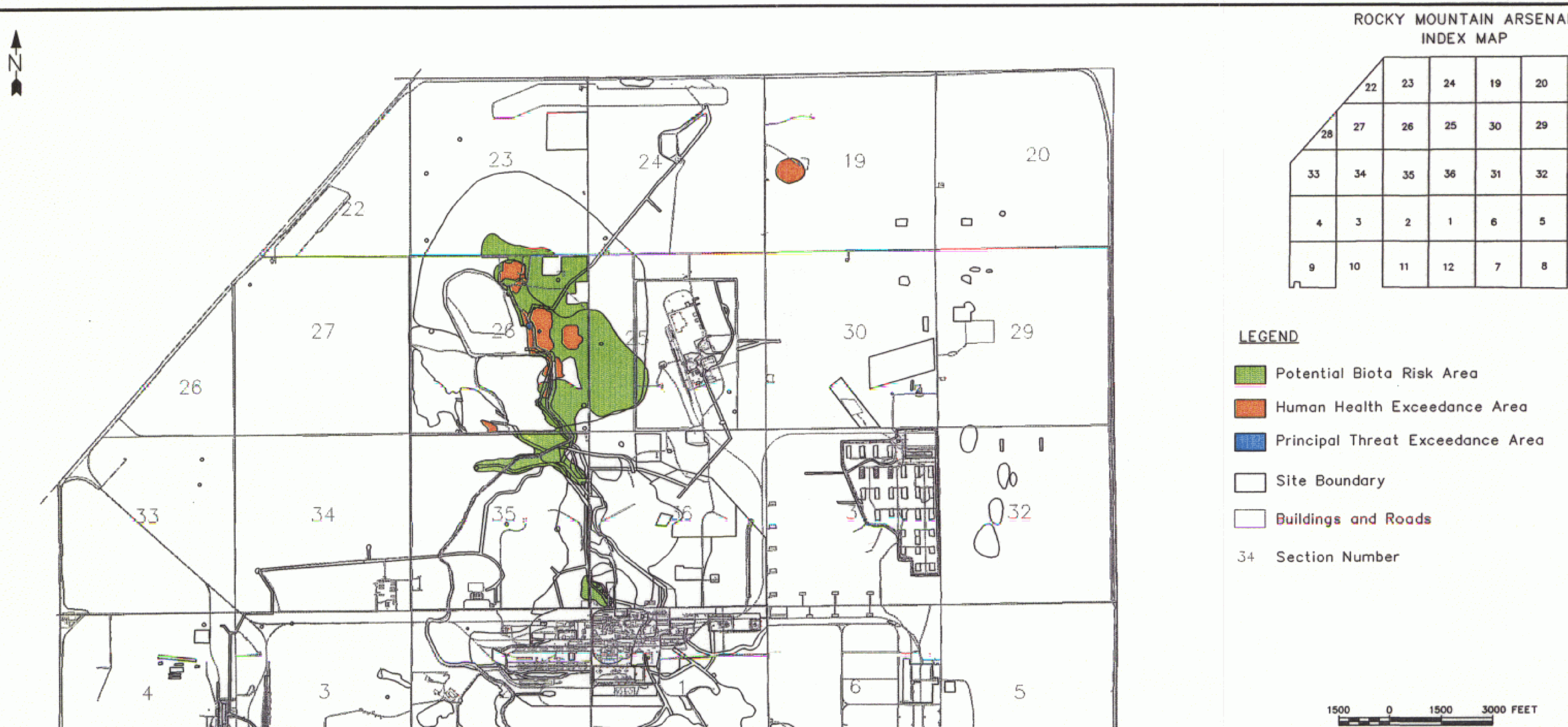
(1) SEC limits for this interval are based on chronic HH SEC, or where appropriate, acute risk-based criteria for the 0- to 1-ft depth interval.

(2) Table 1.4-1 presents acute criteria, HH SEC, and principal threat criteria.

-- not applicable

Table 8.2-1 Comparative Analysis of Alternatives for the Surficial Soil Medium Group

Criteria	Alternative B1: No Additional Action	Alternative B1a: Landfill; No Additional Action	Alternative B3: Landfill	Alternative B5a: Landfill; Caps/Covers with Consolidation	Alternative B9a: In Situ Biological Treatment; Landfill
1. Overall protection of human health and the environment	Does not achieve Human Health or Biota RAOs, but is protective of habitat	Protective: Achieves Human Health RAOs and protects habitat	Protective: Achieves Human Health and Biota RAOs through containment, but short-term impacts to habitat exist; no impacts on groundwater and surface water	Protective: Achieves Human Health RAOs and protects habitat; no impact to groundwater, surface water, and air quality	Protective: Achieves Human Health and Biota RAOs through containment, but short-term impacts to habitat exist
2. Compliance with ARARs	Complies	Complies	Complies	Complies	Complies
3. Long-term effectiveness and permanence	Low Residual Risk concentrations are low	Low Residual Risk: human health exceedance removed and contained; remaining contaminant concentrations are low	Minimal Residual Risk: contaminated soil removed from site and contained	Low Residual Risk; contaminated soil removed and contained in landfill, Basin F or Basin A, and South Plants	Low Residual Risk; human health exceedance removed and agricultural practices to treat remaining low-level contamination
4. Reduction in TMV	No reduction in TMV except by natural attenuation	Mobility reduced for human health exceedance by containment; TMV reduction by natural attenuation only for the remaining 450,000 BCY	Mobility reduced for contaminated soil by containment	Mobility reduced for contaminated soil by containment	Mobility reduced for human health exceedance by containment; TMV reduction for remaining volume by treatment
5. Short-term effectiveness	No risk to workers since no implementation required	Minor short-term risk and environmental impacts during excavation and transport of human health exceedance adequately mitigated; RAOs achieved in 2 years	Low short-term risk and environmental impacts during excavation and transport of contaminated soil; RAOs achieved in 3 years	Low short-term risk and environmental impacts during excavation and transport; RAOs achieved in 3 years	Minor short-term risks and environmental impacts during excavation, transport, and landfarming; RAOs achieved in 5 years
6. Implementability	Feasible: No implementation required	Feasible: No difficulties anticipated	Technically and Administratively Feasible	Technically and Administratively Feasible	Technically Feasible: Difficult administrative feasibility due to questions on variability of reductions from agricultural practices
7. Present worth costs	Capital—$0 Operating—$0 Long-term—$205,000 Total—$205,000	Capital—$2,260,000 Operating—$2,870,000 Long-term—$266,000 Total—$5,390,000	Capital—$13,700,000 Operating—$12,800,000 Long-term—$537,000 Total—$27,000,000	Capital—$2,260,000 Operating—$11,100,000 Long-term—$266,000 Total—$13,600,000	Capital—$2,260,000 Operating—$3,380,000 Long-term—$221,000 Total—$5,860,000
Summary	Not Retained: Does not achieve human health or biota RAOs	Retained: Human health exceedance removed without high short-term impacts	Not Retained: containment is not cost-effective for low contaminant concentrations	Retained: Human health exceedance landfilled and potential biota risk soil consolidated under caps	Retained: Significant risk reduction, although questions on variability of reductions from agricultural practices



Prepared for:

U.S. Army Program Manager
for Rocky Mountain Arsenal

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FIGURE 8.1-1

Exceedance Areas
Surficial Soils Medium Group

Rocky Mountain Arsenal.
Prepared by: Foster Wheeler Environmental Corporation

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Section 9

9.0 DETAILED ANALYSIS OF ALTERNATIVES FOR THE DITCHES/DRAINAGE AREAS MEDIUM GROUP

The Ditches/Drainage Areas Medium Group consists of sites that have varied disposal and release histories. These sites are located throughout RMA (Figure 9.0-1). They were grouped together based on the potential risk they present to biota and the narrow configuration of the sites, which limits the implementability of some remedial alternatives.

The primary COCs present in this medium group are OCPs. Detections of these compounds, as well as detections of arsenic and mercury, are below the CRLs in the majority of the samples collected, and so only pose potential risk to biota. Sites within this medium group are potential sources of surface-water contamination based on the potential pathways identified in the RISR (EBASCO 1992a). Table 9.0-1 presents the characteristics of this medium group, including volumes and COCs.

In the DSA, alternatives were developed and screened based on the general characteristics of the medium group. In the DAA, individual subgroups were not developed for the nine sites, so the retained alternatives apply to the Ditches/Drainage Areas Medium Group as a whole. The characteristics of the sites in this medium group—including contaminant types and contaminant concentrations, site configuration, and depth of contamination—were evaluated to determine whether modifications to the retained alternatives for the Ditches/Drainage Areas Medium Group would be appropriate.

The following sections present the characteristics of the medium group, an evaluation of the retained alternatives against the DAA criteria listed in the NCP (EPA 1990a), and the selection of alternatives, based on a comparative analysis, that was considered in the development of the sitewide alternatives (Section 20).

9.1 MEDIUM GROUP CHARACTERISTICS

The Ditches/Drainage Areas Medium Group is composed of sites CSA-2b (Parking Lot/Scrap Storage), ESA-6c (North Plants Drainage Ditch), NCSA-1c (Basin A to Basin B Ditches), NCSA-1d (Liquid Storage Pool), NCSA-1f (South Plants Drainage Ditches), NCSA-5d (Surface Drainage Canal), NPSA-8c (Miscellaneous Drainages), NPSA-9f (Isolated Detection), and SSA-2c (Overflow Basin and Ditch) (Figure 9.0-1). These ditches and drainages were primarily used to convey surface water away from other sites, including portions of North Plants and South Plants.

Table 9.1-1 provides a summary of contaminants and concentrations for this medium group. As shown in this table, there are no human health exceedances; however, the maximum concentrations of OCPs pose potential risk to biota. The majority of contaminants were detected in the 0- to 1-ft depth interval, but detections occurred in all depth intervals (0 to 10 ft below ground surface). The frequency of detections in the boring samples is listed in Table 9.1-2. The Ditches/Drainage Areas Medium Group consists of 52,000 BCY of contaminated soil (Table 9.0-1). Figure 9.1-1 shows the areas at which biota are potentially at risk.

The sites within this medium group are considered potential sources of surface-water contamination due to the direct contact between the contaminated soil and surface water. However, they are not considered sources of groundwater contamination because the ditches do not intersect the water table and only sporadically contain water. These sites do not encompass contaminated structures.

Habitat at the sites within the Ditches/Drainage Areas Medium Group ranges from natural grasses to weedy forbs. Most of the areas with native grasses are located within the Bald Eagle Management Area. Therefore, the evaluation of alternatives for the medium group must consider the impacts of alternatives on the habitat within these sites. In general, the areas disturbed during remedial activities are restored, unless the disturbed areas are revegetated specifically to exclude biota.

9.2 EVALUATION OF ALTERNATIVES

The six alternatives for the Ditches/Drainage Areas Medium Group in the DSA vary in approach from no action to treatment. The following subsections present a description of each alternative and an evaluation of the alternative against the DAA criteria listed in the NCP (EPA 1990a).

In the DAA the alternatives retained from the DSA were modified to eliminate some treatment alternatives and to include consolidation. As discussed in Section 4.2.5, some of the more aggressive treatment alternatives for soil that poses risks solely to biota were eliminated based on the changes in risk levels for human health and biota. As such, Alternatives B6: Direct Thermal Desorption and B11: In Situ Thermal Treatment were not evaluated in the DAA. The capping alternative was changed from Alternative B5: Caps/Covers to Alternative B5a: Caps/Covers with Consolidation to account for consolidating the contaminated soil at Basin A instead of capping it in place.

9.2.1 Alternative B1: No Additional Action

Alternative B1: No Additional Action (Provisions of FFA) applies to soil posing a potential risk to biota (150,000 SY). An estimated 52,000 BCY of contaminated soil remain in place, and no action is taken to limit biota exposure to COCs or to reduce potential surface-water contamination resulting from contact with contaminated soil. Areas where biota are potentially at risk are monitored (an average of 20 samples per year for the entire medium group) and 5-year site reviews are conducted to assess natural attenuation/degradation and potential migration of contaminants. Ongoing biomonitoring conducted by the USFWS, in addition to the SFS/Risk Assessment process, will be used to determine if any areas where soil posing potential risk to biota remains in place require remediation over the long term. Additional remedial actions taken for this medium group will be determined at such time as they are required. Potential remedial actions consist of landfilling, consolidation, or other technologies appropriate for the physical characteristics of the medium group.

The following discussion presents a detailed evaluation of this alternative against the DAA criteria listed in the NCP (EPA 1990a). For purposes of comparison, Table 9.2-1 summarizes the evaluation of all alternatives developed for the medium group.

9.2.1.1 Overall Protection of Human Health and the Environment

This alternative does not achieve Biota RAOs on a site-specific basis since untreated soil remains in place if no controls are implemented. However, when considering the biota risk management approach described in Section 1.4.2.2, this alternative is adequately protective. Long-term reduction in the toxicity of contaminants only occurs through natural attenuation. Potential impacts to surface water are not reduced.

9.2.1.2 Compliance with ARARs

This alternative complies with action-specific ARARs since long-term monitoring and site reviews are conducted. This alternative does not comply with location-specific ARARs since the Ditches/Drainage Areas Medium Group is located in wetlands and a 100-year flood plain. This alternative complies with the provisions of the FFA (EPA et al. 1989). (ARARs are listed in Appendix A of the Technology Descriptions Volume.)

9.2.1.3 Long-Term Effectiveness and Permanence

The residual risk is low due to the low levels of contaminants in soil. Site reviews and surface-water monitoring are required. The existing habitat is not impacted by this alternative.

9.2.1.4 Reduction in TMV

There is no reduction in TMV except by natural attenuation. The 52,000 BCY of untreated soil remain. There are no treatment residuals associated with this alternative.

9.2.1.5 Short-Term Effectiveness

The time frame until RAOs are achieved is greater than 30 years since natural attenuation is the only process by which contamination can be reduced. Since there is no action, there are no risks to workers or the surrounding community.

9.2.1.6 Implementability

This alternative is technically and administratively feasible. Monitoring services are widely available.

9.2.1.7 Cost

The total present worth cost is $1,180,000 and includes only long-term O&M costs associated with long-term maintenance and site reviews. Table B3.3-B1 details the costing for this alternative.

9.2.2 Alternative B2: Biota Management

Alternative B2: Biota Management (Exclusion, Habitat Modification) applies to 150,000 SY of soil posing potential risk to biota. The 52,000 BCY of contaminated soil remain in place, but exposure pathways to biota are interrupted by a 17,000-ft-long chainlink fence placed around the perimeter of the exceedance volume. In addition, the existing habitat is modified by revegetating the area with grasses that are unappealing as habitat. Revegetation of the 150,000 SY is accomplished over a 3-year period. No actions are taken to reduce potential surface-water contamination resulting from contact with contaminated soil. Long-term activities include maintaining fences, mowing, and monitoring the habitat for damage caused by erosion, disease, pests, etc. Exceedance areas are also monitored (based on 20 soil samples per year). Five-year site reviews are performed to review the effectiveness of the alternative and to assess natural attenuation/degradation and potential migration of contaminants. Ongoing biomonitoring conducted by the USFWS, in addition to the SFS/Risk Assessment process, will be used to determine if any areas where soil posing potential risk to biota remains in place require remediation over the long term. Additional remedial actions taken for this medium group will be determined at such time as they are required. Potential remedial actions consist of landfilling, consolidation, or agricultural practices/landfarming.

The following discussion presents a detailed evaluation of this alternative against the DAA criteria listed in the NCP (EPA 1990a). For purposes of comparison, Table 9.2-1 summarizes the evaluation of all alternatives for this medium group.

9.2.2.1 Overall Protection of Human Health and the Environment

This alternative achieves Biota RAOs since exposure pathways are interrupted through access restrictions and biota controls. Surface-water impacts are not reduced.

9.2.2.2 Compliance with ARARs

This alternative complies with action-specific ARARs since access is adequately controlled and site reviews are conducted. Endangered species are not impacted. This alternative does not comply with location-specific ARARs since sites in the Ditches/Drainage Areas Medium Group are located in wetlands and a 100-year flood plain. Potentially, surface-water controls could be used to modify the 100-year floodplain, thereby achieving compliance with ARARs. The alternative also complies with most provisions of the FFA (EPA et al. 1989), although restricting biota from large areas of RMA is contrary to the goal stated in the FFA (EPA et al. 1989), that significant portions of RMA be made available as open space for public benefit, including, but not limited to, wildlife habitat. Moreover, restricting biota from portions of the on-post environment would impact use of RMA as a National Wildlife Refuge. (ARARs are listed in Appendix A of the Technology Descriptions Volume.)

9.2.2.3 Long-Term Effectiveness and Permanence

The residual risk is low because only low concentrations of contamination remain in place. Fencing and cultivation of unappealing habitat are used to reduce exposures to biota, which constitutes adequate controls. Long-term maintenance, site reviews, surface-water monitoring, and monitoring of wildlife exclusion are required. The habitat quality is eliminated for biota.

9.2.2.4 Reduction in TMV

There is no reduction in TMV except by natural attenuation for the 52,000 BCY of untreated soil that remain in place. Exposure controls are reversible should the fencing and biota controls fail. There are no treatment residuals associated with this alternative.

9.2.2.5 Short-Term Effectiveness

In the short-term, the alternative is protective of workers and the community because PPE adequately protects workers during installation of the fence and revegetation. Dust or vapor emissions are not anticipated. An environmental impact is anticipated by installing the fence, particularly since habitat is eliminated over the 150,000-SY area. The potential for migration of contaminants to surface water is not reduced. The time frame for completion of the alternative is 3 years, which covers the installation of the fence and revegetation with less appealing grasses. Natural attenuation of untreated soil is ongoing.

9.2.2.6 Implementability

This alternative is technically feasible and can be implemented within the required time frame and reliably maintained thereafter. Additional remedial actions can easily be undertaken for the soil left in place. The alternative may not be administratively feasible if it conflicts with the refuge management plan because it limits the mobility and access of biota. Materials, specialists, and equipment are readily available for installing the fence and modifying the habitat.

9.2.2.7 Cost

The total present worth cost is $2,070,000 including $543,000, $51,000, and $1,470,000 for capital, operating, and long-term costs, respectively. Table B3.3-B2 details the costing for this alternative. The cost uncertainties associated with this alternative are low because no soil excavation is required.

9.2.3 Alternative B3: Landfill

Alternative B3: Landfill (On-Post Landfill) addresses 52,000 BCY of contaminated soil. The contaminated soil is excavated, transported to, and placed in a centralized on-post landfill. The landfill has the capacity for multiple cells and construction of the first cell and support facilities requires 1 year. The excavations are backfilled to the existing grade with borrow material from an on-post borrow area. The uppermost 6 inches of soil are supplemented with conditioners and revegetated. No maintenance activities are required because all soil that potentially poses a risk to biota is removed. The borrow area is also recontoured and revegetated to restore habitat.

The following discussion presents a detailed evaluation of this alternative against the DAA criteria listed in the NCP (EPA 1990a). For purposes of comparison, Table 9.2-1 summarizes the evaluation of all alternatives developed for this medium group.

9.2.3.1 Overall Protection of Human Health and the Environment

This alternative achieves Biota RAOs through containment. Contaminated soil is contained in an on-post landfill, thus preventing exposures to biota. Impacts on surface water are reduced. The short-term risks and impacts can be adequately addressed.

9.2.3.2 Compliance with ARARs

This alternative complies with action-specific ARARs, including state regulations on landfill siting, design, and operation. Endangered species are not impacted. This alternative also complies with the location-specific ARARs since wetlands are restored after excavation, and since permanent structures are not constructed in the 100-year flood plain or wetlands. Disposal in the landfill does not trigger LDRs since the landfill is a CAMU (as defined in Section 1.4). This alternative complies with provisions of the FFA (EPA et al. 1989). (ARARs are listed in Appendix A of the Technology Descriptions Volume.)

9.2.3.3 Long-Term Effectiveness and Permanence

The residual risk at the site is minimal since 52,000 BCY of untreated soil are contained in an on-post landfill. There is high confidence in engineering controls for the landfill, and there are no expected difficulties associated with landfill maintenance. Landfill-cell monitoring is required. Revegetation of disturbed areas improves existing habitat at the site, but the habitat at the landfill is eliminated.

9.2.3.4 Reduction in TMV

Exposure pathways are interrupted and the mobility of contaminants reduced through containment of 52,000 BCY in an on-post landfill. Reduction of mobility is only reversible should the landfill fail. There are no treatment residuals associated with this alternative.

9.2.3.5 Short-Term Effectiveness

This alternative involves moderate short-term risks associated with the excavation, transport, and disposal of contaminated soil, but the levels of contamination are low and the volume addressed is small. Workers are protected by PPE and fugitive dust is controlled by water sprays. There are minimal impacts on biota due to the linear nature of the sites and the small volume excavated (150,000 SY). Migration of contaminants to surface water is reduced. The time frame for completion of the alternative is 2 years, based on 1 year for the excavation and transport of 52,000 BCY after 1 year for construction of the on-post landfill.

9.2.3.6 Implementability

This alternative is technically feasible and can be implemented within the required time frame and reliably maintained thereafter. Additional remedial actions can easily be undertaken after removal of the landfill cover. The alternative is administratively feasible since the Subtitle C requirements for landfill siting, design, and operations are achieved. Equipment, specialists, and materials (including clay) are readily available for construction of the landfill, and landfills have been well demonstrated at full scale.

9.2.3.7 Cost

The total present worth cost is $3,430,000 including $1,350,000, $2,040,000, and $37,000 for capital, operating, and long-term costs, respectively. Table B3.3-B3 details the costing for this alternative. A cost uncertainty relative to identifying the extent and depth of contamination exists; however, the magnitude of this uncertainty is small based on the small volume of soil involved and the shallow depth of the excavation.

9.2.4 Alternative B5a: Caps/Covers with Consolidation

Alternative B5a: Caps/Covers (Multilayer Cap) with Consolidation addresses 52,000 BCY of contaminated soil by excavating and transporting it to Basin A for consolidation with contaminated soil from other locations at RMA. These materials are used as gradefill to bring Basin A to design grade prior to containment with a multilayer cap as described in Section 6.4 of the Technology Descriptions Volume. Approximately 2,500,000 BCY of gradefill materials are required for Basin A. The site excavations are backfilled with borrow material from the on-post borrow area. The uppermost 6 inches of soil are supplemented with conditioners and revegetated. The borrow area is also recontoured and revegetated to restore habitat. No maintenance activities are required at these sites because all soil that poses a potential risk to biota is removed.

The following discussion presents a detailed evaluation of this alternative against the DAA criteria listed in the NCP (EPA 1990a). For purposes of comparison, Table 9.2-1 summarizes the evaluation of all alternatives developed for this medium group.

9.2.4.1 Overall Protection of Human Health and the Environment

This alternative achieves Biota RAOs through containment. Contaminated soil that poses a potential risk to biota is excavated and consolidated in Basin A for containment with a multilayer cap to prevent exposure. Impacts on surface water are reduced. The short-term risks and impacts can be adequately addressed.

9.2.4.2 Compliance with ARARs

This alternative complies with action-specific ARARs regarding the construction of caps and the monitoring of contained material. Endangered species are not impacted. This alternative also complies with the location-specific ARARs since wetlands are restored after excavation and permanent structures are not constructed in a 100-year flood plain. Basin A is not located in wetlands or a 100-year flood plain. Consolidation to Basin A does not trigger LDRs since all sites in this medium group are located within the on-post AOC (as defined in Section 1.4). Materials within the consolidation volume may be landfilled based on visual observations such as soil stains, barrels, or newly-discovered evidence of contamination; this landfill volume will be part of the 150,000 CY contingent volume. The alternative also complies with provisions of the FFA (EPA et al. 1989). (ARARs are listed in Appendix A of the Technology Descriptions Volume.)

9.2.4.3 Long-Term Effectiveness and Permanence

The residual risk at the site is minimal since 52,000 BCY of soil are consolidated and contained in Basin A with a multilayer cap. There is high confidence in engineering controls for the cap, and there are no expected difficulties associated with maintenance. Long-term maintenance and site reviews are required. Revegetation of disturbed areas improves habitat quality at the site.

9.2.4.4 Reduction in TMV

Exposure pathways are interrupted and mobility of contaminants reduced through containment of 52,000 BCY of contaminated soil in Basin A and the installation of a multilayer cap. TMV reduction is only reversible should the cap degrade or leak. There are no treatment residuals associated with this alternative.

9.2.4.5 Short-Term Effectiveness

This alternative involves moderate short-term risks associated with the excavation, transport, and consolidation of contaminated soil, but the levels of contamination are low and the volume addressed is small. Workers are protected by PPE and fugitive dust is controlled by water sprays.

There are minimal impacts to biota due to the linear nature of the sites, and only small areas are disrupted. Migration of contaminants to surface water is reduced. The time frame for completion of the alternative is 1 year after 1 year for consolidation of 52,000 BCY of soil.

9.2.4.6 Implementability

This alternative is technically feasible and can be implemented within the required time frame and reliably maintained thereafter. Additional remedial actions require removal of the cap/cover. Equipment, specialists, and materials are readily available for consolidation and multilayer cap construction, and caps have been well demonstrated at full scale.

9.2.4.7 Cost

The total present worth cost is $1,780,000 and includes only O&M costs for the cap/cover. Table B3.3-B5a details the costing for this alternative. A cost uncertainty relative to identifying the extent and depth of contamination exists; however, the magnitude of this uncertainty is small based on the small volume of soil involved and the shallow depth of the excavation.

9.2.5 Alternative B9: In Situ Biological Treatment

Alternative B9: In Situ Biological Treatment (Landfarm/Agricultural Practice) applies to 150,000 SY of the ditches/drainage areas. This alternative achieves remediation to a depth of 12 to 18 inches by mimicking the agricultural practices of tilling, seeding, mulching, and fertilizing. As has been shown in many studies of agricultural soil, the concentrations of OCPs decrease over time when subjected to agricultural practices. In addition to reducing contaminant concentrations, this alternative minimizes the potential for exposures to the contaminated surficial soil. Tilling and mixing of the soil is accomplished with traditional farm equipment or with a soil-mixing device such as those commonly used for damaged roadbed reclamation.

Since mechanisms of contaminant loss are not well understood and untreated soil remains in place, long-term monitoring is necessary until contaminant concentrations do not pose risks to biota. Monitoring is conducted (based on an average of 20 soil samples per year), and 5-year site reviews are performed to assess the effectiveness of the alternative.

The following discussion presents a detailed evaluation of this alternative against the DAA criteria listed in the NCP (EPA 1990a). For purposes of comparison, Table 9.2-1 summarizes the evaluation of all alternatives for this medium group.

9.2.5.1 Overall Protection of Human Health and the Environment

This alternative achieves Biota RAOs by significantly reducing the concentration of contamination and therefore the risks to biota. However, agricultural practices do not completely remove risks to biota. The short-term risks and impacts can be adequately addressed.

9.2.5.2 Compliance with ARARs

This alternative complies with action-specific ARARs, including state regulations on air emissions sources. Endangered species are not impacted. This alternative complies with the location-specific ARARs since the wetlands are restored and permanent structures are not located within a 100-year flood plain. This alternative also complies with provisions of the FFA (EPA et al. 1989). (ARARs are listed in Appendix A of the Technology Descriptions Volume.)

9.2.5.3 Long-Term Effectiveness and Permanence

This alternative has a low residual risk since 150,000 SY of soil remain on site following agricultural practices. Long-term monitoring and site reviews are required since a residual risk exists for biota. The existing habitat is disturbed, but is revegetated to restore habitat value.

9.2.5.4 Reduction in TMV

Landfarm/agricultural practices irreversibly reduce TMV over 150,000 SY of surficial soil, although the processes by which these losses occur are not fully understood. Treatment residuals associated with this alternative consist of soil with residual risks to biota following agricultural practices.

9.2.5.5 Short-Term Effectiveness

This alternative presents a moderate risk to workers and significant short-term impacts to habitat and the community as a result of implementing agricultural practices over a small area. However, adequate controls are provided by PPE for workers and fugitive dust is controlled using water sprays. Vapor emissions are not anticipated, and the disturbed areas are revegetated to restore habitat. The time frame for completion of the alternative is 3 years. Treatment and revegetation of 150,000 SY of surficial soil is feasible in 3 years.

9.2.5.6 Implementability

Technical feasibility and implementation would be difficult for this alternative due to the physical configuration of the ditches. The administrative feasibility is difficult based on concerns regarding the variability of the contaminant reductions and the residual risks remaining after agricultural practices. Equipment, specialists, and materials are readily available for landfarming/agricultural practices and habitat modifications.

9.2.5.7 Cost

The total present worth cost is $1,120,000, including $110,000 and $1,010,000 for operating and long-term costs, respectively. Table B3.3-B9 details the costing for this alternative. This alternative involves costs uncertainties associated with identifying the extent of contamination and the risk reductions offered by agricultural practices.

9.3 COMPARATIVE ANALYSIS OF ALTERNATIVES

The Ditches/Drainage Areas Medium Group contains 52,000 BCY of soil that potentially pose a risk to biota. Due to the direct contact of contaminated soil with surface water, sites in this subgroup are considered potential sources of surface-water contamination. The contaminants that potentially pose a risk to biota are primarily OCPs. No contaminants in this subgroup exceed Human Health SEC (EBASCO 1994a), so proper health and safety equipment and procedures provide adequate worker protection during remedial activities.

Habitat within the medium group ranges from natural grasses to weedy forbs. Several sites are located within the Bald Eagle Management Area. Selection of the preferred alternative must include consideration of the impacts of remedial actions on habitat. Disturbed areas are restored and revegetated following remediation.

Alternative B1: No Additional Action does not achieve Biota RAOs on a site-specific basis, but it was not eliminated from further consideration based on the biota management approach described in Section 1.4.2.2 and the low levels of contamination present in the subgroup. The four remaining alternatives, which include an institutional controls alternative, two containment alternatives, and a treatment alternative, achieve RAOs and meet the two DAA threshold criteria: protection of human health and the environment and compliance with action-specific and location-specific ARARs; however, some of the alternatives do not completely comply with the location-specific ARARs as some sites are located in wetlands and leave contaminated materials in place. The alternatives are different, however, in how well they meet the five balancing criteria.

Alternative B2: Biota Management eliminates habitat at the sites within the medium group, and Alternative B9: In Situ Biological Treatment has significant short-term impacts on habitat. In addition, these alternatives leave residual risks at the site that require long-term monitoring. For these reasons, these alternatives were eliminated from further consideration.

Alternative B3: Landfill, and Alternative B5a: Landfill; Caps/Covers with Consolidation address the contaminated volumes similarly as they both include the excavation and containment of 52,000 BCY of contaminated soil. These alternatives are consistent with NCP guidance (EPA 1990a) on engineering controls for low levels of contamination, and each must address impacts on habitat quality through restoration of wetlands habitat. These alternatives were retained for evaluation in sitewide alternatives.

Consequently, the three alternatives that were retained to represent the Ditches/Drainage Areas Medium Group in the development of sitewide alternatives (Section 20) are the following:

- Alternative B1: No Additional Action (Provisions by FFA)
- Alternative B3: Landfill (On-Post Landfill)
- Alternative B5a: Caps/Covers (Multilayer Cap) with Consolidation

Table 9.0-1 Characteristics of the Ditches/Drainage Areas Medium Group

Characteristic	Ditches/Drainage Areas Medium Group
Contaminants of Concern	
Human Health	none
Biota	OCPs
Exceedance Area (SY)	
Total	150,000
Human Health	0
Biota	150,000
Potential Agent	not applicable
Potential UXO	not applicable
Exceedance Volume (BCY)	
Total	52,000
Human Health	0
Organic	0
Inorganic	0
Principal Threat	0
Biota	52,000
Potential Agent	not applicable
Potential UXO	not applicable
Depth of Contamination (ft)	
Human Health	not applicable
Biota	0–1

Table 9.1-1 Summary of Concentrations for the Ditches/Drainage Area Medium Group

Contaminants of Concern	Range of Concentrations[1] (ppm)	Average Concentration[1] (ppm)	Human Health SEC (ppm)	Human Health Principal Threat Criteria (ppm)
Human Health Exceedance Volume				
None	Not applicable	Not applicable	Not applicable	Not applicable
Biota Volume				
Aldrin	BCRL–0.094	0.005		
Dieldrin	BCRL–2.2	0.27		
Endrin	BCRL–2	0.053		
p,p,DDE	BCRL–0.78	0.027		
p,pDDT	BCRL–0.32	0.01		
Arsenic	BCRL–50	6.6		
Mercury	BCRL--1.9	0.16		

1 Based on concentrations of contaminants of concern within the potential biota risk area for the biota volume.

Table 9.1-2 Frequency of Detections for Ditches/Drainage Medium Group

	Total Samples	BCRL		CRL-SEC(1)		Acute-HH SEC(2)		HH SEC-Pr. Threat(2)		>Pr. Threat(2)	
	Analyzed	Number	%	Number	%	Number	%	Number	%	Number	%
Aldrin	256	226	88.3%	30	11.7%	0	0.0%	0	0.0%	0	0.0%
Benzene	50	49	98.0%	1	2.0%	--	--	0	0.0%	0	0.0%
Carbon Tetrachloride	51	51	100.0%	0	0.0%	--	--	0	0.0%	0	0.0%
Chlordane	243	189	77.8%	54	22.2%	0	0.0%	0	0.0%	0	0.0%
Chloroacetic Acid	67	67	100.0%	0	0.0%	--	--	0	0.0%	0	0.0%
Chlorobenzene	51	50	98.0%	1	2.0%	--	--	0	0.0%	0	0.0%
Chloroform	51	51	100.0%	0	0.0%	--	--	0	0.0%	0	0.0%
p,p,DDE	256	226	88.3%	30	11.7%	--	--	0	0.0%	0	0.0%
p,p,DDT	256	230	89.8%	26	10.2%	0	0.0%	0	0.0%	0	0.0%
Dibromochloropropane	169	166	98.2%	3	1.8%	--	--	0	0.0%	0	0.0%
1,2-Dichloroethane	51	51	100.0%	0	0.0%	--	--	0	0.0%	0	0.0%
1,1-Dichloroethene	11	11	100.0%	0	0.0%	--	--	0	0.0%	0	0.0%
Dicyclopentadiene	143	143	100.0%	0	0.0%	--	--	0	0.0%	0	0.0%
Dieldrin	256	161	62.9%	95	37.1%	0	0.0%	0	0.0%	0	0.0%
Endrin	256	205	80.1%	51	19.9%	0	0.0%	0	0.0%	0	0.0%
Hexachlorocyclopentadiene	257	252	98.1%	5	1.9%	--	--	0	0.0%	0	0.0%
Isodrin	256	233	91.0%	23	9.0%	--	--	0	0.0%	0	0.0%
Methylene Chloride	49	46	93.9%	3	6.1%	--	--	0	0.0%	0	0.0%
Tetrachloroethane	8	8	100.0%	0	0.0%	--	--	0	0.0%	0	0.0%
Tetrachloroethylene	51	51	100.0%	0	0.0%	--	--	0	0.0%	0	0.0%
Toluene	50	47	94.0%	3	6.0%	--	--	0	0.0%	0	0.0%
Trichloroethylene	51	51	100.0%	0	0.0%	--	--	0	0.0%	0	0.0%
Arsenic	157	84	53.5%	73	46.5%	0	0.0%	0	0.0%	0	0.0%
Cadmium	113	98	86.7%	15	13.3%	0	0.0%	0	0.0%	0	0.0%
Chromium	113	33	29.2%	80	70.8%	--	--	0	0.0%	0	0.0%
Lead	113	76	67.3%	37	32.7%	--	--	0	0.0%	0	0.0%
Mercury	200	148	74.0%	52	26.0%	0	0.0%	0	0.0%	0	0.0%

(1) SEC limits for this interval are based on chronic HH SEC, or where appropriate, acute risk-based criteria for the 0- to 1-ft depth interval.

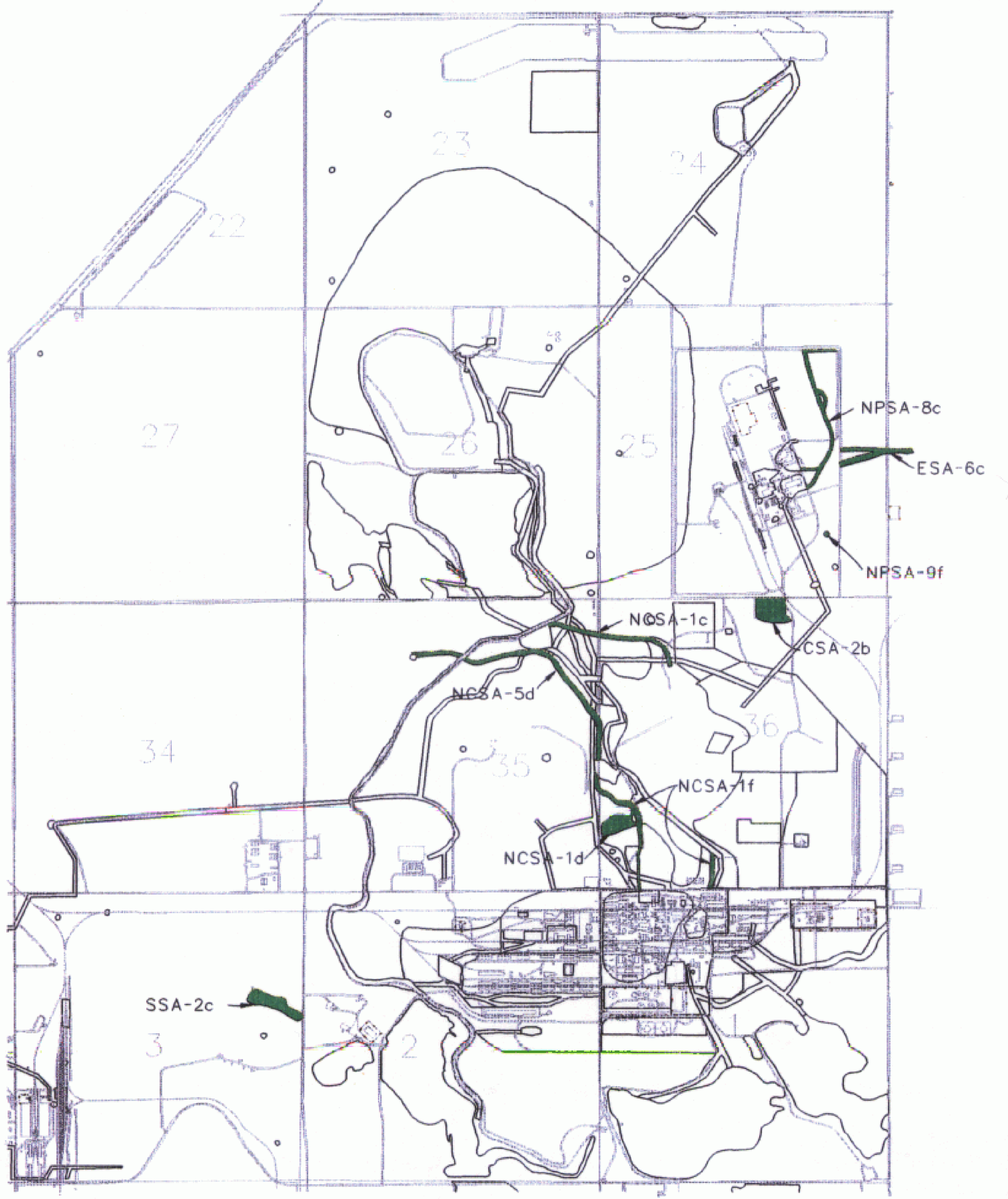
(2) Table 1.4-1 presents acute criteria, HH SEC, and principal threat criteria.

-- not applicable

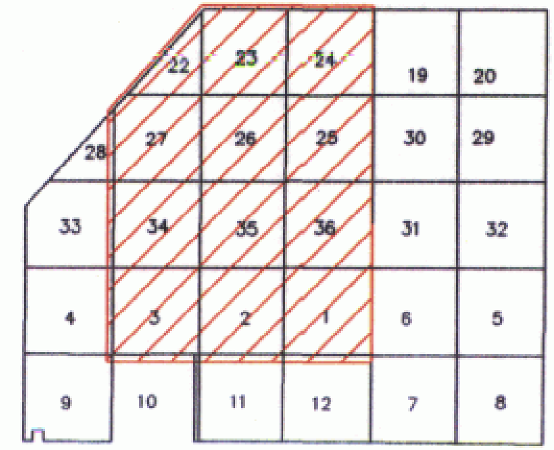
Table 9.2-1 Comparative Analysis of Alternatives for the Ditches/Drainage Areas Medium Group

Criteria	Alternative B1: No Additional Action	Alternative B2: Biota Management	Alternative B3: Landfill
1. Overall protection of human health and the environment	Not Protective: Does not achieve Biota RAOs; surface-water impacts not reduced	Protective: Achieves Biota RAOs by interrupting exposure pathways through access restrictions and biota controls; surface-water impacts not reduced	Protective: Achieves Biota RAOs through containment; impacts to surface water reduced
2. Compliance with ARARs	Does not comply with location-specific ARARs; medium group located in wetlands and a 100-year flood plain	Does not comply with location-specific ARARs; medium group located in wetlands and a 100-year flood plain	Complies: Wetlands restored after excavation
3. Long-term effectiveness and permanence	Low Residual Risk: Low levels of contamination	Low Residual Risk: Low levels of contamination with exposure pathways interrupted	Contaminated soil removed from the site; minimal residual risk
4. Reduction in TMV	Natural attenuation only for 52,000 BCY	Natural attenuation only for 52,000 BCY	Mobility reduced for contaminated soil by containment
5. Short-term effectiveness	No implementation required; more than 30 years to achieve RAOs	Impact to biota due to biota exclusion; minimal risk to workers and community adequately mitigated during fence installation and cultivation of lower-quality habitat; RAOs achieved in 3 years	Moderate short-term risk during excavation and transport of low-level contamination; adequately mitigated; RAOs achieved in 2 years
6. Implementability	Feasible	Technically feasible; Elimination of habitat may not be administratively feasible if it conflicts with refuge management plan	Feasible; No difficulties anticipated
7. Present worth costs	Capital—0 Operating—0 Long-term—$1,180,000 Total—$1,180,000	Capital—$543,000 Operating—$51,000 Long-term—$1,470,000 Total—$2,070,000	Capital—$1,350,000 Operating—$2,040,000 Long-term—$37,000 Total—$3,430,000
Summary	Retained: Only low levels of contamination remain although RAOs not achieved	Not Retained: Habitat eliminated and residual risk not substantially reduced at higher cost than no additional action.	Retained: Contaminated soil removed from site and contained

Criteria	Alternative B5a: Landfill; Caps/Covers with Consolidation	Alternative B9: In Situ Biological Treatment
1. Overall protection of human health and the environment	Protective: Achieves Biota RAOs through containment	Protective: Achieves Biota RAOs, but does not completely remove risk
2. Compliance with ARARs	Complies: Wetlands restored after excavation	Complies: Wetlands restored after excavation
3. Long-term effectiveness and permanence	Minimal Residual Risk: Contaminated soil removed from site	Low Residual Risk: Magnitude of contaminant reduction by landfarming uncertain
4. Reduction in TMV	Mobility reduced for contaminated soil by containment	TMV reduced by landfarming, although magnitude of reduction not certain
5. Short-term effectiveness	Moderate short-term risk during excavation and transport of low-level contamination; adequately mitigated; RAOs achieved in 2 years	Moderate risk during landfarming over relatively small area; adequately mitigated; significant short-term impacts to habitat; RAOs achieved in 3 years
6. Implementability	Feasible	Difficult technical feasibility due to physical characteristics of ditches; difficult administrative feasibility due to concerns on variability of reductions from agricultural practices
7. Present worth costs	Capital—0 Operating—$1,780,000 Long-term—0 Total—$1,780,000	Capital—0 Operating—$110,000 Long-term—$1,010,000 Total—$1,120,000
Summary	Retained: Contaminated soil removed from site and lower cost than landfilling	Not Retained: Concerns about variability in contaminant reduction from agricultural practices; short-term impacts to habitat



ROCKY MOUNTAIN ARSENAL
INDEX MAP



LEGEND

Ditches/Drainage Areas Medium Group
Sites: CSA-2b, Parking Lot/Scrap Storage
ESA-6c, North Plants Drainage Ditch
NCSA-1c, Basin A to Basin B Ditch
NCSA-1d, Liquid Storage Pool
NCSA-1f, South Plants Drainage Ditches
NCSA-5d, Surface Drainage Canal
NPSA-8c, Miscellaneous Drainages
NPSA-9f, Isolated Detection
SSA-2c, Overflow Basin and Ditch

Site Boundary

Buildings and Roads

2 Section Number

1100 0 1100 2200 FEET

Prepared for:

U.S. Army Program Manager
for Rocky Mountain Arsenal

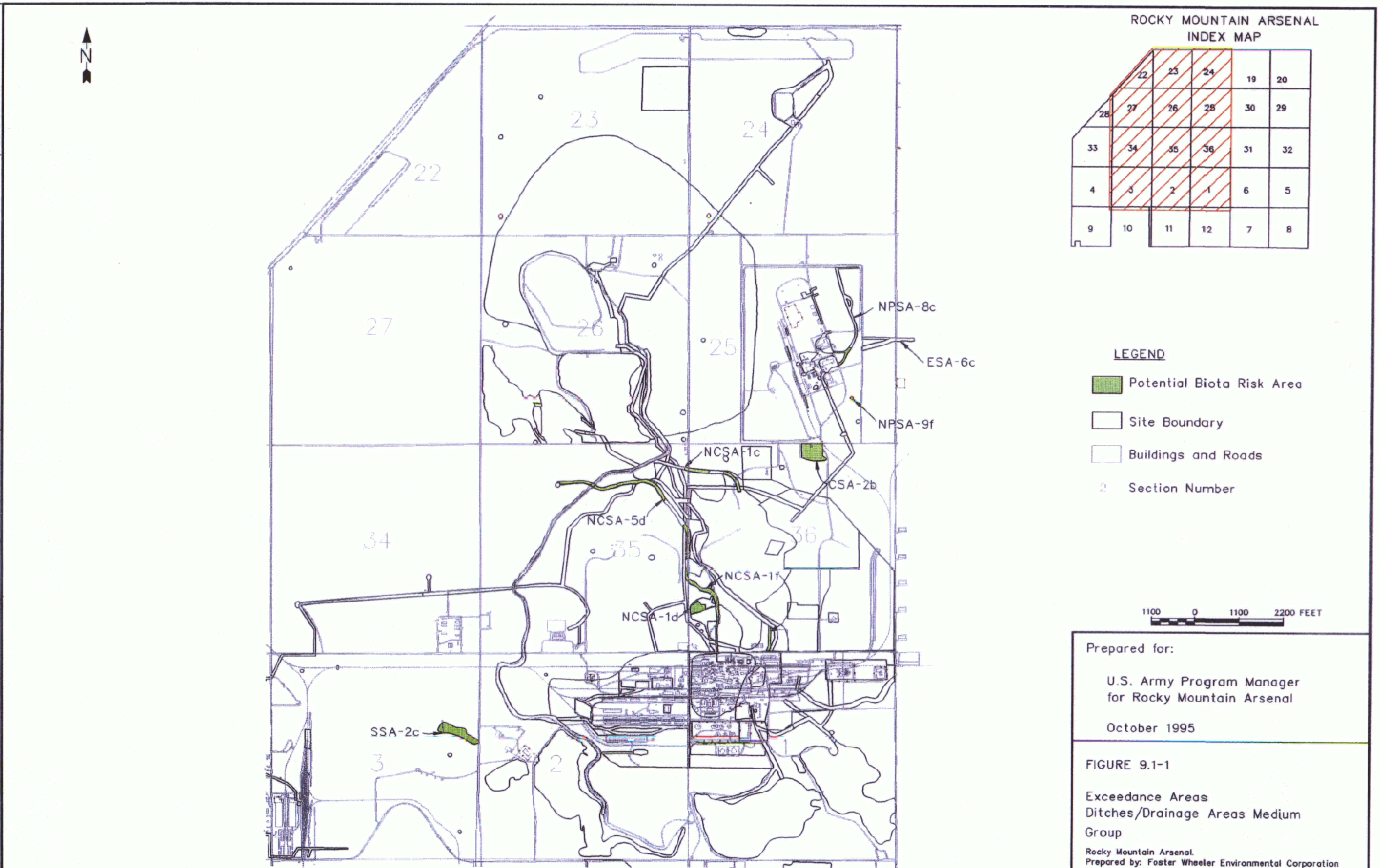
October 1995

FIGURE 9.0-1

Site Locations
Ditches/Drainage Areas Medium Group

Rocky Mountain Arsenal.
Prepared by: Foster Wheeler Environmental Corporation

REVISION NO. 0
FILE NAME 20110\32\F03-013.DWG
DATE 3/2/93
DRAWN BY EMH
APPROVED BY
CHECKED BY



Prepared for:

U.S. Army Program Manager
for Rocky Mountain Arsenal

October 1995

FIGURE 9.1-1

Exceedance Areas
Ditches/Drainage Areas Medium
Group

Rocky Mountain Arsenal.
Prepared by: Foster Wheeler Environmental Corporation

Section 10

10.0 DETAILED ANALYSIS OF ALTERNATIVES FOR THE BASIN A MEDIUM GROUP

The Basin A Medium Group consists of two sites that are within the Basin A high-water line. Basin A is considered distinct from the other basins at RMA because there is potential for agent and UXO to be present at the sites. Manufacturing-wastewater effluent, which contained a combination of organic and inorganic contaminants, was historically disposed in Basin A between 1942 and 1958.

The primary Human Health COCs and contaminants that potentially pose risk to biota in this medium group are OCPs and arsenic. Waste disposal in Basin A has resulted in elevated salt concentrations in the soil due to the high chloride content. Site NCSA-1a (Basin A) contains high levels of contamination, and a part of the site is considered a principal threat area. (See Section 1.4.3 for a discussion of principal threats.) Portions of the Basin A Medium Group potentially contain agent and/or UXO. The two sites within this medium group are also potential sources of groundwater and surface-water contamination based upon the migration pathways identified in the RISR (EBASCO 1992a). Table 10.0-1 presents the characteristics of this medium group, including exceedance volumes and COCs, and Appendix A in Volume IV contains a summary of the calculations of exceedance volumes and areas for the Basin A Medium Group.

During the DSA, alternatives were developed and screened based on the general characteristics of the medium group. Individual subgroups were not developed during the DAA, so the retained alternatives apply to the medium group as a whole. The characteristics of the sites in this medium group—including contaminants and contaminant concentrations, site configuration, and depth of contamination—were reviewed to determine whether changes to the retained alternatives for the Basin A Medium Group would be appropriate. As a result, the alternatives for the medium group were modified from the DSA (EBASCO 1992b) to treat principal threat areas and to contain residual contamination (see Section 10.2).

The following sections present the characteristics of the medium group and an evaluation of the alternatives against the DAA criteria listed in the NCP (EPA 1990a). Based on a comparative analysis of the alternatives, a range of alternatives for this medium group was retained for consideration in the development of the sitewide remedial alternatives (Section 20).

10.1 MEDIUM GROUP CHARACTERISTICS

The Basin A Medium Group is composed of sites NCSA-1a (Basin A) and NCSA-1e (Burn Site) (Figure 10.1-1). These sites, consisting of soil within the high-water line of Basin A, received and retained manufacturing effluent from South Plants via the Lime Settling Basins. Site NCSA-1e was used to incinerate munitions and trash from South Plants. Figure 10.1-1 illustrates both the distribution of the human health exceedance areas, as soil that may pose risks to biota, and principal threat areas, and Figure 10.1-2 presents the location of the potential agent and UXO presence areas relative to the exceedance areas. Under the Volume Refinement Program (EBASCO 1994b) Basin A soil was sampled and analyzed for agent compounds. Several samples collected near the Section 36 Lime Basins Subgroup contained agent compounds, which confirms the presence of agent in Basin A.

Table 10.1-1 provides a summary of contaminants, concentrations, and corresponding exceedance values for this medium group, which contains 300,000 BCY of contaminated soil, and Table 10.1-2 lists the frequency of detections for the Basin A Medium Group. Table 10.1-1 shows that maximum concentrations of OCPs, arsenic, mercury, and chromium exceed the Human Health SEC (EBASCO 1994a). The maximum concentrations of dieldrin (2,600 ppm) and arsenic (28,000 ppm) also exceed the principal threat criteria (10^{-3} excess cancer risk, HI of 1,000) in approximately 32,000 BCY (Table 10.0-1). Soil outside of the human health exceedance area and between 0 and 1 ft below ground surface contains contamination that potentially poses risk to biota (Figure 10.1-1). The majority of Human Health COCs are found in the 0- to 10-ft (or water table) depth interval, but contamination has been detected below 10 ft. The maximum concentrations of most COCs may pose a potential risk to biota, and the average concentrations of most COCs detected may also pose a risk to biota. In addition, both sites in this medium group contain agent and/or UXO. Site NCSA-1e contains a black sludge layer approximately 2 to 5 ft below ground surface that may contain munitions.

The Basin A Medium Group can be subdivided into three regions based on differences in contaminant types and concentrations. The eastern region is characterized by high concentrations of OCPs, arsenic, and chromium that exceed the Human Health SEC (EBASCO 1994a). The southern region is characterized by high concentrations of OCPs, chlordane, and arsenic that exceed the Human Health SEC (EBASCO 1994a). The northern region is characterized by low concentrations of OCPs, arsenic, and mercury; chlordane is present at concentrations exceeding the Human Health SEC (EBASCO 1994a). Portions of these three regions contain agent and potentially contain UXO (Figure 10.1-2).

The Basin A Medium Group primarily consists of unvegetated areas and much of the area has been disturbed by waste disposal activities. The areas that are disturbed during remediation are to be revegetated with native grasses in accordance with a refuge management plan following remediation, so the overall habitat value is improved after remedial actions. However, for alternatives involving containment of contaminated soil and/or residual contamination with a cap/cover, the types of vegetation and maintenance activities are designed to discourage burrowing animals from using these areas as habitat.

Both of the sites within the Basin A Medium Group have been identified as sources of a groundwater plume. The plume occurs in the unconfined aquifer and follows the Basin A Neck paleochannel to the northwest, where it is intercepted and treated by the Basin A Neck IRA treatment system. Groundwater alternatives are currently being evaluated for the Basin A Plume Group in the Water DAA, and soil containment or excavation alternatives must be coordinated with alternatives developed for the water medium. For example, the need for a separate construction-dewatering system may be eliminated depending on the schedule for groundwater remediation.

10.2 BASIN A MEDIUM GROUP EVALUATION OF ALTERNATIVES

The 10 alternatives developed for this medium group vary in approach from no action to containment and treatment. The retained alternatives from the DSA (EBASCO 1992b) were modified to account for the treatment of principal threat volumes and containment of residual contamination at depths more than 10 ft below ground surface. The containment component of all Basin A alternatives was modified to remove slurry walls, which were proposed in the DSA, based on the results of groundwater modeling performed during the DAA.

Second, the removal of FC2A as a COC results in the withdrawal of Alternative 9: Direct Soil Washing, which was retained in the DSA (EBASCO 1992b) solely for treating FC2A. It was not evaluated for the DAA since FC2A is no longer considered a COC. Solvent washing was screened out in the DSA in favor of thermal desorption based on effectiveness and cost considerations. However, recent pilot-scale treatability studies at RMA have demonstrated the potential treatment of soil contaminated with OCPs by solvent washing; ongoing studies will determine whether soil with agent can be treated to a 3X level. As such Alternative 8b: Direct Soil Washing; Direct Solidification; Caps/Covers was reintroduced into the DAA for Basin A.

The following subsections present a description of each alternative and an evaluation of the alternative against the EPA criteria for the DAA. Each alternative developed for the Basin A Medium Group consists of an alternative to address soil with human health exceedances (which is always listed first), an alternative to address soil that potentially poses risk to biota (the "B" alternative), and alternatives for soil with potential presence of agent (the "A" alternative) or UXO (the "U" alternative).

10.2.1 Alternative 1/B1/A1/U1: No Additional Action

Alternative 1: No Additional Action (Provisions of FFA), along with Alternative B1: No Additional Action (Provisions of FFA), Alternative A1: No Additional Action (Provisions of FFA), and Alternative U1: No Additional Action (Provisions of FFA), applies to the entire 670,000 SY of exceedance soil in the Basin A Medium Group. The entire 300,000 BCY, including the human health exceedance volume, soil potentially containing UXO and/or agent, and soil that potentially poses risk to biota, remain in place. No action is taken to reduce human or biota exposure to COCs or to reduce potential groundwater or surface-water contamination from sites in this group. Long-term soil monitoring of the area is conducted (an average of 80 samples per year), and annual groundwater sampling and 5-year site reviews are conducted to assess natural attenuation/degradation and potential migration of contaminants.

The following discussion presents a detailed evaluation of this alternative against the DAA criteria listed in the NCP (EPA 1990a). For purposes of comparison, Table 10.2-1 summarizes the evaluation of all of the alternatives developed for the Basin A Medium Group.

10.2.1.1 Overall Protection of Human Health and the Environment

This alternative does not achieve Human Health or Biota RAOs since untreated soil remains in place and no controls are implemented. The impacts to groundwater are not reduced and the only long-term reduction in TMV is through natural attenuation.

10.2.1.2 Compliance with ARARs

This alternative complies with action- and location-specific ARARs since long-term monitoring and site reviews are conducted and since Basin A is not located in wetlands or a 100-year flood plain. In addition to ARARs, the alternative also complies with provisions of the FFA (EPA et al. 1989). (ARARs are listed in Appendix A of the Technology Descriptions Volume.) This alternative does not comply with Army regulations regarding the management of agent-contaminated materials or UXO since no controls are initiated.

10.2.1.3 Long-Term Effectiveness and Permanence

The residual risk associated with this alternative is high due to the high levels of contamination that remain in the soil. High concentrations of OCPs, chromium, mercury, and arsenic exceeding the Human Health SEC (EBASCO 1994a) and potentially posing a risk to biota remain in place. No action is taken to remove the contamination or eliminate any exposure pathways, including fugitive dust. Site reviews, soil monitoring, and groundwater monitoring are conducted to assess natural attenuation/degradation and potential migration of the contaminants. The existing habitat is neither impacted nor improved by this alternative.

10.2.1.4 Reduction in TMV

There is no reduction in TMV except by natural attenuation since no materials are treated. A total of 300,000 BCY of untreated soil containing human health and biota exceedances and potentially containing agent and UXO remains in place.

10.2.1.5 Short-Term Effectiveness

RAOs are not achieved within 30 years because natural attenuation is the only process by which contamination can be reduced; soil with potential agent and UXO remains on site. This alternative does not pose additional risk to workers and the community during remedial actions since no actions are taken, but the potential risks associated with fugitive dust are not addressed. In addition, there are significant ongoing environmental impacts, including continued migration of contaminants to the groundwater. The existing habitat quality is not impacted or improved.

10.2.1.6 Implementability

The alternative is technically and administratively feasible. Monitoring services are widely available to sample soil and groundwater.

10.2.1.7 Cost

The total present worth cost is $5,770,000 and includes only long-term O&M costs associated with long-term monitoring and site reviews. Table B4.1-1 details the costing for this alternative.

10.2.2 Alternative 1a/B1/A1/U1: Direct Thermal Desorption of Principal Threat Volume; No Additional Action

Alternative 1a: Direct Thermal Desorption (Direct Heating) of Principal Threat Volume; No Additional Action (Provisions of FFA), along with Alternative B1: No Additional Action (Provisions of FFA), Alternative A1: No Additional Action (Provisions of FFA), and Alternative U1: No Additional Action (Provisions of FFA), involves the treatment of 32,000 BCY of principal threat volume in the Basin A Medium Group. This area is cleared of UXO using geophysical surveys or other field-screening methods prior to excavation and then screened for the presence of agent during the excavation of the principal threat volumes. Any identified UXO are excavated, packaged, and transported to an off-post Army facility for demilitarization in accordance with Alternative U4: Detonation (Off-Post Army Facility); Incineration/Pyrolysis (Off-Post Incineration) as discussed in Section 4.3.5. Soil with identified agent contamination is treated by caustic washing in accordance with Alternative A3: Direct Soil Washing (Caustic Solution Washing) (Section 4.4.3); Landfill (On-Post Landfill) as described in Section 4.6.6.

During excavation, a daily soil cover or a plastic liner is placed over the excavated areas to minimize release of odors and volatile contaminants. If dewatering has not been implemented in Basin A as part of the remedial activities developed for the water medium, it is initiated 2 years prior to excavation and continues during the 2-year excavation period. Water is removed from the area at 5 gallons per minute (gpm) and pumped to the CERCLA Wastewater Treatment Plant or a new treatment plant.

The principal threat volume of 32,000 BCY is excavated and hauled to a centralized thermal desorption facility. The soil is assumed to be saturated (a moisture content of 20 percent) due to the high water table in Basin A. Saturated soil is processed through the desorber at a rate of approximately 1,300 BCY/day at an operating temperature of 300°C and a solids residence time of 50 minutes. The processing rate for thermal desorption decreases as the water content of the soil increases due to the additional heat required to evaporate the water before the desorption process can begin. Section 4.6.24 discusses emission controls for off gases from the thermal desorber. Particulates from quench blowdown amount to approximately 1 percent of the total solids feed. This particulate volume of 320 BCY is carried via truck to the on-post landfill for disposal. Treated soil is returned to the site excavation and backfilled. Since thermal desorption removes the organic carbon in the soil, the uppermost 6 inches of soil are supplemented with conditioners and revegetated with native grasses to restore habitat.

The soil remaining in the Basin A Medium Group falls under the no additional action component of the alternative. The remaining volume of 268,000 BCY of contaminated soil remains in place and no controls are initiated. No action is taken in these areas to reduce human or biota exposure to COCs or to reduce potential groundwater contamination. The remaining soil exhibits moderate residual risk for human health and biota based on average contaminant concentrations, although chlordane is the only analyte with an average concentration that exceeds the Human Health SEC (EBASCO 1994a). Long-term monitoring of the area is conducted (an average of 80 samples per year), annual groundwater sampling is conducted, and 5-year site reviews are conducted to assess natural attenuation/degradation and potential migration of contaminants.

The following discussion presents a detailed evaluation for this alternative against the DAA criteria listed in the NCP (EPA 1990a). For purposes of comparison, Table 10.2-1 summarizes the evaluation of all of the alternatives developed for the Basin A Medium Group.

10.2.2.1 Overall Protection of Human Health and the Environment

This alternative does not achieve Human Health or Biota RAOs. Although the principal threat volume is removed and treated, the untreated soil, for which a reduction in contamination can only be achieved through natural attenuation, remains in place and continues to impact groundwater. The short-term impacts can be reduced during excavation of principal threats, but the risks associated with fugitive dust are not addressed.

10.2.2.2 Compliance with ARARs

This alternative complies with action-specific ARARs including state regulations on air emissions sources, landfill siting, design, operation, and impacts to endangered species. In addition, long-term monitoring and site reviews are conducted for areas where no action is taken. Basin A, the centralized thermal desorption facility, and the landfill are not located in wetlands or a 100-year flood plain, thus complying with location-specific ARARs. This alternative complies with the provisions of the FFA (EPA et al. 1989). (ARARs are listed in Appendix A of the Technology Descriptions Volume.) This alternative does not achieve Army regulations regarding agent-contaminated material or UXO since no controls are initiated for the balance of the areas within this medium group.

10.2.2.3 Long-Term Effectiveness and Permanence

The residual risk associated with this alternative is moderate since untreated soil exceeding Human Health SEC (EBASCO 1994a) remains in place. This soil poses a potential risk to biota and potentially contains agent and UXO. Controls associated with the air pollution control equipment on the thermal desorber are adequate and the treatment residuals recovered by the off-gas treatment system are placed in the on-post hazardous waste landfill. There is high confidence in the reliability of the landfill engineering controls and there are no difficulties associated with landfill maintenance. For the balance of the site, no controls are implemented, and the potential risks associated with fugitive dust are not addressed. Site reviews, soil monitoring, and groundwater monitoring are conducted to assess natural attenuation/degradation and potential migration of contaminants. The existing habitat is neither improved nor impacted by the alternative, although habitat associated with the principal threat area is restored through revegetation.

10.2.2.4 Reduction in TMV

The principal threat volume of 32,000 BCY is thermally desorbed to destroy OCPs and remove mercury, but the remaining 268,000 BCY of untreated soil with the potential presence of agent and UXO remain. The organics in the principal threat volume are reduced to below detectable levels or to achieve a destruction removal efficiency (DRE) of >99.99 percent. The TMV reduction by thermal desorption is irreversible. Treatment residuals from the off-gas treatment equipment associated with the thermal desorber and salts (approximately 320 BCY) are contained in the on-post hazardous waste landfill. Groundwater removed during dewatering activities is treated at the CERCLA Wastewater Treatment Plant or a new treatment plant and reinjected on post. For the balance of the site, there is no reduction in TMV except by natural attenuation.

10.2.2.5 Short-Term Effectiveness

This alternative entails significant short-term risks associated with UXO/agent clearance, excavation, transportation, and thermal desorption of contaminated soil. These risks are reduced through engineering controls and PPE, but they cannot be completely removed. Engineering dust controls (such as water sprays) and vapor/odor controls (such as daily covers, tarps, or foams) are employed to reduce short-term risks; however, the adequacy of these controls has not been fully demonstrated, and the possibility exists for vapor/odor emissions during excavation despite these controls. In addition, the preparation of the feedstock prior to thermal desorption presents short-term risks, even though the materials handing is conducted in an enclosed building to control dust and vapors/odors. Although the off-gas control system for the thermal desorber is designed to achieve air quality standards, the emissions from the thermal desorber contain low but acceptable concentrations of some contaminants.

RAOs are not achieved within 30 years because natural attenuation is the only process by which contamination can be reduced for the balance of the site (which also may contain agent and UXO). Excavation and treatment of the principal threat volume is feasible within 1 year after 2 years for construction of the thermal desorption facility and landfill. There are minimal impacts on the environment from disturbing the existing habitat, and groundwater removed during dewatering activities is treated and reinjected on post. However, although the principal threat volume is removed and treated, untreated soil, for which a reduction in toxicity can only be achieved through natural attenuation, remains in place and continues to impact groundwater. In addition, risks to the community and site workers from fugitive dust are not addressed.

10.2.2.6 Implementability

Vapor/odor controls are not well demonstrated and some controls, such as foams, have limited availability. The use of temporary soil covers increases the volume to be excavated and requires handling the soil cover twice, once to lay the cover and once to remove it (i.e., it requires "double handling"), so that contaminated soil can be accessed. Thermal desorption is widely available and has been used to treat similar contaminants; however, the technology has not been demonstrated at the scale required for RMA or on materials with elevated salt contents. The thermal desorption facility can be constructed within the required time frame, but the operation of the unit may be difficult due to the high levels of contamination, high moisture content, materials-handling problems, and the elevated levels of salts in the soil feed. Administrative difficulties associated with demonstrating compliance with permits and performing O&M may lead to delays, and it may be difficult to implement this alternative due to the perceptions regarding the safety of thermal treatment. Equipment, specialists, and materials are readily available for construction of the landfill and for design and construction of the thermal desorber.

10.2.2.7 Cost

The total present worth cost is $15,600,000 including $1,430,000, $9,060,000, and $5,150,000 for capital, operating, and long-term costs, respectively. Table B4.1-1a details the costing for this alternative.

There are three significant uncertainties associated with the costing of this alternative. First, the extent and depth of contamination and extent of UXO/agent presence are difficult to delimit. Second, there is very little operational experience at other sites upon which to base cost estimates for vapor/odor controls and to evaluate their impact on excavation and equipment productivity. Third, the elevated concentrations of the contaminants and salts in the feedstock, the high moisture content of the soil, and the need for materials handling increase uncertainties relative to maintaining the assumed on-line percentage of the thermal desorption unit. These operating conditions are not typical of previous thermal desorption projects and may result in changes in maintenance requirements or delays in implementation, both of which may impact treatment costs. The overall magnitude of these uncertainties is relatively low, however, because the volume of soil to be excavated under this alternative is small compared to that under other alternatives for this medium group.

10.2.3 Alternative 3b/B5/A3/U4: Landfill; Caps/Covers

Alternative 3b: Landfill (On-Post Landfill); Caps/Covers (Soil Cover or Multilayer Cap), combined with Alternative B5: Caps/Covers (Multilayer Cap), Alternative A3: Direct Soil Washing (Caustic Solution Washing); Landfill (On-Post Landfill), and Alternative U4: Detonation

(Off-Post Army Facility); Incineration/Pyrolysis (Off-Post Incineration), consists of the excavation and disposal of 180,000 BCY of human health exceedance soil in a centralized on-post hazardous waste landfill and the containment of 670,000 SY of residual contamination (below 10 ft or the water table) and shallow soil that may pose potential risk to biota with a multilayer cap. Approximately 430,000 SY of soil in the Basin A Medium Group potentially contain agent, which are cleared in accordance with Alternative A3 during excavation activities, and 140,000 SY of soil potentially contain UXO, which are cleared in accordance with Alternative U4.

Prior to excavation, geophysical surveys or other field screening methods are used to identify locations containing UXO. If located, UXO are excavated, packaged, and transported to an off-post Army facility for demilitarization (Alternative U4). Approximately 30,000 BCY of surficial debris and soil associated with UXO clearance are removed and landfilled, and an additional 17,000 BCY of this material, which overlaps with the human health exceedances volume, are also placed in the hazardous waste landfill (Volume IV, Table A-4). The human health exceedance volume is screened for the presence of agent during excavation. Soil testing positive for the potential presence of agent is stockpiled in a secure area until these results are confirmed by RMA laboratory analysis. Any soil with confirmed agent presence is treated by caustic washing. Section 4.4.3 discusses the details of caustic washing. Operating parameters of the caustic washing unit include a processing rate of 35 BCY/day and a liquid waste stream of approximately 1,800 gallons/day. The waste stream is evaporated with a crystallizer that generates approximately 1 pound of salts for every 7.5 gallons of liquid evaporated. These salts are placed in the on-post hazardous waste landfill along with the treated soil.

A daily soil cover or plastic liner is placed over the excavated areas to minimize volatile emissions and odors from the excavation. This alternative also includes dewatering of the excavation using groundwater extraction wells. If dewatering has not been implemented in Basin A as part of the remedial activities for the water medium, it is initiated 2 years prior to excavation and continues during the 2-year excavation period. Water is removed from the area at 5 gpm and pumped to the CERCLA Wastewater Treatment Plant or a new treatment plant.

After excavation, the soil with human health exceedances is transported and disposed in the on-post hazardous waste landfill. Construction of the landfill and support facilities requires 1 year. The landfill has a capacity for multiple cells as discussed in Section 4.6.6. The landfill cover is revegetated after installation, and fencing is installed to exclude biota and prevent damage to the system. Since 210,000 BCY of untreated soil (180,000 BCY) and debris (30,000 BCY) from Basin A are contained in the landfill, the landfill cover requires long-term monitoring and maintenance. Long-term maintenance activities include collecting and treating leachate and monitoring potential leachate migration from the landfill.

After backfilling the excavations, a multilayer cap is installed over the 670,000-SY area with residual contamination (below 10 ft or the water table) as well as over the shallow soil that may potentially pose a risk to biota. The cap consists of a 2-ft-thick layer of compacted, low-permeability soil, a 1-ft-thick biota barrier of crushed concrete, and a 4-ft-thick soil/vegetation layer that includes 6 inches of reconditioned soil.

The borrow area is also regraded and revegetated to restore habitat. The existing habitat at the site is improved after remediation by revegetation; however, the habitat at the landfill site is eliminated because the types of vegetation placed there and the maintenance activities performed discourage burrowing animals from using the landfill area as habitat.

The following discussion presents a detailed evaluation of this alternative against the DAA criteria listed in the NCP (EPA 1990a). For purposes of comparison, Table 10.2-1 summarizes the evaluation of all of the alternatives developed for the Basin A Medium Group.

10.2.3.1 Overall Protection of Human Health and the Environment

This alternative achieves Human Health and Biota RAOs through the containment of human health exceedance soil in a hazardous waste landfill and the containment of residual contamination under a cap. This alternative is protective of the environment because contaminants are contained, which prevents exposures to humans or biota. Since some of the contaminated soil is removed and the residual contamination is contained, impacts to groundwater are greatly reduced. However, excavation of the contaminated soil that potentially contains agent/UXO involves significant short-term impacts that cannot be completely eliminated.

10.2.3.2 Compliance with ARARS

This alternative complies with action-specific ARARs regarding the construction of caps/covers and the monitoring of contained material including state regulations on landfill siting, design, and operation. Endangered species are not impacted. Basin A and the landfill are not located in wetlands or a 100-year flood plain, thus complying with location-specific ARARs. Disposal in the landfill does not trigger LDRs because the landfill is a CAMU (as defined in Section 1.4). In addition to ARARs, this alternative complies with the provisions of the FFA (EPA et al. 1989) and Army Material Command regulations (AMC-R 385-131) (AMC 1987) regarding agent and UXO demilitarization. (ARARs are listed in Appendix A of the Technology Descriptions Volume.)

10.2.3.3 Long-Term Effectiveness and Permanence

The residual risk associated with this alternative is low since the more highly contaminated soils are removed from the site and contained in a hazardous waste landfill and since the soil that poses risks to biota, along with deeper residual contamination, is contained in place. There is high confidence in the reliability of the landfill and multilayer cap engineering controls, and there are no difficulties associated with maintenance. Engineering controls for the landfill are ensured through long-term monitoring. In addition, 5-year site reviews and cap-maintenance operations are conducted to ensure the effectiveness of controls. The existing conditions at the site are improved through revegetation with native grasses; however, habitat at the landfill site is eliminated.

10.2.3.4 Reduction in TMV

The mobility of the contaminants and the exposure pathways to humans and biota are eliminated through the landfilling of 210,000 BCY of soil (180,0000 BCY) and debris (30,000 BCY) and the capping of 670,000 SY of residual contamination. The reduction in contaminant mobility is irreversible so long as the landfill and multilayer cap are maintained. Since these materials are not treated, natural attenuation is the only process by which contaminant toxicity or volume can be reduced. Soil with agent or UXO presence is identified during excavation activities, and then treated and landfilled. Groundwater removed during dewatering activities at a rate of 5 gpm is treated at the CERCLA Wastewater Treatment Plant or a new treatment plant and reinjected on post.

10.2.3.5 Short-Term Effectiveness

This alternative involves significant short-term risks associated with UXO/agent clearance, excavation, transportation, and landfilling of contaminated soil. These risks are reduced through engineering controls and PPE, but they cannot be completely removed. Engineering controls for dust (such as water spraying) or vapor/odor (such as daily covers, tarps, or foams) are initiated to reduce short-term risks; however, the adequacy of these controls has not been fully demonstrated, and the possibility exists for vapor/odor emissions during excavation despite these controls. There are minimal impacts to the environment due to the existing disturbed habitat. Migration of the contaminants to the groundwater is significantly reduced. The time frame until RAOs are achieved is 4 years. Excavation of the 210,000 BCY is feasible within 1 year, following 1 year for the construction of the landfill and 2 years for dewatering. The installation of the 670,000 SY cap and required 2,500,000 BCY of gradefill entails 4 years.

10.2.3.6 Implementability

The alternative is technically feasible and can be implemented within the required time frame and reliably operated and maintained thereafter with periodic landfill-cell monitoring. Vapor/odor controls are not well demonstrated, and some controls such as foams have limited availability. The use of soil covers increases the volume to be excavated and requires double handling to access the contaminated soil. Additional future remedial actions can be undertaken for soil left in place, although the cap adds to the overall site volume. Additional remedial actions for the landfilled soil also involve removal of the landfill cover. The substantive Subtitle C landfill siting, design, and operating regulations are achieved. Equipment, specialists, and materials are readily available for landfill and multilayer cap construction, and the technologies have been well demonstrated at full scale.

10.2.3.7 Cost

The total present worth cost is $73,700,000 including $5,860,000, $66,200,000, and $1,630,000 for capital, operating, and long-term costs, respectively. Table B4.1-3b details the costing for this alternative. There are two significant uncertainties associated with the costing of this alternative. First, the extent and depth of contamination and extent of UXO/agent presence are difficult to estimate. Second, there is very little operating experience at other sites upon which to base cost estimates for vapor/odor controls and to evaluate their impact on excavation and equipment productivity.

10.2.4 Alternative 3c/B5/A3/U4: Direct Thermal Desorption of Principal Threat Volume; Landfill; Caps/Covers

Alternative 3c: Direct Thermal Desorption (Direct Heating) of Principal Threat Volume; Landfill (On-Post Landfill); Caps/Covers (Multilayer Cap), combined with Alternative B5: Caps/Covers (Multilayer Cap), Alternative A3: Direct Soil Washing (Caustic Solution Washing); Landfill (On-Post Landfill), and Alternative U4: Denotation (Off-Post Army Facility); Incineration/Pyrolysis (Off-Post Incineration), consists of the excavation and treatment of 32,000 BCY of principal threat volume, disposal of the remaining human health exceedance volume of 150,000 BCY in a centralized on-post hazardous waste landfill, and containment of 670,000 SY of residual contamination (below 10 ft or the water table) and shallow soil that may pose a potential risk to biota with a multilayer cap. Approximately 430,000 SY of Basin A potentially contain agent, which are cleared in accordance with Alternative A3, and 140,000 SY of soil potentially contain UXO, which are cleared in accordance with Alternative U4.

Prior to excavation, geophysical methods or other field-screening techniques are used to identify locations containing UXO. If located, the UXO are excavated, packaged, and transported to an off-post Army facility for demilitarization (Alternative U4). Approximately 30,000 BCY of surficial debris and soil associated with UXO clearance are removed and landfilled, and an additional 17,000 BCY of this material (Volume IV, Table A-4), which overlaps with the human health exceedance volume, are also placed in the hazardous waste landfill. During excavation, soil testing positive for potential presence of agent is stockpiled in a secure area until the results are confirmed by RMA laboratory analysis. Soil with confirmed agent presence is treated by caustic washing. Section 4.4.3 discusses the details of caustic washing. Operating parameters of the caustic solution washing unit are described in Section 10.2.3.

A daily soil cover or plastic liner is placed over the excavated areas to minimize volatile emissions and odors from the excavation. This alternative also includes dewatering of the excavation using groundwater extraction wells. If dewatering has not been initiated in Basin A as part of the remedial activities developed for the water medium, it is initiated 2 years prior to excavation and continues during the 2-year excavation period. Water is removed from the area at 5 gpm and pumped to the CERCLA Wastewater Treatment Plant or a new treatment plant.

The principal threat volume of 32,000 BCY is excavated and hauled to a centralized thermal desorption facility. The soil is assumed to be saturated (20 percent water) due to the high water table in Basin A. Saturated soil is processed through the desorber at a rate of approximately 1,300 BCY/day at an operating temperature of 300°C and a solids residence time of 50 minutes. The processing rate for thermal desorption decreases as the water content of the soil increases due to the additional heat required to evaporate the water before the desorption process can begin. Section 4.6.24 discusses emission controls for off gases from the thermal desorber. Particulates from quench blowdown amount to approximately 1 percent of the total solids feed. This particulate volume of 320 BCY is carried via truck to the on-post landfill for disposal. Treated soil is landfilled.

The remaining human health exceedance volume is excavated, transported, and disposed in the on-post hazardous waste landfill. Construction of the landfill and support facilities requires 1 year. The landfill has a capacity for multiple cells as discussed in Section 4.6.6. The landfill cover is revegetated and fencing installed to exclude biota and to prevent damage to the system. Since 210,000 BCY of untreated soil (144,000 BCY), treated soil (32,000 BCY), and debris (30,000 BCY) are contained in the landfill, the landfill cover requires long-term monitoring and maintenance. Long-term maintenance activities include collecting and treating leachate and monitoring potential leachate migration from the landfill.

After backfilling the excavations, a low-permeability soil cap is installed over the 670,000-SY area with residual contamination (below 10 ft or the water table) as well as over the surficial soil that may pose a potential risk to biota. The cap consists of a 2-ft-thick layer of compacted, low-permeability soil, a 1-ft-thick biota barrier of crushed concrete, and a 4-ft-thick soil/vegetation layer that includes 6 inches of reconditioned soil. The cap design is described in Section 4.6.6. The containment of Basin A requires placement of approximately 2,500,000 BCY of soil as gradefill to bring the area to the design grade of 3 to 5 percent as described in Section 6.2.1 of the Technology Descriptions Volume. Instead of using borrow material for the fill, contaminated soil that poses a potential risk to biota from other sites can be consolidated within Basin A prior to capping. The concentrations of contamination in the consolidated soil are lower than those in the contaminated soil at Basin A. If the consolidation alternatives are not selected for the other medium groups, then borrow materials from the on-post borrow area can be used as fill. The subsurface is regraded and compacted prior to the installation of the soil cover to minimize variations in the subgrade. The uppermost 6 inches of soil are supplemented with conditioners and revegetated with native grasses, thus improving the habitat at the site. The borrow area is also regraded and revegetated to restore habitat. Although the habitat is improved after remediation, the types of vegetation placed at the site and the maintenance activities performed there discourage burrowing animals from using the capped area as habitat.

The following discussion presents a detailed evaluation of this alternative against the DAA criteria listed in the NCP (EPA 1990a). For purposes of comparison, Table 10.2-1 summarizes the evaluation of all of the alternatives developed for the Basin A Medium Group.

10.2.4.1 Overall Protection of Human Health and the Environment

This alternative achieves Human Health and Biota RAOs by treating the principal threat volume, landfilling the remaining human health exceedance volume, and capping the residual contamination and shallow soil that may pose a potential risk to biota. This alternative is protective of the environment because contaminants are contained in an on-post landfill and residual contamination is capped, which interrupts human and biota exposure pathways and reduces impacts on groundwater. Organic contaminants in the principal threat volume are treated to >99.99 percent DRE or detection levels, and inorganics are reduced below Human Health SEC (EBASCO 1994a). However, the excavation of the contaminated soil for thermal desorption or landfilling (including soil that potentially contains agent/UXO) entails significant short-term impacts that cannot be completely eliminated.

10.2.4.2 Compliance with ARARS

This alternative complies with action-specific ARARs regarding construction of caps/covers and monitoring of contained material including state regulations on air emissions sources and landfill siting, design, and operation. Endangered species are not impacted. Basin A, the landfill, and the treatment facilities are not located in wetlands or a 100-year flood plain, thus complying with location-specific ARARs. In addition to ARARs, this alternative complies with the provisions of the FFA (EPA et al. 1989) and Army Materiel Command regulations (AMC-R 385-131) (AMC 1987) regarding agent and UXO demilitarization. (ARARs are listed in Appendix A of the Technology Descriptions Volume.)

10.2.4.3 Long-Term Effectiveness and Permanence

The residual risk associated with this alternative is low since the principal threat volume is treated and the remaining volume is contained, either at the landfill or under the cap. PRGs are achieved for the principal threat volume, which is treated by thermal desorption. There is high confidence in the reliability of the landfill and multilayer cap engineering controls, and there are no difficulties associated with maintenance. In addition, 5-year site reviews, groundwater compliance monitoring, and cap-maintenance operations are conducted to ensure the effectiveness of controls. The existing habitat at the site is improved by revegetation; however, the habitat at the landfill site is eliminated because the types of vegetation placed there and the maintenance activities performed discourage burrowing animals from using the capped area as habitat.

10.2.4.4 Reduction in TMV

The principal threat volume of 32,000 BCY is thermally desorbed to destroy OCPs. The organics in the principal threat volume are reduced to >99.99 percent DRE or detection levels, virtually eliminating TMV. TMV reduction by thermal desorption is irreversible. The mobility of the contaminants and exposure pathways to humans and biota are eliminated through the landfilling of 210,000 BCY of soil and debris and capping of 670,000 SY of residual contamination so long as the integrity of the landfill and multilayer cap is maintained. Soil with agent and UXO presence is identified during excavation activities and then treated and landfilled. Treatment residuals from the off-gas treatment equipment associated with the thermal desorber and salts (approximately 320 BCY), as well as the salts that are generated during caustic washing, are contained in the on-post hazardous waste landfill. Groundwater is removed during dewatering activities at a rate of 5 gpm, treated at the CERCLA Wastewater Treatment Plant or a new treatment plant, and reinjected on post.

10.2.4.5 Short-Term Effectiveness

This alternative entails significant short-term risks associated with UXO/agent clearance, excavation, transportation, landfilling, and thermal desorption of contaminated soil. These risks are reduced through engineering controls and PPE, but they cannot be completely removed. Engineered dust controls (such as water sprays) and vapor/odor controls (such as daily covers, tarps, or foams) are employed to reduce short-term risks; however, the adequacy of these controls has not yet been fully demonstrated, and the possibility exists for vapor/odor emissions during excavation despite these controls. In addition, the preparation of the feedstock prior to thermal desorption presents short-term risks, although the materials handing is conducted in an enclosed building to control dust and vapors/odors. Although the off-gas control system for the thermal desorber is designed to achieve air quality standards, the emissions from the thermal desorber contain emissions of low but acceptable levels of some contaminants removed from the soil. There are minimal impacts to the environment. Migration of the contaminants to the groundwater is significantly reduced. The time frame until RAOs are achieved is 4 years. Excavation and treatment or disposal of the 210,000 BCY is feasible within 1 year, following 2 years for the construction of the landfill and treatment facilities. The installation of a 670,000-SY cap and 2,500,000 BCY of gradefill takes 4 years.

10.2.4.6 Implementability

Vapor/odor controls are not well demonstrated, and some controls, such as foams, have limited availability. The use of temporary soil covers increases the volume to be excavated and requires double handling to access the contaminated soil. Thermal desorption is widely available and has been used to treat similar contaminants; however, the technology has not yet been demonstrated at the scale required for RMA or on materials with elevated salt contents. The thermal desorption facility can be constructed within the required time frame, but the operation of the unit may be difficult due to the high levels of contamination, high moisture content, materials-handling problems, and the elevated levels of salts in the soil feed. Administrative difficulties associated with demonstrating compliance with permits and performing O&M may lead to delays, and it may be difficult to implement this alternative due to public perceptions regarding the safety of thermal treatment. The landfilling and capping portions of this alternative are technically feasible and can be implemented within the required time frame and reliably operated and maintained thereafter with periodic monitoring and maintenance. Additional future remedial actions can be undertaken for soil left in place, although the cap adds to the overall site volume. Additional remedial actions require removal of the landfill cover. The substantive Subtitle C landfill siting, design, and operating regulations are achieved. Equipment, specialists, and materials are readily available for landfill and multilayer cap construction and for design and construction of the thermal desorber. The technologies have been well demonstrated at full scale.

10.2.4.7 Cost

The total present worth cost is $73,300,000 including $6,800,000, $65,200,000, and $1,310,000 for capital, operating, and long-term costs, respectively. Table B4.1-3c details the costing for this alternative.

There are three significant uncertainties associated with the costing of this alternative. First, the extent and depth of contamination and extent of UXO/agent presence are difficult to estimate. Second, there is very little operational experience at other sites upon which to base cost estimates for vapor/odor controls and to evaluate their impact on excavation and equipment productivity. Third, the elevated concentrations of the contaminants and salts in the feedstock, the high moisture content in the soil, and the need for materials handling increase uncertainties relative to maintaining the assumed on-line percentage of the thermal desorption unit. These operating conditions are not typical of previous thermal desorption projects and may result in changes in maintenance requirements or delays in implementation, both of which may impact treatment costs.

10.2.5 Alternative 6/B5/A1/U1: Caps/Covers

Alternative 6: Caps/Covers (Multilayer Cap), combined with Alternative B5: Caps/Covers (Multilayer Cap), Alternative A1: No Additional Action (Provisions of FFA), and Alternative U1: No Additional Action (Provisions of FFA), involves the containment of the entire 670,000-SY area, including potential agent and UXO presence areas. Before any cover materials are installed, a surface sweep is conducted to determine whether UXO are present in near-surface soil.

The containment of Basin A requires placement of approximately 2,500,000 BCY of soil as gradefill to bring the area to the design grade of 3 to 5 percent as described in Section 6.2.1 of the Technology Descriptions Volume. Instead of using borrow material for the fill, contaminated soil that poses a potential risk to biota from other sites can be consolidated within Basin A prior to capping. The concentrations of contamination in the consolidated soil are lower than those in the contaminated soil at Basin A. If the consolidation alternatives are not selected for the other medium groups, then borrow materials from the on-post borrow area can be used as fill. The subsurface is regraded and compacted prior to the installation of the soil cover to minimize variation in the subgrade. The soil cover consists of a 6-inch-thick layer of concrete and a 4-ft-thick soil/vegetation layer. The uppermost 6 inches of soil are supplemented with conditioners and revegetated with native grasses, thus improving the habitat at the site. The borrow area is also regraded and revegetated to restore habitat. Although the habitat is improved after remediation, the types of vegetation placed at the site and the maintenance activities performed there discourage burrowing animals from using the capped area as habitat. The capping operations require 4 years to complete. Maintenance activities (mowing and replacing eroded soil) ensure the integrity of the cap. In addition to maintenance activities, long-term groundwater sampling is performed to monitor the migration of contaminants.

The following discussion presents a detailed evaluation of the alternative against the DAA criteria listed in the NCP (EPA 1990a). For purposes of comparison, Table 10.2-1 summarizes the evaluation of all of the alternatives developed for the Basin A Medium Group.

10.2.5.1 Overall Protection of Human Health and the Environment

This alternative achieves Human Health and Biota RAOs through containment. Contaminated soil exceeding Human Health SEC (EBASCO 1994a) remains in place, but it is contained by a multilayer cover cap consisting of a low- permeability soil layer, biota barrier, and vegetative layer. The multilayer cover cap interrupts exposure pathways and reduces the migration of contaminants, which could occur as a result of rainwater infiltration, from soil to groundwater.

10.2.5.2 Compliance with ARARs

This alternative complies with action-specific ARARs regarding construction of caps/covers and monitoring of contained material, including state regulations on endangered species. Location-specific ARARs are met because Basin A is not located in wetlands or a 100-year flood plain. In addition to the ARARs, this alternative complies with provisions of the FFA (EPA et al. 1989). Soil potentially containing agent/UXO is contained and is not subjected to Army regulations governing agent/UXO demilitarization. (ARARs are listed in Appendix A of the Technology Descriptions Volume.)

10.2.5.3 Long-Term Effectiveness and Permanence

The residual risk associated with this alternative is low since the contaminated soil is contained. There is high confidence in the engineering controls of the multilayer cover; 5-year reviews and groundwater compliance sampling are conducted to assess the natural attenuation and potential migration of the contaminants. The existing habitat for the site is improved through revegetation with native grasses, although burrowing animals are discouraged from using the capped area for habitat through the types of vegetation placed at the site and the maintenance activities performed there.

10.2.5.4 Reduction in TMV

The mobility of the contaminants and exposure pathways to humans and biota are eliminated through capping. Natural attenuation is the only process by which contaminant toxicity or volume can be reduced. These reductions are irreversible so long as the integrity of the multilayer cover is maintained. There are no treatment residuals associated with this alternative.

10.2.5.5 Short-Term Effectiveness

This alternative involves few short-term risks since no intrusive activities are conducted. Dust controls are adequate for addressing uncontaminated fugitive dust released during construction of the cover, and vapor/odor emissions are not anticipated. Construction of the cover only minimally impacts the environment. Vapor emissions are not anticipated since the contaminated soil is not disturbed. Installation of the 670,000-SY multilayer cover and 2,500,000 BCY of gradefill are feasible within 4 years.

10.2.5.6 Implementability

The alternative is technically feasible and can be implemented within the required time frame and reliably operated and maintained thereafter. Additional remedial actions are easily undertaken for soil left in place, although the cover adds to the overall site volume. The alternative is administratively feasible since the requirements of the cover design and operation are easily achieved. Materials and vendors are readily available for implementation of the alternative.

10.2.5.7 Present Worth Cost

The total present work cost of this alternative is $51,600,000, including $50,100,000 and $1,510,000 for operating and long-term costs, respectively. Table B4.1-6 details the costing for this alternative. There is a low level of uncertainty associated with the cost of this alternative because the materials required to construct the cover are available on post and the area to be capped is well defined (i.e., the uncertainty commonly associated with excavation does not exist).

10.2.6 Alternative 6c/B5/A1/U1: Direct Thermal Desorption of Principal Threat Volume; Caps/Covers

Alternative 6c: Direct Thermal Desorption (Direct Heating) of Principal Threat Volume; Caps/Covers (Multilayer Cap), combined with Alternative B5: Caps/Covers (Multilayer Cap), Alternative A1: No Additional Action (Provision of FFA), and Alternative U1: No Additional Action (Provisions of FFA), addresses the treatment of 32,000 BCY of principal threat volume by thermal desorption and containment of the entire 670,000-SY area with a multilayer cap. During the excavation of the principal threat volume, a daily soil cover or plastic liner is installed to minimize odors and volatile emissions. If dewatering has not been implemented in Basin A as part of the remedial alternatives developed for the water medium, it is initiated 2 years prior to excavation and continues during the 2-year excavation period. Water is removed from the area at 5 gpm and pumped to the CERCLA Wastewater Treatment Plant or a new treatment plant.

Prior to excavation of the principal threat volume, the area is cleared of potential UXO using geophysical surveys or other field-screening methods and then screened for the presence of agent. If located, UXO are excavated, packaged, and transported to an off-post Army facility for demilitarization in accordance with Alternative U4: Detonation (Off-Post Army Facility); Incineration/Pyrolysis (Off-Post Incineration) as discussed in Section 4.3.5. The principal threat soil is also screened for agent during excavation. Soil testing positive for potential agent presence is stockpiled in a secure area until these results are confirmed by RMA laboratory analysis. Soil with confirmed agent presence is treated by caustic washing in accordance with Alternative A3: Direct Soil Washing (Caustic Solution Washing); Landfill (On-Post Landfill). Potential agent and UXO presence areas not screened as part of the principal threat volume are contained by the low-permeability soil cap.

The principal threat volume of 32,000 BCY is excavated and hauled to a centralized thermal desorption facility. The soil is assumed to be saturated (a moisture content of 20 percent) due to the high water table in Basin A. Saturated soil is processed through the desorber at a rate of approximately 1,300 BCY/day at an operating temperature of 300°C and a solids residence time of 50 minutes. The processing rate for thermal desorption decreases as the water content of the soil increases due to the additional heat required to evaporate the water before the desorption process can begin. Section 4.6.24 discusses emission controls for off gases from the thermal desorber. Particulates from quench blowdown amount to approximately 1 percent of the total solids feed. This particulate volume of 320 BCY is carried via truck to the on-post landfill for disposal. Treated soil is returned to the site excavation and backfilled.

The remaining area of 670,000 SY, which contains human health exceedances, soil that potentially poses risk to biota, and soil with potential agent and UXO presence, is contained with a low-permeability soil cap. Before any cover materials are installed, a surface sweep is conducted to confirm UXO are not present in near-surface soil. Following the treatment of principal threat volumes and backfill of the treated soil, a multilayer cap is installed over the 670,000 SY of soil with human health exceedances and soil that potentially poses risk to biota, which also includes the potential agent and potential UXO presence areas. The cap consists of a 2-ft-thick layer of compacted, low-permeability soil, a 1-ft-thick biota barrier of crushed concrete, and a 4-ft-thick soil/vegetation layer that includes 6 inches of reconditioned soil. The cap/cover design is described in Section 4.6.14.

The containment of Basin A requires placement of approximately 2,500,000 BCY of soil as gradefill to bring the area to the design grade of 3 to 5 percent as described in Section 6.2.1 of the Technology Descriptions Volume. Instead of using borrow material for the fill, contaminated soil from other sites can be consolidated within Basin A prior to capping. The concentrations of contamination in the consolidated soil are lower than those in the contaminated soil at Basin A. If the consolidation alternatives are not selected for the other medium groups, then borrow materials from the on-post borrow area are used as fill. Reconditioned soil is used as the final layer of the cap. The remediation of Basin A is completed by revegetating the cap and the borrow area. Although the habitat is improved after remediation, the types of vegetation placed at the site and the maintenance activities performed there discourage burrowing animals from using the capped area as habitat. The cover at Basin A provides a physical barrier to protect human and biota receptors from directly contacting the soil contaminants, potential agent, and potential UXO. Groundwater compliance sampling is performed to monitor the potential migration of contaminants left in place.

The following discussion presents a detailed evaluation of this alternative against the DAA criteria listed in the NCP (EPA 1990a). For purposes of comparison, Table 10.2-1 summarizes the evaluation of all of the alternatives developed for the Basin A Medium Group.

10.2.6.1 Overall Protection of Human Health and the Environment

This alternative achieves Human Health and Biota RAOs through treatment of the principal threat volume and containment of the remaining area with a multilayer cap. Contaminated soil above Human Health SEC (EBASCO 1994a) and shallow soil that may pose potential risk to biota remain in place, but are contained by a multilayer cap composed of a low-permeability soil layer, biota barrier, and vegetative layer. Organic contaminants in the principal threat volume are treated by thermal desorption. The multilayer cap interrupts exposure pathways and reduces the migration of contaminants from the exceedance soil and soil with residual contamination to groundwater. The potential for migration of contaminants to groundwater is also reduced through the treatment of the principal threat volume. Migration of contaminants is monitored through long-term groundwater sampling.

10.2.6.2 Compliance with ARARs

This alternative complies with action-specific ARARs regarding construction of caps/covers and monitoring of contained material including state regulations on air emissions sources and landfill siting, design, and operation. Endangered species are not impacted. Location-specific ARARs are met because Basin A, the treatment facilities, and the landfill are not located in wetlands or a 100-year flood plain. In addition to the ARARs, this alternative complies with provisions of the FFA (EPA et al. 1989) and Army regulations regarding agent and UXO demilitarization. ARARs are listed in Appendix A of the Technology Descriptions Volume.

10.2.6.3 Long-Term Effectiveness and Permanence

The residual risk associated with this alternative is low since the principal threat volume is treated and the remaining area is contained with a cap. There is high confidence in the engineering controls of the multilayer cap. Long-term monitoring, 5-year site reviews, and cap-maintenance operations are conducted to ensure the effectiveness of controls and assess the natural attenuation and potential migration of the contaminants. The existing habitat at the site is improved through revegetation with native grasses, although burrowing animals are discouraged from using the capped area as habitat through the types of vegetation and the maintenance activities performed there.

10.2.6.4 Reduction in TMV

The principal threat volume of 32,000 BCY is thermally desorbed to destroy OCPs and remove mercury, but the 266,000 BCY of untreated soil with the potential presence of agent and UXO remain. The organics in the principal threat volume are treated to >99.99 percent DRE or detection levels, so TMV is virtually eliminated. TMV reduction by thermal desorption is irreversible. Treatment residuals from the off-gas treatment equipment associated with the thermal desorber and salts (approximately 320 BCY) are contained in the on-post hazardous waste landfill. Contaminant mobility is reduced and exposure pathways for humans and biota are interrupted. These reductions are irreversible so long as the integrity of the multilayer cap is maintained. Groundwater removed during dewatering activities at a rate of 5 gpm is treated at the CERCLA Wastewater Treatment Plant or a new treatment plant and reinjected on post.

10.2.6.5 Short-Term Effectiveness

This alternative involves significant short-term risks associated with UXO/agent clearance and excavation, transportation, and thermal desorption of the contaminated soil. These risks are reduced through engineering controls and PPE, but they cannot be completely removed. Engineered dust controls (such as water sprays) and vapor/odor controls (such as daily covers, tarps, or foams) are employed to reduce short-term risks; however, the adequacy of these controls has not yet been fully demonstrated, and the possibility exists for vapor/odor emissions during excavation despite these controls. In addition, the preparation of the feedstock prior to thermal desorption presents short-term risks, although the materials handing is conducted in an enclosed building to control dust and vapors/odors. Although the off-gas control system for the thermal desorber is designed to achieve air quality standards the emissions from the thermal desorber contains emissions of low but acceptable levels of some contaminants. Dust controls are adequate for addressing uncontaminated fugitive dust released during construction of the cap; vapor/odor emissions are not anticipated. Construction of the cap and the restrictions to biota only minimally impact the environment, but the disturbance of borrow areas is required for gradefill and capping materials. The continued migration of contaminants to groundwater is reduced. Treatment of 32,000 BCY is feasible within 3 years, including 2 years for the construction and testing of the thermal desorption facility and construction of the landfill. RAOs are achieved within 4 years based on the time required to install a cap and 2,500,000 BCY of consolidated soil.

10.2.6.6 Implementability

Vapor/odor controls are not well demonstrated and some controls, such as foams, have limited availability. The use of temporary soil covers increases the volume to be excavated and requires double handling to access the contaminated soil. Thermal desorption is widely available and has been used to treat similar contaminants; however, the technology has not been demonstrated at the scale required for RMA or on materials with elevated salt contents. The thermal desorption facility can be constructed within the required time frame, but the operation of the unit may be difficult due to the high levels of contamination, high moisture content, materials-handling difficulties, and the elevated levels of salts in the soil feed. Administrative difficulties associated with demonstrating compliance with permits and performing O&M may lead to delays, and it may be difficult to implement this alternative due to public perceptions regarding the safety of thermal treatment. The capping portion of this alternative is technically feasible and can be implemented within the required time frame and reliably operated and maintained thereafter. The capping portion of this alternative is administratively feasible since the requirements of the cap design and operating regulations are easily achieved. Materials and vendors are readily available for implementation of the landfill and cap. Both of these technologies are well demonstrated at full scale.

10.2.6.7 Cost

The total present worth cost of this alternative is $58,100,000 including $1,430,000, $54,600,000, and $2,070,000 for capital, operating, and long-term costs, respectively. Table B4.1-6c details the costing for this alternative.

There are significant uncertainties associated with the costing of this alternative. First, the extent and depth of contamination and extent of UXO/agent presence are difficult to establish. Second, there is very little operating experience at other sites upon which to base cost estimates for the vapor/odor controls and to evaluate their impact on excavation and equipment productivity. Third, the elevated concentrations of the contaminants and salts in the feedstock, the high moisture content of the soil, and the need for materials handling increase uncertainties relative to maintaining the assumed on-line percentage of the thermal desorption unit. These operating conditions are not typical of previous thermal desorption projects and may result in changes in maintenance requirements or delays in implementation, both of which may impact treatment costs. The overall magnitude of these uncertainties is relatively low, however, because the volume of soil to be excavated under this alternative is small compared to that under other alternatives, because the materials required to construct the cap are available on post, and because the area to be capped is well defined.

10.2.7 Alternative 8b/B5/A5/U4: Direct Soil Washing; Direct Solidification/Stabilization; Caps/Covers

Alternative 8b: Direct Soil Washing (Solvent Washing); Direct Solidification/Stabilization (Cement-Based Solidification); Caps/Covers (Multilayer Cap), along with Alternative B5: Caps/Covers (Multilayer Cap); Alternative A5: Direct Soil Washing (Solvent Washing), and Alternative U4: Detonation (Off-Post Army Facility); Incinerator/Pyrolysis (Off-Post Incineration), treats 165,000 BCY of soil with organic contaminants by solvent washing and 32,000 BCY of soil containing inorganic contaminants by solidification. Residual contamination (below 10 ft or below the water table) and surficial soil that may pose potential risk to biota are contained by a multilayer cap.

Prior to the excavation of the 180,000 BCY of human health exceedance soil, 140,000 SY are screened by geophysical surveys or other field-screening methods to identify any UXO. If located, UXO are excavated, packaged, and shipped off post for demilitarization in accordance with Alternative U4. Approximately 47,000 BCY of surficial metallic debris mixed with the soil are removed and disposed in the on-post landfill. An estimated 17,000 BCY of this volume overlaps the human health volume and is landfilled after separation from contaminated soil to be treated by solvent extraction. In addition, soil that may contain agent is screened using laboratory analysis to identify the presence of agent. Agent-contaminated soil is treated in accordance with Alternative A5: Direct Soil Washing (Solvent Washing), which consists of solvent/caustic washing and disposal of treated soil in the on-post landfill. Solvent/caustic washing uses similar equipment to that described below for solvent washing. The treated agent-contaminated soil is landfilled as required by Army regulations.

During all excavation operations, daily soil covers or plastic liners are used to minimize the emission of volatile organics and odors. Excavations are also dewatered by extracting groundwater from recovery wells installed around the site. If dewatering has not been implemented in Basin A as part of the remedial activities developed for the water medium, it is initiated 2 years prior to excavation and continues during the 3-year excavation period. Groundwater is pumped at a rate of 5 gpm to the CERCLA Wastewater Treatment Plant or a new treatment plant.

The 165,000 BCY of excavated soil contaminated with organics are treated at a centralized solvent extraction facility. Based on treatability studies, nine wash cycles are required to achieve Human Health PRGs. The solvent is recycled between cycles and treated (Section 4.6.21). A total of 120,000 gallons of liquid effluent are generated and treated at an off-post commercial facility as part of solvent washing. The treated soil is then backfilled. A series of individual solvent washing units are used to treat approximately 590 BCY/day.

The 32,000 BCY of soil with inorganic exceedances are solidified by adding cement as a binder at a 20-percent weight ratio to immobilize the arsenic. This soil is solidified using a portable pug mill, which is located near the thermal desorber, that is capable of treating 1,500 BCY/day. The volume of contaminated soil increases by 38 percent based on bulking from excavation and swelling from solidification, resulting in a total volume of 44,000 BCY of solidified soil. The solidified soil is placed in the excavated areas.

Following the treatment of the human health exceedance volume, a low-permeability soil cap is installed over the entire 670,000-SY area to cover the excavation that has been backfilled as well as residual contamination that remains at depth and surficial soil that potentially poses a risk to biota. Before any cover materials are installed, a surface sweep is conducted to identify potential UXO in near-surface soil. The cap consists of a 2-ft-thick layer of compacted, low-permeability soil, a 1-ft-thick biota barrier of crushed concrete, and a 4-ft thick soil/vegetation layer that includes 6 inches of reconditioned soil. The cap design is described in Section 4.6.14.

The containment of Basin A requires placement of approximately 2,500,000 BCY of soil as gradefill to bring the area to the design grade of 3 to 5 percent as described in Section 6.2.1 of the Technology Descriptions Volume. Instead of using borrow material for the fill, contaminated soil that poses a potential risk to biota from other sites can be consolidated within Basin A prior to capping. The concentrations of contamination in the consolidated soil are lower than those in the contaminated soil at Basin A. If the consolidation alternatives are not selected for the other medium groups, then borrow materials from the on-post borrow area can be used as fill. The subsurface is regraded and compacted prior to the installation of the soil cover to minimize variation in the subgrade. The uppermost 6 inches of soil are supplemented with conditioners and revegetated with native grasses, thus improving the habitat at the site. The borrow area is also regraded and revegetated to restore habitat. Although the habitat is improved after remediation, the types of vegetation placed at the site and the maintenance activities performed there discourage burrowing animals from using the capped area as habitat.

The cover at Basin A provides a physical barrier to protect human and biota receptors from directly contacting the soil contaminants, potential agent, and potential UXO.

The following discussion presents a detailed evaluation of this alternative against the DAA criteria listed in the NCP (EPA 1990a). For purposes of comparison, Table 10.2-1 summarizes the evaluation of all of the alternatives developed for the Basin A Medium Group.

10.2.7.1 Overall Protection of Human Health and the Environment

This alternative achieves Human Health and Biota RAOs through treatment of human health exceedance soil and containment of soil that potentially poses risk to biota and the residual contamination (below 10 ft or the water table) with a multilayer cap. This alternative is also protective of the environment since soil with potential agent and UXO presence is removed. The cap reduces further impacts on groundwater and interrupts exposure pathways. However, the excavation of the contaminated soil for treatment (including soil that potentially contains agent/UXO) involves significant short-term impacts that cannot be completely eliminated.

10.2.7.2 Compliance with ARARs

This alternative complies with action-specific ARARs regarding the construction of caps/covers and the monitoring of contained material including state regulations on air emissions sources; landfill siting, design, and operation; monitoring of solidified soil; and impacts on endangered species. Location-specific ARARs are met since Basin A and the treatment facilities and landfill are not located in wetlands or a 100-year flood plain. In addition to the ARARs, this alternative complies with provisions of the FFA (EPA et al. 1989) and Army regulations regarding agent and UXO demilitarization. (ARARs are listed in Appendix A of the Technology Descriptions Volume.)

10.2.7.3 Long-Term Effectiveness and Permanence

The residual risk is low since the human health exceedance volume is treated and soil that poses potential risk to biota and the remaining residual contamination are contained. PRGs are achieved by solvent washing, although nine extraction steps are required. There is high confidence in the reliability of the landfill and multilayer cap engineering controls and there are no difficulties associated with maintenance. The integrity of the controls for the landfill and solidified soil is ensured through long-term maintenance and monitoring. In addition, 5-year site reviews, groundwater compliance monitoring, and cap-maintenance operations are conducted to ensure the effectiveness of the controls. The existing habitat at the site is improved through revegetation with native grasses, although burrowing animals are discouraged from using the capped area as habitat through the types of vegetation placed at the site, as well as the maintenance activities performed there.

10.2.7.4 Reduction in TMV

Soil with agent and UXO is identified during excavation activities and then treated and landfilled (including 47,000 BCY of soil and metallic debris). Solvent washing degrades or reduces organics in the soil to levels below the PRGs (>99.5 percent DRE), although up to nine extraction steps are required. Solidification of inorganics eliminates the mobility of the contaminants and interrupts the exposure pathways for humans and biota. Solvent washing irreversibly eliminates TMV of the organics, and solidification irreversibly eliminates the mobility of the inorganics so long as the integrity of the solidified mass is ensured. The 670,000-SY cap interrupts exposure pathways for humans and biota and eliminates contaminant mobility so long as the integrity of the multilayer cap is maintained.

Treatment residuals include 120,000 gallons of liquid effluent from solvent washing, which is drummed and transported off post for treatment. Groundwater removed during dewatering activities is treated at the CERCLA Wastewater Treatment Plant or a new treatment plant and reinjected on post.

10.2.7.5 Short-Term Effectiveness

This alternative entails significant short-term risks associated with UXO/agent clearance, excavation, transportation, and solvent washing of contaminated soil. These risks are reduced through engineering controls and PPE, but they cannot be completely removed. Engineered dust controls (such as water sprays) or vapor/odor controls (such as daily covers, tarps, or foams) are employed to reduce short-term risks; however, the adequacy of these controls has not been fully demonstrated, and the possibility exists for vapor/odor emissions during excavation despite these controls. In addition, the preparation of the feedstock prior to solvent washing presents short-term risks, although the materials handing is conducted in an enclosed building to control dust and vapors/odors. The impacts to the environment are minimal , and a significant reduction in migration of contaminants to groundwater is achieved. The time frame for completion of the alternative is 4 years, including 1 year for construction of the landfill and treatment facilities and 2 years for dewatering prior to excavation. The treatment of 165,000 BCY by solvent washing requires 1 year. The installation of a 670,000-SY cap and 2,500,000 BCY of gradefill requires 4 years.

10.2.7.6 Implementability

The implementability of this alternative is questionable. There are no performance data available to document the reliable operation of solvent washing at the required scale and efficiency to achieve PRGs, and the process requires, at a minimum, nine extraction steps to achieve PRGs. Given these conditions, the implementability of this technology within the required time frame is doubtful and operation/maintenance problems are likely. Vapor/odor controls during extraction are not well demonstrated and some controls, such as foams, have limited availability. The use of temporary soil covers increases the volume to be excavated and requires double handling to access the contaminated soil.

Additional remedial actions can be undertaken for the soil remaining in place, but the cap adds to the overall volume for any excavation activities. The substantive requirements for landfill siting, design, and operation are achieved. The solidification facility, landfill, and cap can be constructed within the required time frame and reliably operated and maintained thereafter. A limited number of vendors are available for design and construction of the washing unit, but equipment, specialists, and materials are readily available for construction of the landfill, clay/soil cap, and solidification unit.

10.2.7.7 Cost

The total present worth cost is $105,000,000 including $9,760,000, $93,900,000, and $1,530,000 for capital, operating, and long-term costs, respectively. Table B4.1-8b details the costing for this alternative.

There are four significant uncertainties associated with the costing of this alternative. First, the extent and depth of contamination and extent of UXO/agent presence are difficult to establish. Second, there is very little operational experience at other sites upon which to base cost estimates for the performance of the vapor/odor controls and to evaluate their impact on excavation and equipment productivity. Third, there are no operating data for the solvent washing technology by which uncertainties relative to maintaining the on-line percentage and extraction efficiency can be well defined. Fourth, variations in the contaminant concentrations of the feedstock may result in unforeseen delays associated with equipment maintenance and treatment.

10.2.8 Alternative 13d/B5/A3/U4: Direct Thermal Desorption; Direct Solidification/ Stabilization; Caps/Covers

Alternative 13d: Direct Thermal Desorption (Direct Heating); Direct Solidification/Stabilization (Cement-Based Solidification); Caps/Covers (Multilayer Cap), with Alternative B5: Caps/Covers (Multilayer Cap), Alternative A3: Direct Soil Washing (Caustic Solution Washing); Landfill (On-Post Landfill), and Alternative U4: Detonation (Off-Post Army Facility); Incineration/Pyrolysis (Off-Post Incineration), treats 165,000 BCY of soil with organic exceedances by thermal desorption and 32,000 BCY of inorganic exceedances by solidification. The 670,000 SY of residual contamination (below 10 ft or the water table) and shallow soil that may pose potential risk to biota are contained by a multilayer cap.

Prior to the excavation of the 180,000 BCY of contaminated soil, 140,000 SY are screened by geophysical survey or other field-screening methods to identify any UXO. If located, UXO are excavated, packaged, and shipped off post for demilitarization in accordance with Alternative U4. Approximately 47,000 BCY of surficial metallic debris mixed with soil are removed and disposed in the on-post landfill. The 17,000 BCY of this volume overlap the human health exceedance volume and are landfilled after being separated from the contaminated soil to be treated by thermal desorption. In addition, soil with the potential presence of agent is stockpiled in a secure area and sampled during excavation. Any agent identified and confirmed by RMA laboratory analysis is treated by direct soil washing in accordance with Alternative A3. Section 4.4.3

discusses the details of direct soil washing. Operating parameters of the caustic solution washing unit are described in Section 10.2.3.

During all excavation operations, daily soil covers or plastic liners are used to minimize the emission of volatile emissions and odors. Excavations are also dewatered by extracting groundwater from recovery wells installed around the site. If dewatering has not been has not been implemented in Basin A as part of the remedial activities for the water medium, it is initiated 2 years prior to excavation and continues during excavation. Groundwater is pumped at 5 gpm to the CERCLA Wastewater Treatment Plant or a new treatment plant.

The thermal desorber requires approximately 1 year to build and an additional year for testing. The soil from Basin A has a moisture content of 20 percent, which can be processed in the thermal desorber at an approximate rate of 1,300 BCY/day (operating temperature of 300°C and a soil residence time of 50 minutes). Section 4.6.24 discusses emission controls for off gases from thermal desorption. In the soil, 1 percent of the total solids feed (1,650 BCY) of particulates from the scrubber blowdown are placed in the on-post landfill. The treated soil without human health exceedances for inorganics is backfilled in Basin A.

Approximately 32,000 BCY of soil that require solidification to address elevated levels of arsenic are transported to the solidification facility for further treatment. The 32,000 BCY of soil with inorganic exceedances are solidified at a rate of 1,500 BCY/day using a pug mill located near the thermal desorber. The soil with elevated concentrations of inorganics is treated by adding cement as a binder at a weight ratio of 20 percent, thereby immobilizing the arsenic in the soil. The volume of contaminated soil increases by approximately 38 percent due to bulking from excavation and swelling from solidification. This results in a total volume of 44,000 BCY of solidified soil for this medium group. The solidified soil is placed in the site excavations and covered with the treated soil from thermal desorption.

Following treatment of the human health exceedance volume, a low-permeability soil cap is installed over the entire 670,000-SY area, covering the excavation that has been backfilled, the residual contamination that remains at depth, and the surficial soil that potentially poses a risk to biota. The cap consists of a 2-ft-thick layer of compacted, low-permeability soil, a 1-ft-thick biota barrier of crushed concrete, and a 4-ft-thick soil/vegetation layer that includes 6 inches of reconditioned soil. The cap design is described in Section 4.6.14. The containment of Basin A requires placement of approximately 2,500,000 BCY of soil as gradefill to bring the area to the design grade of 3 to 5 percent as described in Section 6.2.1 of the Technology Descriptions Volume. Instead of using borrow material for the fill, contaminated soil that poses a potential risk to biota from other sites can be consolidated within Basin A prior to capping. The concentrations of contamination in the consolidated soil are lower than those in the contaminated soil at Basin A. If the consolidation alternatives are not selected for the other medium groups, then borrow materials from the on-post borrow area can be used as fill. The subsurface is regraded and compacted prior to the installation of the soil cover to minimize variation in the subgrade. The uppermost 6 inches of soil are supplemented with conditioners and revegetated with native grasses, thus improving the habitat at the site. The borrow area is also regraded and revegetated to restore habitat. Although the habitat is improved after remediation, the types of vegetation placed at the site and the maintenance activities performed there discourage burrowing animals from using the capped area as habitat.

The following discussion presents a detailed evaluation of this alternative against the DAA criteria listed in the NCP (EPA 1990a). For purposes of comparison, Table 10.2-1 summarizes the evaluation of all of the alternatives developed for the Basin A Medium Group.

10.2.8.1 Overall Protection of Human Health and the Environment

This alternative achieves Human Health and Biota RAOs through treatment of the human health exceedance volume and containment of the remaining residual contamination and shallow soil that may pose potential risk to biota by a multilayer cap. This alternative is also protective of human health and the environment since all soil with potential agent and UXO presence is removed. The containment of residual contamination significantly reduces further impacts on groundwater. However, the excavation of the contaminated soil for treatment (including soil that potentially contains agent/UXO) entails significant short-term impacts that cannot be completely eliminated.

10.2.8.2 Compliance with ARARs

This alternative complies with action-specific ARARs regarding the construction of caps/covers and the monitoring of contained material including state regulations on air emissions sources, landfill siting, design, and operation; monitoring of solidified soil; and impacts on endangered species. Location-specific ARARs are met since Basin A, the treatment facilities, and the landfill are not located in wetlands or a 100-year flood plain. In addition to the ARARs, this alternative complies with provisions of the FFA (EPA et al. 1989) and Army regulations regarding agent and UXO demilitarization. (ARARs are listed in Appendix A of the Technology Descriptions Volume.)

10.2.8.3 Long-Term Effectiveness and Permanence

The residual risk is low since the human health exceedance volume is treated and the remaining residual contamination (below 10 ft or the water table) and shallow soil that may pose potential risk to biota are contained. PRGs are achieved by thermal desorption. There is high confidence in the reliability of the landfill and multilayer cap engineering controls and there are no difficulties associated with maintenance. The integrity of the controls for the landfill and solidified soil is ensured through long-term monitoring and maintenance. In addition, long-term groundwater compliance monitoring, 5 year site reviews, and cap-maintenance operations are conducted to ensure the effectiveness of the controls. The existing habitat at the site is improved through revegetation with native grasses, although burrowing animals are discouraged from using the capped area for habitat through the types of vegetation placed at the site and the maintenance activities performed there.

10.2.8.4 Reduction in TMV

All 165,000 BCY of soil with organic human health exceedances are thermally desorbed to destroy OCPs. The organics are treated to >99.99 percent DRE or detection levels, so TMV is virtually eliminated. TMV reduction by thermal desorption is irreversible. Approximately 32,000 BCY of soil with inorganic exceedances are treated by solidification. Solidification eliminates the mobility of the contaminants and interrupts exposure pathways to humans and biota. The 47,000 BCY of soil containing UXO debris is landfilled. Any UXO- or agent-contaminated soil is treated and landfilled. Treatment residuals associated with this alternative include 1,650 BCY of blowdown solids from the off-gas treatment equipment, the salts from the treatment of the washing solution, and groundwater from the dewatering system. The latter is treated and reinjected on-post.

10.2.8.5 Short-Term Effectiveness

This alternative entails significant short-term risks associated with UXO/agent clearance and excavation, transportation, and thermal desorption of contaminated soil. These risks are reduced through engineering controls and PPE, but they cannot be completely removed. Engineered dust controls (such as water sprays) or vapor/odor controls (such as daily covers, tarps, or foams) are employed to reduce short-term risks; however, the adequacy of these controls has not been fully demonstrated, and the possibility exists for vapor/odor emissions during excavation despite these controls. In addition, the preparation of the feedstock prior to thermal desorption presents short-term risks, although the materials handing is conducted in an enclosed building to control dust and vapors/odors. Although the off-gas control system for the thermal desorber is designed to achieve air quality standards the emissions from the thermal desorber contain low but acceptable levels of some contaminants. The impacts to the environment are minimal and a significant reduction in migration of contaminants to the groundwater is achieved. The time frame for completion of the alternative is 4 years, including the 2 years for construction of the landfill and thermal desorption facility and for dewatering activities. The installation of a 670,000 SY cap and 2,500,000 BCY of gradefill entails 4 years.

10.2.8.6 Implementability

Vapor/odor controls are not well demonstrated and some controls, such as foams, have limited availability. The use of temporary soil covers increases the volume to be excavated and requires double handling to access the contaminated soil. Thermal desorption is widely available and has been used to treat similar contaminants; however, the technology has not been demonstrated at the scale required for RMA. The thermal desorption facility can be constructed within the required time frame, but the operation of the unit may be difficult due to the high levels of contamination, high moisture content, problems associated with material handling, and the elevated salt concentrations in the soil feed. Administrative difficulties associated with demonstrating compliance with permits and performing O&M may lead to delays, and it may be difficult to implement this alternative due to public perceptions regarding the safety of thermal treatment. The solidification facility, landfill, and cap can be constructed within the required time frame and reliably operated and maintained thereafter. Several vendors are available for design and construction of the thermal desorber. The equipment, specialists, and materials are readily available for landfill and multilayer cap construction and for the solidification unit. These three technologies are well demonstrated at full scale.

10.2.8.7 Cost

The total present worth cost is $85,100,000 including $6,110,000, $77,400,000, and $1,640,000 for capital, operating, and long-term costs, respectively. Table B4.1-13d details the costing for this alternative.

There are three significant uncertainties associated with the costing of this alternative. First, the extent and depth of contamination and extent of UXO/agent presence are difficult to estimate. Second, there is very little operational experience at other sites upon which to base cost estimates for vapor/odor controls and to evaluate their impact on excavation and equipment productivity. Third, the elevated concentrations of the contaminants and salts in the feedstock, the high moisture content of the soil, and the need for materials handling increase uncertainties relative to maintaining the assumed on-line percentage of the thermal desorption unit. These operating conditions may result in changes in maintenance requirements or delays in implementation, both of which may impact treatment costs.

10.2.9 Alternative 17/B3/A3/U4: In Situ Physical/Chemical Treatment: In Situ Thermal Treatment

Alternative 17: In Situ Physical/Chemical Treatment (Soil Flushing); In Situ Thermal Treatment (Surface Soil Heating), along with Alternative B3: Landfill (On-Post Landfill), Alternative A3: Direct Soil Washing (Caustic Solution Washing); Landfill (On-Post Landfill), and Alternative U4: Detonation (Off-Post Army Facility); Incineration/Pyrolysis (Off-Post Incineration), consists of treating the highest levels of contamination in the surficial soil using in situ heating and flushing and treating the remaining contaminants from the deeper soil using in situ soil flushing techniques.

Prior to in situ heating, 430,000 SY of Basin A soil that potentially contain agent are screened for agent presence by drilling borings and analyzing the soil at RMA's laboratory. Any agent-contaminated soil is excavated and treated by caustic washing in accordance with Alternative A3. Operating parameters of the caustic solution washing unit are described in Section 10.2.3. In addition, 140,000 SY of soil that may contain UXO is cleared using geophysical surveys or other field-screening methods. If located, UXO are excavated, packaged, and transported to an existing off-post facility for demilitarization in accordance with Alternative U4. The 47,000 BCY of surficial metallic debris and soil associated with UXO removal are excavated and transported to the on-post landfill.

Surficial soil containing human health exceedances is treated using in situ heating. Surface soil heating raises the temperature of the soil to more than 250°C, mobilizing the organic contaminants located in the near-surface soil. The mobilized contaminants are then collected and treated in the off-gas treatment system (Section 4.6.29). Two soil heating units are used to treat 310,000 SY of Basin A human health exceedance soil; this volume contains the highest levels of OCPs. Each surface soil unit treats a 50-ft by 50-ft block of soil and has a treatment rate of approximately 17,000 SY/year. The liquid sidestream from in situ heating, which contains predominantly salts, is transported to the thermal desorption facility, where it and the scrubber effluent from the desorber are treated (see Section 4.6.24). If a thermal desorption facility is not built, the liquid sidestream could be treated by a crystallizer.

Following in situ heating, in situ soil flushing is initiated to remove the lower levels of OCPs, arsenic, and mercury from subsurface soil and from that portion of the shallow soil that poses a risk to biota. These contaminants are mobilized by flushing dilute surfactant solutions, applied by ponding the solutions within a bermed area, through the unsaturated soil to the underlying groundwater. The flushed contaminants are subsequently collected and treated at the Basin A

Neck IRA treatment system after the system is expanded to handle a capacity of approximately 70 gpm. After the treated soil has been allowed to drain for 1 year, the uppermost 6 inches over the entire area are supplemented with conditioners and revegetated with native grasses to restore the habitat. Long-term groundwater sampling is performed to monitor potential migration of contaminants.

The following discussion presents a detailed evaluation of this alternative against the DAA criteria listed in the NCP (EPA 1990a). For purposes of comparison, Table 10.2-1 summarizes the evaluation of all of the alternatives developed for the Basin A Medium Group.

10.2.9.1 Overall Protection of Human Health and Environment

This alternative does not achieve RAOs based on the level of contamination remaining after treatment. Soil heating reduces the concentration of organics in the surface soil, but does not achieve PRGs. Soil flushing reduces contaminant concentrations and future migration to groundwater (after flushing has been completed), but does not achieve RAOs. Although this alternative does not involve large-scale intrusive activities, the short-term impacts are high based on the long duration of treatment activities (16 years).

10.2.9.2 Compliance with ARARs

This alternative complies with action-specific ARARs regarding the construction of caps/covers and the monitoring of contained material, including state regulations on air emissions sources and endangered species. Location-specific ARARs are met since Basin A and the landfill are not located in wetlands or a 100-year flood plain. This alternative complies with provisions of the FFA (EPA et al. 1989) and Army regulations regarding agent and UXO demilitarization. (ARARs are listed in Appendix A of the Technology Descriptions Volume.)

10.2.9.3 Long-Term Effectiveness and Permanence

The residual risk is moderate since human health exceedances, soil that may pose risks to biota, and residual contamination (below 10 ft or the water table) are treated, although not to PRGs. Therefore, contamination that remains may pose a risk to human health and biota. Monitoring of the treated soil and groundwater is required to assess natural attenuation/degradation and ongoing migration to groundwater. The overall habitat quality for the site is improved through revegetation, offsetting the habitat loss incurred during implementation of the alternative, but some risk to biota remains.

10.2.9.4 Reduction in TMV

Soil flushing can theoretically reduce contaminant levels for most of the COCs through the flushing of four soil-pore volumes. However, soil washing treatability studies that were performed in a reactor vessel with agitation indicate that soil flushing would at best reduce the concentrations of OCPs to within the acceptable risk range for human health (10^{-6} to 10^{-4} excess cancer risk), but not achieve PRGs (10^{-6} excess cancer risk). The residual OCP concentrations are also anticipated to pose a risk to biota. Therefore, TMV is reduced, but not enough to achieve RAOs. Soil with identified agent and UXO presence is treated and landfilled. The salts from the treatment of the caustic washing solution are also landfilled.

10.2.9.5 Short-Term Effectiveness

This alternative entails significant short-term risks associated with UXO/agent clearance. These risks are reduced, but not completely removed, through engineering controls and PPE. The in situ thermal treatment of soil also entails short-term impacts. The long duration of treatment operations results in continuing migration of contaminants to groundwater and potential exposure of humans and biota to contaminated soil for 16 years. Although the off-gas control system for in situ heating is designed to achieve air quality standards, the emissions from the in situ heating unit contain low levels of the contaminants removed from the soil. The time frame for completion of the alternative is 16 years (6 years for soil flushing after 10 years for soil heating). Because the soil in Basin A is disturbed and poorly vegetated, environmental impacts are low. Migration of contaminants to the groundwater is reduced following soil flushing.

10.2.9.6 Implementability

Soil flushing of Basin A is not implementable based on its lack of demonstrated effectiveness for similar or easier-to-treat contaminants at other sites and on the geohydrology of Basin A.

Although the vast majority of the flushing solution is collected at the Basin A Neck IRA, there is a potential for leakage of the flushing solution through the Section 36 bedrock ridge (northeast of Basin A) or, because the water table in Basin A will be elevated, downward into the Denver Formation.

Materials and vendors are available to construct and operate a soil flushing system. In situ surface soil heating is currently not implementable because full-scale in situ heating units have yet to be constructed or tested at any hazardous waste site. The technology was demonstrated at pilot scale at RMA; however, full-scale units have not been developed, and several problems were identified in the pilot-scale test regarding the durability of the equipment. In addition, administrative difficulties associated with demonstrating compliance with permits and performing O&M may lead to delays, and it may be difficult to implement this alternative due to public perceptions regarding the safety of in situ thermal treatment and the thermal-treatment portion of the off-gas control system.

10.2.9.7 Cost

The total present worth cost is $166,000,000 including $8,810,000, $157,000,000, and $669,000 for capital, operating, and long-term costs, respectively. Table B4.1-17 details the costing for this alternative.

There are three significant uncertainties associated with the costing of this alterative. First, the extent and depth of contamination and extent of UXO/agent presence are difficult to estimate. Second, there is no experience at other sites by which costs for the performance of in situ heating or soil flushing can be well defined. In the absence of any full-scale operating experience, there is a high level of uncertainty relative to maintaining the on-line percentage assumed for the in situ heating technology, and in the absence of any pilot- or full-scale demonstrations at RMA, there is a high level of uncertainty relative to estimating the time needed for operations or the total cost of the soil flushing technology. Third, changes in maintenance requirements or delays in implementation for either technology may impact treatment costs.

10.2.10 Alternative 19b/B5/A3/U4: In Situ Thermal Treatment; In Situ Solidification/ Stabilization; Caps/Covers

Alternative 19b: In Situ Thermal Treatment (RF/Microwave Heating); In Situ Solidification/ Stabilization (Cement-Based Solidification); Caps/Covers (Multilayer Cap), along with Alternative B5: Caps/Covers (Multilayer Cap); Alternative A3: Direct Soil Washing (Caustic Solution Washing); Landfill (On-Post Landfill), and Alternative U4: Detonation (Off-Post Army Facility); Incineration/Pyrolysis (Off-Post Incineration), treats 165,000 BCY of soil with organics contamination by in situ RF heating and 32,000 BCY of soil with inorganics contamination by in situ solidification. After in situ treatment of the exceedance soils, a multilayer cap is installed to contain residual contamination (below 10 ft or the water table) and shallow soil that potentially poses risk to biota.

Prior to treatment, the excavated materials are screened for agent presence; positive results are confirmed by RMA laboratory analysis. If identified, agent-contaminated soil is treated by caustic washing in accordance with Alternative A3. In addition, 140,000 SY of soil that may contain UXO are cleared using geophysical surveys or other field-screening methods. If located, UXO are excavated, packaged, and transported to an existing off-post Army facility for demilitarization in accordance with Alternative U4. The 47,000 BCY of surficial metallic debris mixed with soil are excavated and transported to the on-post landfill to complete the treatment of UXO.

The 165,000 BCY of soil that contain organics exceeding the Human Health SEC (EBASCO 1994a) are treated in situ by RF heating. RF heating elevates the temperature of the soil to more than 250°C, which mobilizes the organic contaminants. The mobilized contaminants are then collected and treated in the off-gas treatment system as described in Section 4.6.31. One RF unit is used for Basin A. The unit treats a block of soil approximately 100 ft long by 48 ft wide by 10 ft deep. The treatment rate is approximately 130 BCY/day (assuming a moisture content of 20 percent). The treatment rate decreases as the moisture content increases. To reduce heating costs, the area is dewatered prior to treatment. Groundwater is pumped from recovery wells around the site to the CERCLA Wastewater Treatment Plant, the Basin A Neck IRA, or a new treatment plant. The liquid sidestream, which contains predominantly salts, is transported, along with the scrubber effluent from that system, to the thermal desorption facility for treatment. If a thermal desorption facility is not built, the liquid sidestream could be treated by a crystallizer/evaporator.

RF heating only treats the organic contaminants, so soil containing elevated levels of inorganics is addressed through in situ cement-based solidification. The human health inorganic exceedance volume of 32,000 BCY is solidified by a transportable track-mounted boring/mixing unit and a cement batch plant capable of processing 600 BCY of soil per day as described in Section 10.2 of the Technology Descriptions Volume. Portland cement is mixed with soil at a ratio of 0.2 tons of cement per ton of soil. Upon solidification, the soil swells approximately 10 to 25 percent due to the incorporation of the cement.

Following the in situ treatment of the human health exceedances, a low-permeability soil cap is installed over the entire 670,000-SY area where residual contamination and soil that poses potential risk to biota remain in place. The cap consists of a 2-ft-thick layer of compacted, low-permeability soil, a 1-ft-thick biota barrier of crushed concrete, and a 4-ft-thick soil/vegetation layer that includes 6 inches of reconditioned soil. The cap design is described in Section 10.2.3. The containment of Basin A requires placement of approximately 2,500,000 BCY of soil as gradefill to bring the area to the design grade of 3 to 5 percent as described in Section 6.2.1 of the Technology Descriptions Volume. Instead of using borrow material for the fill, contaminated soil that poses a potential risk to biota from other sites can be consolidated within Basin A prior to capping. The concentrations of contamination in the consolidated soil are lower than those in the contaminated soil at Basin A. If the consolidation alternatives are not selected for the other medium groups, then borrow materials from the on-post borrow area can be used as fill. The subsurface is regraded and compacted prior to the installation of the soil cover to minimize variation in the subgrade. The uppermost 6 inches of soil are supplemented with conditioners and revegetated with native grasses, thus improving the habitat at the site. The borrow area is also regraded and revegetated to restore habitat. Although the habitat is improved after remediation, the types of vegetation placed at the site and the maintenance activities performed there discourage burrowing animals from using the capped area as habitat. Long-term groundwater sampling is performed to monitor potential migration of contaminants.

The following discussion presents a detailed evaluation of this alternative against the DAA criteria listed in the NCP (EPA 1990a). For purposes of comparison, Table 10.2-1 summarizes the evaluation of all of the alternatives developed for the Basin A Medium Group.

10.2.10.1 Overall Protection of Human Health and Environment

This alternative achieves Human Health and Biota RAOs through the containment of the treated soil, soil that poses a potential risk to biota, and residual contamination (below 10 ft or the water table). RF heating does not achieve PRGs. Solidification of inorganics eliminates the mobility of the contaminants and interrupts the exposure pathways to humans and biota. Migration of contaminants to the groundwater is reduced through the installation of the cap. This alternative is protective of human health and the environment since soil with potential agent and UXO presence is removed. Although this alternative does not entail large-scale intrusive activities, the short-term impacts are high based on the long duration of treatment activities (8 years).

10.2.10.2 Compliance with ARARs

This alternative complies with action-specific ARARs regarding the construction of caps/covers and the monitoring of contained material including state regulations on air emissions sources, monitoring of solidified soil, and endangered species. Location-specific ARARs are met since Basin A and the landfill are not located in wetlands or a 100-year flood plain. In addition to the ARARs, this alternative complies with provisions of the FFA (EPA et al. 1989) and Army regulations regarding agent and UXO demilitarization. (ARARs are listed in Appendix A of the Technology Descriptions Volume.)

10.2.10.3 Long-Term Effectiveness and Permanence

The residual risk is low since the entire site is contained and the human health exceedances are treated to concentrations near the Human Health PRGs. The residual contamination (below 10 ft or the water table) and soil that may pose a risk to biota are contained with the cap.

Long-term groundwater compliance monitoring, 5-year site reviews, and cap-maintenance operations are conducted to ensure the effectiveness of the controls. Controls are adequate for monitoring the solidified soil and are ensured through long-term monitoring. The overall habitat quality for the site is improved through revegetation, offsetting the habitat loss incurred during implementation of the alternative, although the types of vegetation placed at the site and the maintenance activities performed there discourage burrowing animals from using the capped area as habitat.

10.2.10.4 Reduction in TMV

RF heating can theoretically achieve Human Health and Biota RAOs with low residual risk since OCPs and volatile metals can be driven from the soil by this form of in situ thermal treatment. However, the pilot-scale test of the RF technology at RMA, as described in the Technology Descriptions Volume Section 8.2.1.2, failed to confirm the temperature distribution and OCP removal efficiencies required for confident treatment of soil to achieve PRGs. The contaminant removal through RF heating is irreversible. Soil identified as containing UXO is treated and landfilled. Soil identified as containing agent is landfilled following caustic washing, as are the salts that result from the treatment of the washing solution. The 32,000 BCY of soil with inorganic exceedances are solidified in place and the balance of contaminated soil is capped, which reduces the mobility of contaminants and interrupts the exposure pathways. Groundwater from the dewatering system is treated and reinjected on post.

10.2.10.5 Short-Term Effectiveness

This alternative entails significant short-term risks associated with UXO/agent clearance, which are reduced, but not completely removed, through engineering controls and PPE. The in situ thermal treatment of soil also entails short-term impacts. The long duration of treatment operations results in continuing migration of contaminants to groundwater and potential exposure of humans and biota to contaminated soil for 8 years. Although the off- gas control system for in situ heating is designed to achieve air quality standards, the emissions from the in situ heating unit contain low concentrations of the contaminants removed from the soil. The time frame for completion of the alternative is 8 years, including 1 year for construction of the heating unit and 2 years for dewatering prior to treatment.

10.2.10.6 Implementability

In situ thermal heating is currently not implementable because full-scale in situ heating units have never been built or tested. The technology was demonstrated at a pilot-scale at RMA; however, full-scale units have not been developed, and several problems were identified in the pilot-scale test regarding the durability of the equipment. In addition, administrative difficulties associated with demonstrating compliance with permits and performing O&M may lead to delays, and it may be difficult to implement this alternative due to the perceptions regarding the safety of in situ thermal treatment and the thermal-treatment portion of the off-gas control system. In situ solidification is a demonstrated technology, and full-scale units are available. The capping and landfilling portions of this alternative are technically feasible because they can be constructed within the required time frame and reliably operated and maintained thereafter. Additional remedial actions can be easily undertaken for soil left in place (except for the solidified portion), although the cap adds to the overall site volume. Equipment, specialists, and materials are readily available for the landfill and multilayer cap construction.

10.2.10.7 Cost

The total present worth cost is $119,000,000 including $15,000,000, $103,000,000, and $1,730,000 for capital, operating, and long-term costs, respectively. Table B4.1-19b details the costing for this alternative.

There are three significant uncertainties associated with the costing of this alternative. First, the extent and depth of contamination and extent of UXO/agent presence are difficult to estimate. Second, there are no full-scale demonstrations of the in situ heating technology at other hazardous waste sites by which actual construction and operational costs can be documented. This uncertainty is especially noteworthy because the pilot-scale demonstration of the technology at RMA indicated there were potential problems regarding the durability of the equipment. Third, the lack of full-scale implementation data increases uncertainties relative to maintaining the assumed on-line percentage of the heating units. The level and depth of contamination at RMA may result in changes in treatment times or delays in implementation, both of which may impact treatment costs.

10.3 COMPARATIVE ANALYSIS OF ALTERNATIVES

The Basin A Medium Group contains 300,000 BCY of contaminated soil. The predominant COCs are OCPs, although mercury and arsenic are also present. Manufacturing wastewater effluent, which contained a combination of organic and inorganic contaminants, was historically dumped into Basin A. As such, the contamination patterns are relatively homogeneous compared to the heterogeneous contamination patterns of disposal trenches and sites with isolated spills. Fewer than 6 percent of the samples in Basin A contained an OCP exceeding the Human Health SEC (EBASCO 1994a) (Table 10.1-2), but nearly 34 percent of the samples contained concentrations of OCPs that may pose potential risk to biota. The contaminants in the exceedance volumes in Basin A represent a relatively low risk to human health as the average concentrations of individual OCPs are below or slightly above the Human Health SEC (EBASCO 1994a). Nonetheless, the contaminated soil poses a potential risk to biota (Table 10.1-1).

Approximately 32,000 BCY of contaminated soil within Basin A are considered to represent a principal threat volume based on elevated levels of OCPs, primarily chlordane. The principal threat areas consist of low-lying areas in the central and southern portions of the basin where liquids may have ponded (Figure 10.1-1). These areas are not contiguous, but they are defined by multiple samples with higher levels of dieldrin than are found in nearby borings. The principal threat volume is contained within the uppermost several feet, but it extends to the water table.

A large portion of Basin A potentially contains Army agent and UXO (Figure 10.1-2). Although the agent-contaminated liquid wastes were treated in the sumps that lie within the production areas, in the Buried M-1 Pits, and in the Section 36 Lime Basins prior to disposal in the basin, agent was detected in Basin A soil during the Soil Volume Refinement Program in several samples collected near the Lime Basins. UXO was removed from the surface of Basin A prior to the RI program, indicating that subsurface UXO may be present in the eastern portion of the basin, near sites in the Complex Disposal Trenches Subgroup.

The Basin A area primarily consists of disturbed habitat. As such, disturbance of the basin during remedial actions does not present a significant decrease in available habitat. Although the sites in Basin A have been identified as sources of a contaminated groundwater plume, the Basin A Neck IRA treatment system intercepts contaminated groundwater immediately downgradient of the site.

The presence of OCPs at high concentrations and the potential presence of agent and UXO indicate that controls are required for the protection of site workers and the community for remedial actions that involve excavation of the Basin A soil. On a daily basis, only those areas actively being excavated are left open, and covers or plastic liners are used to limit odor/vapor emissions. Furthermore, areas to be excavated are screened for agent using field sampling and cleared for subsurface UXO using geophysical surveys.

In summary, some areas of Basin A contain high concentrations of OCPs, but any contaminants being mobilized from the soil are intercepted by the Basin A Neck IRA. However, agent and UXO are potentially present. The short-term risks of potential worker and community exposure to UXO, agent, release of vapors, and the long time period needed to complete a treatment alternative (5 to 16 years) must be balanced against the short time frame required to complete a containment alternative (4 years) and the risks of leaving contamination in place.

Alternative 1: No Additional Action, Alternative 1a: Direct Thermal Desorption of Principal Threat Volume and Alternative 17: In Situ Physical/Chemical Treatment; In Situ Thermal Treatment do not achieve Human Health or Biota RAOs based on the residual risks associated with each alternative; these were eliminated from further consideration. The remaining seven alternatives achieve RAOs and comply with action- and location-specific ARARs (Table 10.2-1).

The landfill alternatives (Alternative 3b: Landfill; Caps/Covers and Alternative 3c: Direct Thermal Desorption of Principal Threat Volume; Landfill; Caps/Covers) achieve RAOs as containment reduces contaminant mobility and the potential for exposures. Landfilling and capping have been well demonstrated and there is high confidence in the engineering controls and maintenance of these operations. Conversely, both the technical and administrative implementabilty of thermal desorption for Basin A are difficult based on the characteristics of the soil to be treated and concerns regarding thermal treatment. The high-level risk presented to site workers by clearance and treatment of agent and UXO is addressed through PPE. The costs of $73,700,000 and $73,300,000, for Alternatives 3b and 3c, respectively, are lower than those involving full treatment. Based on the cost effectiveness and permanent containment offered by landfilling and capping, these alternatives were carried forward for development of the sitewide alternatives (Section 20).

Alternative 6: Caps/Covers provides low long-term residual risks without incurring short-term risks. This alternative also interrupts exposure pathways and reduces the impacts on groundwater. There are no treatment residuals associated with this alternative. This technology has been well demonstrated and entails low short-term risks since Basin A soil is not excavated. The cost of $51,600,000 indicates that this alternative is cost effective. This alternative was carried forward for development of the sitewide alternatives (Section 20).

Alternative 6c: Direct Thermal Desorption of Principal Threat Volume; Caps/Covers involves limited excavation and treatment. Although this alternative exhibits a comparatively low cost of $58,100,000, the drawbacks of the alternative include the hazards of agent/UXO clearance. In addition, both the technical and administrative implementability of thermal desorption for Basin A are difficult based on the characteristics of the soil to be treated and concerns regarding thermal treatment. As a result, the cost increase compared to in-place containment does not justify the increased hazards of excavating and treating the principal threat exceedances. This alternative was not retained for further consideration.

Alternative 8b: Direct Soil Washing; Direct Solidification/Stabilization; Caps/Covers treats all contamination (which achieves PRGs) and treats residual contamination through the installation of a multilayer cap. However, this alternative has several disadvantages. The implementation of this alternative requires multiple solvent washing units that are difficult to operate and maintain. Treatment residuals include 120,000 gallons of liquid, which require additional off-post treatment. The alternative also entails significant short-term risks related to excavation and agent/UXO clearance. The cost of this alternative, $105,000,000 (despite the high degree of uncertainty associated with the estimate), indicates that this alternative is not cost effective. For these reasons, this alternative was not retained for further consideration.

Alternative 13d: Direct Thermal Desorption; Direct Solidification/Stabilization; Caps/Covers reduces contaminant concentrations through treatment (which achieves PRGs) and contains the residual contamination. This alternative exhibits significant risks related to excavation and clearance of agent-contaminated soil and/or UXO and difficulties in implementability related to thermal desorption. Since the alternative ultimately relies on containment, the risk reduction for thermal desorption does not warrant the higher cost for thermal desorption ($85,100,000) compared to containment alternatives. Consequently, this alternative was not retained.

Alternative 19b: In Situ Thermal Treatment; In Situ Solidification/Stabilization; Caps/Covers is not capable of achieving RAOs and is not yet available for full-scale operation. This alternative is also the most expensive alternative ($119,000,000). Accordingly, this alternative was not retained based on the lack of equipment for full-scale operation and high cost.

Consequently, the alternatives that were retained to represent the Basin A Medium Group in the development of the sitewide alternatives (Section 20) are the following:

- Alternative 3b: Landfill (On-Post Landfill); Caps/Covers (Soil Cover or Multilayer Cap)
- Alternative 3c: Direct Thermal Desorption (Direct Heating) of Principal Threat Volume; Landfill (On-Post Landfill); Caps/Covers (Multilayer Cap)
- Alternative 6: Caps/Covers (Multilayer Cap)

Table 10.0-1 Characteristics of Basin A Medium Group

Characteristic	Basin A Medium Group
Contaminants of Concern	
Human Health	OCPs, As, Hg, Cr
Biota	OCPs, As, Hg
Exceedance Areas (SY)	
Total	670,000
Human Health	310,000
Principal Threat	35,000
Biota	350,000
Potential Agent	430,000
Potential UXO	140,000
Exceedance Volume (BCY)	
Total	300,000
Human Health	180,000
Organic	160,000
Inorganic	32,000
Principal Threat	32,000
Biota	120,000
Potential Agent	710
Potential UXO	94
Depth of Contamination (ft)	
Human Health	0–10, mostly 0–5
Biota	0–1

Contaminants of Concern	Range of Concentrations[2] (ppm)	Average Concentration[2] (ppm)	Human Health SEC (ppm)	Human Health Principal Threat Criteria (ppm)	Human Health Acute Criteria (ppm)
Human Health Exceedance Volume					
Aldrin	BCRL–720	42	71	720	3.8
Dieldrin	BCRL–2,600	150	41	410	3.7
Endrin	BCRL–3,200	110	230	230,000	56
Isodrin	BCRL–160	9	52	52,000	Not applicable
Chlordane	BCRL–2,900	100	55	3,700	12
Arsenic	BCRL–28,000	350	420	4,200	270
Chromium	BCRL–98	13	39	7,500	2,400
p,p,DDT[1]	BCRL–105	3	410	13,500	14
p,p,DDE[1]	BCRL–21	1.4	1,250	12,500	Not applicable
Mercury[1]	BCRL–11,000	140	570	570,000	82
Biota Volume					
Aldrin	BCRL–1.9	0.04			
Dieldrin	BCRL–3.6	0.53			
Endrin	BCRL–3.0	0.10			
Arsenic	BCRL–230	25			
Mercury	BCRL–54	0.67			
p,p,DDT	BCRL–0.73	0.01			
p,p,DDE	BCRL–0.71	0.01			

1 Presents biota risk, but was detected in the human health exceedance volume.
2 Based on modeled concentrations within the human health exceedance volume or potential biota risk area.

Table 10.1-2 Frequency of Detections for Basin A Medium Group

	Total Samples	BCRL		CRL-SEC(1)		Acute-HH SEC(2)		HH SEC-Pr. Threat(2)		>Pr. Threat(2)	
	Analyzed	Number	%	Number	%	Number	%	Number	%	Number	%
Aldrin	452	339	75.0%	70	15.5%	30	6.6%	12	2.7%	1	0.2%
Benzene	115	109	94.8%	6	5.2%	--	--	0	0.0%	0	0.0%
Carbon Tetrachloride	115	115	100.0%	0	0.0%	--	--	0	0.0%	0	0.0%
Chlordane	401	306	76.3%	80	20.0%	14	3.5%	23	5.7%	0	0.0%
Chloroacetic Acid	122	119	97.5%	3	2.5%	--	--	0	0.0%	0	0.0%
Chlorobenzene	108	103	95.4%	5	4.6%	--	--	0	0.0%	0	0.0%
Chloroform	115	115	100.0%	0	0.0%	--	--	0	0.0%	0	0.0%
p,p,DDE	452	373	82.5%	79	17.5%	--	--	0	0.0%	0	0.0%
p,p,DDT	452	382	84.5%	68	15.0%	2	0.4%	0	0.0%	0	0.0%
Dibromochloropropane	203	201	99.0%	2	1.0%	--	--	0	0.0%	0	0.0%
1,2-Dichloroethane	115	115	100.0%	0	0.0%	--	--	0	0.0%	0	0.0%
1,1-Dichloroethene	52	52	100.0%	0	0.0%	--	--	0	0.0%	0	0.0%
Dicyclopentadiene	213	207	97.2%	6	2.8%	--	--	0	0.0%	0	0.0%
Dieldrin	451	233	51.7%	151	33.5%	33	7.3%	24	5.3%	10	2.2%
Endrin	464	308	66.4%	139	30.0%	9	1.9%	8	1.7%	0	0.0%
Hexachlorocyclopentadiene	417	383	91.8%	34	8.2%	--	--	0	0.0%	0	0.0%
Isodrin	452	375	83.0%	74	16.4%	--	--	3	0.7%	0	0.0%
Methylene Chloride	86	69	80.2%	17	19.8%	--	--	0	0.0%	0	0.0%
Tetrachloroethane	3	3	100.0%	0	0.0%	--	--	0	0.0%	0	0.0%
Tetrachloroethylene	115	105	91.3%	10	8.7%	--	--	0	0.0%	0	0.0%
Toluene	103	98	95.1%	5	4.9%	--	--	0	0.0%	0	0.0%
Trichloroethylene	115	111	96.5%	4	3.5%	--	--	0	0.0%	0	0.0%
Arsenic	500	162	32.4%	301	60.2%	8	1.6%	26	5.2%	3	0.6%
Cadmium	285	199	69.8%	86	30.2%	0	0.0%	0	0.0%	0	0.0%
Chromium	285	34	11.9%	249	87.4%	--	--	2	0.7%	0	0.0%
Lead	285	192	67.4%	93	32.6%	--	--	0	0.0%	0	0.0%
Mercury	499	225	45.1%	270	54.1%	2	0.4%	2	0.4%	0	0.0%

(1) SEC limits for this interval are based on chronic HH SEC, or where appropriate, acute risk-based criteria for the 0- to 1-ft depth interval.

(2) Table 1.4-1 presents acute criteria, HH SEC, and principal threat criteria.

-- not applicable

CRITERIA	Alternative 1: No Additional Action	Alternative 1a: Direct Thermal Desorption of Principal Threat Volume; No Additional Action	Alternative 3b: Landfill; Caps/Covers	Alternative 3c: Direct Thermal Desorption of Principal Threat Volume; Landfill; Caps/Covers	Alternative 6: Caps/Covers
1. Overall protection of human health and the environment	Not Protective: Does not achieve Human Health or Biota RAOs; Groundwater impacts continue	Not Protective: Does not achieve Human Health or Biota RAOs; Groundwater impacts continue	Protective: Achieves Human Health and Biota RAOs through containment; impacts on groundwater greatly reduced	Protective: Achieves Human Health and Biota RAOs through treatment and containment; impacts on groundwater reduced	Protective: Achieves Human Health and Biota RAOs through containment; impacts on groundwater greatly reduced
2. Compliance with ARARs	Does comply with agent/UXO regulations	Does not comply with agent/UXO regulations	Complies	Complies	Complies
3. Long-term effectiveness and permanence	High Residual Risk: High-level contamination remains; impacts to groundwater and risks from fugitive dust remain	Moderate Residual Risk: Principal threat volume (32,000 BCY) removed and treated; risk for balance of site remains	Low Residual Risk: Contaminated soil removed and/or contained	Low Residual Risk: Principal threat volume treated; balance of contaminated soil removed and/or contained	Low Residual Risk: Contaminated soil contained in place
4. Reduction in TMV	300,000 BCY remain untreated; TMV reduction by natural attenuation only	Thermal desorption destroys OCPs for 32,000 BCY; TMV reduction by natural attenuation only for balance of site	Mobility of contaminants reduced by containment; toxicity and volume not reduced	Thermal desorption destroys OCPs for 32,000 BCY; for balance of soil, mobility of contaminants reduced by containment	Mobility of contaminants reduced through containment; toxicity and volume not reduced
5. Short-term effectiveness	Existing disturbed habitat not changed	Significant risk to workers and community during agent/UXO screening and excavation, transportation, and treatment of principal threat volume; however, relatively lower overall risk due to small soil volume	Significant risk to workers and community during agent/UXO screening, excavation, and transportation and disposal of human health exceedance soil; RAOs achieved in 4 yrs	Significant risk to workers and community during agent/UXO screening and excavation, transportation, and treatment/disposal of human health exceedances; RAOs achieved in 4 yrs	Protective of workers and the community; no intrusive action; RAOs achieved in 4 yrs
6. Implementability	Feasible; No implementation required	Technical and administrative difficulty for thermal treatment	Feasible	Technical and administrative difficulty for thermal treatment	Feasible
7. Present worth costs	Capital—$0 Operating—$0 Long-term—$5,770,000 Total—$5,770,000	Capital—$1,430,000 Operating—$9,060,000 Long-term—$5,150,000 Total—$15,600,000	Capital—$5,860,000 Operating—$66,200,000 Long-term—$1,630,000 Total—$73,700,000	Capital—$6,800,000 Operating—$65,200,000 Long-term—$1,310,000 Total—$73,300,000	Capital—$0 Operating—$50,100,000 Long-term—$1,510,000 Total—$51,600,000
Summary	Not Retained: Not protective of human health and the environment	Not Retained: Not protective of human health and the environment	Retained: Contaminated soil contained	Retained: Contaminated soil contained and treated although administrative feasibility limited	Retained: Contaminated soil contained in place

CRITERIA	Alternative 6c: Direct Thermal Desorption of Principal Threat Volume; Caps/Covers	Alternative 8b: Direct Soil Washing; Direct Solidification/Stabilization; Caps/Covers	Alternative 13d: Direct Thermal Desorption; Direct Solidification/Stabilization; Caps/Covers	Alternative 17: In Situ Physical/Chemical Treatment; In Situ Thermal Treatment	Alternative 19b: In Situ Thermal Treatment; In Situ Solidification/Stabilization; Caps/Covers
1. Overall protection of human health and the environment	Protective: Achieves Human Health and Biota RAOs through treatment and containment; impacts to groundwater reduced	Protective: Achieves Human Health and Biota RAOs through treatment and containment of biota and residual contamination; Groundwater impacts reduced	Protective: Achieves Human Health and Biota RAOs through treatment and containment of biota and residual contamination; Groundwater impacts reduced	Not Protective: Does not achieve RAOs based on levels of contamination remaining after treatment; contaminant levels and impacts on groundwater are reduced	Protective: Achieves Human Health and Biota RAOs through treatment and containment of treated soil in addition to biota and residual contamination; PRGs not achieved by RF heating; Groundwater impacts reduced
2. Compliance with ARARs	Complies	Complies	Complies	Complies	Complies
3. Long-term effectiveness and permanence	Low Residual Risk: Principal threat volume treated, balance of contaminated soil contained	Low Residual Risk: Human health exceedances treated, balance of contaminated soil contained	Low Residual Risk: Human health exceedances treated, balance of contaminated soil contained	Moderate Risk: Contaminant levels reduced but residual risk to human health and biota remain	Low Residual Risk: Human health exceedances treated, balance of contaminated soil contained
4. Reduction in TMV	Thermal desorption destroys OCPs in 32,000 BCY; mobility reduced for balance of contaminants through containment	Solvent washing reduces organics to below PRGs; mobility eliminated in solidified mass; mobility reduced for balance of site contaminants through containment; 120,000 gallons treatment residual drummed and transported off post	Thermal desorption reduces organics to below PRGs; mobility eliminated in solidified mass; mobility reduced for balance of site contaminants through containment	TMV reduced through in situ heating and in situ flushing, PRGs not achieved and residual risk remains	TMV reduced by treatment, but not eliminated; mobility reduced for treated soil and balance of contaminants through containment
5. Short-term effectiveness	Significant risk to workers and community during agent/UXO screening, excavation, transportation, and treatment of principal threat volume; however, small magnitude of risk due to small soil volume; RAOs achieved in 4 yrs	Significant risk to workers and community during agent/UXO screening, excavation, transportation, and treatment of human health exceedances; RAOs achieved in 4 yrs	Significant risk to workers and community during agent/UXO screening, excavation, transportation, and treatment of human health exceedances; RAOs achieved in 4 yrs	Significant risks to workers and community during agent/UXO screening and in situ treatment over the long treatment duration	Significant risks to workers and community during agent/UXO screening and in situ treatment over the long treatment duration; RAOs achieved in 8 yrs
6. Implementability	Technical and administrative difficulty for thermal desorption	Very difficult to implement due to lack of performance data and available, tested equipment at required scale	Technical and administrative difficulty for thermal desorption	Not currently implementable since full-scale in situ heating units are not available and unable to control in situ flushing	Not currently implementable since full-scale in situ heating units are not available
7. Present worth costs	Capital—$1,430,000 Operating—$54,600,000 Long-term—$2,070,000 Total—$58,100,000	Capital—$9,760,000 Operating—$93,900,000 Long-term—$1,530,000 Total—$105,000,000	Capital—$6,110,000 Operating—$77,400,000 Long-term—$1,640,000 Total—$85,100,000	Capital—$8,810,000 Operating—$157,000,000 Long-term—$669,000 Total—$166,000,000	Capital—$15,000,000 Operating—$103,000,000 Long-term—$1,730,000 Total—$119,000,000
Summary	Not Retained: Long-term risks not reduced enough to justify increased cost compared to in-place containment	Not Retained: High cost and very difficult to implement	Not Retained: High cost for larger treatment volume without reducing long-term risk compared to containment alternatives	Not retained: Not commercially available, unable to control soil flushing, does not achieve RAOs	Not Retained: Not commercially available, high cost, long-term risks not reduced compared to thermal desorption

Prepared for:

U.S. Army Program Manager
for Rocky Mountain Arsenal

October 1995

FIGURE 10.1-1

Exceedance Areas
Basin A Medium Group

Rocky Mountain Arsenal.
Prepared by: Foster Wheeler Environmental Corporation

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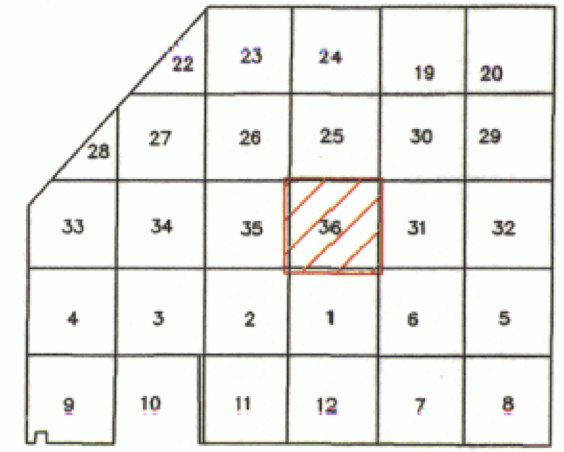
ROCKY MOUNTAIN ARSENAL
INDEX MAP



LEGEND

Human Health Exceedance Area and Potential Biota Risk Area

Potential Agent and UXO Presence Area

Site Boundary

Buildings and Roads

36 Section Number

300 0 300 600 FEET

Prepared for:

U.S. Army Program Manager
for Rocky Mountain Arsenal

October 1995

FIGURE 10.1-2

Potential Agent/UXO Presence Areas
Basin A Medium Group

Rocky Mountain Arsenal.
Prepared by: Foster Wheeler Environmental Corporation

Section 11

11.0 DETAILED ANALYSIS OF ALTERNATIVES FOR THE BASIN F MEDIUM GROUP

The Basin F Medium Group consists of two sites that have related histories and similar contaminant types. Contamination of soil in this medium group results from Basin F operations. The sites include a wastepile of sludge and soil removed from Basin F during the Basin F IRA (Figure 11.0-1) (EBASCO 1992a) and the Former Basin F site, NCSA-3. The Basin F IRA consisted of removing Basin F sludges, excavating all Basin F soil to a depth of 6 inches below the level of the original asphalt liner and selected hotspots to a maximum depth of 6 ft, stabilizing sludges by drying and mixing them with contaminated soil before placement in the lined wastepile, and grading, capping, and revegetating the site. This medium group is separated into two subgroups—Basin F Wastepile and Former Basin F—each containing one site. Figure 11.0-1 illustrates the locations of the subgroups and the related sites.

The primary Human Health COCs for this medium group include OCPs and CLC2A. DCPD and DBLP are also present at concentrations above Human Health SEC (EBASCO 1994a). Both subgroups contain OCPs at concentrations that exceed the principal threat criteria. Since potential biota risks are evaluated only within 1 ft of the ground surface, and both subgroups are capped, biota risks are not addressed for this medium group. The Former Basin F Subgroup is identified as a source of groundwater contamination. Habitat is disturbed and the fencing around the wastepile makes it unaccessible to most wildlife. The sites within this medium group do not have the potential for the presence of agent or UXO. Table 11.0-1 presents the characteristics of this medium group, and Appendix A presents a summary of the calculation of exceedance areas and volumes.

In the DSA (EBASCO 1992b), the Basin F Medium Group consisted of only one site, the wastepile. In the DAA, this medium group was modified to include another site, the Former Basin F site, based on similar use histories and contaminant types and on the applicability of RCRA closure requirements to both sites. In this manner, the evaluation of alternatives for both sites recognizes the joint CERCLA/RCRA jurisdiction over remedial actions. As required by the Colorado Department of Public Health and Environment (CDPHE), the closure of the Former Basin F and Basin F Wastepile shall be completed in the full compliance with the Colorado

Hazardous Waste Management Act, and its implementing regulations, and consistent with the Consent Decree entered in the U.S. v. Colorado, Civil Action No. 89-C-1646 (June 30, 1994). The closure of the Submerged Quench Incinerator, Tanks 101-103, Ponds A and B and three storage warehouses (791, 792, and 798) shall be completed in accordance with the closure plans approved pursuant to Compliance Order on Consent No. 93-08-05-01, In the Matter of the Rocky Mountain Arsenal Submerged Quench Incinerator (August 6, 1993), and all requirements contained therein.

The characteristics of the two sites—including contaminants and contaminant concentrations, site configuration, and depth of contamination—were used to determine the subset of applicable alternatives for each site from the range of alternatives retained in the DSA (EBASCO 1992b).

The sections to follow present the characteristics of the subgroups, an evaluation of the retained alternatives against the DAA criteria listed in the NCP (EPA 1990a), and the selection of alternatives, based on a comparative analysis, that was considered in the development of the sitewide alternatives (Section 20).

11.1 BASIN F WASTEPILE SUBGROUP CHARACTERISTICS

The Basin F Wastepile Subgroup is composed only of one site, the wastepile (Figure 11.0-1). This site contains contaminated sludge from above the original Basin F asphalt liner and contaminated soil from below the liner. The 33-ft-high wastepile covers an area of 75,000 SY and contains 580,000 BCY of materials. The wastepile liner system consists of two layers of geomembrane liner (primary and secondary layers), two layers of geonet, and one layer of geotextile as shown in Figure 11.1-1. The upper geonet overlies the primary geomembrane and allows leachate retained by the primary geomembrane to flow to leachate collection sumps (primary sumps) for collection and removal. The second geonet acts as the transmissive component of the leak detection system, allowing leachate that penetrates the primary (upper) geomembrane and flow to leakage collection sumps (secondary sumps) for collection and removal. Approximately 20,000 BCY of additional contaminated materials in the liner system and subgrade would also require removal and treatment or disposal for alternatives involving excavation of the wastepile, giving a total excavation volume of 600,000 BCY.

The existing wastepile cover system consists of one geomembrane layer, two geonet layers, two geotextile layers, and four soil layers as shown in Figure 11.1-1. The geomembrane serves as a very low permeability barrier to prevent infiltration of water into the wastepile. The primary component of the drainage layer system is a geonet layer that allows water percolating through the overlying soil layers to flow over the surface of the geomembrane and exit through drains at the toe of the wastepile side slope. The cohesive cover is a 1-ft-thick layer of fine-grained silt and clay soil that serves to minimize the infiltration of rainfall through the soil layers. The cohesive cover is overlain by a 6-inch-thick layer of topsoil that supports a vegetative cover for the wastepile cover system. This top layer prevents stormwater runoff from eroding the topsoil cover.

An assessment of the integrity of the wastepile (hereafter referred to as the Wastepile Assessment Report) was conducted (HLA 1994a) to address the following concerns:

- Leachate removal varies seasonally, suggesting that precipitation may be infiltrating the cover.
- Historically, the Cell 2 primary liner may not have functioned properly, thus allowing leachate generated from Cell 2 to pass directly to the secondary liner. In addition, no leachate was removed from the Cell 2 primary sump in February and March 1993, indicating that the Cell 2 primary liner may no longer be functional.
- Since the Cell 2 primary liner may not have functioned properly, concerns regarding the integrity of the secondary liner have been raised.

The Basin F Wastepile Assessment Report (HLA 1994a) determined that leachate generation in the wastepile has followed expected trends with the exception of a seasonal fluctuation that has accounted for approximately 30,000 gallons of leachate per year for the last few years. The seasonal fluctuation may be the result of precipitation infiltrating the cover, although no direct evidence of such infiltration was found, or it may possibly be the result of crystal plugging in or around the leachate collection and removal sump due to gradual temperature changes within the sump and subsequent precipitation or dissolution of salts in the leachate.

The assessment concluded that the seasonal fluctuations do not impact the operation of the waste pile. The leachate collection and removal system has the capacity to effectively remove the additional volume of leachate that is generated during the seasonal fluctuations. Excessive liquid head (greater than 1 ft above the top of the primary liner) has not built up as a result of the seasonal fluctuations. In addition, the volume of leachate associated with the seasonal fluctuations has not caused an exceedance of the leakage rate at which some corrective action would be required, i.e., 160 gallons/acre/day (HLA 1994a). Enhanced O&M procedures at the wastepile were implemented to address potential pathways of infiltration. Standard operating procedures were developed and are being implemented to repair existing cracks and animal burrow holes in the wastepile cover and to identify and repair future surface features that could possibly result in infiltration.

As a result of enhanced maintenance practices (i.e., large volume heated water flushes conducted in the Cell 2 primary sump from May to September 1993), the Cell 2 primary sump is now collecting approximately 95 percent of the Cell 2 leachate. Restoration of the Cell 2 primary sump has been successful, thus indicating that the primary liner in Cell 2 is functioning properly. Enhanced sump maintenance, including the implementation of routine large volume heated-water flushes, is being incorporated into wastepile O&M procedures to maintain proper operating conditions in Cell 2.

In addition, a comprehensive review of groundwater-elevation and water-quality data upgradient and downgradient of the wastepile does not indicate that leachate has been released through the secondary liner. The secondary liner appears to be functioning as designed (i.e., to contain leachate that passes through the primary liner of the waste pile). The State does not agree with the Army's assessment of wastepile performance (see letters from J. Edson to C. Scharmann, 12/20/93, 5/27/94).

Table 11.1-1 provides a summary of contaminants, concentrations, and exceedance values for this subgroup. The concentrations of contaminants in this subgroup were inferred from RI sampling at Basin F prior to the implementation of the IRA. Maximum concentrations of OCPs, CLC2A, and VOCs exceed the Human Health SEC (EBASCO 1994a), and the maximum concentrations of aldrin and dieldrin are above the principal threat criteria (10^{-3} excess cancer risk, HI of 1,000). In addition, the wastepile materials contain high levels of salts due to the high chloride content in wastewater stored in the former Basin F. A total of 580,000 BCY of contaminated soil and sludge was placed in the wastepile as part of the IRA. The exceedance volume for this subgroup is 600,000 BCY, which accounts for the 20,000 BCY of contaminated materials in the leachate systems and subgrade.

Large mammals and burrowing animals are currently excluded from the Basin F Wastepile Subgroup through fencing and maintenance activities. The alternatives that consist of excavating and treating the wastepile result in an improvement in habitat quality following revegetation. The remaining alternatives, which consist of continuing to exclude various species of animals, do not result in an improvement in habitat quality, and mitigation is required to replace the lost habitat.

11.2 BASIN F WASTEPILE SUBGROUP EVALUATION OF ALTERNATIVES

The six alternatives for the Basin F Wastepile Subgroup include no action, containment, and treatment approaches. The alternatives retained in the DSA (EBASCO 1992b) for this subgroup (formerly the Basin F Wastepile Medium Group) were modified to indicate that, because of relatively low concentrations of inorganics, solidification is not required following the treatment of organic contaminants. In addition, one alternative (solvent extraction) has been reintroduced and one alternative (soil washing) has been removed based on the results of several treatability studies. A new containment alternative has also been added. It should be noted that the preferred alternative for the Basin F Wastepile must be consistent with the state-approved RCRA closure; therefore, the alternative selected in the DAA may be modified when the RCRA closure plan is finalized and accepted by the state.

Solvent extraction was screened out in the DSA (EBASCO 1992b) in favor of thermal desorption based on cost and effectiveness concerns. However, treatability studies at RMA have demonstrated that solvent extraction could effectively remove OCPs. Furthermore, the high salt content of the wastepile materials, although it would not impact the cost of solvent extraction significantly, would increase the cost of thermal desorption and create operational problems due to potential fouling and higher maintenance requirements. As a result of its potential effectiveness, solvent extraction has been reintroduced into for the wastepile as Alternative 8a: Direct Soil Washing (Solvent Extraction); Landfill. Alternative 9: Direct Soil Washing (Caustic Solution Washing); Direct Thermal Desorption (Direct Heating) was retained in the DSA (EBASCO 1992b) for its ability to remove FC2A and salts prior to thermal treatment. This alternative is no longer retained for this subgroup for two reasons. First, FC2A is no longer a COC since previous positive detections have been discounted due to analytical interferences. Second, soil washing generates a large liquid effluent volume that requires treatment according to RCRA regulations. Alternative 3: Landfill was added to evaluate the disposal of the Basin F Wastepile in a new hazardous waste landfill; this alternative would include pretreatment, such as drying, to comply with landfill requirements. The following subsections present a description of each alternative and an evaluation of the alternative against the DAA criteria listed in the NCP (EPA 1990a).

11.2.1 Alternative 1: No Additional Action

Alternative 1: No Additional Action (Provisions of FFA) applies to the 75,000 SY of exceedance area in the Basin F Wastepile Subgroup. The 580,000 BCY of exceedance volume contained in the wastepile remain in place and no additional controls are implemented. No additional actions (beyond the existing fence and cover) are taken to reduce human or biota exposure to COCs. The Wastepile Assessment report (HLA 1994a) indicated that the existing cover is adequately reducing infiltration, the primary liner is functioning properly with the enhanced O&M procedures, and the secondary liner appears to be functioning as designed. An average long-term leachate volume of 13,300 gallons/year is pumped from the wastepile leachate-collection and leak-detection systems. The leachate is drummed and shipped off post for incineration. Long-term maintenance is required to ensure the integrity of the existing liner and cap. Five-year site reviews and annual groundwater compliance monitoring are conducted to assess the integrity of the wastepile cover and the potential migration of contaminants.

The following discussion presents a detailed evaluation of this alternative against the DAA criteria listed in the NCP (EPA 1990a). For purposes of comparison, Table 11.2-1 summarizes the evaluation of all alternatives developed for this subgroup.

11.2.1.1 Overall Protection of Human Health and the Environment

This alternative achieves RAOs through the existing containment systems. Untreated soil remains in place, but the potential for human exposure is prevented due to the existing cover. Long-term protection of groundwater is achieved since the cover and liner systems are functioning properly. The short-term impacts are minimal since intrusive activities are not conducted.

11.2.1.2 Compliance with ARARs

This alternative does not achieve action-specific ARARs for wastepile closure because the cover does not provide the infiltration control, erosion controls, or lower maintenance requirements of a Subtitle C landfill cap. It does achieve action-specific ARARs regarding the liner, leachate-control system, and maintenance and monitoring activities. This alternative complies with location-specific ARARs as the wastepile is not located in wetlands or a 100-year flood plain. The alternative complies with provisions of the FFA (EPA et al. 1989). (ARARs are presented in Appendix A of the Technology Descriptions Volume.)

11.2.1.3 Long-Term Effectiveness and Permanence

There is low residual risk associated with this alternative. Although high levels of OCPs, VOCs, and CLC2A above the Human Health SEC (EBASCO 1994a) or principal threat criteria remain, exposure pathways are interrupted by the existing cap and engineering controls. Site reviews, groundwater monitoring, cover and leachate collection system maintenance, and leachate treatment are required. The existing habitat is neither improved nor impacted by this alternative as the fence around the wastepile remains in place.

11.2.1.4 Reduction in TMV

There is no reduction in TMV resulting from this alternative and no treatment residuals are generated since no materials are treated; however, the wastepile is contained. A total of 580,000 BCY of untreated soil and sludge remains contained in the wastepile.

11.2.1.5 Short-Term Effectiveness

This alternative is protective of workers and the community. The existing habitat is not affected by the alternative. The existing containment system achieves RAOs.

11.2.1.6 Implementability

The alternative is technically and administratively feasible. Services are available to sample groundwater, continue cover and leachate collection system maintenance, and treat leachate.

11.2.1.7 Cost

The total present worth cost is $3,020,000 and includes only long-term costs. Table B4.2-1 details the costing for this alternative. This alternative exhibits moderate cost uncertainties relative to long-term maintenance activities and leachate treatment (due to the high cost of leachate treatment).

11.2.2 <u>Alternative 2: Access Restrictions</u>

Alternative 2: Access Restrictions (Modifications to FFA) leaves 580,000 BCY of exceedance soil and sludge contained in place. In addition to the existing restrictions of a fence and an interim cover, exclusion of biota from the wastepile is promoted by revegetation with grasses unappealing to biota. Revegetation of 75,000 SY is accomplished over a 3-year period, and long-term maintenance of the vegetation and the existing fence is performed. The importance of maintaining and respecting access restrictions to prevent inadvertent exposures is presented in an ongoing public education program. Preventing burrowing animals from using the cover as habitat reduces damage to the cover, thereby reducing infiltration pathways and maintenance activities. An average long-term leachate volume of 13,300 gallons/year is pumped from the wastepile. The leachate is drummed and shipped off post for incineration. Long-term maintenance is required to maintain the integrity of the existing liner and the cap. Five-year site reviews and annual groundwater compliance monitoring are conducted to review the effectiveness of the alternative, assess the integrity of the wastepile cover, and assess the potential migration of contaminants.

The following discussion presents a detailed evaluation of this alternative against the DAA criteria listed in the NCP (EPA 1990a). For purposes of comparison, Table 11.2-1 summarizes the evaluation for all alternatives developed for this subgroup.

11.2.2.1 Overall Protection of Human Health and the Environment

This alternative achieves RAOs through the existing containment systems. Exposure pathways are interrupted through access restrictions and the existing cap. The biota controls decrease the maintenance activities required for the cover. The short-term impacts are minimal since intrusive activities are not conducted.

11.2.2.2 Compliance with ARARs

This alternative does not achieve action-specific ARARs for wastepile closure because the cover does not provide the infiltration control, erosion controls, or lower maintenance requirements of a Subtitle C landfill cap. It does achieve action-specific ARARs regarding the liner, leachate control system, and maintenance and monitoring activities. This alternative complies with location-specific ARARs as the wastepile is not located in wetlands or a 100-year flood plain. The alternative complies with the provisions of the FFA (EPA et al. 1989). (ARARs are listed in Appendix A of the Technology Descriptions Volume.)

11.2.2.3 Long-Term Effectiveness and Permanence

The residual risk for this alternative is low. High levels of OCPs, VOCs, and CLC2A above the Human Health SEC (EBASCO 1994a) or principal threat criteria remain, but exposure pathways are interrupted through access restrictions and the existing cap. Site reviews, long-term cover and leachate control system maintenance, and groundwater monitoring are conducted. Biota controls of fencing and cultivation of habitat that is unappealing to biota serve to eliminate habitat beyond the existing fencing.

11.2.2.4 Reduction in TMV

There is no reduction in TMV resulting from this alternative and residuals are not generated since no materials are treated. Approximately 580,000 BCY of untreated soil remain, but are contained within the existing cap. Human and biota exposure are interrupted by engineering controls for the wastepile, land-use restrictions, fencing, and biota controls.

11.2.2.5 Short-Term Effectiveness

This alternative entails minimal short-term risk to workers and the community because activities are nonintrusive. Personal protective equipment adequately protects workers during revegetation. Dust and vapor emissions are not anticipated. There is minimal impact to the existing disturbed habitat. Long-term assurance that RAOs are met can be achieved in 3 years, including 1 year for fence installation and 3 years for revegetation.

11.2.2.6 Implementability

The alternative is technically and administratively feasible as the alternative can be completed within the required time frame and reliably maintained thereafter. Services are available to initiate the access restrictions, sample groundwater, continue cover and leachate collection system maintenance, and treat leachate.

11.2.2.7 Cost

The total present worth cost for the alternative is $3,150,000 including $3,000, $43,000, and $3,100,000 for capital, operating, and long-term costs, respectively. Table B4.2-2 details the costing for this alternative. This alternative exhibits moderate cost uncertainties relative to long-term maintenance activities and leachate treatment (due to the high cost of leachate treatment).

11.2.3 Alternative 3: Landfill

Alternative 3: Landfill (On-Post Landfill) addresses 600,000 BCY of contaminated soil by containment in a landfill and application of indirect heat to soil/sludge that requires drying prior to landfilling. The excavation of the wastepile for treatment involves the removal of the existing cover (75,000 BCY) as overburden material. For the purpose of conceptual design and cost estimation, it has been assumed that volatile emissions and noxious odors are controlled during excavation by enclosing the wastepile with rigid-frame, negative-pressure vapor enclosures (however, the use of odor-suppressing foams will be evaluated during the remedial design). Vapor control systems are included with these enclosures to prevent impacts on the community. The containment structures utilized during the excavation are fabricated from aluminum structural members covered with a coated synthetic fabric. On a level surface, the structures can be erected without foundations, although large precast concrete blocks are used for ballast.

Air pollution control systems draw air from the structures for treatment with a wet scrubber, reducing the level of personal protective equipment required for safe working conditions within the structures. Because the air pollution control system creates negative pressure within the structures, entry and exit doors can be opened for short periods of time without releasing contaminants or odors, thus eliminating the need for airlocks. The structures are fabricated from a synthetic fabric coated to achieve very low air permeability, and are designed to withstand wind velocities of 80 miles per hour (mph) and a snow load of 4 ft. The alkaline aqueous solution from the wet scrubber system is neutralized and subsequently treated at the CERCLA Wastewater Treatment Plant, the Basin A Neck IRA or at a new groundwater treatment plant.

In order to control vapors/odors during excavation, two negative-pressure structures are used. One structure houses excavation activities as the other structure is torn down, moved, or re-erected. The uppermost 10 ft of the wastepile are removed as one layer by relocating the structures as necessary. The remainder of the wastepile is removed in three additional 10-ft-thick layers. The length of each structure is 640 ft (to cover the entire length of the wastepile) and is increased by adding additional sections for the second and third excavation layers to account for increased length due to the side slopes of the wastepile. A temporary 60-mil HDPE liner and 1-ft-thick compacted soil cover is placed over the excavated area prior to moving each structure. This temporary soil cover will minimize the release of vapors/odors until one of the structures is relocated over the area. Following excavation, the soil cover is stockpiled for reuse, and the temporary HDPE liner is removed, washed, shredded, and placed in the on-post landfill.

After excavation, unsaturated wastepile materials are transported and disposed in a specifically designed, triple-lined cell in the on-post hazardous waste landfill. Construction of the landfill and support facilities requires 1 year. The landfill has a capacity for multiple cells as discussed in Section 4.6.6. The landfill cover is revegetated after installation and fencing is installed to exclude biota and prevent damage to the system. Since a total of 600,000 BCY of untreated soil are contained in the landfill, the landfill cover requires long-term monitoring and maintenance. Long-term maintenance activities include collecting and treating leachate and monitoring potential leachate migration from the landfill.

Any materials encountered during the excavation of the wastepile that fail EPA's paint filter test will be dried so that they pass this test prior to disposal. The soil drying/materials handling system requires approximately one year for mobilization, construction, and setup. For the purpose of cost estimation, it is assumed that the moisture content of any saturated materials is approximately 25 percent by weight and must be reduced to 10 percent during drying. However, the initial moisture content may be significantly higher than 25 percent, and the final moisture content that meets the specified performance criteria (i.e., the paint filler test) may be significantly higher than 10 percent. Due to the high moisture content, the soil drying/materials handling system has an approximate processing rate of 20 to 40 tons/hour. The system operates at a temperature of approximately 200°F. Section 4.6.24 discusses emission controls for off gases from soil drying. A portion of the VOCs that are present in the saturated materials will be desorbed from the soil collected and treated as discussed in Section 7.1 of the Technology Descriptions Volume. An estimated 100,000-150,000 BCY may require drying prior to disposal.

The excavation is backfilled with 76,000 BCY of soil from the on-post borrow area, and 93,000 BCY of soil from the stockpiled cover and the ramp constructed for access to the wastepile during excavation. Revegetation of the disturbed areas with native grasses results in an increase in the habitat quality compared to the existing conditions. The borrow area is recontoured and revegetated to improve habitat quality.

The following discussion presents a detailed evaluation of this alternative against the DAA criteria listed in the NCP (EPA 1990a). For purposes of comparison, Table 11.2-1 summarizes the evaluation of all alternatives developed for this subgroup.

11.2.3.1 Overall Protection of Human Health and the Environment

This alternative achieves RAOs through containment of contaminated soil in an on-post landfill. The potential for migration of contaminants to groundwater is minimized. The excavation of contaminated soil entails significant short-term risks based on the odor/vapor generation and high levels of contamination.

11.2.3.2 Compliance with ARARs

The alternative complies with action-specific ARARs including state regulations on air emissions sources from drying and landfill siting, design, and operations. The alternative complies with the location-specific ARARs as the wastepile, materials handling/drying facility, and landfill are not located in wetlands or a 100-year flood plain. Disposal in the landfill does not trigger LDRs since the landfill is a CAMU (as defined in Section 1.4). The alternative also complies with the provisions of the FFA (EPA et al. 1989). (ARARs are listed in Appendix A of the Technology Descriptions Volume.)

11.2.3.3 Long-Term Effectiveness and Permanence

The residual risks are minimal since all 600,000 BCY of soil are removed and landfilled. There is high confidence in the engineering controls associated with the enhanced triple-lined cell. Revegetation of disturbed areas improves the existing habitat, offsetting losses incurred during excavation; however, habitat is restricted at the landfill.

Containment of the 600,000 BCY within the landfill will interrupt exposure pathways and reduce the mobility of contaminants. The drying of saturated materials will reduce the TMV somewhat and allow the materials to be landfilled.

11.2.3.4 Short-Term Effectiveness

This alternative entails high short-term risks associated with excavation, transportation, soil drying, and materials handling of highly contaminated soil, some of which has the potential for generating contaminated vapors or odors. These risks are reduced through the use of vapor enclosures and personal protective equipment, but they cannot be completely eliminated. Vapor enclosures are installed to collect and treat vapors and odors from the excavation; however, field demonstrations of vapor enclosures have not indicated that adequate controls can consistently be achieved. The short-term risks to workers inside the vapor enclosures are increased due to the confined working area and the dependence on the performance of the air treatment system. The possibility exists for vapor or odor emissions during excavation despite these controls. In addition, the preparation of the feedstock prior to soil drying presents short-term risks, although the materials handling is conducted in an enclosed building to control dust and vapors/odors. Although the off-gas control system for the soil dryer is designed to achieve air quality standards, the emissions may contain low but acceptable levels of some volatile organic contaminants. The impacts are minimal to the existing poor-quality habitat during excavation and treatment, and overall habitat quality is improved. The time frame to achieve RAOs is 3 years. Excavation and treatment of 600,000 BCY of soil is feasible within 2 years after the 1 year required for construction of the materials handling/drying facility and landfill.

11.2.3.5 Implementability

Soil drying and material handling equipment is widely available; however, the technology has not been demonstrated at the scale required for RMA. The soil drying/material handling facility can be constructed within the required time frame, but the operation of the unit may be difficult due to the high levels of contamination, high moisture content, problems with materials handling, and the elevated levels of salts in the soil feed. Administrative difficulties associated with demonstrating compliance with emission requirements and performing O&M may lead to delays.

Vapor enclosures have not been demonstrated at full scale for hazardous waste operations similar to RMA, although construction of vapor enclosures is well documented. Excavation within vapor enclosures requires the installation of a temporary HDPE and double handling of existing cover soil when the enclosure must be moved and re-erected on top of the wastepile. The operation of the vapor enclosures for the Basin F wastepile entails moving the multiple enclosures a total of 53 times to completely cover the site.

11.2.3.6 Cost

The total cost for this alternative is \$43,200,000 including \$13,700,000, \$29,300,000, and \$178,000 for capital, operating, and long-term costs, respectively. Table B4.2-13b details the costing for this alternative.

The excavation of the wastepile entails a large cost uncertainty due to the lack of operating experience with which to evaluate the potential problems associated with excavation productivity inside a vapor enclosure, relocation of the structure, and operation of the air treatment system for the enclosure. The estimated direct costs to construct and operate the vapor enclosures are \$16,300,000. The costs for operating the soil dryer unit also entail a high level of uncertainty relative to maintaining the assumed on-line percentage because of the anticipated high maintenance requirements caused by the high moisture content, problems with materials handling, and presence of elevated salt concentrations in the soil feed. Possible delays in implementation and variations in contaminant levels in the soil feed may also increase soil drying costs.

11.2.4 <u>Alternative 6d: Caps/Covers</u>

Alternative 6d: Caps/Covers (Composite Cap) addresses the Basin F Wastepile Subgroup through the installation of a 75,000-SY composite cap to augment the existing cover. Section 6.4 of the Technology Descriptions Volume discusses composite caps in detail. The uppermost 1 ft of the existing soil cover is removed and incorporated into the composite cap as illustrated in Figure 11.2-1. The composite cap consists of (from the bottom up) a geogrid, 12-inch soil cover layer, a geosynthetic clay liner, a 60-mil geomembrane liner, a 1-ft-thick sand drainage layer, an additional geosynthetic filter layer (12-ounce geotextile), a 1-ft-thick biota barrier of crushed cobbles, and a 2-ft-thick soil/vegetation layer augmented with 6 inches of reconditioned soil. The 6 inches of reconditioned soil is revegetated. The fill materials are excavated from borrow areas located on post, and cobbles and sand are obtained off post. The borrow area is regraded and revegetated to restore habitat.

Once the composite cap is installed, an average long-term leachate volume of 13,300 gallons/year is pumped from the leachate collection system (the volume is expected to continually decrease as the wastepile dewaters). The leachate is shipped off post for incineration. The composite cap provides a physical barrier to protect human and biota receptors from directly contacting contaminated soil and sludge. The cap also reduces the potential for migration of contaminants from the wastepile to groundwater by reducing infiltration into the wastepile. The composite cap also provides high-quality vegetation, which reduces maintenance activities associated with erosion repair. Maintenance activities such as mowing and replacement of eroded soil ensure the continued integrity of the composite cap containment system. Five-year site reviews and annual groundwater compliance monitoring are conducted to review the effectiveness of the alternative, and monitor the potential migration of contaminants.

The following discussion presents a detailed evaluation of this alternative against the DAA criteria listed in the NCP (EPA 1990a). For purposes of comparison, Table 11.2-1 summarizes the evaluation of all alternatives developed for this subgroup.

11.2.4.1 Overall Protection of Human Health and the Environment

This alternative achieves RAOs. Human exposure pathways are interrupted by containment of the wastepile and augmentation of the existing cap by a composite cap. Potential groundwater impacts and leachate generation are reduced through the installation of an improved cap and continued operation of the leachate collection system. The short-term impacts are minimal since intrusive activities are not conducted.

11.2.4.2 Compliance with ARARs

This alternative complies with action-specific ARARs regarding construction of a Subtitle C cap and monitoring of contained material. Location-specific ARARs are met as the wastepile is not located in wetlands or a 100-year flood plain. Endangered species are not impacted. In addition, the alternative complies with the provisions of the FFA (EPA et al. 1989). (ARARs are listed in Appendix A of the Technology Descriptions Volume.)

11.2.4.3 Long-Term Effectiveness and Permanence

The risk associated with this alternative is minimal. The 580,000 BCY of untreated soil are contained with a 75,000-SY composite cap. Long-term monitoring, cap and leachate collection system maintenance, and site reviews are conducted. An additional cap provides greater long term certainty of reliable performance. Leachate treatment is required. The existing habitat is improved through revegetation; however, biota exclusions are maintained by the alternative.

11.2.4.4 Reduction in TMV

The enhancement of the existing cap through the installation of a 75,000-SY composite cap interrupts exposure pathways and reduces the mobility of contaminants. The reduction in mobility is only reversible should the cap degrade or leak. Off-post treatment of the leachate is required.

11.2.4.5 Short-Term Effectiveness

The alternative entails minimal short-term risks to workers and the community during the remedial action since no intrusive activities are conducted. Personal protective equipment adequately protects workers during installation of the composite cap. Uncontaminated fugitive dust associated with cap construction is controlled by water sprays, and vapor emissions are not anticipated. There is a minimal impact to biota due to the existing disturbed habitat and biota exclusions are maintained. The potential migration of contaminants to groundwater is reduced. Modification of the existing cap is feasible within 1 year.

11.2.4.6 Implementability

The alternative is technically feasible and can be implemented within the required time frame and reliably maintained thereafter. Additional remedial actions are easily undertaken for soil left in place, although the cap adds to the overall site volume. The alternative is administratively feasible as the substantive requirements of cap/cover design and construction are met. Materials, specialists, and equipment are readily available for composite cap construction. Composite caps are well demonstrated at full scale. Services are available to sample groundwater, continue leachate collection system maintenance, and treat leachate.

11.2.4.7 Cost

The total present worth cost for the alternative is $8,050,000, including $4,680,000 and $4,010,000 for operating and long-term costs, respectively. Table B4.2-6d details the costing for this alternative. There is a low level of uncertainty associated with the operating cost of this alternative since the materials required to construct the cap are available on post and the area to be capped is well defined (i.e., the uncertainty associated with excavation does not exist). This alternative exhibits moderate cost uncertainties relative to long-term maintenance activities and leachate treatment (due to the high cost of leachate treatment).

11.2.5 Alternative 8a: Direct Soil Washing

Alternative 8a: Direct Soil Washing (Solvent Washing) treats 600,000 BCY of contaminated soil and subgrade material through the solvent washing process, which has been reintroduced into the DAA as described in Section 11.2. The excavation of the wastepile for treatment involves the removal of the existing cover (75,000 BCY) as overburden material. Volatile emissions and noxious odors are controlled during excavation by enclosing excavation areas with a rigid-frame negative-pressure vapor enclosure. Vapor control systems are included with these enclosures to prevent impacts on the community. The containment structures utilized during the excavation are fabricated from aluminum structural members covered with a coated synthetic fabric. On a level surface, the structures can be erected without foundations, although large precast concrete blocks are used for ballast.

Air pollution control systems draw air from the structures for treatment with a wet scrubber, reducing the level of personal protective equipment required for safe working conditions within the structures. Because the air pollution control system creates negative pressure within the structures, entry and exit doors can be opened for short periods of time without releasing contaminants or odors, thus eliminating the need for airlocks. The structures are fabricated from a synthetic fabric coated to achieve very low air permeability, and are designed to withstand wind velocities of 80 mph and a snow load of 4 ft. The alkaline aqueous solution from the wet scrubber system is neutralized and subsequently treated at the CERCLA Wastewater Treatment Plant, the Basin A Neck IRA or at a new groundwater treatment plant.

In order to control vapors/odors during excavation, two negative-pressure structures are used. One structure houses excavation activities as the other structure is torn down, moved, and re-erected. The 90-ft-wide structures are commercially available and are placed on top of the wastepile. An 11-ft-deep excavation is contained within each structure. The uppermost 10 ft of the wastepile are removed as one layer by relocating the structures as necessary. The remainder of the wastepile is removed in three additional 10-ft-thick layers. The length of each of the four structures is 640 ft (to cover the entire length of the wastepile) and is increased by adding additional sections for the second and third layers to account for the side slopes of the wastepile. A temporary 60-mil HDPE liner and 1-ft-thick compacted soil cover is placed over the excavated area prior to moving each structure. This temporary soil minimizes the release of vapors/odors until one of the structures is relocated over the area. Following excavation, the soil cover is stockpiled for reuse, and temporary HDPE liner is removed, washed, shredded, and placed in the on-post landfill.

Since all of the soil and sludge in the wastepile contains high levels of salts, all 600,000 BCY of materials are treated by solvent washing as part of this alternative. Based on pilot-scale studies at RMA (HLA 1994a), nine wash cycles are required to achieve Human Health PRGs. The solvent is recycled between wash cycles and treated through distillation (Section 4.6.20). A total of 360,000 gallons of liquid effluent is generated and treated at an off-post commercial facility as part of solvent washing. A total of 30 solvent washing units is required to maintain a throughput of approximately 1,200 BCY/day.

The treated soil is landfilled and the overburden replaced. In addition, the excavation is backfilled with stockpiled materials from the excavation of the wastepile and 93,000 BCY of soil from the on-post borrow area. The disturbed area is then revegetated with native grasses.

The following discussion presents a detailed evaluation of this alternative against the DAA criteria listed in the NCP (EPA 1990a). For purposes of comparison, Table 11.2-1 summarizes the evaluation of all alternatives developed for this subgroup.

11.2.5.1 Overall Protection of Human Health and the Environment

This alternative achieves RAOs through treatment and landfilling of 600,000 BCY of soil by solvent washing. The soil is treated to remove organic contaminants through solvent washing. Groundwater impacts are also prevented. The excavation of contaminated soil entails significant short-term risks based on the generation of odors/vapors and high levels of contamination.

11.2.5.2 Compliance with ARARs

This alternative complies with the action-specific ARARs regarding air emission sources, and landfill siting, design, and operation. Endangered species are not impacted. Location-specific ARARs are met as the wastepile, treatment facilities, and landfill are not located in wetlands or a 100-year flood plain. Disposal in the landfill does not trigger LDRs since the landfill is a CAMU (as defined in Section 1.4). In addition to the ARARs, this alternative complies with the provisions of the FFA (EPA et al. 1989). (ARARs are listed in Appendix A of the Technology Descriptions Volume.)

11.2.5.3 Long-Term Effectiveness and Permanence

The residual risk for the 600,000 BCY of treated soil is minimal since solvent washing achieves PRGs and the soil is landfilled. An estimated 360,000 gallons of liquid effluent from solvent washing is drummed and transported off-post for treatment. Habitat quality is improved by revegetation of disturbed areas, offsetting any habitat lost during excavation. There is high confidence in the engineering controls of the landfill, and no difficulties are associated with landfill maintenance.

11.2.5.4 Reduction in TMV

Solvent washing irreversibly removes organic contaminants from the soil (>99.5 percent DRE). The liquid effluent from solvent washing (360,000 gallons) requires off-post disposal. The treated soil is contained in the on-post landfill. The containment is only reversible should the landfill degrade or leak.

11.2.5.5 Short-Term Effectiveness

This alternative entails high short-term risks associated with excavation, transport, and treatment of highly contaminated soil, some of which has the potential for generating contaminated vapors or odors. These risks are reduced through the use of vapor enclosures and personal protective equipment, but they cannot be completely eliminated. The vapor enclosures collect and treat vapors and odors from the excavation; however, the adequacy of the air treatment system has not been fully demonstrated and field demonstrations of vapor enclosures have not indicated that adequate controls can consistently be achieved. The short-term risks to workers inside the vapor enclosures are increased due to the confined working area and are dependent on the performance of the air treatment system. The possibility exists for vapor/odor emissions during excavation despite these controls. There is minimal impact to the existing habitat. Potential migration of contaminants to groundwater is reduced. Excavation and treatment of 600,000 BCY of soil is feasible within 5 years based on 2 years for constructing a 30-unit soil washing facility and 3 years of operation.

11.2.5.6 Implementability

In order to control vapors/odors during excavation, 2 negative-pressure structures are utilized. One structure houses excavation activities as the other structure is torn down, moved, or re-erected. Vapor enclosures have not been demonstrated at full scale for hazardous waste operations similar to RMA, although construction of vapor enclosures is well documented. Excavation within vapor enclosures requires the installation of a HDPE cover and double handling of the existing cover when the enclosure must be moved and re-erected on top of the Basin F Wastepile during operations. The operation of vapor enclosures for the Basin F Wastepile entails moving the enclosures a total of 53 times to completely cover the site. The construction of a landfill is technically and administratively feasible. Equipment, specialists, and materials are readily available for landfill construction, although landfill monitoring is required.

This alternative is very difficult to implement due to the large number of treatment units (30) required to treat the volume of Basin F Wastepile soil, since solvent washing requires nine extraction steps to achieve PRGs (based on pilot-scale studies at RMA), within the required time frame. Although commercial solvent washing units are available, the technology has not yet been demonstrated at the scale required for RMA. Accordingly, implementation may be difficult and may result in delays.

11.2.5.7 Cost

The total cost for this alternative is $242,000,000 including $66,300,000, $175,000,000, and $368,000 for capital, operating, and long-term costs, respectively. Table B4.2-8a details the costing for this alternative.

There are two significant uncertainties associated with the costing of this alternative. First, there are no other full-scale demonstrations at other hazardous waste sites with which to evaluate problems associated with excavation productivity inside a vapor enclosure, relocation of the structure, and operation of the air treatment system for the enclosure. The estimated direct costs to construct and operate the vapor enclosures are $16,300,000. Second, the lack of full-scale implementation data increases uncertainties relative to maintaining the assumed on-line percentage of the solvent washing units. The variability and high concentrations of contamination in the Basin F Wastepile may result in changes in treatment times or delays in implementation, both of which may impact treatment costs.

11.2.6 Alternative 13b: Direct Thermal Desorption; Landfill

Alternative 13b: Direct Thermal Desorption (Direct Heating); Landfill (On-Post Landfill) treats 600,000 BCY of contaminated soil by direct thermal desorption and containment in a landfill. The excavation of the wastepile for treatment involves the removal of the existing cover (75,000 BCY) as overburden material. Volatile emissions and noxious odors are controlled during excavation by enclosing the wastepile with rigid-frame, negative-pressure vapor enclosures with vapor collection and treatment systems (described in Section 11.2.5). The wastepile is excavated in 4 layers (each 10 ft thick) using 2 negative-pressure vapor enclosures. A temporary 60-mil HDPE liner and one-foot-thick soil cover are placed over the excavated area prior to relocating the enclosures. Following excavation, the liner system components are removed, shredded, washed, and placed in the on-post landfill.

The 600,000 BCY of excavated soil are treated by thermal desorption since the soil contains high levels of OCPs, VOCs, and CLC2A. The thermal desorption facility requires approximately 1 year to build, and the testing of the thermal desorber requires an additional year. The moisture content of soil is assumed to be 20 percent. Due to this high moisture content, the thermal desorber has a soil processing rate of approximately 1,300 BCY/day. The thermal desorber has an operating temperature of 300°C and a solids residence time of 50 minutes. Section 4.6.24 discusses emission controls for off-gases from thermal desorption. Approximately 6,000 BCY (or 1 percent of the total soil feed) are recovered as particulates from the scrubber blowdown and are placed in the on-post hazardous waste landfill. The treated soil is contained in the on-post landfill.

The excavation is backfilled with the stockpiled cover from the wastepile, soil used for the access ramp, and 93,000 BCY of soil from the on-post borrow area. Revegetation of the disturbed areas with native grasses results in an increase in the habitat quality compared to the existing conditions. The borrow area is recontoured and revegetated to improve habitat quality.

The following discussion presents a detailed evaluation of this alternative against the DAA criteria listed in the NCP (EPA 1990a). For purposes of comparison, Table 11.2-1 summarizes the evaluation of all alternatives developed for this subgroup.

11.2.6.1 Overall Protection of Human Health and the Environment

This alternative achieves RAOs through treatment of the contaminated soil and containment of treated soil in an on-post landfill. The soil is treated through thermal desorption. The potential for migration of contaminants to groundwater is eliminated. The excavation of contaminated soil entails significant short-term risks based on the generation of odors/vapors and high levels of contamination.

11.2.6.2 Compliance with ARARs

The alternative complies with action-specific ARARs including state regulations on air emissions sources and landfill siting, design, and operations. The alternative complies with the location-specific ARARs as the wastepile, thermal desorption facility, and landfill are not located in wetlands or a 100-year flood plain. Disposal in the landfill does not trigger LDRs since the landfill is a CAMU (as defined in Section 1.4). The alternative also complies with the provisions of the FFA (EPA et al. 1989). (ARARs are listed in Appendix A of the Technology Descriptions Volume.)

11.2.6.3 Long-Term Effectiveness and Permanence

The residual risks are minimal since all 600,000 BCY of soil are removed, treated, and landfilled. Approximately 1 percent of the soil feed is recovered from the off-gas treatment equipment and is contained in the on-post landfill. There is high confidence in the engineering controls associated with the landfill. Revegetation of disturbed areas improves the existing habitat, offsetting losses incurred during excavation; however, habitat is restricted at the landfill.

11.2.6.4 Reduction in TMV

Thermal desorption degrades or destroys organic compounds in the soil to below detection levels or >99.99 percent DRE, and the TMV is eliminated. The TMV reduction in 600,000 BCY of soil is irreversible. Scrubber blowdown solids from off-gas treatment equipment (6,000 BCY) are contained in the on-post landfill along with the treated soil. The containment is only reversible should the landfill degrade or leak.

11.2.6.5 Short-Term Effectiveness

This alternative entails high short-term risks associated with excavation, transportation, and thermal desorption of highly contaminated soil, some of which has the potential for generating contaminated vapors or odors. These risks are reduced through the use of vapor enclosures and personal protective equipment, but they cannot be completely eliminated. Vapor enclosures are installed to collect and treat vapors and odors from the excavation; however, field demonstrations of vapor enclosures have not indicated that adequate controls can consistently be achieved. The short-term risks to workers inside the vapor enclosures are increased due to the confined working area and the dependence on the performance of the air treatment system. The possibility exists for vapor or odor emissions during excavation despite these controls. In addition, the preparation of the feedstock prior to thermal desorption presents short-term risks, although the materials handling is conducted in an enclosed building to control dust and vapors/odors. Although the off-gas control system for the thermal desorber is designed to achieve air quality standards, the emissions from the thermal desorber contain low but acceptable levels of some contaminants. The impacts are minimal to the existing habitat during excavation and treatment. The time frame to achieve RAOs is 5 years. Excavation and treatment of 600,000 BCY of soil is feasible within 3 years after the 2 years required for construction of the thermal desorption facility and landfill.

11.2.6.6 Implementability

Thermal desorption is widely available and has been used to treat similar contaminants; however, the technology has not been demonstrated at the scale required for RMA. The thermal desorption facility can be constructed within the required time frame, but the operation of the unit may be difficult due to the high levels of contamination, high moisture content, problems with materials handling, and the elevated levels of salts in the soil feed. Administrative difficulties associated with demonstrating compliance with permits and performing O&M may lead to delays, and it may be difficult to implement this alternative due to the perceptions regarding the safety of thermal treatment.

Vapor enclosures have not been demonstrated at full scale for hazardous waste operations similar to RMA, although construction of vapor enclosures is well documented. Excavation within vapor enclosures requires the installation of a temporary HDPE liner and double handling of existing cover soil when the enclosure must be moved and re-erected on top of the wastepile. The operation of the vapor enclosures for the Basin F Wastepile entails moving the multiple enclosures a total of 53 times to completely cover the site.

11.2.6.7 Cost

The total cost for this alternative is $172,000,000 including $46,800,000, $125,000,000, and $344,000 for capital, operating, and long-term costs, respectively. Table B4.2-13b details the costing for this alternative.

There are two significant uncertainties associated with the costing of this alternative. First, there are no other full-scale demonstrations at other hazardous waste sites with which to evaluate problems associated with excavation productivity inside a vapor enclosure, relocation of the structure, and operation of the air treatment system for the enclosure can be evaluated. The estimated direct costs to construct and operate the vapor enclosures are $16,300,000. Second, the elevated concentrations of the contaminants and salts in the feedstock, the high moisture content of the soil, and the need for materials handling increase uncertainties relative to maintaining the assumed on-line percentage of the thermal desorption unit. These operating conditions are not typical of previous thermal desorption projects, and may result in changes in maintenance requirements or delays in implementation, both of which may impact treatment costs.

11.3 COMPARATIVE ANALYSIS OF ALTERNATIVES

The Basin F Wastepile Subgroup consists of 580,000 BCY of contaminated sludge and soil removed from Basin F and placed from a wastepile during the Basin F IRA and an additional 20,000 BCY of contaminated materials from the liner system and subgrade. As discussed in Section 11.1, the wastepile is contained by a composite cover, and a liner consisting of a leachate collection layer and a leachate detection layer (or secondary liner). The wastepile consists of three individual cells, each of which contains a leachate sump for the primary and secondary leachate collection layers. A chain-link fence surrounds the wastepile to further limit exposure pathways beyond the physical barrier provided by the composite cap.

The materials in the wastepile primarily contain OCPs, although VOCs and CLC2A are also present. In addition, the materials in the wastepile contain ammonia and percent levels of salts. These constituents are not COCs, but their presence impacts the performance of several technologies and the evaluation of remedial alternatives. Some samples of materials placed in the wastepile were collected for chemical analysis during the Basin F IRA, and samples of the sludge material and underlying soil were analyzed before the IRA was initiated. These samples indicate that the materials within the wastepile contain high levels of contamination (approximately 10,000 ppm total OCPs), although specific contaminant distributions are not available. The entire volume of the Basin F Wastepile is considered to exceed the principal threat criteria since the pre-IRA samples exceeded the principal threats criteria for several of the OCPs.

The presence of high levels of OCP contamination, volatiles, and ammonia indicates that extensive controls are required for the protection of site workers for remedial actions that involve excavation of the wastepile. Extensive monitoring is required to evaluate potential community exposure, and odor-control management is required to mitigate community concerns. Site workers involved in excavation require Level B protection, which includes supplied air, and the excavation is conducted within vapor enclosures (which is discussed in Section 11.2.5) to control the release of vapors and odors from the excavation. These controls reduce the productivity of excavation operations and substantially increase their cost and difficulty.

The wastepile was constructed within the areal extent of Basin F, which was devegetated and did not provide any useable habitat. Fencing associated with the wastepile limits the use of the site for habitat. Thus, disturbance of the vegetation associated with any additional remedial actions conducted for the wastepile would not reduce available habitat.

In summary, the excavation alternatives provide increased confidence in the long-term secure disposal of Basin F waste, which represents the largest proportion of principal threat volume for all soil medium groups. The selection of an excavation alternative, over maintaining the wastepile in place, would entail higher short-term risks associated with Level B work and strict vapor controls. This would be balanced by significant reduction in long-term risks associated with potential contaminant migration. The excavation alternatives must be viewed in terms of time needed to complete the alternative and implementability. Excavation and landfill (3 years) can be achieved in a shorter length of time than the treatment-based alternatives (5 years).

Alternative 1: No Additional Action and Alternative 2: Access Restrictions are protective of human health as the existing containment system interrupts exposure pathways. However, the existing cover does not meet performance standards in Subtitle C regulations regarding final covers for in-place closure. These alternatives were therefore eliminated from further consideration. The four remaining alternatives include two containment alternatives and two treatment alternatives. All alternatives achieve RAOs, are protective of human health and the environment over the long term, and comply with action-specific and location-specific ARARs, thereby satisfying the threshold criteria. The alternatives are distinguished by the five balancing criteria (Table 11.2-1).

Alternative 6d: Caps/Covers provides low long-term residual risks without incurring the high short-term risks related to excavation. This alternative improves the existing cap and achieves RCRA landfill cover requirements. This technology has been well demonstrated and entails low short-term risks since the wastepile is not excavated, but there is long term uncertainty for the performance reliability. There are no treatment residuals associated with this alternative. The cost of $8,050,000 indicates that this alternative is also cost effective. This alternative was carried forward for development of the sitewide alternatives (See Section 20).

Alternative 3: Landfill exhibits short-term risks posed during excavation and drying any saturated materials but this alternative reduces long-term uncertainties associated with improvement to the present wastepile. Also, there is high confidence in the engineering controls of the triple-lined landfill cell for these highly contaminated materials. Although it entails a higher cost ($43,200,000) than improvements to the present containment system, this alternative was retained for further evaluation based on the improved long-term protection offered by landfilling the wastepile.

Alternative 8a: Direct Soil Washing; Landfill achieves PRGs through treatment; however, this alternative has several disadvantages. The implementation of this alternative requires a large number of extraction units which makes operation and materials handling very difficult. Treatment residuals include 360,000 gallons of liquid, which will require off-post treatment and disposal. The alternative also entails significant short-term risks during excavation and handling of the wastepile. The cost of $242,000,000 is also a negative factor when considering the cost effectiveness of this option. For these reasons, this alternative was not retained for further consideration.

Alternative 13b: Direct Thermal Desorption; Landfill achieves PRGs through treatment. This alternative exhibits significant risks posed during excavation and handling of the wastepile. Thermal desorption entails a higher cost ($172,000,000) than containment alternatives. Although this alternative entails a high cost and high short-term impacts, thermal desorption of the wastepile was retained for further evaluation to serve as an alternative to landfilling and in-place containment as part of the development of sitewide alternatives.

Consequently, the alternatives that were retained to represent the Basin F Wastepile Subgroup in the development of the sitewide alternatives (Section 20) are the following:

- Alternative 3: Landfill (On-Post Landfill)
- Alternative 6d: Caps/Covers (Multilayer Cap)
- Alternative 13b: Direct Thermal Desorption (Direct Heating); Landfill (On-Post Landfill)

11.4 FORMER BASIN F SUBGROUP CHARACTERISTICS

The Former Basin F Subgroup is composed of site NCSA-3 (former Basin F) (Figure 11.0-1). In 1988–89, the Basin F IRA was conducted to remove Basin F liquid and sludge, the asphalt liner of the basin, and highly contaminated soil from beneath the liner. As discussed in Section 11.0, the soil and sludge were placed in the Basin F Wastepile during the IRA. The existing site contains contaminated soil that was not removed in the IRA. A 2- to 5-ft-thick soil cover (average thickness of 3 ft) and up to 10 ft of gradefill was placed over the former Basin F following the construction of the wastepile. The soil cover was revegetated at the conclusion of the IRA.

The Former Basin F Subgroup contains soil contaminated by wastewater that infiltrated during Basin F operations. Table 11.4-1 provides a summary of contaminants, exceedance volume concentrations, and exceedance values, and Table 11.4-2 summarizes the frequency of detections for samples taken in the subgroup. The Human Health SEC (EBASCO 1994a) are exceeded by average and maximum concentrations of OCPs and CLC2A in 520,000 BCY of human health exceedance volume. The total soil volume required to excavate all of the 520,000 BCY of exceedances (which occurs at various depths) is 740,000 BCY. The concentrations of aldrin and dieldrin (maximums of 2,900 ppm, and 1,100 ppm, respectively) also exceed the principal threat criteria (10^{-3} excess cancer risk, HI of 1,000) in approximately 180,000 BCY, although less than 5 percent of the samples for these OCPs exceed the principal threat criteria. To excavate all of the 180,000 BCY of principal threat volume, which occurs at various depths, 250,000 BCY of soil from the former basin require excavation.

These Human Health COCs were found from 0 to 10 ft below ground surface, but were primarily detected in the 0- to 5-ft depth interval; however, residual contamination exists from below 10 ft to the water table (approximately 40 ft). Since biota risks are evaluated only for the 0- to 1-ft depth interval, and the former Basin F is contained by a cap, alternatives specifically addressing biota are not developed. Figure 11.4-1 shows the distribution of the exceedance areas, including principal threat areas, for this subgroup, and Table 11.0-1 lists the exceedance volumes and areas.

The former Basin F site has been identified as a source of groundwater contamination. Although the Basin F IRA removed the majority of the source for groundwater contamination, high concentrations of COCs are still present above the water table at the site. As discussed in Section 11.0, the Basins C and F Plume occurs in the unconfined aquifer and extends from the vicinity of Basins C and F in Section 26 to the northeast toward the North Boundary Containment System (NBCS). Contaminated groundwater north of the former Basin F is intercepted by the Basin F Groundwater IRA extraction system and treated at the Basin A Neck IRA treatment system.

Groundwater alternatives are being evaluated that address improved performance for the existing groundwater treatment systems or the addition of new remediation systems. Coordination of alternatives developed for the soil medium with those developed for the water medium is limited to source containment or removal as it is unlikely, due to the high contaminant mass already present in the aquifer, that the remediation of the former Basin F would result in the shutdown of existing systems.

The Former Basin F Subgroup was revegetated with crested wheat grass under the IRA. Under most of the alternatives developed for this subgroup, the areas disturbed during remedial actions are revegetated with native grasses in accordance with a refuge management plan. In most instances, the overall habitat is improved, which should offset the short-term loss of habitat resulting from remedial actions. The institutional controls alternative includes provisions for modifying the habitat by seeding other grasses to reduce the desirability of the area for biota. In this instance, the habitat quality is lowered over an area of 350,000 SY.

11.5 FORMER BASIN F SUBGROUP EVALUATION OF ALTERNATIVES

The alternatives developed for the Former Basin F Subgroup include no action, containment, and treatment approaches. It should be noted that the preferred alternative for the Former Basin F site must be consistent with the state-approved RCRA closure; therefore, the alternative selected in the DAA may be modified when the RCRA closure plan is finalized and accepted by the state.

During the DAA, four modifications were made to alternatives retained for this subgroup. First, principal threat volumes were addressed by all treatment alternatives and the nomenclature changed to clearly indicate that solidification of organic compounds is not required following treatment of inorganic compounds (e.g., Alternative 13a versus Alternative 13). Second, the slurry-wall component of the containment alternative (Alternative 6c) was deleted because it was determined that this is not necessary for containment. Third, the alternative developed to address removal of FC2A and salts prior to thermal treatment (Alternative 9) was removed from consideration. FC2A is no longer considered a COC as previous detections have been discounted due to analytical interferences, and the soil-washing component of the alternative generates a large liquid effluent volume that requires treatment in accordance with RCRA regulations. Fourth, alternatives involving excavation or in situ treatment were modified to include the installation of a RCRA-equivalent cap to address residual contamination more than 10 ft below ground surface. The following subsections present a description of each alternative and an evaluation of the alternative against the EPA criteria for the DAA.

11.5.1 Alternative 1: No Additional Action

Alternative 1: No Additional Action (Provisions of FFA) applies to all 350,000 SY of exceedance area in the Former Basin F Subgroup. The 520,000 BCY of human health exceedance volume and residual contamination below 10 ft remain in place without implementation of additional controls. The existing cap interrupts exposure pathways, but no additional action is taken to reduce human exposure to COCs or to reduce potential groundwater contamination from this site. Long-term activities include maintenance of the existing cap and monitoring of untreated soil (an average of 42 samples per year). Five-year site reviews and annual groundwater compliance monitoring are conducted to assess the potential migration of contaminants.

The following discussion presents a detailed evaluation of this alternative against the DAA criteria listed in the NCP (EPA 1990a). For purposes of comparison, Table 11.5-1 summarizes the evaluation of all alternatives developed for this subgroup.

11.5.1.1 Overall Protection of Human Health and the Environment

This alternative achieves RAOs by interrupting exposure pathways and reducing migration of contaminants to groundwater. Untreated soil exceeding Human Health SEC (EBASCO 1994a) and principal threat criteria remains, but the potential for human exposure is reduced due to the existing cover. Natural attenuation/degradation is the only process by which long-term reduction in the toxicity of the contaminants can be achieved. Groundwater impacts are not reduced beyond the protection provided by the existing cap. The short-term impacts are minimal since intrusive activities are not conducted.

11.5.1.2 Compliance with ARARs

This alternative does not achieve action-specific ARARs regarding the existing cover because it does not achieve the performance required by Subtitle C regulations. This alternative complies with location-specific ARARs as the site is not located in wetlands or a 100-year flood plain. The alternative also complies with provisions of the FFA (EPA et al. 1989). (ARARs are listed in Appendix A of the Technology Descriptions Volume.)

11.5.1.3 Long-Term Effectiveness and Permanence

There is a moderate residual risk for exposure associated with this alternative. High levels of OCPs, CLC2A, and DCPD remain above the principal threat criteria, although exposure pathways are interrupted by the existing cap. Site reviews, soil monitoring, and groundwater monitoring are required. The existing habitat is not changed by this alternative. There is low confidence in the long-term reliability of the existing cover since the cover does not include a biota barrier or low-permeability soil layer.

11.5.1.4 Reduction in TMV

No treatment residuals are generated since no materials are treated. Mobility of the contaminants is reduced, but not eliminated, for the 520,000 BCY of untreated soil and residual contamination (i.e., that contamination more than 10 ft below ground surface) contained by the existing cover.

11.5.1.5 Short-Term Effectiveness

This alternative poses no short-term risk to workers and the community since no actions are taken. The existing habitat is not changed by the alternative, and long-term protection of the groundwater is uncertain. RAOs are achieved since the existing cover interrupts exposure pathways.

11.5.1.6 Implementability

The alternative is technically and administratively feasible since no additional action is required. Monitoring services are available for sampling soil and groundwater.

11.5.1.7 Cost

The total present worth cost is $3,370,000 including only long-term costs. Table B4.3-1 details the costing for this alternative. The cost uncertainty associated with this alternative is low since intrusive activities are not conducted and maintenance activities for the cover are limited.

11.5.2 Alternative 1a: Direct Thermal Desorption of Principal Threat Volume; No Additional Action

Alternative 1a: Direct Thermal Desorption (Direct Heating) of Principal Threat Volume; No Additional Action (Provisions of FFA) involves treatment of the principal threat exceedances in the Former Basin F Subgroup. The existing soil cap, amounting to 110,000 SY, is excavated from these areas as overburden and stockpiled nearby. To treat the principal threat volume of 180,000 BCY, which occurs at various depths, a total of 250,000 BCY is excavated and hauled to a centralized facility for thermal desorption.

Volatile emissions and noxious odors are controlled during excavation by enclosing the area with rigid-frame, negative-pressure vapor enclosures with vapor collection and treatment systems (described in Section 11.2.5). The negative-pressure vapor enclosures are relocated as excavation activities proceed to control vapors. Two enclosures are required to allow excavation within one enclosure and to tear down, relocate, and reassemble a second enclosure, thereby maintaining uninterrupted excavation productivity. The excavation is partially backfilled with borrow materials and a temporary cover is placed on the sideslopes of the excavation to control vapors prior to moving a structure. The first structure is placed on alternating rows to excavate trenches to depths of 10 ft, and the second structure is located to excavate the remaining rows of ridges.

The thermal desorber requires 1 year to build and another year for testing before soil can be processed. (Section 4.6.24 discusses the details of thermal desorption.) The thermal desorber processes dry soil from this subgroup at a rate of approximately 2,000 BCY/day and has a soil residence time of 30 minutes, achieving a soil discharge temperature of 300°C. (Section 4.6.24 discusses emission controls for off gases from thermal desorption.) Particulates from quench blowdown amount to approximately 1 percent of the total solids feed. This particulate volume of 2,500 BCY is disposed in the centralized on-post landfill along with the treated soil. The excavation is backfilled and the stockpiled overburden is replaced and compacted to repair the existing cover. The disturbed area of 110,000 SY is revegetated with native grasses to restore the habitat.

Following thermal desorption, the treated soil is placed in an on-post landfill. The on-post landfill is a multiple-cell facility requiring 1 year for construction of the first cell and associated facilities (Section 4.6.6). The landfill cover is revegetated to limit erosion and control surface-water infiltration, and fencing is installed around the landfill to preserve the integrity of the landfill cover and leachate-control system. Long-term maintenance of the landfill cover, leachate collection and treatment, and groundwater monitoring are required.

The remaining human health exceedance area in the former Basin F Subgroup is addressed by the no additional action component of this alternative. An exceedance volume of 270,000 BCY and residual contamination more than 10 ft below ground surface remain in place and no additional controls are implemented. The existing soil cap interrupts exposure pathways, but no additional action is taken in these areas to reduce human or biota exposure to COCs or to reduce potential groundwater contamination from this site. Long-term activities include maintenance of the existing cap, monitoring of untreated soil (an average of 42 samples per year), and annual groundwater compliance monitoring. Five-year site reviews are conducted to assess natural attenuation/degradation and potential migration of contaminants.

The following discussion presents a detailed evaluation of this alternative against the DAA criteria listed in the NCP (EPA 1990a). For purposes of comparison, Table 11.5-1 summarizes the evaluation of all alternatives developed for this subgroup.

11.5.2.1 Overall Protection of Human Health and the Environment

This alternative achieves RAOs by interrupting exposure pathways and reducing migration of contaminants to groundwater. The principal threat volume is treated through thermal desorption, but untreated soil remains below the existing cover. The potential for human exposure is reduced due to the existing cover. Groundwater impacts are reduced (the existing cover reduces infiltration) and the principal threat volume is treated, but residual contamination is left in place. The excavation of contaminated soil entails significant short-term risks based on the generation of odors/vapors and the high levels of contamination.

11.5.2.2 Compliance with ARARs

This alternative complies with action-specific ARARs, including state regulations on air emissions sources and landfill siting, design, and operation. However, this alternative does not achieve action-specific ARARs regarding the performance requirements of a Subtitle C cover. Endangered species are not impacted. The alternative complies with the location-specific ARARs as the site, treatment facility, and landfill are not located in wetlands or a 100-year flood plain. The alternative also complies with provisions of the FFA. (EPA et al. 1989) (ARARs are listed in Appendix A of the Technology Descriptions Volume.)

11.5.2.3 Long-Term Effectiveness and Permanence

There is low residual risk associated with this alternative. Although OCPs and CLC2A remain at concentrations exceeding the Human Health SEC (EBASCO 1994a), exposure pathways are interrupted by the existing cap, and 250,000 BCY of soil associated with the principal threat soil volume are treated by thermal desorption and landfilled. Approximately 1 percent of the soil feed is recovered from the off-gas treatment equipment and landfilled. Site reviews, soil monitoring, and groundwater monitoring are required. There is a high level of confidence in the engineering controls associated with the landfill, and no difficulties are associated with landfill maintenance. There is low confidence in the long-term reliability of the existing cover since the cover does not include a biota barrier or low-permeability soil layer. Vegetation is restored over the excavation area, although the types of vegetation placed at the site are designed to discourage burrowing animals from using the area as habitat. The existing habitat of the balance of the site is neither improved nor impacted by this alternative.

11.5.2.4 Reduction in TMV

TMV is eliminated for the 250,000 BCY of soil associated with the principal threat volume that is thermally desorbed to degrade OCPs, DCPD, and CLC2A to detection levels or >99.99 percent DRE. TMV reduction by thermal desorption is irreversible. Approximately 2,500 BCY of blowdown solids are landfilled along with the treated soil. The 270,000 BCY of untreated soil and residual contamination more than 10 ft below ground surface remain in place, but are contained by the existing cover.

11.5.2.5 Short-Term Effectiveness

This alternative entails high short-term risks associated with excavation, transportation, and thermal desorption of highly contaminated soil, some of which has the potential for generating contaminated vapors or odors. These risks are reduced through the use of vapor enclosures and personal protective equipment, but they cannot be completely eliminated. The vapor enclosures are installed to collect and treat vapors and odors from excavation; however, field demonstrations of vapor enclosures have not indicated that adequate controls can consistently be achieved. The short-term risks to workers inside the vapor enclosures are increased due to the confined working area and the dependence on the performance of the air treatment systems. The possibility exists for vapor or odor emissions during excavation despite these controls. In addition, the preparation of the feedstock prior to thermal desorption presents short-term risks, although the materials handling is conducted in an enclosed building to control dust and vapors/odors. Although the off-gas control system for the thermal desorber is designed to achieve air quality standards the emissions from the thermal desorber contain low but acceptable levels of some contaminants. There is minimal impact on or improvement to the existing habitat. The potential for migration of contaminants to groundwater is reduced, but not eliminated. This alternative achieves RAOs through the existing cover and reduces long-term risks through treatment of the principal threat volume. Excavation and treatment of 250,000 BCY of principal threat volume is feasible within 1 year after 2 years for construction of the treatment facility and landfill.

11.5.2.6 Implementability

Thermal desorption is widely available and has been used to treat similar contaminants; however, the technology has not been demonstrated at the scale required for RMA. The thermal desorption facility can be constructed within the required time frame, but the operation of the unit may be difficult due to the high levels of contamination, materials-handling problems, and the elevated levels of salts in the soil feed. Administrative difficulties associated with demonstrating compliance with permits and operating and maintenance regulations may lead to delays, and it may be difficult to implement this alternative due to the perceptions regarding the safety of thermal treatment.

Vapor enclosures have not been demonstrated at full scale for hazardous waste operations similar to RMA, although construction of vapor enclosures is well documented. Excavation within vapor enclosures requires temporary covers when the structure must be moved within the site during operations. The operation of the vapor enclosure for the excavation of the principal threats within the former Basin F site entails relocating the multiple structures a total of 32 times to completely cover the area to be excavated.

11.5.2.7 Cost

The total present worth cost is $58,400,000 including $19,800,000, $35,400,000, and $3,170,000 for capital, operating, and long-term costs, respectively. Table B4.3-1a details the costing for this alternative.

There are three significant uncertainties associated with the costing of this alternative. First, the extent and depth of contamination are difficult to estimate. Second, there are no other full-scale demonstrations at other hazardous waste sites with which to evaluate problems associated with excavation productivity inside a vapor enclosure, relocation of the structure, and operation of the air treatment system for the enclosure. Third, the elevated concentrations of the contaminants and salts in the feedstock and the need for materials handling increase uncertainties relative to maintaining the assumed on-line percentage of the thermal desorption unit. These operating

conditions are not typical of previous thermal desorption projects, and may result in changes in maintenance requirements or delays in implementation, both of which may impact treatment costs.

11.5.3 Alternative 2a: Direct Thermal Desorption of Principal Threat Volume; Access Restrictions

Alternative 2a: Direct Thermal Desorption (Direct Heating) of Principal Threat Volume; Access Restrictions (Modifications to FFA) involves treatment by thermal desorption of the principal threat volume found in the Former Basin F Subgroup and the initiation of access restrictions and habitat modifications for the balance of the site. The habitat modifications reduce the maintenance activities and improve the engineering controls of the cover. To treat the principal threat volume of 180,000 BCY, which occurs at various depths, 250,000 BCY is excavated and hauled to a centralized facility for thermal desorption. Prior to excavating the contaminated soil, 110,000 SY of the existing soil cover are excavated as overburden and stockpiled nearby.

Volatile emissions and noxious odors are controlled during excavation by enclosing the area with rigid-frame, negative-pressure vapor enclosures with vapor collection and treatment systems (described in Section 11.2.5). Two enclosures are required to maintain a consistent excavation rate since relocation of the enclosures is required. The excavation is partially backfilled prior to relocating the enclosures, and temporary covers are installed during relocation as discussed in Section 11.5.2.

The thermal desorber takes 1 year to build and requires another year for testing before soil can be processed. (Section 4.6.24 discusses the details of thermal desorption.) The dry soil is processed through the desorber at a rate of approximately 2,000 BCY/day. After a residence time of 30 minutes, the soil is discharged at a temperature of 300°C. (Section 4.6.24 discusses emission controls for off gases from thermal desorption.) Particulates from scrubber blowdown, approximately 1 percent of the total feed (2,500 BCY), are disposed in the on-post hazardous waste landfill along with the treated soil. The excavation is backfilled and the stockpiled overburden is replaced and compacted to restore the cover. Revegetation is performed in conjunction with the remaining area of the former basin as discussed below.

Following thermal desorption, the treated soil is placed in an on-post landfill. The on-post landfill is a multiple-cell facility requiring 1 year for construction of the first cell and associated facilities (Section 4.6.6). The landfill cover is revegetated to limit erosion and control surface-water infiltration, and fencing is installed around the landfill to preserve the integrity of the landfill cover and leachate-control system. Long-term maintenance of the landfill cover, leachate collection and treatment, and groundwater monitoring are required.

The remaining human health exceedance area in the Former Basin F Subgroup is addressed by access restrictions. An exceedance volume of 270,000 BCY and residual contamination more than 10 ft below ground surface remain in place, but exposure pathways are interrupted through the existing cover and the initiation of access controls. Human and biota access to the site are restricted by the installation of 12,000-ft-long chain-link fence around the perimeter. The fence is posted with warning signs. Over a 3-year period, 350,000 SY (which includes the area thermally desorbed) are revegetated with less desirable grasses to reduce the value of the habitat for wildlife and discourage burrowing animals from using the site as habitat. The habitat modifications and fencing require long-term maintenance to ensure the effectiveness of these controls. To prevent inadvertent exposure, an ongoing public education program is implemented to illustrate the importance of respecting the site access restrictions. Other long-term activities include maintenance of the existing cover and monitoring of exceedance areas (an average of 42 samples per year). Five-year site reviews, and annual groundwater compliance monitoring activities are conducted to review the effectiveness of the alternative and to assess potential migration of contaminants.

The following discussion presents a detailed evaluation of this alternative against the DAA criteria listed in the NCP (EPA 1990a). For purposes of comparison, Table 11.5-1 summarizes the evaluation of all alternatives developed for this subgroup.

11.5.3.1 Overall Protection of Human Health and the Environment

This alternative achieves RAOs since the principal threat volume is treated through thermal desorption and the potential for human exposure is reduced by the existing cover and access restrictions. TMV is eliminated for principal threat soil by treatment. Groundwater impacts are not reduced beyond the protection provided by the existing cover, except for treatment of the principal threat volume. The excavation of contaminated soil entails significant short-term risks based on odor/vapor generation and the high levels of contamination.

11.5.3.2 Compliance with ARARs

This alternative complies with action-specific ARARs including state regulations on air emissions sources and landfill siting, design, and operation. Access to the site is controlled and site reviews are conducted. However, this alternative does not achieve action-specific ARARs regarding performance requirements of a Subtitle C cover. Endangered species are not impacted. The alternative complies with the location-specific ARARs as the site, treatment facility, and landfill are not located in wetlands or a 100-year flood plain. The alternative also complies with provisions of the FFA (EPA et al. 1989). (ARARs are listed in Appendix A of the Technology Descriptions Volume.)

11.5.3.3 Long-Term Effectiveness and Permanence

There is low residual risk associated with this alternative. Approximately 250,000 BCY of soil associated with the principal threat soil volume are treated by thermal desorption. Although concentrations of OCPs and CLC2A exceeding the Human Health SEC (EBASCO 1994a) remain in place, exposure pathways are interrupted through the existing cover and engineering controls. Biota controls, consisting of fencing and cultivation of a lower quality habitat, reduce biota exposures. Approximately 1 percent of the soil feed is recovered from the off-gas treatment equipment and landfilled along with treated soil. Human and biota exposures are restricted using fencing, biota controls, and land-use restrictions. Long-term maintenance, site reviews, groundwater monitoring, and monitoring of wildlife exclusion are required. There is a high level of confidence in the engineering controls associated with the landfill, and no difficulties are associated with landfill maintenance. There is low confidence in the long-term reliability of the existing cover since the cover does not include a biota barrier or low-permeability soil layer. The existing habitat is eliminated through the use of biota controls.

11.5.3.4 Reduction in TMV

TMV is eliminated for the 250,000 BCY of soil associated with the principal threat volume that is thermally desorbed to degrade OCPs, DCPD, and CLC2A to detection levels or >99.99 percent DRE. TMV reduction by thermal desorption is irreversible. Approximately 2,500 BCY of blowdown solids are landfilled along with treated soil. The 270,000 BCY of untreated soil and residual contamination more than 10 ft below ground surface remain in place, but it is contained by the existing cover. The interruption of exposure pathways and reduction in mobility are only reversible should the existing cap degrade or leak.

11.5.3.5 Short-Term Effectiveness

This alternative entails high short-term risks associated with excavation, transportation, and thermal desorption of highly contaminated soil, some of which has the potential for generating contaminated odors or vapors. These risks are reduced through the use of vapor enclosures and personal protective equipment, but cannot be completely eliminated. The vapor enclosures are installed to collect and treat vapors and odors from excavation; however, field demonstrations of vapor enclosures have not indicated that adequate controls can consistently be achieved. The short-term risks to workers inside the vapor enclosures are increased due to the confined working area and the dependence on the performance of the air treatment systems. The possibility exists for vapor or odor emissions during excavation in spite of these controls. In addition, the preparation of the feedstock prior to thermal desorption presents short-term risks, although the materials handling is conducted in an enclosed building to control dust and vapors/odors. Although the off-gas control system for the thermal desorber is designed to achieve air quality standards the emissions from the thermal desorber contain low but acceptable levels of some contaminants. There is minimal impact to the existing habitat. The potential for migration of contaminants to groundwater is reduced, but not eliminated. The time frame to achieve RAOs is 3 years. Excavation and treatment of 250,000 BCY of principal threat volume is feasible within 1 year after 2 years for construction of the treatment facility and landfill. Installation of the perimeter fencing and cultivation of lower quality habitat is feasible within 3 years.

11.5.3.6 Implementability

Thermal desorption is widely available and has been used to treat similar contaminants; however, the technology has not been demonstrated at the scale required for RMA. The thermal desorption facility can be constructed within the required time frame, but the operation of the unit may be difficult due to the high levels of contamination, materials-handling problems, and the elevated levels of salts in the soil feed. Administrative difficulties associated with demonstrating compliance with permits and performing O&M may lead to delays, and it may be difficult to implement this alternative due to the perceptions regarding the safety of thermal treatment.

Vapor enclosures have not been demonstrated at full scale for hazardous waste operations similar to RMA, although construction of vapor enclosures is well documented. Excavation within vapor enclosures requires temporary covers when the structure must be moved within the site during operations. The operation of the vapor enclosure for the excavation of the principal threat volume entails moving the multiple structures a total of 32 times to completely cover the site.

11.5.3.7 Cost

The total present worth cost is $59,200,000 including $20,200,000, $35,500,000, and $3,490,000 for capital, operating, and long-term costs, respectively. Table B4.3-2a details the costing for this alternative.

There are three significant uncertainties associated with the costing of this alternative. First, the extent and depth of contamination are difficult to estimate. Second, there are no other full-scale demonstrations at other hazardous waste sites with which to evaluate problems associated with excavation productivity inside a vapor enclosure, relocation of the structure, and operation of the air treatment system for the enclosure. Third, the elevated concentrations of the contaminants and salts in the feedstock and the need for materials handling increase uncertainties relative to maintaining the assumed on-line percentage of the thermal desorption unit. These operating

conditions are not typical of previous thermal desorption projects, and may result in changes in maintenance requirements or delays in implementation, both of which may impact treatment costs.

11.5.4 Alternative 3b: Landfill; Caps/Covers

Alternative 3b: Landfill (On-Post Landfill); Caps/Covers (Soil Cover or Multilayer Cap) involves excavating and landfilling the human health exceedance volume (520,000 BCY), backfilling with the existing cover material and borrow material, and installing a low-permeability soil cap over 520,000 SY to contain residual contamination at depths greater than 10 ft. To landfill all of the 520,000 BCY human health exceedance volume (which occur at various depths), 740,000 BCY of soil is excavated. The existing 350,000-SY soil cover is removed during excavation and stockpiled for backfilling. The 740,000 BCY associated with the human health exceedance volume is excavated, transported, and placed in the on-post hazardous waste landfill.

Volatile emissions and noxious odors are controlled during excavation by enclosing the area with rigid-frame, negative-pressure vapor enclosures with vapor collection and treatment systems (described in Section 11.2.5). Two enclosures are required to maintain a consistent excavation rate since relocation of the enclosures is required. The excavation is partially backfilled prior to relocating the enclosure, and temporary covers are installed during relocation as discussed in Section 11.5.2.

The on-post landfill is a multiple-cell facility requiring 1 year for construction of the first cell and associated facilities (Section 4.6.6). The landfill cover is revegetated to limit erosion and control surface-water infiltration, and fencing is installed around the landfill to preserve the integrity of the landfill cover and leachate control system. Long-term maintenance of the landfill cover, leachate collection and treatment, and groundwater monitoring are required.

Prior to installation of the cap/cover, the excavations are backfilled with borrow soil and the stockpiled cover materials are backfilled, and the subsurface is compacted and regraded to minimize variations in the subgrade. Approximately 1,600,000 BCY of gradefill from the on-post borrow areas are required to create adequate slopes that will promote drainage of surface water.

The multilayer cap consists of a 2-ft-thick layer of compacted low-permeability soil, a 1-ft-thick biota barrier of crushed concrete, and a 4-ft-thick soil/vegetation layer that includes 6 inches of reconditioned soil. Most of the fill materials are excavated from an on-post borrow area, but the crushed concrete is obtained off post. The cap is revegetated, but the types of vegetation placed at the site and the maintenance activities performed there are designed to discourage burrowing animals from using the capped area as habitat. The borrow area is also recontoured and revegetated to restore the habitat. Long-term activities include maintaining the revegetated area and repairing damage caused by erosion. Five-year site reviews are conducted to review the effectiveness of the alternative.

The following discussion presents a detailed evaluation of this alternative against the DAA criteria listed in the NCP (EPA 1990a). For purposes of comparison, Table 11.5-1 summarizes the evaluation for all alternatives developed for this subgroup.

11.5.4.1 Overall Protection of Human Health and the Environment

This alternative achieves RAOs. The human health exceedance volume and principal threat volume are excavated and contained in an on-post landfill. Further protection is provided by a multilayer cap, which is installed to contain residual contamination at depths greater than 10 ft below ground surface. The removal of the contaminated soil and installation of the cap interrupt the exposure pathways and minimize any future impacts to groundwater. The excavation of contaminated soil entails significant short-term risks based on the generation of odors/vapors and the high levels of contamination.

11.5.4.2 Compliance with ARARs

This alternative complies with action-specific ARARs including state regulations on landfill siting, design, and operation and construction of covers. The design of the multilayer cap achieves the performance criteria of Subtitle C regulations. Endangered species are not impacted. This alternative complies with location-specific ARARs as the site and landfill are not located in wetlands or a 100-year flood plain. Disposal in the landfill does not trigger LDRs since the landfill is a CAMU (as defined in Section 1.4). The alternative also complies with provisions of the FFA (EPA et al. 1989). (ARARs are listed in Appendix A of the Technology Descriptions Volume.)

11.5.4.3 Long-Term Effectiveness and Permanence

There is minimal residual risk associated with this alternative since untreated soil (740,000 BCY) is contained in the on-post landfill and residual contamination more than 10 ft below ground surface is contained through the installation of a 450,000-SY multilayer cap. There is high confidence in the engineering controls of the landfill and cap and no difficulties are associated with the landfill or cap maintenance. Landfill and cap monitoring and maintenance are required. Habitat quality is improved by revegetating disturbed areas, although the types of vegetation placed at the site and the maintenance activities performed there are designed to discourage burrowing animals from using the capped area as habitat. The habitat at the landfill is eliminated.

11.5.4.4 Reduction in TMV

The mobility of contaminants in 740,000 BCY of untreated soil is reduced and the human and biota exposure pathways are interrupted through containment in the on-post landfill. The mobility of any residual contaminants is also reduced through the installation of the 450,000-SY multilayer cap. Mobility reduction is only reversible should the landfill or cap degrade or leak. There are no treatment residuals associated with this alternative and there is no reduction in toxicity or volume.

11.5.4.5 Short-Term Effectiveness

This alternative entails high short-term risks associated with excavation, materials handling, transportation, and landfilling of highly contaminated soil, some of which has the potential for generating contaminated vapors or odors. These risks are reduced through the use of vapor enclosures and personal protective equipment, but they cannot be completely eliminated. The vapor enclosures are installed to collect and treat vapors and odors from the excavation; however, field demonstrations of vapor enclosures have not indicated that adequate controls can consistently be achieved. The short-term risks to workers inside the vapor enclosures are increased due to the confined working area and are dependent on the performance of the air treatment systems. The possibility exists for vapor or odor emissions during excavation despite these controls. The alternative has a minimal impact on the existing habitat. The types of vegetation placed at the site and the maintenance activities performed there are designed to discourage burrowing animals from using the capped area as habitat. RAOs can be achieved in the 4-year time period required for the construction of the landfill, excavation of contaminated soil, and installation of the cap.

11.5.4.6 Implementability

This alternative is technically feasible as it can be completed within the required time frame and reliably maintained and operated thereafter. Additional remedial actions require removal of the landfill cover. The alternative is administratively feasible as it achieves the substantive requirements of landfill siting, design, and operation and of multilayer cap design and construction. Equipment, specialists, and materials are readily available for construction of the landfill and cap, both of which are well demonstrated at full scale. Vapor enclosures have not been demonstrated at full scale for hazardous waste operations similar to RMA, although construction of vapor enclosures is well documented. In addition, vapor enclosures are not available from many vendors. Excavation within vapor enclosures requires temporary covers when the structures must be moved as operations proceed at the site. The multiple structures are relocated a total of 109 times.

11.5.4.7 Cost

The total present worth cost is $111,000,000 including $29,400,000, $80,600,000, and $1,420,000 for capital, operating, and long-term costs, respectively. Table B4.3-3b details the costing for this alternative.

There are two significant uncertainties associated with the costing of this alternative. First, the extent and depth of contamination are difficult to estimate. Second, there are no other full-scale demonstrations at other hazardous waste sites with which to evaluate problems associated with excavation productivity inside a vapor enclosure, relocation of the structure, and operation of the air treatment system for the enclosure.

11.5.5 Alternative 3c: Direct Thermal Desorption of Principal Threat Volume; Landfill; Caps/Covers

Alternative 3c: Direct Thermal Desorption (Direct Heating) of Principal Threat Volume; Landfill (On-Post Landfill); Caps/Covers (Multilayer Cap) involves the treatment of 180,000 BCY of principal threat volume by thermal desorption and containment of the treated soil and remaining exceedance soil in the on-post landfill. A 450,000-SY multilayer cap is installed to contain any residual contamination at depths greater than 10 ft. Approximately 350,000 BCY of the existing Basin F cover are excavated as overburden and stockpiled nearby for backfilling prior to capping. To treat the 180,000 BCY of soil that exceed the principal threat criteria, which occurs at varying depths, 250,000 BCY are excavated and transported to the thermal desorber for treatment.

Volatile emissions and noxious odors are controlled during excavation by enclosing the area with rigid-frame, negative-pressure vapor enclosures with vapor collection and treatment systems (described in Section 11.2.5). Two enclosures are required to maintain a consistent excavation rate since relocation of the enclosures is required. The excavation is partially backfilled prior to relocating the enclosure, and temporary covers are installed during relocation as discussed in Section 11.5.2.

The thermal desorber takes 1 year to build and requires another year for testing before soil can be processed. (Section 4.6.24 discusses details of thermal desorption.) The dry soil from this subgroup is processed through the desorber at a rate of approximately 2,000 BCY/day. A residence time of 30 minutes is required to achieve a soil discharge temperature of 300°C. (Section 4.6.24 discusses emission controls for the treatment of off gases from thermal desorption.) Approximately 1 percent of the total soil feed (2,500 BCY) is recovered as particulates from scrubber blowdown and is disposed in the on-post landfill. The thermally desorbed soil, untreated human health exceedance volume, and treatment residuals from thermal desorption, are landfilled.

The remaining soil associated with the human health exceedance volume (490,000 BCY) is excavated, transported, and placed in the on-post hazardous waste landfill along with the 250,000

BCY of treated soil. The on-post landfill is a multiple-cell facility requiring 1 year for construction of the first cell and associated facilities (Section 4.6.6). The landfill cover is revegetated to limit erosion and control surface-water infiltration, and fencing is installed around the landfill to preserve the integrity of the landfill cover and leachate-control system. Long-term maintenance of the landfill cover, leachate collection and treatment, and groundwater monitoring are required.

Prior to installation of the cap/cover, the stockpiled materials from the existing soil cover are backfilled, and the subsurface is compacted and regraded to minimize variations in the subgrade. Approximately 1,600,000 BCY of gradefill from the on-post borrow areas is required to create adequate slopes at the site to promote drainage of surface water. The multilayer cap consists of a 2-ft-thick layer of compacted low-permeability soil, a 1-ft-thick biota barrier of crushed concrete, and a 4-ft-thick soil/vegetation layer that includes 6 inches of reconditioned soil. Most of the fill materials are excavated from an on-post borrow area, but the crushed concrete is obtained off post. The cap is revegetated, but the types of vegetation placed at the site and the maintenance activities performed there are designed to discourage burrowing animals from using the capped area as habitat. The borrow area is also recontoured and revegetated to restore the habitat. Long-term activities include maintaining the revegetated area and repairing erosion damage. Five-year site reviews are conducted to review the effectiveness of the alternative.

The following discussion presents a detailed evaluation of this alternative against the DAA criteria listed in the NCP (EPA 1990a). For purposes of comparison, Table 11.5-1 summarizes the evaluation of all alternatives developed for this subgroup.

11.5.5.1 Overall Protection of Human Health and the Environment

This alternative achieves RAOs. The principal threat volume is treated by thermal desorption and the treated soil, along with the balance of the human health exceedance volume, is contained in the on-post landfill. A multilayer cap is installed over the excavated area to contain residual contamination at depths greater than 10 ft. Removal of the contaminated soil and installation of the cap interrupts the exposure pathways and minimizes potential future impacts to groundwater.

The excavation of contaminated soil entails significant short-term risks based on the generation of odors/vapors and the high levels of contamination.

11.5.5.2 Compliance with ARARs

This alternative complies with action-specific ARARs including state regulations on air emissions sources and landfill siting, design, and operation and construction of covers. Endangered species are not impacted. The design of the multilayer cap achieves the performance criteria of Subtitle C regulations. This alternative complies with location-specific ARARs as the site, thermal treatment facility, and landfill are not located in wetlands or a 100-year flood plain. Disposal in the landfill does not trigger LDRs since the landfill is a CAMU (as defined in Section 1.4). The alternative also complies with provisions of the FFA (EPA et al. 1989). (ARARs are listed in Appendix A of the Technology Descriptions Volume.)

11.5.5.3 Long-Term Effectiveness and Permanence

There is minimal residual risk associated with this alternative since the soil associated with the principal threat volume (250,000 BCY) is thermally desorbed and contained, along with the untreated soil (500,000 BCY) in the on-post landfill. Containment of residual contamination is provided through containment with a 450,000-SY multilayer cap. Approximately 1 percent of the soil feed from the thermal desorber off-gas treatment equipment is placed in the on-post landfill. There is high confidence in the engineering controls of the landfill and cap and no difficulties are associated with the landfill or cap maintenance. Habitat quality is improved by revegetating disturbed areas, although the types of vegetation placed at the site and the maintenance activities performed there are designed to discourage burrowing animals from using the capped area as habitat. The habitat at the landfill is eliminated.

11.5.5.4 Reduction in TMV

Thermal desorption eliminates the TMV of organic compounds in 250,000 BCY of soil associated with the principal threat volume by treating the soil to below detection levels or >99.99 percent DRE. TMV reduction by thermal desorption is irreversible. The mobility of contaminants in 490,000 BCY of untreated soil is reduced and the human and biota exposure pathways are interrupted through containment of the treated and untreated soil in the on-post landfill. The mobility of any residual contamination is also reduced through the installation of the 450,000-SY multilayer cap. Mobility reduction is only reversible should the landfill or cap degrade or leak. Approximately 2,500 BCY of blowdown solids containing salts are landfilled.

11.5.5.5 Short-Term Effectiveness

This alternative entails high short-term risks associated with excavation, transportation, and thermal desorption of contaminated soil of highly contaminated soil, some of which has the potential for generating contaminated vapors or odors. These risks are reduced through the use of vapor enclosures and personal protective equipment, but they cannot be completely eliminated. The vapor enclosures are installed to collect and treat vapors and odors from excavation; however, field demonstrations of vapor enclosures have not indicated that adequate controls can consistently be achieved. The short-term risks to workers inside the vapor enclosures are increased due to the confined working area and the dependence on the performance of the air treatment systems. The possibility exists for vapor or odor emissions during excavation despite these controls. In addition, the preparation of the feedstock prior to thermal desorption presents short-term risks, although the materials handling is conducted in an enclosed building to control dust and vapors/odors. Although the off-gas control system for the thermal desorber is designed to achieve air quality standards, the emissions from the thermal desorber contain low but acceptable levels of some contaminants. The alternative has a minimal impact on the existing habitat. The types of vegetation placed at the site and the maintenance activities performed there are designed to discourage burrowing animals from using the capped area as habitat. RAOs can be achieved in 5 years. Excavation of 740,000 BCY, landfilling of 490,000 BCY, and treatment of 250,000 BCY are feasible within 2 years after the 2 years required for construction of the thermal desorption and landfill facilities. The installation of the 450,000-SY multilayer cap and 1,600,000 BCY of gradefill is feasible within 3 years. Natural attenuation/degradation of residual contamination is ongoing.

11.5.5.6 Implementability

Thermal desorption is widely available and has been used to treat similar contaminants; however, the technology has not been demonstrated at the scale required for RMA. The thermal desorption facility can be constructed within the required time frame, but the operation of the unit may be difficult due to the high levels of contamination, materials-handling problems, and the elevated concentrations of salts in the soil feed. Administrative difficulties associated with demonstrating compliance with permits and performing O&M may lead to delays, and it may be difficult to implement this alternative due to the perceptions regarding the safety of thermal treatment. Vapor enclosures have not been demonstrated at full scale for hazardous waste operations similar to RMA, although construction of vapor enclosures is well documented. Excavation within vapor enclosures requires temporary covers when the structure must be moved within the site. The excavation of 740,000 BCY entails relocating the multiple enclosures a total of 109 times to completely cover the site. Additional remedial actions require removal of the landfill cover, and the cap at the site adds to the overall site volume. The containment portion of the alternative is administratively feasible as it achieves the substantive requirements of siting, design, and operating and construction regulations. Equipment, specialists, and materials are readily available for construction of the landfill and cap, both of which are well demonstrated at full scale.

11.5.5.7 Cost

The total present worth cost is $132,000,000 including $35,200,000, $95,000,000, and $1,320,000 for capital, operating, and long-term costs, respectively. Table B4.3-3c details the costing for this alternative.

There are three significant uncertainties associated with the costing of this alternative. First, the extent and depth of contamination are difficult to estimate. Second, there are no other full-scale demonstrations at other hazardous waste sites with which to evaluate problems associated with excavation productivity inside a vapor enclosure, relocation of the structure, and operation of the air treatment system for the enclosure. Third, the elevated concentrations of the contaminants and salts in the feedstock and the need for materials handling increase uncertainties relative to maintaining the assumed on-line percentage of the thermal desorption unit. These operating

conditions are not typical of previous thermal desorption projects, and may result in changes in maintenance requirements or delays in implementation, both of which may impact treatment costs.

11.5.6 Alternative 6: Caps/Covers

Alternative 6: Caps/Covers (Multilayer Cap) addresses the human health exceedance areas by installing a 450,000-SY multilayer cap over the existing soil cover. The subsurface is compacted and regraded to minimize variations in the subgrade. Approximately 1,600,000 BCY of gradefill from the on-post borrow area is required to create adequate slopes at the site to promote drainage of surface water. The low-permeability soil cap consists of a 2-ft-thick layer of compacted low-permeability soil, a 1-ft-thick biota barrier of crushed concrete, and a 4-ft-thick soil/vegetation layer that includes 6 inches of reconditioned soil. Most of the fill materials are excavated from an on-post borrow area, but the crushed concrete is obtained off post. The cap is revegetated, but the types of vegetation placed at the site and the maintenance activities performed there are designed to discourage burrowing animals from using the capped area as habitat. The borrow area is also recontoured and revegetated to restore the habitat. Long-term activities include maintaining the revegetated area and repairing damage caused by erosion. Five-year site reviews and annual groundwater compliance monitoring are conducted to review the effectiveness of the alternative.

The following discussion presents a detailed evaluation of this alternative against the DAA criteria listed in the NCP (EPA 1990a). For purposes of comparison, Table 11.5-1 summarizes the evaluation of all alternatives developed for this subgroup.

11.5.6.1 Overall Protection of Human Health and the Environment

This alternative achieves RAOs since the human health exceedance volume and residual contamination more than 10 ft below ground surface are contained by the multilayer cap. Potential future groundwater impacts are greatly reduced. The short-term impacts are minimal since intrusive activities are not conducted.

11.5.6.2 Compliance with ARARs

This alternative complies with action-specific ARARs regarding construction of covers and monitoring of contained material. The design of the multilayer cap achieves the performance criteria of Subtitle C regulations. Endangered species are not impacted. This alternative complies with location-specific ARARs as the site is not located in wetlands or a 100-year flood plain. The alternative also complies with provisions of the FFA (EPA et al. 1989). (ARARs are listed in Appendix A of the Technology Descriptions Volume.)

11.5.6.3 Long-Term Effectiveness and Permanence

There is low residual risk associated with this alternative. Untreated soil (740,000 BCY) and residual contamination more than 10 ft below ground surface are contained through installation of a multilayer cap over the 450,000-SY site. Long-term monitoring and site reviews are required for untreated soil and erosion control and vegetative-cover maintenance are required for the cap. Habitat quality is improved by revegetating disturbed areas, although the types of vegetation placed at the site and the maintenance activities performed there are designed to discourage burrowing animals from using the capped area as habitat.

11.5.6.4 Reduction in TMV

No materials are treated—740,000 BCY of untreated soil and residual contamination more than 10 ft below ground surface remain in place. Exposure pathways are interrupted and mobility of contaminants is reduced through the installation of the 450,000-SY multilayer cap. Mobility reduction is only reversible should the cap degrade or leak. There are no treatment residuals associated with this alternative.

11.5.6.5 Short-Term Effectiveness

There is minimal short-term risk to workers and the community associated with this alternative since no intrusive activities are conducted. Uncontaminated fugitive dust associated with cap construction is controlled by water sprays, and vapor emissions are not anticipated. The alternative has a minimal impact on biota due to the existing disturbed habitat, although the types of vegetation placed at the site and the maintenance activities performed there are designed to discourage burrowing animals from using the capped area as habitat. RAOs can be achieved in the 2-year time period required for the installation of the 450,000-SY cap and 1,600,000 BCY of gradefill.

11.5.6.6 Implementability

This alternative is technically feasible as it can be completed within the required time frame and reliably maintained and operated thereafter. Additional remedial actions are easily undertaken for soil left in place, although the cap adds to the overall site volume. The alternative is administratively feasible as it achieves the substantive requirements of multilayer cap design and construction regulations.

11.5.6.7 Cost

The total present worth cost is $31,900,000, including $30,500,000 and $1,450,000 for operating and long-term costs, respectively. Table B4.3-6 details the costing for this alternative. There is a low level of uncertainty associated with the cost of this alternative since the materials required to construct the cap are available on post and the area to be capped is well defined (i.e., the uncertainty associated with excavation does not exist).

11.5.7 Alternative 6b: In Situ Solidification/Stabilization; Caps/Covers

Alternative 6b: In Situ Solidification/Stabilization (Silica/Proprietary Agent-Based Solidification); Caps/Covers (Multilayer Cap) treats 180,000 BCY of principal threat volume by solidification using silica or a proprietary solidification agent. The predominant COCs in this subgroup are organic compounds that are amenable to solidification. The treated soil is then contained by a 450,000-SY multilayer cap. It is assumed that this cap is RCRA-equivalent, which will meet the performance criteria to be specified by the parties prior to the remedial design.

The principal threat volume of 180,000 BCY is solidified using a transportable track-mounted boring/mixing unit and a cement batch plant capable of processing 600 BCY/day. Silica or a proprietary solidification agent is used instead of portland cement to minimize odor and vapor emissions. Upon solidification, the soil may swell by up to 20 percent due to incorporation of the reagents. Borrow soil from the on-post borrow area is recontoured over the solidified soil (450,000 SY).

A multilayer cap is then installed over the entire site to contain human health exceedance soil and residual contamination at depths more than 10 ft below ground surface. The subgrade is compacted before any cover materials are installed. The low-permeability soil cap consists of a 2-ft-thick layer of compacted low-permeability soil, a 1-ft-thick biota barrier of crushed concrete, and a 4-ft-thick soil/vegetation layer that includes 6 inches of reconditioned soil. Most of the fill materials are from an on-post borrow area, but the crushed concrete is obtained off post. In addition approximately 350,000 BCY of surficial soil adjacent to Basin F (to the north, northeast, and east) will be used as fill. The cap is revegetated with native grasses. The types of vegetation placed at the site and the maintenance activities performed there are designed to discourage burrowing animals from using the area as habitat. The borrow area is also recontoured and revegetated. Maintenance activities, such as mowing and replacement of eroded cap materials, ensure the continued integrity of the multilayer cap. Five-year site reviews are conducted to review the effectiveness of the alternative and to assess potential migration of contaminants.

The following discussion presents a detailed evaluation of this alternative against the DAA criteria listed in the NCP (EPA 1990a). For purposes of comparison, Table 11.5-1 summarizes the evaluation of all the alternatives developed for this subgroup.

11.5.7.1 Overall Protection of Human Health and the Environment

This alternative achieves RAOs through treatment and immobilization of contaminants. Solidification in combination with a multilayer cap eliminates exposure pathways and reduces migration of contaminants to groundwater by rainwater infiltration.

11.5.7.2 Compliance with ARARs

This alternative complies with action-specific ARARs including state regulations on air emissions sources, monitoring of solidified soil, and endangered species. Location-specific ARARs are met as the subgroup is not located in wetlands or a 100-year flood plain. (ARARs are listed in Appendix A of the Technology Descriptions Volume.)

11.5.7.3 Long-Term Effectiveness and Permanence

The residual risks associated with this alternative are minimal. A total of 180,000 BCY of principal threat soil is solidified in place. There is high confidence in the immobilization of contaminants by solidification; however, monitoring of the soil and cap is required. There is high confidence in engineering controls for the cap and there are no expected difficulties with maintenance. Revegetation of disturbed areas improves the existing habitat.

11.5.7.4 Reduction in TMV

Solidification interrupts exposure pathways and reduces the mobility of contaminants. This mobility reduction is irreversible so long as the integrity of the solidified materials is maintained. For residual contamination, pathways of exposure are interrupted and mobility of contaminants reduced through installation of the multilayer cap. The mobility reduction is only reversible should the cap degrade. There are no residuals associated with the solidification process, but the solidified soil requires monitoring.

11.5.7.5 Short-Term Effectiveness

This alternative entails short-term risks associated with in situ treatment. Personal protective equipment adequately protects workers, and fugitive dust associated with excavation is controlled by water sprays. Any vapors/odors generated during treatment are collected in a hood and treated in the off-gas control system. Although the off-gas control system is designed to achieve air quality standards, the emissions from the in situ solidification unit contain low but acceptable levels of some contaminants. RAOs can be achieved in 4 years. Solidification is feasible within 1 year, and the cap will take 3 years to construct.

11.5.7.6 Implementability

The alternative is technically feasible and can be implemented within the required time frame. The alternative is administratively feasible since the regulations for in-place treatment are achieved. Volatile emissions and noxious odors are controlled during treatment with a hood associated with the solidification unit. Personnel and equipment are available for groundwater compliance monitoring.

11.5.7.7 Cost

The total present worth cost is $66,400,000, including $63,500,000 and $2,860,000 for operating and long-term costs, respectively. Table B4.3-6b details the costing for this alternative.

There are two significant uncertainties associated with the costing of this alternative. First, the exact location of the principal threat exceedance volume that will be solidified in place is difficult to establish. Second, there is little operational experience with in situ solidification upon which to base estimates of on-line percentage, productivity, and potential emissions or operational problems.

11.5.8 Alternative 6c: Direct Thermal Desorption of Principal Threat Volume; Caps/Covers

Alternative 6c: Direct Thermal Desorption (Direct Heating) of Principal Threat Volume; Caps/Covers (Multilayer Cap) involves the thermal treatment of 180,000 BCY and the containment of 450,000 SY. Approximately 110,000 BCY of the existing Basin F cover are excavated from principal threat areas as overburden and stockpiled nearby. To include all of the 180,000 BCY of soil that exceed the principal threat criteria (which occur at various depths), a total of 250,000 BCY are excavated, transported to the thermal desorber for treatment, and landfilled.

Volatile emissions and noxious odors are controlled during excavation by enclosing the area with rigid-frame, negative-pressure vapor enclosures with vapor collection and treatment systems (described in Section 11.2.5). Two enclosures are required to maintain a consistent excavation rate since relocation of the enclosures is required. The excavation is partially backfilled prior to relocating the enclosure, and temporary covers are installed prior to relocation as discussed in Section 11.5.2.

The thermal desorber takes 1 year to build and requires another year for testing before soil can be processed. (Section 4.6.24 discusses details of thermal desorption.) The dry soil from this subgroup is processed through the desorber at a rate of approximately 2,000 BCY/day, requiring a residence time of 30 minutes to achieve a soil discharge temperature of 300°C. (Section 4.6.24 discusses emission controls for the treatment of off gases from thermal desorption.) Approximately 1 percent of the total soil feed (2,500 BCY) is recovered as particulates from scrubber blowdown and is disposed, along with the thermally desorbed soil, in the on-post landfill.

Following thermal desorption, the treated soil is placed in the on-post landfill. The on-post landfill is a multiple-cell facility requiring 1 year for construction of the first cell and associated facilities (Section 4.6.6). The landfill cover is revegetated to limit erosion and control surface-water infiltration, and fencing is installed around the landfill to preserve the integrity of the landfill cover and leachate control system. Long-term maintenance of the landfill cover, leachate collection and treatment, and groundwater monitoring are required.

The excavation is backfilled with the stockpiled cover material and borrow material, and then is covered with a 450,000-SY low-permeability soil cap. Prior to capping, 1,600,000 BCY of gradefill are installed to achieve the design grades for capping. The subsurface is compacted and regraded to minimize variations in the subgrade. The multilayer cap consists of a 2-ft-thick layer of compacted low-permeability soil, a 1-ft-thick biota barrier of crushed concrete, and a 4-ft-thick soil/vegetation layer that includes 6 inches of reconditioned soil. Most of the fill materials are excavated from an on-post borrow area, but the crushed concrete is obtained off post. The cap is revegetated, but the types of vegetation placed at the site and the maintenance activities performed there are designed to discourage burrowing animals from using the capped area as habitat. The borrow area is also recontoured and revegetated to restore the habitat. Long-term activities include maintaining the revegetated area and repairing damage caused by erosion. Five-year site reviews and annual groundwater compliance monitoring activities are conducted to review the effectiveness of the alternative and monitor the potential migration of contaminants.

The following discussion presents a detailed evaluation of this alternative against the DAA criteria listed in the NCP (EPA 1990a). For purposes of comparison, Table 11.5-1 summarizes the evaluation of all alternatives developed for this subgroup.

11.5.8.1 Overall Protection of Human Health and the Environment

This alternative achieves RAOs since the principal threat volume is treated by thermal desorption and landfilled, while the balance of the human health exceedance volume and residual contamination more than 10 ft below ground surface are contained by a multilayer cap. The treatment of the principal threat volume and installation of the cap interrupts the exposure pathways and minimizes the potential future impacts to groundwater. The excavation of contaminated soil entails significant short-term risks based on the generation of odors/vapors and the high levels of contamination.

11.5.8.2 Compliance with ARARs

This alternative complies with action-specific ARARs including state regulations on air emissions sources, operation and construction of covers, and design, siting, and operation of landfills. The design of the multilayer cap achieves the performance criteria of Subtitle C regulations. Endangered species are not impacted. This alternative complies with location-specific ARARs as the site, thermal treatment facility, and landfill are not located in wetlands or a 100-year flood plain. The alternative also complies with provisions of the FFA (EPA et al. 1989). (ARARs are listed in Appendix A of the Technology Descriptions Volume.)

11.5.8.3 Long-Term Effectiveness and Permanence

There is low residual risk associated with this alternative. The soil associated with the principal threat volume (250,000 BCY) is thermally desorbed and landfilled. Approximately 1 percent of the soil feed from the thermal desorber off-gas treatment equipment is also placed in the on-post landfill. The untreated soil (490,000 BCY) and residual contamination more than 10 ft below ground surface are contained through the installation of a multilayer cap over the 450,000-SY site. There is high confidence in the engineering controls of the landfill and cap and there are no difficulties associated with the landfill or cap maintenance. Landfill and cap monitoring and maintenance are required. Habitat quality is improved by revegetating disturbed areas, although the types of vegetation placed at the site and the maintenance activities performed there are designed to discourage burrowing animals from using the capped area as habitat.

11.5.8.4 Reduction in TMV

Thermal desorption eliminates the TMV of organic compounds in 250,000 BCY of soil associated with the principal threat volume to below detection levels or >99.99 percent DRE. TMV reduction by thermal desorption is irreversible. The mobility of the contaminants in 490,000 BCY of untreated soil and of the residual contamination more than 10 ft below ground surface is reduced and exposure pathways are interrupted through the installation of the 450,000 SY-multilayer cap. Mobility reduction is only reversible should the landfill or cap degrade or leak. Approximately 2,500 BCY of blowdown solids are landfilled along with the treated soil.

11.5.8.5 Short-Term Effectiveness

This alternative entails high short-term risks associated with excavation, transportation, and thermal desorption of highly contaminated soil, some of which has the potential for generating contaminated vapors or odors. These risks are reduced through the use of vapor enclosures and personal protective equipment, but they cannot be completely eliminated. The vapor enclosures are installed to collect and treat vapors and odors from the excavation; however, field demonstrations of vapor enclosures have not indicated that adequate controls can consistently be achieved. The short-term risks to workers inside the vapor enclosures are increased due to the confined working area and the dependence on the performance of the air treatment systems. The possibility exists for vapor or odor emissions during excavation despite these controls. In addition, the preparation of the feedstock prior to thermal desorption presents short-term risks, although the materials handling is conducted in an enclosed building to control dust and vapors/odors. Although the off-gas control system for the thermal desorber is designed to achieve air quality standards, the emissions from the thermal desorber contain low but acceptable levels of some contaminants. The alternative has a minimal impact on the existing habitat. The types of vegetation placed at the site and the maintenance activities performed there are designed to discourage burrowing animals from using the capped area as habitat. RAOs can be achieved in 5 years. Excavation and treatment of 250,000 BCY are feasible within 1 year after the 2 years required for construction of the thermal desorption and landfill facility. The installation of the 450,000-SY multilayer cap and 1,600,000 BCY of gradefill is feasible within 3 years.

11.5.8.6 Implementability

Thermal desorption is widely available and has been used to treat similar contaminants; however, the technology has not yet been demonstrated at the scale required for RMA. The thermal desorption facility can be constructed within the required time frame, but the operation of the unit may be difficult due to the high levels of contamination, materials-handling problems, and the elevated concentrations of salts in the soil feed. Administrative difficulties associated with demonstrating compliance with permits and performing O&M may lead to delays, and it may be difficult to implement this alternative due to the perceptions regarding the safety of thermal treatment. Vapor enclosures have not been demonstrated at full scale for hazardous waste operations similar to RMA, although construction of vapor enclosures is well documented. Excavation within vapor enclosures requires temporary covers when the structure must be moved within the site. The operation of the vapor enclosure for the excavation of the principal threats entails relocating the multiple structures a total of 32 times to completely cover the area. Additional remedial actions require removal of the landfill cover or the Basin F cap. The containment portion of the alternative is administratively feasible as it achieves the substantive requirements of landfill and cap siting, design, and operation. Equipment, specialists, and materials are readily available for construction of the landfill and cap, both of which are well demonstrated at full scale. In addition, equipment, materials, and personnel for long-term monitoring activities are readily available.

11.5.8.7 Cost

The total present worth cost is $88,200,000 including $19,800,000, $67,000,000, and $1,440,000 for capital, operating, and long-term costs, respectively. Table B4.3-6c details the costing for this alternative.

There are three significant uncertainties associated with the costing of this alternative. First, the extent and depth of contamination are difficult to estimate. Second, there are no other full-scale demonstrations at other hazardous waste sites with which to evaluate problems associated with excavation productivity inside a vapor enclosure, relocation of the structure, and operation of the air treatment system for the enclosure. Third, the elevated concentrations of the contaminants and salts in the feedstock and the need for materials handling increase uncertainties relative to maintaining the assumed on-line percentage of the thermal desorption unit. These operating conditions are not typical of previous thermal desorption projects, and may result in changes in maintenance requirements or delays in implementation, both of which may impact treatment costs.

11.5.9 Alternative 13c: Direct Thermal Desorption; Caps/Covers

Alternative 13c: Direct Thermal Desorption (Direct Heating); Caps/Covers (Multilayer Cap) involves the excavation and treatment of 740,000 BCY of soil associated with the human health exceedances. In general, the exceedances consist of OCPs, VOCs, CLC2A, DCPD, and arsenic contamination. A 450,000-SY cap is installed over the site to contain any residual contamination at depths greater than 10 ft. The 350,000 BCY of soil from the existing cover are excavated as overburden and set aside for backfilling prior to installing the cap. The treated soil is landfilled.

Volatile emissions and noxious odors are controlled during excavation by enclosing the area with rigid-frame, negative-pressure vapor enclosures with vapor collection and treatment systems (described in Section 11.2.5). Two enclosures are required to maintain a consistent excavation rate since relocation of the enclosures is required. The excavation is partially backfilled prior to relocating the enclosure, and temporary covers are installed prior to relocation as discussed in Section 11.5.2.

The thermal desorber takes approximately 1 year to build and requires an additional year for testing before soil can be processed. (Section 4.6.24 discusses the details of thermal desorption.) The dry soil from this subgroup is processed through the desorber at a rate of approximately 2,000 BCY/day. The thermal desorber operates with a soil discharge temperature of 300°C and requires a residence time of 30 minutes. (Section 4.6.24 discusses the treatment of off gases from thermal desorption.) Approximately 1 percent of the total soil feed (7,400 BCY) is recovered as particulates from scrubber blowdown and is disposed in the on-post hazardous waste landfill along with the treated soil. The backfilled areas are revegetated with native grasses to improve habitat.

Following thermal desorption, the treated soil is placed in an on-post landfill. The on-post landfill is a multiple-cell facility requiring 1 year for construction of the first cell and associated facilities (Section 4.6.6). The landfill cover is revegetated to limit erosion and control surface-water infiltration, and fencing is installed around the landfill to preserve the integrity of the landfill cover and leachate control system. Long-term maintenance of the landfill cover, leachate collection and treatment, and groundwater monitoring are required.

Prior to installation of the cap/cover, the stockpiled cover materials are backfilled, and the subsurface is compacted and regraded to minimize variations in the subgrade. Approximately 1,600,000 BCY of gradefill from the on-post borrow areas are required to create adequate slopes at the site to promote drainage of surface water. The multilayer cap consists of a 2-ft-thick layer of compacted low-permeability soil, a 1-ft-thick layer biota barrier of crushed concrete, and a 4-ft-thick soil/vegetation layer that includes 6 inches of reconditioned soil. Most of the fill materials are excavated from an on-post borrow area, but the crushed concrete is obtained off post. The cap is revegetated, but the types of vegetation placed at the site and the maintenance activities performed there are designed to discourage burrowing animals from using the capped area as habitat. The borrow area is also recontoured and revegetated to restore the habitat. Long-term activities include maintaining the revegetated area and repairing damage caused by erosion. Five-year site reviews are conducted to review the effectiveness of the alternative.

The following discussion presents a detailed evaluation of this alternative against the DAA criteria listed in the NCP (EPA 1990a). For purposes of comparison, Table 11.5-1 summarizes the evaluation of all alternatives developed for this subgroup.

11.5.9.1 Overall Protection of Human Health and the Environment

This alternative achieves RAOs since the human health exceedance volume is treated by thermal desorption and landfilled, and the residual contamination more than 10 ft below ground surface is contained by a multilayer cap. Treatment and installation of the cap interrupts the exposure pathways and minimizes the potential future impacts to groundwater. The excavation of contaminated soil entails significant short-term risks based on the generation of odors/vapors and the high levels of contamination.

11.5.9.2 Compliance with ARARs

This alternative complies with action-specific ARARs including state regulations on air emission sources, operation and construction of covers, and design, siting, and operation of landfills. Endangered species are not impacted. The design of the multilayer cap achieves the performance criteria of Subtitle C regulations. This alternative complies with location-specific ARARs as the site, thermal treatment facility, and landfill are not located in wetlands or a 100-year flood plain. The alternative also complies with provisions of the FFA (EPA et al. 1989). (ARARs are listed in Appendix A of the Technology Descriptions Volume.)

11.5.9.3 Long-Term Effectiveness and Permanence

The residual risk is minimal since thermal desorption achieves PRGs for 740,000 BCY of soil associated with the human health exceedance volume. Approximately 1 percent of the soil feed from the thermal desorber off-gas treatment equipment is placed in the on-post landfill along with the treated soil. The installation of a multilayer cap over 450,000 SY provides containment for any residual contamination more than 10 ft below ground surface. There is high confidence in the engineering controls of the landfill and cap and there are no difficulties associated with the landfill or cap maintenance. Landfill and cap monitoring and maintenance are required. Habitat quality is improved by revegetating disturbed areas, although the types of vegetation placed at the site and the maintenance activities performed there are designed to discourage burrowing animals from using the capped area as habitat. The habitat at the landfill is eliminated.

11.5.9.4 Reduction in TMV

Thermal desorption eliminates the TMV of organic compounds in 740,000 BCY of treated soil. TMV reduction by thermal desorption reduces contamination to below detection levels or >99.99 percent DRE and is irreversible. Approximately 7,400 BCY of blowdown solids are landfilled along with the treated soil.

11.5.9.5 Short-Term Effectiveness

This alternative entails high short-term risks associated with excavation, transportation, and thermal desorption of highly contaminated soil, some of which has the potential for generating contaminated vapors or odors. These risks are reduced through the use of vapor enclosures and personal protective equipment, but they cannot be completely eliminated. The vapor enclosures are installed to collect and treat vapors and odors from excavation; however, field demonstrations of vapor enclosures have not indicated that adequate controls can consistently be achieved. The short-term risks to workers inside the vapor enclosures are increased due to the confined working area and the dependence on the performance of the air treatment systems. The possibility exists for vapor or odor emissions during excavation despite these controls. In addition, the preparation of the feedstock prior to thermal desorption presents short-term risks, although the materials handling is conducted in an enclosed building to control dust and vapors/odors. Although the off-gas control system for the thermal desorber is designed to achieve air quality standards, the emissions from the thermal desorber contain low but acceptable levels of some contaminants. The alternative has a minimal impact on the existing habitat, although the types of vegetation placed at the site and the maintenance activities performed there are designed to discourage burrowing animals from using the capped area as habitat. RAOs can be achieved in 6 years. Excavation and treatment of 740,000 BCY is feasible within 2 years after the 2 years required for construction of the thermal desorption and landfill facility. The installation of the 450,000-SY multilayer cap and 1,600,000 BCY of gradefill is feasible within 3 years.

11.5.9.6 Implementability

Thermal desorption is widely available and has been used to treat similar contaminants; however, the technology has not been demonstrated at the scale required for RMA. The thermal desorption facility can be constructed within the required time frame, but the operation of the unit may be difficult due to the high levels of contamination, materials-handling problems, and the elevated concentrations of salts in the soil feed. Administrative difficulties associated with demonstrating compliance with permits and performing O&M may lead to delays, and it may be difficult to implement this alternative due to public perceptions regarding the safety of thermal treatment. Vapor enclosures have not been demonstrated at full scale for hazardous waste operations similar to RMA, although construction of vapor enclosures is well documented. Excavation within vapor enclosures requires temporary covers when the structure must be moved within the site. The operation of the vapor enclosures for the excavation of the exceedance soil entails moving the multiple enclosures a total of 109 times to completely cover the area. Additional remedial actions are easily undertaken, although the cap adds to the overall site volume. The containment portion of the alternative is administratively feasible as it achieves the substantive requirements of multilayer cap design and construction regulations. Equipment, specialists, and materials are readily available for construction of the cap, which has been well demonstrated at full scale.

11.5.9.7 Cost

The total present worth cost is \$177,000,000 including \$49,700,000, \$126,000,000, and \$1,220,000 for capital, operating, and long-term costs, respectively. Table B4.3-13c details the costing for this alternative.

There are three significant uncertainties associated with the costing of this alternative. First, the extent and depth of contamination are difficult to estimate. Second, there are no other full-scale demonstrations at other hazardous waste sites with which to evaluate problems associated with excavation productivity inside a vapor enclosure, relocation of the structure, and operation of the air treatment system for the enclosure. Third, the elevated concentrations of contamination and salts in the feedstock and the need for materials handling increase uncertainties relative to maintaining the assumed on-line percentage of the thermal desorption unit. These operating

conditions are not typical of previous thermal desorption projects, and may result in changes in maintenance requirements or delays in implementation, both of which may impact treatment costs.

11.5.10 Alternative 19c: In Situ Thermal Treatment; Caps/Covers

Alternative 19c: In Situ Thermal Treatment (RF/Microwave Heating); Caps/Covers (Multilayer Cap) treats a total of 740,000 BCY of contaminated soil in the Former Basin F Subgroup. A 450,000-SY cap is then installed to contain residual contamination at depths greater than 10 ft. RF heating raises the temperature of the soil to more than 250°C, mobilizing the organic contaminants. The mobilized contaminants are collected and treated in the off-gas treatment system described in Section 4.6.30. Based on the large volume (740,000 BCY) to be treated, two RF heating units are required. Each RF heating unit treats a 100-ft-long, 48-ft-wide, 10-ft-deep block of soil. The former Basin F site has a soil moisture content of approximately 10 percent, allowing a treatment rate of 180 BCY/day. The liquid sidestream from in situ heating, which contains predominantly salts, is transported to the thermal desorption facility for treatment with the scrubber effluent or it is treated by a crystallizer/evaporator. Although the existing cover is not contaminated and is not targeted for treatment by this alternative, it is heated to treat the underlying contaminated soil, which degrades the organic carbon in the cover soil.

Prior to installation of the cap/cover, the subsurface is compacted and regraded to minimize variations in the subgrade. Approximately 1,600,000 BCY of gradefill from the on-post borrow areas is required to create adequate slopes at the site to promote drainage of surface water. The cap consists of a 2-ft-thick layer of compacted low-permeability soil, a 1-ft-thick layer biota barrier of crushed concrete, and a 4-ft-thick soil/vegetation layer that includes 6 inches of reconditioned soil. Most of the fill materials are excavated from an on-post borrow area, but the crushed concrete is obtained off post. The cap is revegetated, but the types of vegetation placed at the site and the maintenance activities performed there are designed to discourage burrowing animals from using the capped area as habitat. The borrow area is also recontoured and revegetated to restore the habitat. Long-term activities include maintaining the revegetated area and repairing damage caused by erosion. Five-year site reviews are conducted to review the effectiveness of the alternative.

The following discussion presents a detailed evaluation of this alternative against the DAA criteria listed in the NCP (EPA 1990a). For purposes of comparison, Table 11.5-1 summarizes the evaluation of all alternatives developed for this subgroup.

11.5.10.1 Overall Protection of Human Health and the Environment

The alternative does not achieves RAOs. RF heating reduces contaminant concentrations, but does not achieve PRGs. The potential for migration of contaminants to groundwater is reduced through the installation of the cap. Although this alternative does not entail a large amount of intrusive activity, the short-term impacts are high based on the long duration of treatment activities.

11.5.10.2 Compliance with ARARs

This alternative complies with action-specific ARARs, including state regulations on air emission sources and the operation and construction of covers. The design of the multilayer cap achieves the performance criteria of Subtitle C regulations. Endangered species are not impacted. This alternative complies with location-specific ARARs as the site is not located in wetlands or a 100-year flood plain. The alternative also complies with provisions of the FFA (EPA et al. 1989). (ARARs are listed in Appendix A of the Technology Descriptions Volume.)

11.5.10.3 Long-Term Effectiveness and Permanence

The residual risk is low since the entire site is contained and the human health exceedances are treated to concentrations near the Human Health PRGs. The treated soil and residual contamination more than 10 ft below ground surface are contained with the cap. Long-term monitoring, 5-year site reviews, and cap-maintenance operations are conducted to ensure the effectiveness of the controls. The overall habitat quality for the site is improved through revegetation, offsetting the habitat losses during implementation of the alternative, although the types of vegetation placed at the site and the maintenance activities performed there discourage burrowing animals from using the capped area as habitat.

11.5.10.4 Reduction in TMV

RF heating can theoretically achieve Human Health and Biota RAOs with low residual risk since OCPs can be driven from the soil by this form of in situ thermal treatment. However, pilot-scale testing of the RF technology at RMA, as described in the Technology Descriptions Volume Section 8.2.1, failed to confirm the temperature distribution and OCP removal efficiencies required for confident treatment of soil to achieve PRGs. The contaminant removal through RF heating is irreversible. The site is capped, which reduces the mobility of contaminants and interrupts the exposure pathways.

11.5.10.5 Short-Term Effectiveness

This alternative entails low short-term risk to workers and the community during remedial actions since no intrusive activities are conducted. Personal protective equipment adequately protects workers during in situ treatment of contaminated soil and cap/cover installation. Fugitive dust is controlled by water sprays. However, the in situ thermal treatment of soil entails short-term impacts due to the long duration of treatment operations (6 years), during which time there is a potential for contaminants to continue to migrate to groundwater. Although the off-gas control system for in situ heating is designed to achieve air quality standards, the emissions from the in situ heating unit contain low levels of the contaminants removed from the soil. Habitat quality is eventually improved by revegetation following installation of the cap, although restrictions to burrowing animals are implemented to preserve the integrity of the cap. RAOs can be achieved in 9 years. In situ thermal treatment of 740,000 BCY is feasible within 6 years based on the use of two units, and the installation of the 450,000-SY multilayer cap and 1,600,000 BCY of gradefill is feasible within 3 years.

11.5.10.6 Implementability

In situ thermal heating is currently not implementable because no full-scale in situ heating units have been constructed or demonstrated. The technology was demonstrated at pilot scale at RMA; however, several problems were identified in the pilot-scale test regarding the durability of the equipment. The resolution of these problems may lead to delays in the construction of full-scale units and in the operation of the in situ heating units. In addition, administrative difficulties associated with demonstrating compliance with permits and performing O&M may lead to delays, and it may be difficult to implement this alternative due to public perceptions regarding the safety of in situ thermal treatment and the thermal-treatment portion of the off-gas control system. Additional remedial actions for the treated soil are easily undertaken, but the cap adds to the overall site volume. The containment portion of the alternative is administratively feasible as it achieves the substantive requirements of multilayer cap design and construction. Equipment, specialists, and materials are readily available for construction of the cap, and caps are well demonstrated at full scale.

11.5.10.7 Cost

The total present worth cost is $264,000,000 including $26,500,000, $236,000,000, and $663,000 for capital, operating, and long-term costs, respectively. Table B4.3-19d details the costing for this alternative.

There are two significant uncertainties associated with the costing of this alternative. First, there are no full-scale demonstrations of the in situ heating technology at other hazardous waste sites by which actual construction and operation costs can be documented. This uncertainty is especially noteworthy because the pilot-scale demonstration of the technology at RMA indicated there were potential problems regarding the durability of the equipment. Second, the lack of full-scale implementation data increases uncertainties relative to maintaining the assumed on-line percentage of the heating units. The concentrations and depth of contamination at RMA may result in changes in treatment times or delays in implementation, both of which may impact treatment costs.

11.6 COMPARATIVE ANALYSIS OF ALTERNATIVES

The Former Basin F Subgroup consists of 740,000 BCY of exceedance soil that was not removed from the basin during the Basin F IRA in 1989. A soil cover averaging 3 ft in thickness was placed over this soil and the cover was revegetated at the conclusion of the IRA. OCPs and CLC2A are the primary exceedance contaminants. Since biota exceedances are only evaluated for the 0- to 1-ft depth interval and a 3-ft-thick cover (on average) is installed over the former

Basin F site, alternatives were not developed to address biota exposure. In general, the average concentration of OCPs in the human health exceedance volume substantially exceeds the Human Health SEC (EBASCO 1994a) (Table 11.4-1), although the concentrations of individual OCPs exceed the Human Health SEC (EBASCO 1994a) in less than 6 percent of the samples collected (Table 11.4-2). Less than 5 percent of the samples analyzed for aldrin and dieldrin exceed the principal threat criteria (Table 11.4-2), which results in a principal threat exceedance volume of 180,000 BCY. Due to the varying depths of the human health exceedances, a total of 250,000 BCY is required to be excavated to address the principal threat volume, and a total of 740,000 BCY is required for ex situ alternatives addressing the entire human health exceedance.

The soil cover installed during the IRA interrupts exposure pathways from the soil to humans and biota (excluding burrowing animals), so the current residual risk for exposure is low. However, high concentrations of COCs are still present below the soil cover, which does not provide long-term protection of groundwater from leaching of contaminants. Contaminated groundwater is intercepted north of the former Basin F site by the Basin F Groundwater IRA extraction system and the NBCS.

The Former Basin F Subgroup was revegetated with crested wheat grass. Disturbance of this habitat during remedial actions does not represent a significant impact.

The presence of high concentrations of OCPs in some areas indicates that protection of site workers and the community is required for alternatives that involve excavation. The area excavated at any one time is limited and vapor enclosures are used to reduce odor emissions from the excavations.

In summary, the Former Basin F Subgroup contains soil that exceeds the Human Health SEC and the principal threat criteria for OCP concentrations. The existing soil cover limits exposure pathways, but contaminants may still leach to groundwater (and be intercepted by the groundwater treatment systems in place at RMA). In evaluating alternatives for this subgroup, the short-term risks of worker exposure and community concerns from the potential release of vapors must be balanced against the long-term risks of leaving the contamination in place.

Alternative 1: No Additional Action achieves Human Health RAOs for exposure, but does not improve the long-term protection of groundwater and does not achieve ARARs for caps, so it was eliminated from further consideration. Alternative 1a: Direct Thermal Desorption of Principal Threat Volume; No Additional Action reduces long-term risks by treating the principal threat areas, but still does not eliminate migration of contaminants to groundwater. Therefore, this alternative was also eliminated from consideration. Alternative 2a: Direct Thermal Desorption of Principal Threat Volume; Access Restrictions reduces long-term risks through access controls and treatment of principal threat areas, but does not reduce the potential for continued groundwater contamination and does not achieve ARARs for caps. Moreover, this alternative requires the elimination of 350,000 SY from use as habitat, so it too was eliminated from further consideration. The remaining seven alternatives, which consist of various containment and treatment processes, achieve RAOs and meet the two DAA threshold criteria: protection of human health and the environment and compliance with action- and location-specific ARARs. They are distinguished by how well they meet the five balancing criteria.

The landfill alternatives (Alternative 3b: Landfill; Caps/Covers and Alternative 3c: Direct Thermal Desorption of Principal Threat Volume; Landfill; Caps/Covers) achieve RAOs at the site, and although the majority of the contaminated soil is not treated, the potential for exposures and mobility of contaminants are reduced through containment. Landfilling and capping have been well demonstrated and there is high confidence in the engineering controls and maintenance of these operations. The thermal desorption of soil from the former Basin F site exhibits difficult administrative and technical implementability based on the characteristics of the soil and concerns regarding thermal treatment. The costs of $111,000,000 and $132,000,000 for Alternatives 3b and 3c, respectively, is well below the cost of the full treatment alternatives; however, significant short-term risks are incurred during excavation operations. Based on the cost effectiveness and permanent containment offered by landfilling and capping, these alternatives were carried forward for development of the sitewide alternatives (see Section 20).

Alternative 6: Caps/Covers provides low long-term residual risks without incurring short-term risks. This option also interrupts exposure pathways and reduces the potential for future impacts on groundwater. This technology has been well demonstrated and entails low short-term risks since Basin F soil is not excavated. In addition, there are no treatment residuals associated with this alternative. The cost of $31,900,000 indicates that this alternative is also cost effective. This alternative was carried forward for development of the sitewide alternatives (see Section 20).

Alternative 6b: In Situ Solidification/Stabilization; Caps/Covers entails significantly lower short-term impacts and engineering controls than landfilling or excavating and treating the principal threat volume. This alternative is considered cost effective and has lower short-term impacts than ex-situ alternatives. It was therefore retained for further consideration.

Alternative 6c: Direct Thermal Desorption of Principal Threat Volume; Caps/Covers entails limited excavation and treatment prior to capping. Although this alternative costs $88,200,000, which is lower than full treatment alternatives, it still generates high short-term impacts associated with excavation and treatment and it is less protective than Alternative 3c. In addition, the thermal desorption of soil from the former Basin F site exhibits difficult administrative and technical implementability based on the characteristics of the soil and concerns regarding thermal treatment. Therefore this alternative is not retained for further consideration.

Alternative 13c: Direct Thermal Desorption; Caps/Covers reduces contamination through treatment that achieves PRGs and containment of the residual contamination and treated soil. This alternative exhibits significant risks during excavation and treatment, and thermal desorption exhibits limited administrative feasibility based on concerns regarding thermal treatment technologies. In addition, the high levels of contamination and salts, along with problems with materials handling, will result in operating difficulties. Since the alternative ultimately relies on containment, the risk reduction for thermal desorption does not warrant the much higher cost ($177,000,000) for this alternative compared to containment or partial treatment/containment alternatives. This alternative was not retained since it is not cost effective.

Alternative 19c: In Situ Thermal Treatment; Caps/Covers is not capable of achieving RAOs through treatment based on the limited DRE achieved by this technology, and relies on containment to be protective. Additionally, the in situ thermal treatment process is not available for full-scale operation. This alternative is also the most expensive alternative ($264,000,000). This alternative was not retained based on the lack of equipment for full-scale operation and its high cost.

Consequently, the alternatives that were retained to represent the Former Basin F Subgroup in the development of the sitewide alternatives (Section 20) are the following:

- Alternative 3b: Landfill (On-Post Landfill); Caps/Covers (Soil Cover or Multilayer Cap)
- Alternative 3c: Direct Thermal Desorption (Direct Heating) of Principal Threat Volume; Landfill (On-Post Landfill); Caps/Covers (Multilayer Cap)
- Alternative 6: Caps/Covers (Multilayer Cap)
- Alternative 6b: In Situ Solidification/Stabilization (Silica/Proprietary Agent-Based Solidification); Caps/Covers (Multilayer Cap)

The groundwater control system evaluated for the Basins C and F Plume is located north of the former Basin F site. As such, the selection of these alternatives does not impact the evaluation of groundwater alternatives.

Table 11.0-1 Characteristics of the Basin F Medium Group

Characteristic	Basin F Wastepile Subgroup Group[1]	Former Basin F Subgroup
Contaminants of Concern		
Human Health	OCPs, volatiles, CLC2A	OCPs, DBCP, CLC2A, DCPD
Biota	none	OCPs, As
Exceedance Area (SY)		
Total	75,000	350,000
Human Health	75,000	350,000
Principal Threat	75,000	94,000
Biota	0	0
Potential Agent	not applicable	not applicable
Potential UXO	not applicable	not applicable
Exceedance Volume (BCY)		
Total	580,000[2]	740,000
Human Health	580,000	740,000
Organic	580,000	740,000
Inorganic	0	0
Principal Threat	580,000	250,000
Biota	0	0
Potential Agent	not applicable	not applicable
Potential UXO	not applicable	not applicable
Depth of Contamination (ft)		
Human Health	not applicable	0-10, mostly 0-5
Biota	not applicable	not applicable

1 Basin F Wastepile is aboveground and contains material from the former Basin F.

2 Approximately 20,000 BCY of additional contaminated materials in the liner system and subgrade would also require removal and treatment or disposal for alternatives involving excavation of the Basin F Wastepile.

Contaminants of Concern	Range of Concentrations[1] (ppm)	Average Concentration (ppm)	Human Health SEC (ppm)	Human Health Principal Threat Criteria (ppm)	Human Health Acute Criteria (ppm)
Human Health Exceedance Volume					
Aldrin	0.1-3,100	Not Available	71	720	3.8
Dieldrin	0.1-700	Not Available	41	410	3.7
Endrin	9.2-900	Not Available	230,000	230,000	56
Isodrin	3.16-3,000	Not Available	52	52,000	Not applicable
Chloroacetic Acid	110-760	Not Available	77	77,000	3,900
1,2-Dichloroethane	3,4-110	Not Available	320	3,200	Not applicable
DCPD	1,500-2,000	Not Available	3,700	1,000,000	54,000
Biota Volume					
None		Not applicable	Not applicable	Not applicable	Not applicable

[1] Concentrations inferred from remedial investigations sampling at NCSA-3 prior to Basin F interim response action.

Table 11.2-1 Comparative Analysis of Alternatives for the Basin F Wastepile Subgroup

Criteria	Alternative 1: No Additional Action	Alternative 2: Access Restrictions	Alternative 3: Landfill
1. Overall protection of human health and the environment	Achieves RAOs due to existing cover, liner, and leachate collection systems	Achieves RAOs due to existing cover, liner, and leachate collection systems; RAOs achieved in 3 years	Achieves RAOs through containment
2. Compliance with ARARs	Does not comply with ARARs on landfill covers	Does not comply with ARARs on landfill covers	Complies
3. Long-term effectiveness and permanence	Low Residual Risk: High levels of contamination contained by existing system	Low Residual Risk: High levels of contamination contained by existing system; access controls decrease maintenance and potential for exposure	Minimal Residual Risk. Containment in triple-lined landfill cell provides additional reliability as opposed to existing containment
4. Reduction in TMV	Alternative does not result in further reduction in TMV	Alternative does not result in further reduction in TMV	TMV reduced by drying of soils, placement in landfill ensures long-term reliability of containment
5. Short-term effectiveness	No implementation required	Minimal short-term risk to workers and the community: minimal activity required; RAOs achieved in 3 years	High short-term risk associated with excavation, transportation, treatment; vapor enclosures required; RAOs achieved in 3 years
6. Implementability	No implementation required; services include groundwater sampling, leachate collection maintenance, and leachate treatment	Feasible	Technology not well demonstrated; Administrative Difficulties
7. Present worth costs	Capital—$0 Operating—$0 Long-term—$3,020,000 Total—$3,020,000	Capital—$3,000 Operating—$43,000 Long-term—$3,100,000 Total—$3,150,000	Capital—$13,700,000 Operating—$29,300,000 Long-term—$178,000 Total—$43,200,000
Summary	Not Retained: Existing cover does not achieve ARARs	Not Retained: Existing cover does not achieve ARARs	Retained: Achieves ARARs and provides long term reliable containment of contaminated soils

Table 11.2-1 Comparative Analysis of Alternatives for the Basin F Wastepile Subgroup

Criteria	Alternative 6d: Caps/Covers	Alternative 8a: Direct Soil Washing	Alternative 13b: Direct Thermal Desorption; Landfill
1. Overall protection of human health and the environment	Achieves RAOs due to augmented cover and liner/leachate collection systems	Achieves RAOs through treatment and containment	Achieves RAOs through treatment and containment
2. Compliance with ARARs	Complies	Complies	Complies
3. Long-term effectiveness and permanence	Minimal Residual Risk: Augmented containment provides protection	Minimal Residual Risk: Treated soil achieves PRGs and is contained in landfill	Minimal Residual Risk: Treated soil achieves PRGs and is contained in landfill
4. Reduction in TMV	Mobility reduced for 600,000 BCY through containment	TMV eliminated through treatment and containment; 360,000 gallons of liquid sidestream requires off-post disposal	TMV eliminated through treatment and containment
5. Short-term effectiveness	Minimal short-term risk workers and the community: no intrusive activities conducted; RAOs achieved in 1 year	High short-term risk associated with excavation, transportation, treatment; vapor enclosures required; RAOs achieved in 5 years	High short-term risk associated with excavation, transportation, treatment; vapor enclosures required; RAOs achieved in 5 years
6. Implementability	Feasible	Very difficult to implement due to large number of units required and no performance data available at required scale	Technically difficult to implement; administrative feasibility limited for thermal desorption
7. Present worth costs	Capital—$0 Operating—$4,680,000 Long-term—$4,010,000 Total—$8,050,000	Capital—$66,300,000 Operating—$175,000,000 Long-term—$368,000 Total—$242,000,000	Capital—$46,800,000 Operating—$125,000,000 Long-term—$344,000 Total—$172,000,000
Summary	Retained: Augmented cover achieves ARARs	Not Retained: High cost and not feasible to operate large number of units	Retained: Removes and treats contaminated soil although high cost and high short-term impact

Table 11.4–1 Summary of Concentrations for the Former Basin F Subgroup

Contaminants of Concern	Range of Concentrations[1] (ppm)	Average Concentration[1] (ppm)	Human Health SEC (ppm)	Human Health Principal Threat Criteria (ppm)	Human Health Acute Criteria (ppm)
Human Health Exceedance Volume					
Aldrin	BCRL–2,900	260	71	720	3.8
Dieldrin	BCRL–1,100	130	41	410	3.7
Endrin	BCRL–710	47	230	230,000	56
Isodrin	BCRL–10,000	360	52	52,000	Not applicable
Chloroacetic Acid	BCRL–7,000	960	77	77,000	3,900
DCPD	BCRL–20,000	670	3,700	1,000,000	54,000
p,p,DDT[1]	BCRL–53	0.4	410	13,500	14
Arsenic[1]	BCRL–45	7.6	420	4,200	270

[1] Based on modeled concentrations within the human health exceedance volume or potential biota risk area.

Table 11.4-2 Frequency of Detections for The Former Basin F Subgroup

	Total Samples Analyzed	BCRL Number	BCRL %	CRL-SEC(1) Number	CRL-SEC(1) %	Acute-HH SEC(2) Number	Acute-HH SEC(2) %	HH SEC-Pr. Threat(2) Number	HH SEC-Pr. Threat(2) %	>Pr. Threat(2) Number	>Pr. Threat(2) %
Aldrin	223	172	77.1%	26	11.7%	7	3.1%	7	3.1%	11	4.9%
Benzene	175	168	96.0%	7	4.0%	--	--	0	0.0%	0	0.0%
Carbon Tetrachloride	151	151	100.0%	0	0.0%	--	--	0	0.0%	0	0.0%
Chlordane	215	202	94.0%	13	6.0%	0	0.0%	0	0.0%	0	0.0%
Chloroacetic Acid	109	83	76.1%	5	4.6%	--	--	21	19.3%	0	0.0%
Chlorobenzene	147	145	98.6%	2	1.4%	--	--	0	0.0%	0	0.0%
Chloroform	151	142	94.0%	9	6.0%	--	--	0	0.0%	0	0.0%
p,p,DDE	224	223	99.6%	1	0.4%	--	--	0	0.0%	0	0.0%
p,p,DDT	223	219	98.2%	3	1.3%	1	0.4%	0	0.0%	0	0.0%
Dibromochloropropane	315	308	97.8%	5	1.6%	--	--	2	0.6%	0	0.0%
1,2-Dichloroethane	151	150	99.3%	1	0.7%	--	--	0	0.0%	0	0.0%
Dicyclopentadiene	309	282	91.3%	25	8.1%	--	--	2	0.6%	0	0.0%
Dieldrin	223	153	68.6%	45	20.2%	7	3.1%	8	3.6%	10	4.5%
Endrin	223	172	77.1%	38	17.0%	3	1.3%	10	4.5%	0	0.0%
Hexachlorocyclopentadiene	228	227	99.6%	1	0.4%	--	--	0	0.0%	0	0.0%
Isodrin	223	181	81.2%	27	12.1%	--	--	15	6.7%	0	0.0%
Methylene Chloride	137	133	97.1%	4	2.9%	--	--	0	0.0%	0	0.0%
Tetrachloroethylene	151	140	92.7%	11	7.3%	--	--	0	0.0%	0	0.0%
Toluene	174	156	89.7%	18	10.3%	--	--	0	0.0%	0	0.0%
Trichloroethylene	151	150	99.3%	1	0.7%	--	--	0	0.0%	0	0.0%
Arsenic	183	78	42.6%	105	57.4%	0	0.0%	0	0.0%	0	0.0%
Cadmium	207	191	92.3%	16	7.7%	0	0.0%	0	0.0%	0	0.0%
Chromium	207	22	10.6%	185	89.4%	--	--	0	0.0%	0	0.0%
Lead	197	129	65.5%	68	34.5%	--	--	0	0.0%	0	0.0%
Mercury	131	117	89.3%	14	10.7%	0	0.0%	0	0.0%	0	0.0%

(1) SEC limits for this interval are based on chronic HH SEC, or where appropriate, acute risk-based criteria for the 0- to 1-ft depth interval.

(2) Table 1.4-1 presents acute criteria, HH SEC, and principal threat criteria.

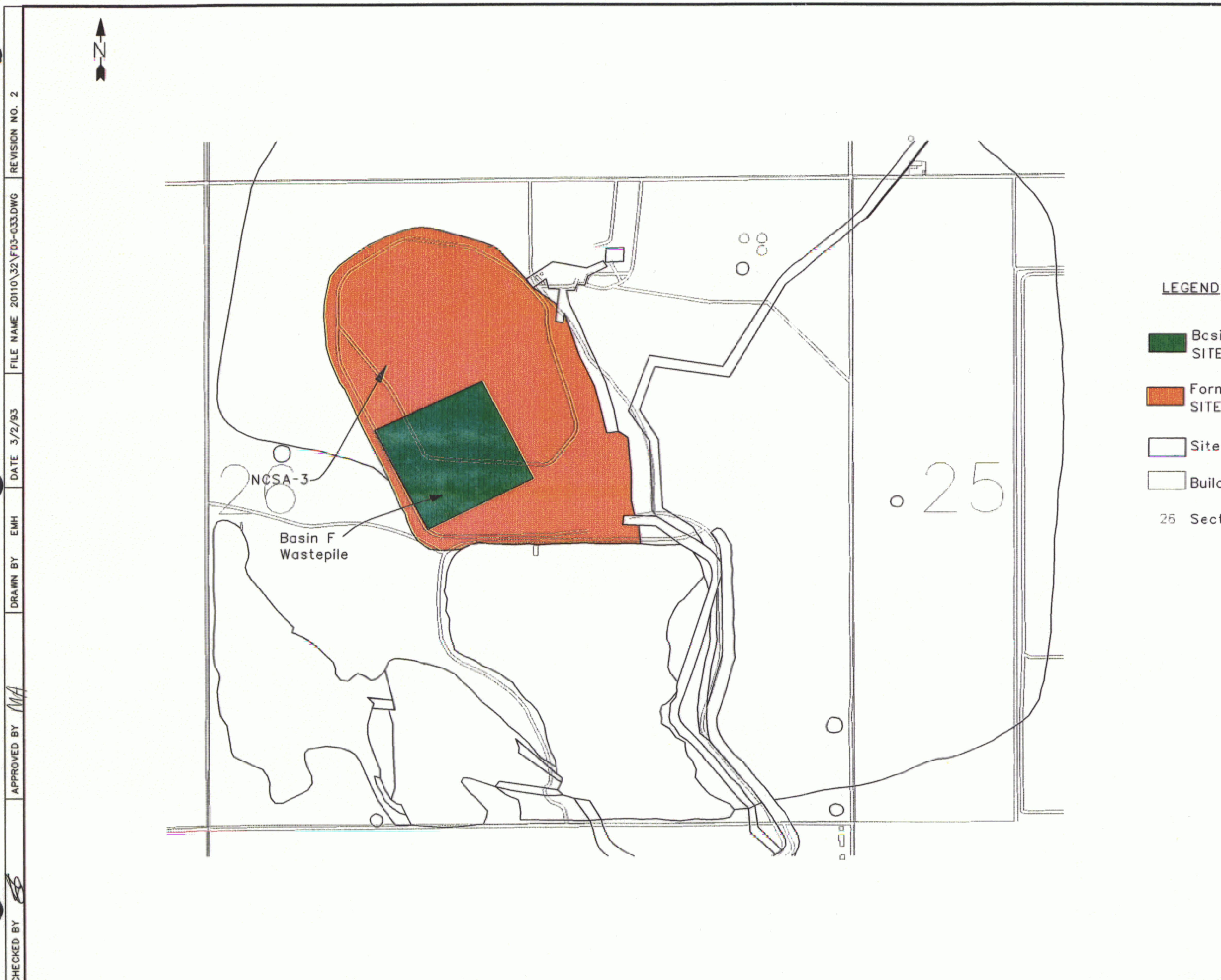
-- not applicable

Table 11.5-1 Comparative Analysis of Alternatives for the Former Basin F Subgroup

Criteria	Alternative 1: No Additional Action	Alternative 1a: Direct Thermal Desorption of Principal Threat Volume; No Additional Action	Alternative 2a: Direct Thermal Desorption of Principal Threat Volume; Access Restrictions	Alternative 3b: Landfill; Caps/Covers	Alternative 3c: Direct Thermal Desorption of Principal Threat Volume; Landfill; Caps/Covers
1. Overall protection of human health and the environment	Protective: Achieves RAOs through existing cover although continued groundwater impacts possible	Protective: Achieves RAOs through thermal treatment and the existing cover although continued groundwater impacts possible	Protective: Achieves RAOs through thermal desorption and the existing cover although continued groundwater impacts possible	Protective: Achieves RAOs through containment; impacts to groundwater greatly reduced	Protective: Achieves RAOs through treatment and containment; impacts to groundwater greatly reduced
2. Compliance with ARARs	Does not comply with ARARs for caps/covers	Does not comply with ARARs for caps/covers	Does not comply with ARARs for caps/covers	Complies	Complies
3. Long-term effectiveness and permanence	Moderate Residual Risk: Contamination above SEC and principal threat criteria remains; continued potential impacts to groundwater	Low Residual Risk: Principal threat volume removed and treated; exposure pathways reduced through existing cover	Low Residual Risk: Principal threat volume treated; exposure pathways reduced through existing cover and access controls	Minimal Residual Risk: Contaminated soil removed and residual contamination contained with upgraded cover	Minimal Residual Risk: Principal threat volume treated, balance of contaminated soil removed and residual contamination contained
4. Reduction in TMV	520,000 BCY remain untreated below existing cover	Thermal desorption destroys OCPs in 180,000 BCY; 270,000 BCY remain untreated below existing cover	Thermal desorption destroys OCPs in 180,000 BCY; 270,000 BCY remain untreated below existing cover	Mobility of contaminants reduced by containment; toxicity and volume not reduced	Thermal desorption destroys OCPs in 180,000 BCY; for balance of soil, mobility of contaminants reduced by containment
5. Short-term effectiveness	No implementation required	High short-term risk to workers and community during excavation, transportation, and treatment/disposal of principal threat volume; RAOs achieved in 1-2 years	High short-term risk to workers and community during excavation, transportation, and treatment/disposal of principal threat volume; RAOs achieved in 3 years	High short-term risk to workers and community during excavation, transportation, and disposal of human health exceedances; RAOs achieved in 4 years	High short-term risk to workers and community during and excavation, transportation, and treatment/disposal of human health exceedances; RAOs achieved in 5 years
6. Implementability	No implementation required Feasible	Technically difficult to implement; administrative difficulty for thermal treatment	Technically difficult to implement; administrative difficulty for thermal treatment	Feasible; however, vapor/odor control not demonstrated	Technically difficult to implement; administrative difficulty for thermal treatment
7. Present worth costs	Capital—$0 Operating—$0 Long-term—$3,370,000 Total—$3,370,000	Capital—$19,800,000 Operating—$35,400,000 Long-term—$3,170,000 Total—$58,400,000	Capital—$20,200,000 Operating—$35,500,000 Long-term—$3,490,000 Total—$59,200,000	Capital—$29,400,000 Operating—$80,600,000 Long-term—$1,420,000 Total—$111,000,000	Capital—$35,200,000 Operating—$95,000,000 Long-term—$1,320,000 Total—$132,000,000
Summary	Not Retained: Existing cover does not achieve ARARs and potential groundwater impacts continue	Not Retained: Existing cover does not achieve ARARs and potential groundwater impacts continue	Not Retained: Existing cover does not achieve ARARs and potential groundwater impacts continue	Retained: Contaminated soil contained in landfill	Retained: Contaminated soil contained and treated although administrative feasibility limited

Table 11.5-1 Comparative Analysis of Alternatives for the Former Basin F Subgroup

Criteria	Alternative 6: Caps/Covers	Alternative 6b: In Situ Solidification/Stabilization; Caps/Covers	Alternative 6c: Direct Thermal Desorption of Principal Threat Volume; Caps/Covers	Alternative 13c: Direct Thermal Desorption; Caps/Covers	Alternative 19c: In Situ Thermal Treatment; Caps/Covers
1. Overall protection of human health and the environment	Protective: Achieves RAOs through in-place containment; potential impacts to groundwater greatly reduced	Protective: RAOs achieved through treatment and in-place containment	Protective: Achieves RAOs through treatment and in-place containment; potential impacts to groundwater greatly reduced	Protective: Achieves RAOs through treatment and containment; potential impacts to groundwater greatly reduced	Protective: Achieves RAOs through treatment and containment; potential impacts to groundwater greatly reduced
2. Compliance with ARARs	Complies	Complies	Complies	Complies	Complies
3. Long-term effectiveness and permanence	Low Residual Risk: Contaminated soil contained in place	Minimal Residual Risk: PRGs achieved through solidification and containment	Low Residual Risk: Principal threat volume treated, balance of contaminated soil contained in-place	Minimal Residual Risk: Human health exceedances treated, residual contaminated soil contained	Low Residual Risk: Human health exceedances treated, residual contamination below 10 ft contained
4. Reduction in TMV	Exposure pathways and mobility of contaminants reduced through containment	Mobility reduced for solidified soil (180,000 BCY) and through containment	Thermal desorption destroys organics in 180,000 BCY; mobility reduced for balance of contaminants through containment	Thermal desorption reduces organics to below PRGs; mobility reduced for residual contamination below 10 ft through containment	TMV reduced by treatment, but not eliminated; mobility reduced for treated soil and balance of contaminants through containment
5. Short-term effectiveness	Minimal short-term risk: Protective of workers and the community; no intrusive action; RAOs achieved in 2 years	Short-term risks during in situ treatment; RAOs achieved in 4 years	High short-term risk to workers and community during excavation, transportation, and treatment/disposal of principal threat volume; RAOs achieved in 5 years	High short-term risk to workers and community during excavation, transportation, and treatment/disposal of entire human health exceedance volume; RAOs achieved in 6 years	Low short-term risk to workers and community during in situ treatment over the long treatment duration; RAOs achieved in 9 years
6. Implementability	Feasible	Feasible	Technically difficult to implement; administrative difficulty for thermal desorption	Technically difficult to implement; administrative difficulty for thermal desorption	Not currently implementable since full-scale in situ heating units are not available
7. Present worth costs	Capital—$0 Operating—$30,500,000 Long-term—$1,450,000 Total—$31,900,000	Capital—$0 Operating—$63,500,000 Long-term—$2,860,000 Total—$66,400,000	Capital—$19,800,000 Operating—$67,000,000 Long-term—$1,440,000 Total—$88,200,000	Capital—$49,700,000 Operating—$126,000,000 Long-term—$1,220,000 Total—$177,000,000	Capital—$26,500,000 Operating—$236,000,000 Long-term—$663,000 Total—$264,000,000
Summary	Retained: Contaminated soil contained in place	Retained: Contaminated soil treated at lower short-term risks and adequately contained.	Not Retained: Higher cost and more difficult to implement without reducing long-term risk sufficiently compared to Alternative 6 and 6b	Not Retained: High cost for larger treatment volume without reducing long-term risk sufficiently compared to partial treatment/containment alternatives	Not Retained: Technology not demonstrated at full scale; very high cost treatment and uncertain ORE without reducing long-term risk sufficiently compared to other alternatives



Prepared for:

U.S. Army Program Manager
for Rocky Mountain Arsenal

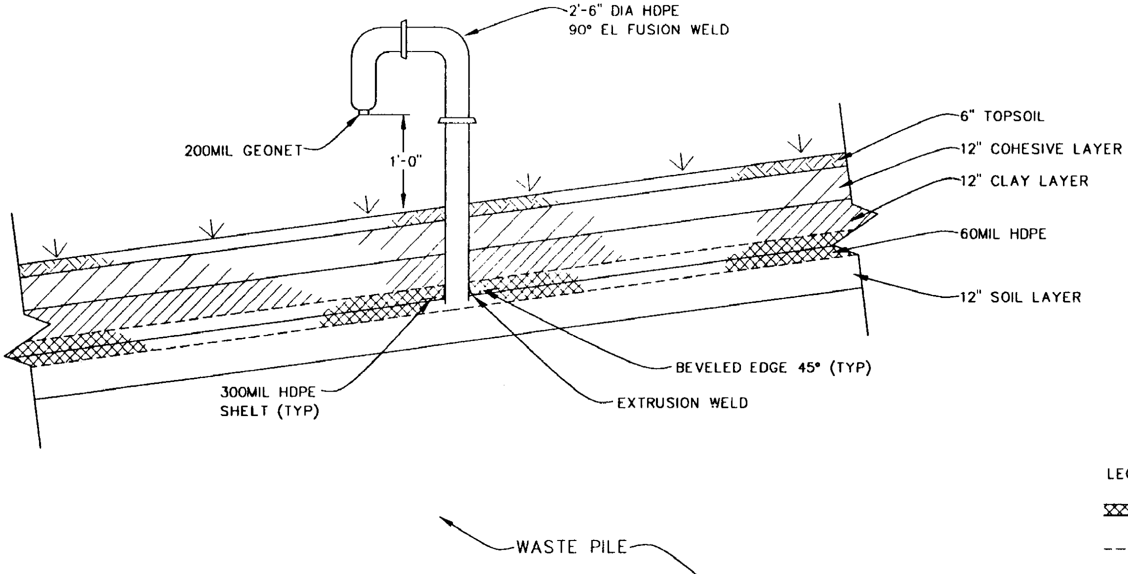
October 1995

FIGURE 11.0-1

Site Location
Basin F Medium Group

Rocky Mountain Arsenal.
Prepared by: Foster Wheeler Environmental Corporation

CHECKED BY	APPROVED BY	DRAWN BY EMH	DATE 12/7/93	FILE NAME 80004\F01-002.DWG	REVISION NO. 1

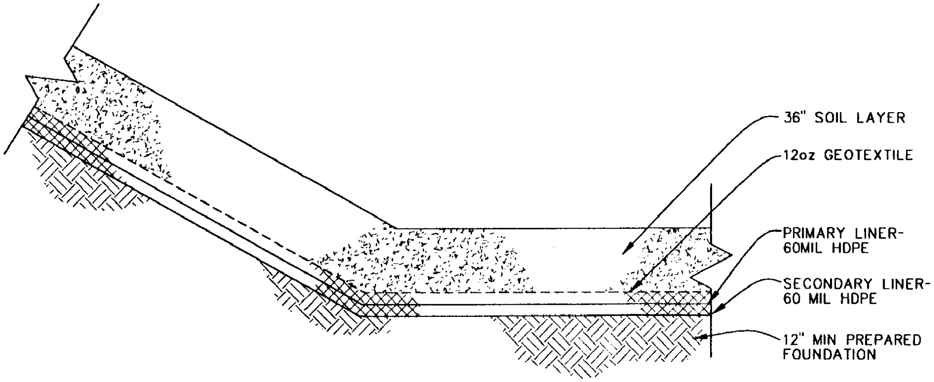


LEGEND

200 mil HDPE GEONET

GEOTEXTILE

VEGETATION



Prepared for:

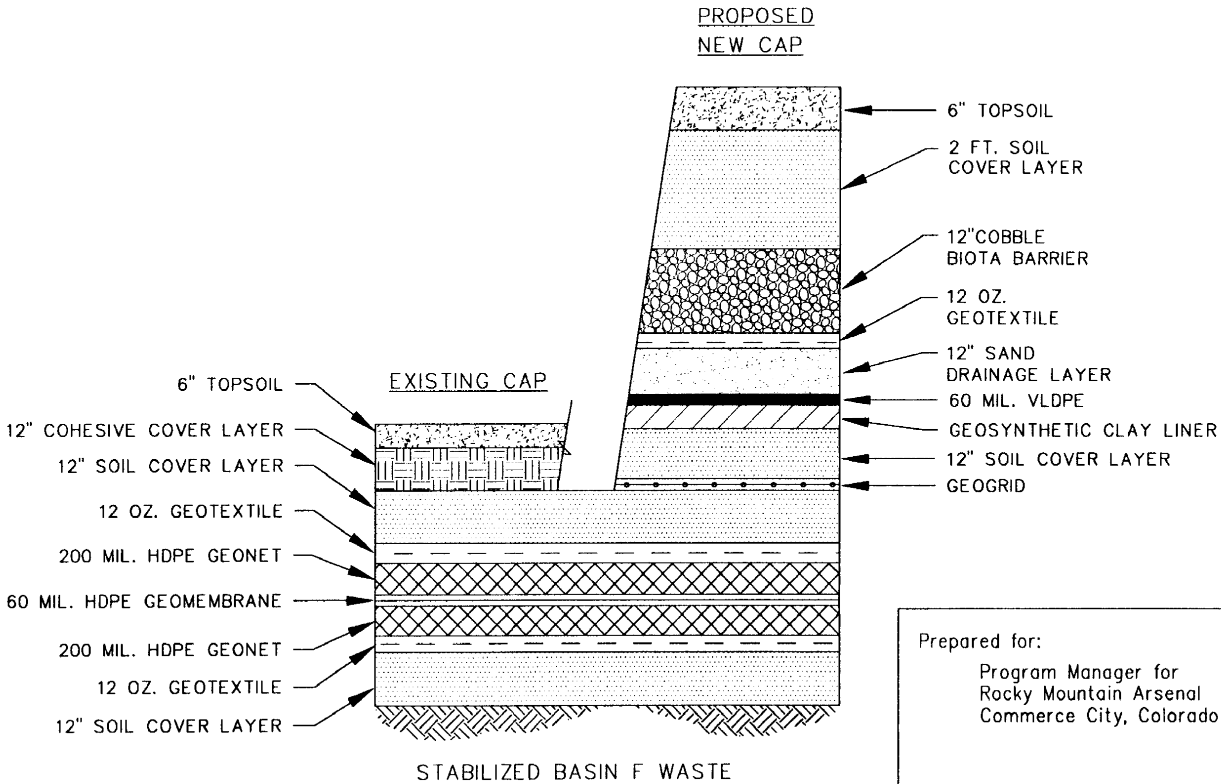
U.S. Army Program Manager
for Rocky Mountain Arsenal

PREPARED AUGUST 1995

FIGURE 11.1-1

EXISTING LINER AND FINAL COVER
BASIN F WASTEPILE

Rocky Mountain Arsenal.
Prepared by: Foster Wheeler Environmental Corporation



Prepared for:

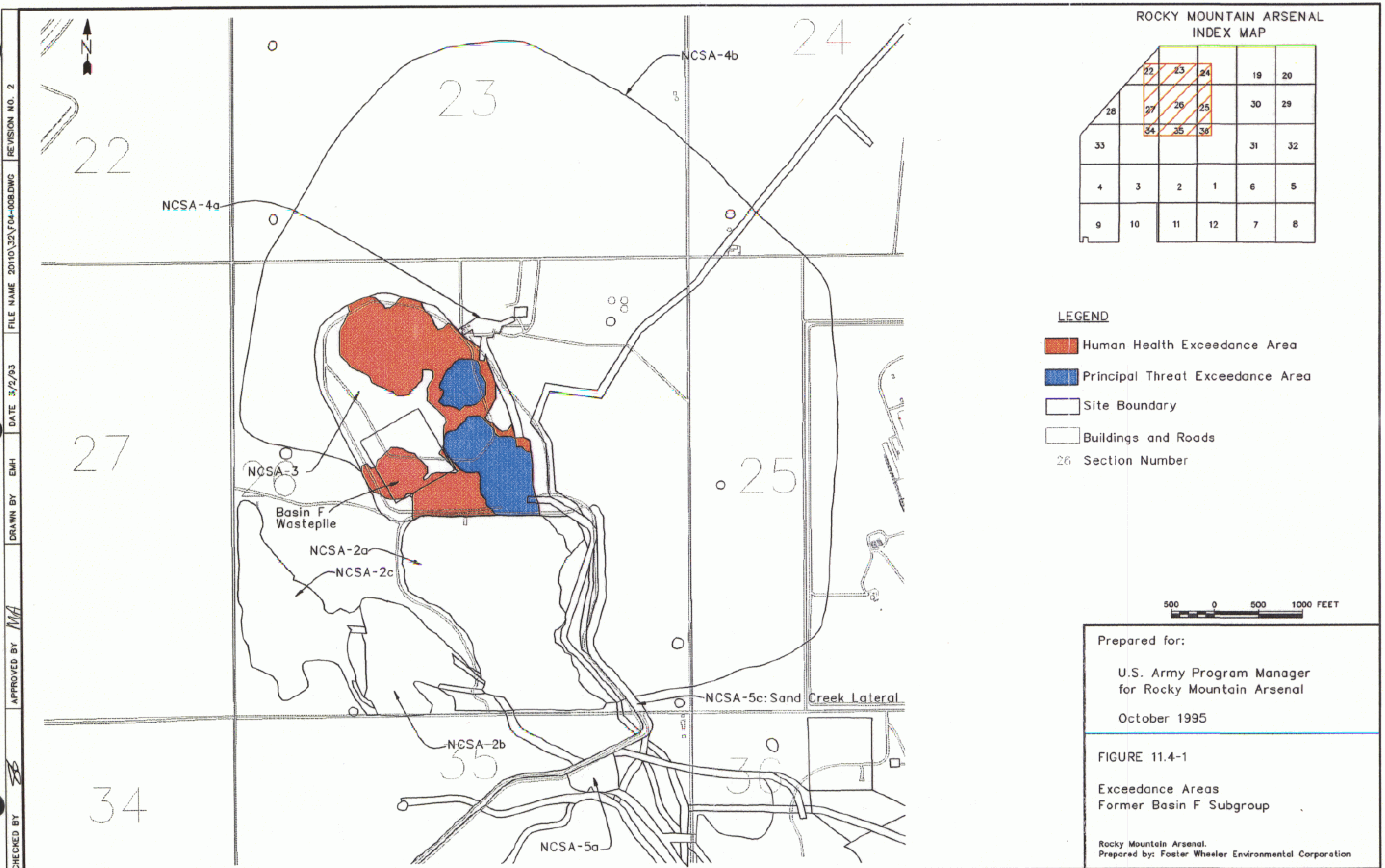
Program Manager for
Rocky Mountain Arsenal
Commerce City, Colorado

FIGURE 11.2-1

COMPOSITE CAP
BASIN F: WASTEPILE

Rocky Mountain Arsenal.
Prepared by: Foster Wheeler Environmental Corporation

9/22/94 MSE 80004/F01-001.DWG



Prepared for:

U.S. Army Program Manager
for Rocky Mountain Arsenal

October 1995

FIGURE 11.4-1

Exceedance Areas
Former Basin F Subgroup

Rocky Mountain Arsenal.
Prepared by: Foster Wheeler Environmental Corporation

Section 12

12.0 DETAILED ANALYSIS OF ALTERNATIVES FOR THE SECONDARY BASINS MEDIUM GROUP

The Secondary Basins Medium Group consists of five sites, four inactive liquid disposal basins (Basins B, C, D, and E) and one site adjacent to the former Basin F site, site NCSA-4a (Deep Disposal Well Facility) (Figure 12.0-1). Based on the contamination patterns, the Basin F Exterior Subgroup, except for site NCSA-4a, was transferred from the Secondary Basins Medium Group to the Surficial Soils Medium Group. For the same reason, site NCSA-3 (the former Basin F site) was transferred to the Basin F Medium Group.

The primary Human Health and Biota COCs present in this medium group are OCPs, which are present at relatively low concentrations (only 16 percent of the exceedance volume consists of human health exceedances, the remainder only consists of biota exceedances). Sites within this medium group are also potential sources of groundwater contamination. Table 12.0-1 presents the characteristics of the medium group, including exceedance volumes and COCs, and Appendix A of Volume IV presents a summary of the volume and area calculations.

In the DSA, alternatives were developed and screened based on the general characteristics of the medium group. In the DAA, the characteristics of the medium group—including contaminant types and concentrations, site configuration, and depth of contamination—were reevaluated to determine which of the alternatives retained in the DSA (EBASCO 1992b) apply. In some cases, the alternatives were modified to account for the treatment of principal threat areas.

The following sections present the characteristics of the medium group, an evaluation of the retained alternatives against the DAA criteria listed in the NCP (EPA 1990a), and the selection of alternatives, based on a comparative analysis, that were considered in the development of the sitewide alternatives (Section 20).

12.1 SECONDARY BASINS MEDIUM GROUP CHARACTERISTICS

The Secondary Basins Medium Group is composed of sites NCSA-2a (Basin C), NCSA-2b (Basin D), NCSA-2c (Basin E), NCSA-5a (Basin B), and NCSA-4a (Deep Disposal Well Facility). The basins contain soil contaminated by infiltrating wastewater that flowed through ditches from Basin A. They are also expected to contain slightly elevated concentrations of salts since they were used to store wastewater with high chloride contents. Contamination at site NCSA-4a is isolated and is the probable result of spills or leaks that occurred during operation of the well in the early 1960s.

Figure 12.1-1 shows the location of the exceedance areas and Table 12.1-1 provides a summary of contaminants, exceedance volume concentrations, and corresponding exceedance criteria. The Human Health SEC are exceeded by maximum concentrations of OCPs at depths ranging from 0 to 10 ft below ground surface. Fewer than 2 percent of the samples for any OCP exceed the Human Health SEC (EBASCO 1994a) (Table 12.1-2). Soil in the 0- to 1-ft depth interval potentially poses risks to biota. Figure 12.1-1 shows the physical configurations of the sites and the distribution of exceedance areas, and Table 12.0-1 lists the exceedance areas and volumes.

Sites in the Secondary Basins Medium Group have been identified as historical sources of groundwater contamination. Basin C has been further identified as the source of a groundwater plume. This plume occurs in the unconfined aquifer and migrates to the northeast from the vicinity of Basins C and F toward the NBCS, where the groundwater is intercepted and treated. The southern limit of the plume appears to be separated from the Basin A Neck Plume by a bedrock ridge, although it is possible that a portion of the Basin A Neck Plume historically migrated and/or may currently be moving through the bedrock into the Basins C and F Plume area at the southern end of Basin C. Therefore, alternatives addressing treatment or containment of the exceedance volume should be evaluated as to how they eliminate further leaching of contamination to the groundwater. Moreover, groundwater alternatives that address improved performance of the NBCS or the addition of individual plume group remediation systems should also be evaluated. Coordination of alternatives developed for the soil medium with those developed for the water medium is limited to source containment or removal rather than eliminating the need for the NBCS altogether. It is unlikely that the NBCS could be shut down following the remediation of this medium group because of the mass loading already in the aquifer.

The habitat at the sites within this medium group contains weedy forbs and areas of disturbed vegetation. Basin B is located on the edge of a prairie dog colony area that is considered a desirable habitat. Under most of the alternatives developed for this medium group, the areas disturbed during remedial actions are revegetated with native grasses in accordance with a refuge management plan. In most instances the overall habitat value is improved, offsetting the short-term loss of habitat that results from remedial actions. The exception is the institutional controls alternative, which includes provisions for modifying the habitat by seeding lower-quality grasses to reduce the desirability of the area for biota. In this instance, the habitat quality is lowered and the available habitat area at RMA is reduced.

12.2 SECONDARY BASINS MEDIUM GROUP EVALUATION OF ALTERNATIVES

The alternatives for the Secondary Basins Medium Group vary in approach from no action to treatment. During the DAA, five modifications were made to alternatives retained for this subgroup. First, the nomenclature was changed to indicate clearly that solidification of inorganics is not required following treatment of organics (e.g., Alternative 13a versus Alternative 13). Second, the slurry-wall component of the containment alternative (Alternative 6) was deleted based on the local hydrogeology and the proximity of the Basin F Groundwater IRA treatment system. Third, the alternative developed to address removal of FC2A (Alternative 9a) was removed from consideration. FC2A is no longer considered a COC as previous detections have been discounted due to analytical interferences. Furthermore, the soil-washing component of the alternative generates a large liquid effluent volume that requires treatment following RCRA regulations. Fourth, one alternative (Alternative 3f) was added to evaluate the consolidation of soil posing potential risk to biota into Basin A prior to capping of the basins, while human health exceedances from the Secondary Basins are placed in a landfill. Finally, one alternative (Alternative 3b) was added to consider the in situ containment of soil posing potential risk to biota after human health exceedances are placed in a landfill.

The following subsections present a description of each alternative and an evaluation of the alternative against the DAA criteria listed in the NCP (EPA 1990a). The alternatives for this medium group consist of a component to address human health exceedances (which is listed first) and a component to address areas that potentially pose risk to biota (the "B" alternative).

12.2.1 Alternative 1/B1: No Additional Action

Alternative 1: No Additional Action (Provisions of FFA), along with Alternative B1: No Additional Action (Provisions of FFA), applies to all 500,000 SY of human health exceedance volume and soil that potentially poses risk to biota. An estimated 170,000 BCY of human health exceedance volume and soil that potentially poses risk to biota remain in place, and no action is taken to reduce human or biota exposure to COCs or to reduce potential groundwater contamination from sites in this group. Long-term monitoring of untreated soil (an average of 66 samples per year), annual groundwater sampling, and 5-year site reviews are conducted to assess natural attenuation/degradation and potential migration of contaminants in the area.

The following discussion presents a detailed evaluation of this alternative against the DAA criteria listed in the NCP (EPA 1990a). For purposes of comparison, Table 12.2-1 summarizes the evaluation of all alternatives developed for this medium group.

12.2.1.1 Overall Protection of Human Health and the Environment

This alternative does not achieve Human Health or Biota RAOs because untreated soil remains in place and controls are not implemented. The toxicity of contaminants can only be reduced by natural attenuation, and impacts on groundwater are not reduced.

12.2.1.2 Compliance With ARARs

This alternative complies with action- and location-specific ARARs because long-term monitoring and site reviews are conducted and because sites in this medium group are not located within wetlands or a 100-year flood plain. This alternative also complies with provisions of the FFA (EPA et al. 1989). (ARARs are listed in Appendix A of the Technology Descriptions Volume.)

12.2.1.3 Long-Term Effectiveness and Permanence

This alternative entails moderate residual risk because OCP concentrations, although low, exceed Human Health SEC (EBASCO 1994a) and because soil posing potential risk to biota remains in place. In addition, potential impacts to groundwater are not reduced. Since no controls are implemented, site reviews, soil monitoring, and groundwater monitoring are required. The existing habitat quality is not changed.

12.2.1.4 Reduction in TMV

Since none of the 170,000 BCY of soil is treated, natural attenuation is the only means by which TMV is reduced. There are no treatment residuals.

12.2.1.5 Short-Term Effectiveness

RAOs are not achieved for more than 30 years. Since there is no remedial action, there are no workers at risk and there is no risk to the community from dust or other emissions. The existing habitat quality is not changed. Natural attenuation is the only process by which a reduction in contamination can be achieved.

12.2.1.6 Implementability

This alternative is technically feasible because there is no action to implement, and administratively feasible because there is no permitting required. Monitoring services for soil and groundwater are readily available.

12.2.1.7 Costs

The total estimated present worth cost of this alternative is $4,550,000 for monitoring and site reviews; no capital and other operating costs are involved. Table B4.4-1 details the costing for this alternative. The cost uncertainty relative to monitoring and site reviews is low.

12.2.2 <u>Alternative 2/B2: Access Restrictions</u>

Alternative 2: Access Restrictions (Modifications to FFA), along with Alternative B2: Biota Management (Exclusion, Habitat Modification), applies to the total area of 500,000 SY where the

Human Health SEC (EBASCO 1994a) are exceeded and where biota face potential risk. The 170,000 BCY of human health exceedance volume and soil that potentially poses risk to biota remain in place, but exposure pathways are interrupted. Human and biota access to the sites is restricted by the installation of a 27,000-ft-long chain-link fence around the perimeter of the site. In addition, the quality of the habitat is reduced, in order to exclude biota, by revegetating the areas with grasses that are unappealing to biota. Habitat modification of 500,000 SY is accomplished over a 3-year period. Long-term activities include maintaining fences, mowing and spot-herbiciding revegetated areas, and monitoring for erosion and vegetation damage. The importance of maintaining and respecting access restrictions to prevent inadvertent exposure is presented in an ongoing public education program. No actions are taken to reduce potential groundwater contamination. Long-term monitoring of untreated soil (an average of 66 samples per year), annual groundwater sampling, and 5-year site reviews are conducted to review the effectiveness of the alternative and to assess natural attenuation/degradation and potential migration of contaminants.

The following discussion presents a detailed evaluation of this alternative against the DAA criteria listed in the NCP (EPA 1990a). For purposes of comparison, Table 12.2-1 summarizes the evaluation of all alternatives developed for this medium group.

12.2.2.1 Overall Protection of Human Health and the Environment

This alternative achieves RAOs by interrupting exposure pathways through access restrictions and biota controls, but the potential for migration of contaminants to groundwater is not reduced. The short-term risk associated with implementing access restrictions is low.

12.2.2.2 Compliance With ARARs

This alternative complies with action- and location-specific ARARs because access to the site is adequately controlled, site reviews are conducted, endangered species are not impacted, and sites are not located within wetlands or a 100-year flood plain. This alternative complies with provisions of the FFA (EPA et al. 1989). (ARARs are listed in Appendix A of the Technology Descriptions Volume.)

12.2.2.3 Long-Term Effectiveness and Permanence

This alternative entails a moderate residual risk. Although fencing, land-use restrictions, and cultivation of lower-quality habitat reduce the potential for human and biota exposure, concentrations of OCPs exceeding the Human Health SEC (EBASCO 1994a) remain in soil, and soil that potentially poses risk to biota remains in place. The controls implemented are adequate, but long-term maintenance, site reviews, groundwater monitoring, and monitoring of wildlife-exclusion areas are required. The habitat at the sites within this medium group is eliminated as a result of the institutional controls enacted.

12.2.2.4 Reduction in TMV

Exposure pathways for humans and biota are interrupted over 500,000 SY through land-use restrictions, fencing, and biota controls, although exposure interruptions are reversible should any of these controls fail. Since none of the 170,000 BCY of soil is treated, the only means by which TMV can be achieved is through natural attenuation. There are no treatment residuals associated with this alternative.

12.2.2.5 Short-Term Effectiveness

This alternative entails low short-term risks to both workers and the community. While fences are installed and lower-quality habitat is cultivated, workers are adequately protected by personal protective equipment. Dust and vapor emissions that could potentially impact the surrounding community are not anticipated. The potential for contaminant migration to groundwater is not reduced through access restrictions. The installation of fencing is completed within several months, but RAOs are not achieved for 3 years while lower-quality habitat is cultivated. Natural attenuation of contaminants is ongoing.

12.2.2.6 Implementability

This alternative is technically feasible because it can be constructed within the required time frame and reliably maintained thereafter. Any additional remedial actions are easily undertaken as well. The alternative is also administratively feasible and there is no permitting required.

Materials, specialists, and equipment are readily available for fence installation and habitat modifications.

12.2.2.7 Costs

The total estimated present worth cost of the alternative is $5,820,000 including $866,000 in capital costs, $187,000 in operating costs, and $4,760,000 in long-term expenditures. Table B4.4-2 details the costing for this alternative. The cost uncertainty associated with implementing the access restrictions is low.

12.2.3 Alternative 3/B3: Landfill

Alternative 3: Landfill (On-Post Landfill), paired with Alternative B3: Landfill (On-Post Landfill), addresses 170,000 BCY of contaminated soil by excavating and placing it in a centralized on-post hazardous waste landfill (Section 4.6.6). Construction of the first cell of the multiple-cell landfill and associated facilities takes 1 year. The landfill area is revegetated following installation of the cover and fencing. The landfill requires annual monitoring, long-term cover maintenance, leachate collection and treatment, and groundwater monitoring. The excavations at the sites are backfilled to existing grade with soil from the on-post borrow area. The uppermost 6 inches of soil are supplemented with conditioners to promote the growth of vegetation. The disturbed area is then revegetated with native grasses. The borrow area is also recontoured and revegetated to restore habitat. Fencing at the landfill excludes biota from that area.

The following discussion presents a detailed evaluation of this alternative against the DAA criteria listed in the NCP (EPA 1990a). For purposes of comparison, Table 12.2-1 summarizes the evaluation of all alternatives developed for this medium group.

12.2.3.1 Overall Protection of Human Health and the Environment

This alternative achieves RAOs through containment in an on-post landfill. Landfilling prevents human and biota exposures and greatly reduces groundwater impacts, but there are short-term impacts associated with excavation of contaminated soil.

12.2.3.2 Compliance with ARARs

This alternative complies with action-specific ARARs including state regulations on landfill siting, design, and operation and impacts on endangered species. Habitat is reduced during excavation, however. Location-specific ARARs are met as no permanent structures are constructed within a 100-year flood plain, and the landfill is not located in wetlands or a 100-year flood plain. Disposal in the landfill does not trigger LDRs since the landfill is a CAMU (as defined in Section 1.4). This alternative complies with the provisions of the FFA (EPA et al. 1989). (ARARs are listed in Appendix A of the Technology Descriptions Volume.)

12.2.3.3 Long-Term Effectiveness and Permanence

The residual risk is minimal since soil that exceeds Human Health SEC or potentially poses risk to biota is removed from the site. There is high confidence in the engineering controls of the landfill and there are no expected difficulties associated with landfill maintenance, although landfill-cell monitoring is required. Habitat quality, which is disturbed during excavation, is restored and improved by revegetation.

12.2.3.4 Reduction in TMV

Although no materials are treated, pathways of exposure are interrupted and the mobility of 170,000 BCY of contaminants is reduced through containment in the landfill. Mobility reduction is irreversible so long as the integrity of the landfill design is maintained. There are no treatment residuals associated with this alternative.

12.2.3.5 Short-Term Effectiveness

This alternative entails moderate risk to workers and the surrounding community during the excavation and transportation of contaminated soil. Personal protective equipment protects workers from physical and chemical hazards, and water sprays control fugitive dust. No other emissions are anticipated. The time frame until RAOs are achieved is 2 years, including 1 year to excavate the 170,000 BCY following 1 year for the construction of the landfill. Since no materials are treated, natural attenuation is the only means by which the toxicity and volume can be reduced.

12.2.3.6 Implementability

The alternative is technically feasible and can be implemented within the required time frame and reliably operated and maintained thereafter with periodic landfill-cell monitoring. Equipment, specialists, and materials are readily available for construction of the landfill, and the landfill technology has been well demonstrated at full scale. Additional remedial actions require removal of the landfill cover. The administrative feasibility associated with permits, performing O&M, and public acceptance is adequate.

12.2.3.7 Cost

The total present worth cost is $9,750,000 including $4,420,000, $5,210,000, and $119,000 for capital, operating, and long-term costs, respectively. Table B4.4-3 details the costing for this alternative. There is moderate uncertainty associated with the costing of this alternative because the quantities and characteristics of material to be excavated and landfilled can only be estimated prior to excavation. However, the shallow nature of contamination reduces the magnitude of this uncertainty.

12.2.4 <u>Alternative 3b/B5: Landfill; Caps/Covers (Soil Cover)</u>

Alternative 3b: Landfill (On-Post Landfill); Caps/Covers (Soil Cover), along with alternative B5: Caps/Covers (Soil Cover) consists of the excavation and disposal of 32,000 BCY of human health exceedance soil in a centralized on-post hazardous waste landfill as well as the containment of 140,000 BCY of soil that may pose potential risk to biota with a soil cover. Construction of the first cell of the multiple-cell landfill and associated facilities takes 1 year. The landfill area is revegetated following installation of the cover and fencing. The landfill requires annual monitoring, long-term cover maintenance, leachate collection and treatment, and groundwater monitoring.

After backfilling the excavations, a soil cover is installed over the entire site (500,000 SY) to contain soils that may pose a risk to biota (Figure 12.2-1). The soil cover consists of a 2-ft-thick layer of common fill (soil from the dikes surrounding these sites will provide 100,00 BCY of fill). The uppermost 6 inches of soil are supplemented with conditioners to promote the growth of vegetation. The disturbed area is then revegetated with native grasses. The borrow area is also recontoured and revegetated to restore habitat.

Fencing at the landfill excludes biota from that area. The soil cover is revegetated with native grasses and the borrow area is also recontoured and revegetated. The types of grasses placed at the site and the maintenance activities performed there are designed to discourage burrowing animals from using the capped area as habitat. Maintenance activities, such as grass mowing and replacement of eroded cover materials, ensure the continued integrity of the soil cover. Five-year site reviews are conducted to review the effectiveness of the alternative and to assess potential migration of contaminants.

The following discussion presents a detailed evaluation of this alternative against the DAA criteria listed in the NCP (EPA 1990a). For purposes of comparison, Table 12.2-1 summarizes the evaluation of all alternatives for this medium group.

12.2.4.1 Overall Protection of Human Health and the Environment

This alternative achieves Human Health and Biota RAOs through the containment of human health exceedance soil in a hazardous waste landfill, as well as the containment of soil that may pose a risk to biota under a soil cover. This alternative is protective of the environment because contaminants are contained, which prevents human or biota exposures. Since some of the contaminated soil is removed and the remaining contamination is contained, the impacts to groundwater are greatly reduced. However, the excavation of the contaminated soil involves short-term impacts that cannot be completely eliminated.

12.2.4.2 Compliance with ARARS

This alternative complies with action-specific ARARs regarding the construction of caps/covers and state regulations on landfill siting, design, and operation. Endangered species are not impacted. The Secondary Basins medium group and the landfill are not located in wetlands or a 100-year flood plain, thus complying with location-specific ARARs. Disposal in the landfill does not trigger LDRs since the landfill is a CAMU (as defined in Section 1.4). This alternative complies with the provisions of the FFA (EPA et al. 1989). (ARARs are listed in Appendix A of the Technology Descriptions Volume.)

12.2.4.3 Long-Term Effectiveness and Permanence

The residual risk associated with this alternative is minimal since higher levels of contamination are removed from the site and contained in a hazardous waste landfill, and the soil that poses risks to biota is contained in place. There is high confidence in the reliability of the landfill and soil cover engineering controls, and there are no difficulties associated with maintenance. The integrity of the controls for the landfill is ensured through long-term monitoring. In addition, 5-year site reviews and soil cover-maintenance operations are conducted to ensure the effectiveness of controls. The habitat quality is improved through revegetation, although the types of grasses and maintenance activities performed are designed to discourage burrowing animals from using the covered area as habitat.

12.2.4.4 Reduction in TMV

Although no materials are treated, pathways of exposure are interrupted and the mobility of 170,000 BCY of contaminants is reduced through containment in the landfill and installation of the soil cover. The mobility reduction is irreversible so long as the integrity of the landfill and soil cover are maintained. Since the contaminated soil is not treated, the only reduction in toxicity or volume is through natural attenuation. There are no treatment residuals associated with this alternative.

12.2.4.5 Short-Term Effectiveness

While the short term risk associated with capping is low, there is some risk to workers and the surrounding community during the excavation of contaminated soil. These risks are reduced through engineering controls and personal protective equipment, but they cannot be completely removed. Personal protective equipment protects workers from physical and chemical hazards, and water sprays control fugitive dust. Vapor emissions are not anticipated. The time frame until RAOs are achieved is 2 years. Excavation of the 32,000 BCY of human health exceedance soil and installation of the 40,000-SY soil cover is feasible within 1 year, following 1 year for the construction of the landfill.

12.2.4.6 Implementability

The alternative is technically feasible and can be implemented within the required time frame and reliably operated and maintained thereafter with periodic landfill cell monitoring. Additional future remedial actions can be undertaken for soil left in place, although the cover adds to the overall site volume. Additional remedial actions for the landfilled soil also involve removal of the landfill cover. The substantive requirements associated with Subtitle C siting, design, and operating regulations are achieved. Equipment, specialists, and materials are readily available for landfill and soil cover construction. The technologies have been well demonstrated at full scale.

12.2.4.7 Cost

The total present worth cost is $8,550,000 including $832,000, $6,320,000, and $1,400,000, for capital, operating, and long-term costs, respectively. Table B4.1-3b details the costing for this alternative. There is a low level of uncertainty associated with the costing of this alternative. The materials required to construct the cover are available on post and the area to be covered is well defined. Furthermore, the volume of soil excavated is small, which reduces the magnitude of uncertainties associated with estimating the quantities and characteristics of soil prior to excavation.

12.2.5 Alternative 3f/B5a: Landfill; Caps/Covers with Consolidation

Alternative 3f: Landfill (On-Post Landfill); Caps/Covers (Multilayer Cap) with Consolidation, along with Alternative B5a: Caps/Covers (Multilayered Cap) with Consolidation, addresses the soil with human health exceedances and soil that potentially poses risk to biota through containment. The human health exceedance soil, 32,000 BCY, is placed in a centralized on-post hazardous waste landfill (Section 4.6.6). Construction of the first cell of the multiple-cell landfill and associated facilities takes 1 year. The landfill area is revegetated following installation of the cover and fencing. The landfill requires annual monitoring, long-term cover maintenance, leachate collection and treatment, and groundwater monitoring.

The less contaminated soils which pose a potential risk to biota (140,000 BCY) are consolidated as gradefill in Basin A prior to containment with a multilayer cap. (Section 4.6.14 discusses multilayer caps in detail.) As discussed in Section 10.2, the containment of Basin A requires a large amount of gradefill to achieve the design grade of 3 to 5 percent. Excavating soil from areas with low levels of contamination (i.e., Secondary Basins) and consolidating the soil in areas of higher contamination, such as Basin A, helps meet the requirement for gradefill to achieve a cap design of 3 to 5 percent and reduces the overall impact on the large borrow area at RMA (compared to a landfilling alternative).

The site excavations are backfilled with soil from the dikes surrounding the basins and clean borrow material from the on-post borrow area, and the uppermost 6 inches of soil are supplemented with conditioners to promote the growth of vegetation. Site remediation is completed by revegetation with native grasses. The borrow area is also recontoured and revegetated. No maintenance activities are required at the site because all of the soil that exceeds the Human Health SEC or that potentially poses risk to biota is removed.

The following discussion presents a detailed evaluation of this alternative against the DAA criteria listed in the NCP (EPA 1990a). For purposes of comparison, Table 12.2-1 summarizes the evaluation of all of the alternatives developed for the Secondary Basin Medium group.

12.2.5.1 Overall Protection of Human Health and the Environment

This alternative is protective of human health and the environment. RAOs are achieved because contaminated soil is excavated and contained. The impacts to groundwater are greatly reduced by removing the contaminated soil from the Secondary Basins medium group. There are some short-term risks associated with excavating contaminated soil.

12.2.5.2 Compliance With ARARs

This alternative complies with action-specific ARARs that apply to state regulations on landfill siting, design, and operation, the construction of covers and the monitoring of contained material. The Secondary Basins Medium Group, Basin A, and the landfill are not located within wetlands or a 100-year flood plain, thus complying with location-specific ARARs. Disposal in the landfill doe snot trigger LDRs since the landfill is a CAMU, and consolidation to Basin A does not trigger LDRs since all sites in this medium group are located within the on-post AOC (as defined in Section 1.4). Materials within the consolidation volume may be landfilled based on visual observations such as soil stains, barrels, or newly-discovered evidence of contamination; this landfill volume will be part of the 150,000 CY contingent volume. The alternative also complies with provisions of the FFA (EPA et al. 1989) and regulations pertaining to protection of endangered species. (ARARs are listed in Appendix A of the Technology Descriptions Volume.)

12.2.5.3 Long-Term Effectiveness and Permanence

Soil that exceeds the Human Health SEC or potentially poses risk to biota is removed from the site, so residual risk at the site is minimal. Long-term groundwater monitoring and site reviews are required as part of the consolidation alternative in Basin A, but the controls are adequate and there is high confidence in the design and controls for the cap. There is high confidence in the engineering controls for the landfill and there and no expected difficulties associated with landfill maintenance, although landfill-cell monitoring is required. Habitat quality at the site is improved by revegetation, offsetting losses from excavation.

12.2.5.4 Reduction in TMV

Exposure pathways are interrupted and mobility is reduced for 170,000 BCY by containment in the landfill and consolidation and containment in Basin A. Mobility reduction is irreversible so long as the integrity of the landfill, and the Basin A cap, are maintained. Since no materials are treated, natural attenuation is the only means by which the toxicity and volume can be reduced. There are no treatment residuals since there is no treatment.

12.2.5.5 Short-Term Effectiveness

This alternative entails low risk to workers and the community during the excavation and transport of soil. These risks are mitigated by personal protective equipment for workers and water sprays to control fugitive dust. Vapor emissions are not anticipated. The environmental impacts of the alternative are minimal since the existing habitat is less desirable. The time frame until RAOs are achieved is 2 years, including the 1 year required to move the 170,000 BCY of soil to Basin A and the landfill, following 1 year for the construction of the landfill.

12.2.5.6 Implementability

This alternative is technically feasible and has been well demonstrated at full scale. The alternative can be implemented within the required time frame and reliably maintained thereafter. Additional remedial actions are easily undertaken, but the cap adds to the overall site volume in Basin A. The alternative is administratively feasible because the hazardous waste landfill meets Subtitle C design requirements and construction regulations. The alternative is easily implemented because of the availability of equipment, specialists, and materials.

12.2.5.7 Costs

The total estimated present worth cost of this alternative is $5,760,000, including $832,000, $4,910,000, and $22,000 for capital, operating, and long-term costs, respectively. Table B4.4-3f details the costing for this alternative. There is a moderate uncertainty associated with the cost of this alternative because the quantities and characteristics of materials to be excavated can only be estimated prior to excavation. However, the shallow depths at which the contamination is present reduce the magnitude of this uncertainty.

12.2.6 Alternative 6/B5: Caps/Covers

Alternative 6: Caps/Covers (Multilayer Cap), in combination with Alternative B5: Caps/Covers (Multilayer Cap), involves the installation of a 500,000-SY, multilayer cap to contain areas with human health exceedances and soil that potentially poses a risk to biota. (Section 4.6.14 discusses low-permeability soil caps in detail.) The subgrade is compacted before any cover materials are installed and crowned with common fill and soil to achieve the design grade of 3 to 5 percent. Approximately 2,800,000 BCY of soil are needed as gradefill, of which 100,000 BCY consist of soil from the dikes that surround these sites. (The dikes need to be removed to prevent the ponding of water on the capped area.) The on-post borrow area supplies the 2,800,000 BCY of gradefill and most of the materials for the cap. The multilayer cap consists of a 2-ft-thick layer of compacted low-permeability soil, a 1-ft-thick biota barrier of crushed concrete, and a 4-ft-thick soil/vegetation layer that includes 6 inches of reconditioned soil. The cap is revegetated with native grasses and the borrow area is also recontoured and revegetated. The types of grasses placed at the site and the maintenance activities performed are designed to discourage burrowing animals from using the capped area as habitat. Maintenance activities, such as grass mowing and replacement of eroded cap materials, ensure the continued integrity of the soil cover. Five-year site reviews and annual groundwater sampling are conducted to review the effectiveness of the alternative and to assess potential migration of contaminants.

The following discussion presents a detailed evaluation of this alternative against the DAA criteria listed in the NCP (EPA 1990a). For purposes of comparison, Table 12.2-1 summarizes the evaluation of all alternatives developed for this medium group.

12.2.6.1 Overall Protection of Human Health and the Environment

This alternative is protective of human health and the environment because RAOs are achieved by containing contaminated soil and preventing human and biota exposures. The impacts of contaminated soil on groundwater are greatly reduced because rainwater infiltration through the capped area to the groundwater below is reduced. The short-term risks associated with installation of the cap are low.

12.2.6.2 Compliance With ARARs

This alternative complies with the action-specific ARARs that apply to the construction of covers and the monitoring of contained material. The alternative also complies with location-specific ARARs since sites in the medium group are not located within wetlands or a 100-year flood plain. Endangered species are not impacted, and the alternative complies with the provisions of the FFA. (EPA et al. 1989) (ARARs are listed in Appendix A of the Technology Descriptions Volume.)

12.2.6.3 Long-Term Effectiveness and Permanence

This alternative entails a minimal residual risk since the 170,000 BCY of untreated soil are contained by a 500,000-SY multilayer cap in which there is high confidence for the engineering and controls. The habitat quality is improved by revegetation, although the types of grasses placed at the site and maintenance activities performed are designed to discourage burrowing animals from using the capped area as habitat. Long-term monitoring and site reviews are required, as are erosion control and vegetative maintenance.

12.2.6.4 Reduction in TMV

Exposure pathways are interrupted and mobility is reduced for 170,000 BCY of contaminated soil by containment, and is only reversible should the cap degrade or leak. Since no materials are treated, the toxicity and volume are only reduced by natural attenuation. There are no treatment residuals associated with this alternative.

12.2.6.5 Short-Term Effectiveness

The short term risk associated with capping is minimal. Personal protective equipment adequately protects workers during cap installation, and the surrounding community is protected from fugitive dust from uncontaminated soil from gradefill and cap construction by water sprays. Vapor emissions are not anticipated. Impacts to the environment are minimal. Disturbed areas are revegetated, although the types of grasses placed at the site and maintenance activities performed are designed to discourage burrowing animals from using the capped area as habitat.

RAOs are achieved after the 2-year time frame required to install the cap. Natural attenuation of untreated soil is ongoing.

12.2.6.6 Implementability

This alternative is technically feasible and has been well demonstrated at full scale. Construction is feasible within the required time frame and the cap is reliably maintained thereafter. Additional remedial actions are easily undertaken for the soils left in place, although the cap adds to the overall site volume. The alternative is administratively feasible because it meets Subtitle C design and construction requirements for caps/covers, and is easily implemented since materials, specialists, and equipment are readily available for cap construction.

12.2.6.7 Costs

The total estimated present worth cost of this alternative is $50,500,000, which includes 48,400,00 and 2,120,000 for capital operating costs and long-term expenditures, respectively. Table B4.4-6 details the costing for this alternative. There is a low level of uncertainty associated with the costing of this alternative because the materials required to construct the cap are available on post and the area to be capped is well defined (i.e., the uncertainty commonly associated with excavation does not exist).

12.2.7 Alternative 13a/B3: Direct Thermal Desorption

Alternative 13a: Direct Thermal Desorption (Direct Heating), combined with Alternative B3: Landfill (On-Post Landfill), treats 32,000 BCY of soil with human health exceedances and contains 140,000 BCY of soil that may pose a potential risk to biota in the on-post hazardous waste landfill.

The human health exceedance volume is excavated and transported to the centralized thermal desorption facility for treatment. (Section 4.6.24 discusses the details of thermal desorption.) The facility takes approximately 1 year to build and requires an additional year for testing before soil can be processed. For soil from this medium group, the thermal desorber has a processing rate of approximately 2,000 BCY/day, operating with a soil discharge temperature of 300°C and a residence time of 30 minutes. (Section 4.6.24 discusses emission controls for off gases from thermal desorption.) Approximately 1 percent of the total soil feed (320 BCY) is recovered as particulates from scrubber blowdown and is disposed into the on-post hazardous waste landfill. The treated soil is returned to the site excavations and used as backfill. Since thermal desorption destroys the natural organic content of the soil, the uppermost 6 inches of soil over the backfilled area of 92,000 SY are supplemented with conditioners and revegetated with native grasses.

The soil posing a potential risk to biota, 140,000 BCY, is excavated and placed in the on-post hazardous waste landfill (see Section 4.6.6 for a complete description of landfill construction). Construction of the first cell of the multiple-cell landfill and associated facilities takes 1 year. The landfill area is revegetated following installation of the cover and fencing. The landfill requires annual monitoring, long-term cover maintenance, leachate collection and treatment, and groundwater monitoring. The biota excavations at the site are backfilled to existing grade with soil from the dikes surrounding the basins and from the on-post borrow area. As with the thermally desorbed soil, the uppermost 6 inches of soil over the backfilled area of 410,000 SY are supplemented with conditioners and revegetated with native grasses. The borrow area is also recontoured and revegetated to restore habitat. Fencing at the landfill excludes biota from that area.

The following discussion presents a detailed evaluation of this alternative against the DAA criteria listed in the NCP (EPA 1990a). For purposes of comparison, Table 12.2-1 summarizes the evaluation of all of the alternatives developed for the Secondary Basins Medium Group.

12.2.7.1 Overall Protection of Human Health and the Environment

This alternative achieves both Human Health and Biota RAOs since human health exceedance soil is treated to remove or destroy the COCs and soil that poses potential risk to biota is removed and contained. Migration of contaminants to groundwater is eliminated by the thermal treatment and containment. There are short-term risks associated with excavation and thermal desorption of contaminated soil.

12.2.7.2 Compliance With ARARs

This alternative complies with action-specific ARARs including state regulations on air emission sources and the siting, design, and operation of a landfill. Sites within the medium group, the thermal desorption facility, and the landfill are not located within wetlands or a 100-year flood plain, thus complying with location-specific ARARs. Endangered species are not impacted. The alternative also complies with provisions of the FFA (EPA et al. 1989). (ARARs are listed in Appendix A of the Technology Descriptions Volume.)

12.2.7.3 Long-Term Effectiveness and Permanence

The residual risks are minimal since PRGs are achieved for the human health exceedance soil through treatment and soil that potentially poses risk to biota is removed and contained. The treated soil is returned to the site after treatment. Approximately 1 percent of the solids feed is recovered from the off-gas treatment equipment and placed in the on-post landfill, which is maintained with no difficulty. The habitat quality is improved by revegetation following backfill of the excavated soil, offsetting losses to habitat incurred as a result of excavation.

12.2.7.4 Reduction in TMV

In the 32,000 BCY of thermally desorbed soil, organics are treated to detection levels or >99.99 percent DRE. TMV reduction by thermal desorption is irreversible. Treatment residuals include 320 BCY of blowdown solids and salts that are landfilled on post. Mobility is reduced for the 140,000 BCY of landfilled soil.

12.2.7.5 Short-Term Effectiveness

This alternative entails moderate short-term risks associated with excavation, transportation, and thermal desorption of contaminated soil. These risks are addressed through personal protective equipment and dust controls such as water sprays. In addition, the preparation of the feedstock prior to thermal desorption presents short-term risks, although the materials handling is conducted in an enclosed building to control dust. Emissions from the thermal desorber contain low but acceptable levels of some contaminants, although the off-gas control system for the thermal desorber is designed to achieve air quality standards. The environmental impacts are minimal;

the disturbed areas are revegetated and potential migration of contaminants to groundwater is reduced. The thermal desorption facility and landfill take 2 years to construct after which excavation, transportation, and treatment of the 32,000 BCY of soil takes 1 year. Landfilling of 140,000 BCY is feasible within 1 year. RAOs are achieved after 3 years.

12.2.7.6 Implementability

Thermal desorption is widely available and has been used to treat similar contamination; however, the technology has not been demonstrated at the scale required for RMA. The thermal desorption facility can be constructed within the required time frame and should be reliably operated for the contaminants and levels of contamination in the soil feed, although material handling and elevated levels of salts may cause operational problems. Administrative difficulties associated with demonstrating compliance with permits and performing O&M may lead to delays, and it may be difficult to implement this alternative due to the public perceptions regarding the safety of thermal treatment. Several sources of vendors are available for design and construction of the landfill, and equipment, specialists, and materials are readily available for landfill construction.

12.2.7.7 Costs

The total estimated present worth cost of this alternative is \$10,800,000 including \$4,410,000, \$6,340,000, \$92,000 for capital, operating, and long-term costs, respectively. Table B4.4-13a details the costing for this alternative.

There are two uncertainties associated with the costing of this alternative. First, the extent and depth of contamination are not fully delineated. Second, the elevated concentrations of salts in the feedstock and the need for materials handling significantly increase uncertainties relative to maintaining the assumed on-line percentage of the thermal desorption unit. These operating conditions are not typical of previous thermal desorption projects, and may result in changes in maintenance requirements or delays in implementation, both of which may impact treatment costs. However, the overall magnitude of these uncertainties is small based on the relatively shallow nature of contamination and the small volume and low level of contamination to be treated.

12.2.8 Alternative 19a/B3: In Situ Thermal Treatment

Alternative 19a: In Situ Thermal Treatment (RF/Microwave Heating), combined with Alternative B3: Landfill (On-Post Landfill), addresses 32,000 BCY of soil with human health exceedances by RF heating and 140,000 BCY of soil that potentially poses a risk to biota by landfilling. (Sections 4.6.6 and 4.6.31 discuss landfills and RF heating in detail.) RF heating mobilizes the organic contaminants by raising the temperature of the soil to more than 250°C. The mobilized contaminants are collected and treated in the off-gas treatment system as described in Section 4.6.31. The RF heating unit treats a 100-ft-long, 48-ft-wide, 10-ft-deep block of soil. Assuming a moisture content of approximately 10 percent, the treatment rate is 128 BCY/day. The liquid sidestream from in situ heating, which contains predominantly salts, is transported to the thermal desorption facility for treatment in the evaporator. The uppermost 6 inches of soil over the treated human health area, 92,000 SY, are supplemented with conditioners to provide a growth medium for vegetation. The treated area is then revegetated with native grasses.

The soil posing a potential risk to biota, 140,000 BCY, is excavated and placed in the on-post hazardous waste landfill. Construction of the first cell of the landfill and associated facilities takes 1 year. The landfill area is revegetated following installation of the cover and fencing. The landfill requires annual monitoring, long-term cover maintenance, leachate collection and treatment, and groundwater monitoring. The biota excavations at the site are backfilled to existing grade with soil from the dikes surrounding the basins and from the on-post borrow area. The borrow area is also recontoured and revegetated to restore habitat. Fencing at the landfill excludes biota from that area.

The following discussion presents a detailed evaluation of this alternative against the DAA criteria listed in the NCP (EPA 1990a). For purposes of comparison, Table 12.2-1 summarizes the evaluation of all of the alternatives developed for the Secondary Basins Medium Group.

12.2.8.1 Overall Protection of Human Health and the Environment

RF microwave heating does not achieve Human Health RAOs as residual contamination remains after treatment. Biota RAOs are achieved as 140,000 BCY of soil that potentially pose risk to biota are removed from the site and landfilled. The potential for migration of contaminants to groundwater is reduced by treatment of the contaminated soil and containment. There are short-term risks associated with excavation and in situ treatment.

12.2.8.2 Compliance with ARARs

This alternative complies with action-specific ARARs, including state regulations on air emissions sources and regulations pertaining to endangered species. Sites within this medium group and the landfill are not located within wetlands or a 100-year flood plain, thus complying with location-specific ARARs. The alternative also complies with provisions of the FFA (EPA et al. 1989). (ARARs are listed in Appendix A of the Technology Descriptions Volume.)

12.2.8.3 Long-Term Effectiveness and Permanence

The residual risk is low since the soil is treated to near Human Health PRGs and soil that potentially poses risk to biota is removed and landfilled. Although all of the 32,000 BCY of human health exceedance soil are treated in place and the OCP contamination is reduced to within acceptable concentrations, PRGs are not achieved and some residual risk remains. Monitoring and controls are not required, and the habitat quality is improved by revegetation. Residual risk to biota remains.

12.2.8.4 Reduction in TMV

RF/microwave heating can theoretically achieve Human Health and Biota RAOs with low residual risk since OCPs can be driven from the soil by this form of in situ thermal treatment. However, the pilot-scale test of the RF technology at RMA, as described in the Technology Descriptions Volume, (Section 8.2.1) failed to confirm the temperature distribution and OCP-removal efficiencies required for confident treatment of soil to achieve PRGs. TMV reduction by in situ RF/microwave heating is irreversible. Mobility is reduced for the 140,000 BCY of landfilled soil.

12.2.7.5 Short-Term Effectiveness

This alternative entails moderate risks to workers and the community because 140,000 BCY of contaminated soil are excavated and transported after 32,000 BCY are treated in place. The short-term risks associated with the excavation and transport of contaminated soil are controlled through personal protective equipment and dust controls such as water sprays. The in situ thermal treatment of soil also entails short-term impacts. Although the off-gas control system for in situ heating is designed to achieve air quality standards, the emissions from the in situ heating unit contain low levels of the contaminants removed from the soil. Impacts on the environment are minimal since the existing habitat quality is improved following treatment and migration of contaminants to groundwater is reduced. The treatment of 32,000 BCY of contaminated soil is feasible within 1 year after 2 years to construct the heating system, and landfilling of 140,000 BCY is feasible within 1 year after 1 year for construction of the landfill.

12.2.7.6 Implementability

In situ thermal heating is currently not implementable because no full-scale units have been constructed or demonstrated. The technology was demonstrated at pilot-scale at RMA, but several problems regarding the durability of the equipment were identified. In addition, administrative difficulties associated with demonstrating compliance with permits and performing O&M may lead to delays, and it may be difficult to implement this alternative due to public perceptions regarding the safety of in situ thermal treatment and the thermal treatment portion of the off-gas control system. The landfill portion of the alternative achieves substantive requirements of Subtitle C landfill siting, design, and operation regulations.

12.2.7.7 Costs

The total estimated present worth cost of this alternative is $31,600,000, including $17,500,000 and $14,100,000 for capital and operating costs, respectively. Table B4.4-19a details the costing for this alternative.

There are two significant uncertainties associated with the costing of this alternative. First, there are no full-scale demonstrations of the in situ heating technology at other hazardous waste sites to provide documentation of actual construction and operational costs. This uncertainty is especially noteworthy because the pilot-scale demonstration of the technology at RMA indicated there were potential problems regarding the durability of the equipment. Second, the lack of full-scale implementation data increases uncertainties relative to maintaining the assumed on-line percentage of the heating unit. The level and depth of contamination at RMA may result in changes in treatment times or delays in implementation, both of which may impact treatment costs.

12.3 COMPARATIVE ANALYSIS OF ALTERNATIVES

The Secondary Basins Medium Group contains approximately 170,000 BCY of soil predominantly contaminated with OCPs. This contamination resulted primarily from infiltrating wastewater that flowed through ditches from Basin A, so the contamination patterns in the basins are relatively homogeneous compared to the heterogenous contamination in the disposal trench and spill sites. Contamination at site NSCA-4a probably resulted from spills or leaks during the operation of that facility. Fewer than 2 percent of the OCP samples exceed the Human Health SEC (Table 12.1-2). The sites in this medium group represent a relatively low risk to human health as the average concentrations of individual OCPs in the human health exceedance volume are about equal to the Human Health SEC (EBASCO 1994a) (Table 12.1-1).

In general, the habitat at the sites within this medium group contains weedy forbs or areas of disturbed vegetation, although Basin B is located on the edge of a prairie dog colony area that is considered to be a desirable habitat. Remedial actions that disturb the existing habitat include revegetation following remediation. In most instances, the overall habitat value is improved, offsetting the short-term loss of habitat incurred during remedial actions.

Alternatives that involve excavation of human health exceedances require protection for site workers during remedial activities, but the short-term risk to workers is minimal with the use of proper personal protective equipment. The degree of contamination in sites in this medium group does not necessitate special measures for odor control or community protection during remedial activities.

In summary, the Secondary Basins Medium Group contains soil that exceeds the Human Health SEC and soil with low levels of contamination that potentially poses risk to biota. Habitat impacts and community protection are not significant factors for consideration in retaining alternatives for this medium group.

Alternative 1: No Additional Action (Provisions of FFA) does not achieve Human Health or Biota RAOs as contaminated and uncontained soil remain without controls being initiated, so it was eliminated from further consideration. Alternative 19a: In Situ Thermal Treatment is not capable of achieving RAOs based on the pilot-scale treatability studies at RMA. In addition, the in situ thermal treatment process is not yet available for full-scale operation. Accordingly, this alternative was not retained. The remaining six alternatives achieve RAOs and achieve the two threshold criteria, protection of human health and the environment and compliance with action- and location-specific ARARs. The alternatives are distinguished by how well they meet the five balancing criteria.

Of the protective alternatives, Alternative 2/B2: Access Restrictions has one of the lowest cost (other than no additional action and Alternative 3f: Caps/Covers with Consolidation) ($5,820,000), but is the least protective since contaminants remain in place, untreated and uncontained. In addition, the alternative results in the removal of 500,000 SY for use as habitat. Alternative 2 requires more than 3 years in order to effectively modify the habitat and protect biota. Alternative 2 was not retained based on the residual risks.

Alternative 13a/B3: Direct Thermal Desorption manages low concentrations of contamination through a costly treatment process that achieves PRGs and containment of the remaining contamination. Since the alternative ultimately relies on containment, the risk reduction gained by thermal desorption does not warrant its higher cost compared to landfilling or landfilling/capping alternatives. This alternative was therefore not retained.

Alternative 3: Landfill, Alternative 3b: Landfill; Caps/Covers, Alternative 3f/B5a: Landfill; Caps/Covers with Consolidation and Alternative 6/B5: Caps/Covers, and exhibit similar levels of effectiveness. They all achieve RAOs and reduce exposure pathways and groundwater contamination through engineering controls. All four alternatives improve habitat and result in minimal residual risk at the site. All involve technologies that have been well proven at full scale and can be implemented within relatively short time frames.

Consequently, the alternatives that were retained to represent the Secondary Basins Medium Group in the development of the sitewide alternatives (Section 20) are the following:

- Alternative 3: Landfill (On-Post Landfill)
- Alternative 3b: Landfill (On-Post Landfill); Caps/Covers (Soil Cover or Multilayer Cap)
- Alternative 6/B5: Caps/Covers (Multilayer Cap)

Table 12.0–1 Characteristics of the Secondary Basins Medium Group

Characteristic	Secondary Basins Subgroup
Contaminants of Concern	
Human Health	OCPs, Cr
Biota	OCPs, As, Hg
Exceedance Areas (SY)	
Total	500,000
Human Health	92,000
Principal Threat	0
Biota	410,000
Potential Agent	not applicable
Potential UXO	not applicable
Exceedance Volume (BCY)	
Total	170,000
Human Health	32,000
Organic	31,000
Inorganic	100
Principal Threat	0
Biota	140,000
Depth of Contamination (ft)	
Human Health	0–10
Biota	0-1

Table 12.1-1 Summary of Concentrations for the Secondary Basins Medium Group

Contaminants of Concern	Range of Concentrations[1] (ppm)	Average Concentration[1] (ppm)	Human Health SEC (ppm)	Human Health Principal Threat Criteria (ppm)	Human Health Acute Criteria (ppm)
Human Health Exceedance Volume					
Aldrin	BCRL–180	21.6	71	720	3.8
Dieldrin	BCRL–120	28.2	41	410	3.7
Chlordane	BCRL–3.0	0.68	55	3,700	12
Endrin[2]	BCRL–8.4	2.1	230,000	230,000	56
Chromium[3]	BCRL-120	—	39	7.500	NA
Arsenic[2]	BCRL–140	9.8	420	4,200	270
Mercury[2]	BCRL–1.6	0.17	570	570,000	82
Biota Volume					
Aldrin	BCRL–2.7	0.08			
Dieldrin	BCRL–3.4	0.69			
Endrin	BCRL–0.57	0.07			
p,p,DDE	BCRL–1.0	0.006			
Arsenic	BCRL–56	10			
Mercury	BCRL–0.23	0.086			

1 Based on modeled concentrations within the human health exceedance volume or potential biota risk area.
2 Presents biota risk, but was detected in the human health exceedance volume.
3 Present above human health criteria in site NCSA-4a only. Summary presented for this site.

Table 12.1-2 Frequency of Detections for Secondary Basins Medium Group

	Total Samples	BCRL		CRL-SEC(1)		Acute-HH SEC(2)		HH SEC-Pr. Threat(2)		>Pr. Threat(2)	
	Analyzed	Number	%	Number	%	Number	%	Number	%	Number	%
Aldrin	1520	641	42.2%	829	54.5%	47	3.1%	3	0.2%	0	0.0%
Benzene	189	189	100.0%	0	0.0%	--	--	0	0.0%	0	0.0%
Carbon Tetrachloride	168	168	100.0%	0	0.0%	--	--	0	0.0%	0	0.0%
Chlordane	1466	1339	91.3%	127	8.7%	0	0.0%	0	0.0%	0	0.0%
Chloroacetic Acid	210	209	99.5%	1	0.5%	--	--	0	0.0%	0	0.0%
Chlorobenzene	164	164	100.0%	0	0.0%	--	--	0	0.0%	0	0.0%
Chloroform	168	168	100.0%	0	0.0%	--	--	0	0.0%	0	0.0%
p,p,DDE	1532	1473	96.1%	59	3.9%	--	--	0	0.0%	0	0.0%
p,p,DDT	1528	1466	95.9%	62	4.1%	0	0.0%	0	0.0%	0	0.0%
Dibromochloropropane	378	377	99.7%	1	0.3%	--	--	0	0.0%	0	0.0%
1,2-Dichloroethane	168	168	100.0%	0	0.0%	--	--	0	0.0%	0	0.0%
Dicyclopentadiene	354	354	100.0%	0	0.0%	--	--	0	0.0%	0	0.0%
Dieldrin	1514	405	26.8%	942	62.2%	149	9.8%	18	1.2%	0	0.0%
Endrin	1509	673	44.6%	836	55.4%	0	0.0%	0	0.0%	0	0.0%
Hexachlorocyclopentadiene	1469	1447	98.5%	22	1.5%	--	--	0	0.0%	0	0.0%
Isodrin	1531	1363	89.0%	168	11.0%	--	--	0	0.0%	0	0.0%
Methylene Chloride	107	92	86.0%	14	13.1%	--	--	0	0.0%	0	0.0%
Tetrachloroethylene	168	166	98.8%	2	1.2%	--	--	0	0.0%	0	0.0%
Toluene	189	189	100.0%	0	0.0%	--	--	0	0.0%	0	0.0%
Trichloroethylene	168	168	100.0%	0	0.0%	--	--	0	0.0%	0	0.0%
Arsenic	638	334	52.4%	304	47.6%	0	0.0%	0	0.0%	0	0.0%
Cadmium	504	450	89.3%	54	10.7%	0	0.0%	0	0.0%	0	0.0%
Chromium	504	85	16.9%	417	82.7%	--	--	2	0.4%	0	0.0%
Lead	504	372	73.8%	132	26.2%	--	--	0	0.0%	0	0.0%
Mercury	500	411	82.2%	89	17.8%	0	0.0%	0	0.0%	0	0.0%

(1) SEC limits for this interval are based on chronic HH SEC, or where appropriate, acute risk-based criteria for the 0- to 1-ft depth interval.

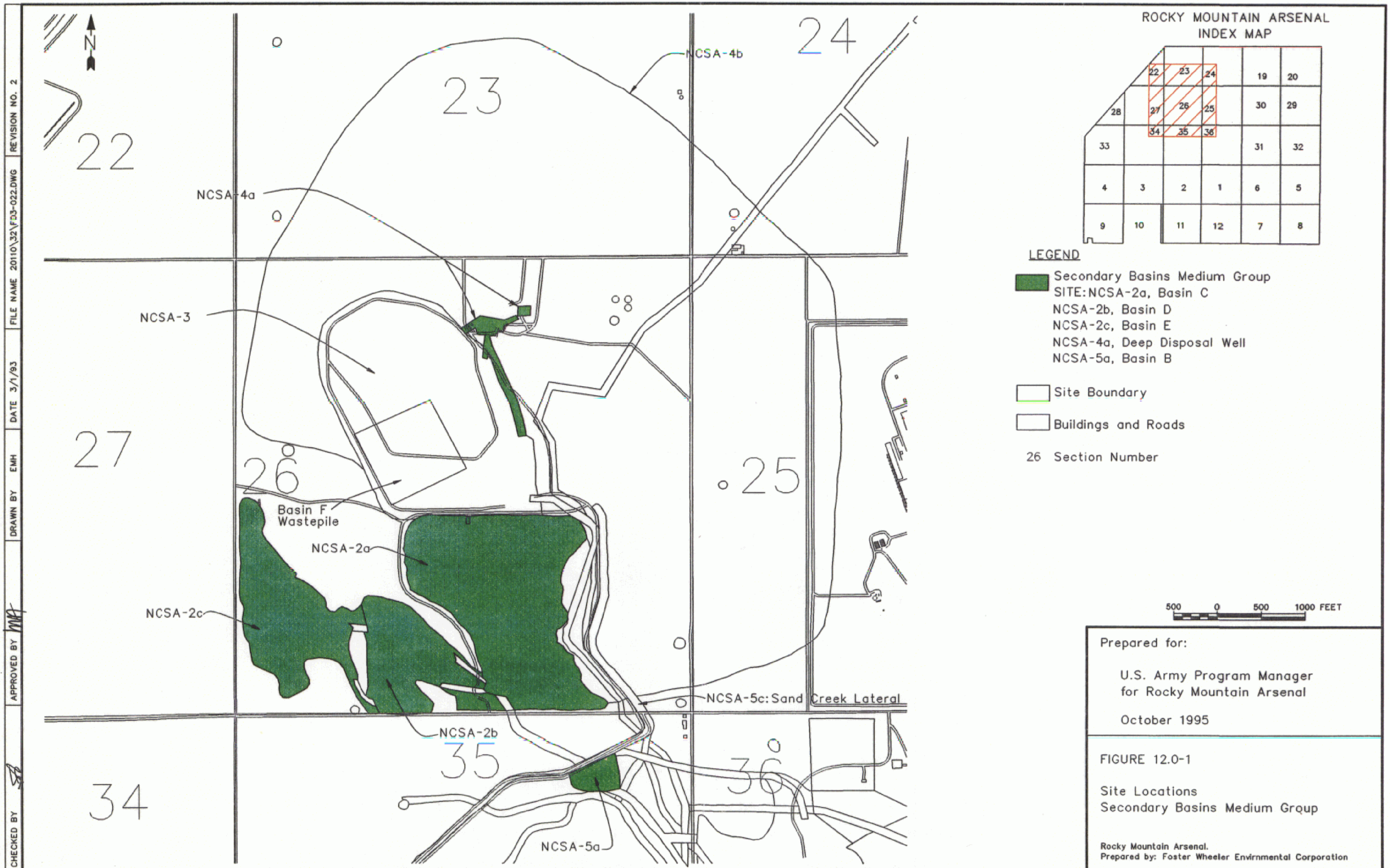
(2) Table 1.4-1 presents acute criteria, HH SEC, and principal threat criteria.

-- not applicable

Table 12.2-1 Comparative Analysis of Alternatives for the Secondary Basins Medium Group

Criteria	Alternative 1: No Additional Action	Alternative 2: Access Restrictions	Alternative 3: Landfill	Alternative 3b: Landfill; Caps/Covers
1. Overall protection of human health and the environment	Not Protective: Does not achieve Human Health or Biota RAOs; does not reduce impacts to groundwater	Achieves RAOs, but does not reduce impacts on groundwater	Protective: Achieves RAOs through removal and containment; impacts to groundwater greatly reduced	Protective: Achieves RAOs through removal and containment; impacts to groundwater greatly reduced
2. Compliance with ARARs	Complies	Complies	Complies	Complies
3. Long-term effectiveness and permanence	Moderate Residual Risk: Low concentrations that remain exceed Human Health SEC and pose potential risk to biota	Moderate Residual Risk: Exposure pathways interrupted, but contamination remains	Minimal Residual Risk: Contaminated soil removed from the site	Minimal Residual Risk: Some contaminated soil removed from the site; soil left in place contained by soil cover
4. Reduction in TMV	Natural attenuation only for 170,000 BCY	Natural attenuation only for 170,000 BCY	Exposure pathways and mobility reduced for 170,000 BCY through containment	Exposure pathways and mobility reduced for 170,000 BCY through containment
5. Short-term effectiveness	No implementation required; existing habitat quality poor; more than 30 years to achieve RAOs	Low short-term risks adequately mitigated during fence installation and cultivation of lower-quality habitat; RAOs achieved in 3 years	Risk to workers and community associated with excavation and transportation adequately mitigated; RAOs achieved in 2 years	Risk to workers and community associated with excavation and transportation adequately mitigated; RAOs achieved in 2 years
6. Implementability	Feasible	Feasible	Feasible	Feasible
7. Present worth costs	Capital—$0 Operating—$0 Long-term—$4,550,000 Total—$4,550,000	Capital—$866,000 Operating—$187,000 Long-term—$4,760,000 Total—$5,820,000	Capital—$4,420,000 Operating—$5,210,000 Long-term—$119,000 Total—$9,750,000	Capital—$832,000 Operating—$6,320,000 Long-term—$1,400,000 Total—$8,550,000
Summary	Not Retained: Not protective of human health and the environment	Not Retained: Contamination above Human Health SEC and that poses potential risk to biota remains	Retained: Contaminated soil contained	Retained: Contaminated soil contained

Criteria	Alternative 3f: Landfill; Caps/Covers with Consolidation	Alternative 6: Caps/Covers	Alternative 13a: Direct Thermal Desorption	Alternative 19a: In Situ Thermal Treatment
1. Overall protection of human health and the environment	Protective: Achieves RAOs through removal and containment; impacts to groundwater greatly reduced	Protective: Achieves RAOs through containment; impacts to groundwater greatly reduced	Protective: Achieves Human Health RAOs through treatment and Biota RAOs through containment; impacts to groundwater greatly reduced	In situ thermal treatment does not achieve Human Health RAOs; Biota RAOs achieved through removal and containment; impacts to groundwater reduced
2. Compliance with ARARs	Complies	Complies	Complies	Complies
3. Long-term effectiveness and permanence	Minimal Residual Risk: Contaminated soil removed from the site	Minimal Residual Risk: Entire site contained	Minimal Residual Risk: PRGs achieved for Human Health exceedance soil; soil that poses potential risk to biota removed and contained	Low Residual Risk: Soil that poses potential risk to biota removed, levels reduced for human health exceedance volume do not achieve PRGs
4. Reduction in TMV	Exposure pathways and mobility reduced for 170,000 BCY through containment	Exposure pathways and mobility reduced for 170,000 BCY by inplace containment	TMV eliminated for 32,000 BCY treated; mobility eliminated for 140,000 BCY removed and landfilled	TMV reduced for 32,000 BCY treated; mobility eliminated for 140,000 BCY removed and landfilled
5. Short-term effectiveness	Risk to workers and community associated with excavation and transportation; adequately mitigated; RAOs achieved in 2 years	Minimal risk to workers and the community; no intrusive action; RAOs achieved in 2 years	Short-term risk to workers and the community during excavation, transportation, and treatment adequately mitigated; RAOs achieved after 3 years	Risk to workers and the community during excavation and transport adequately mitigated
6. Implementability	Technically feasible	Technically and administratively feasible	Technically feasible: Administrative difficulty for thermal desorption	Not currently implementable since full-scale in situ heating units are not available; Administrative difficulties
7. Present worth costs	Capital—$832,000 Operating—$4,910,000 Long-term—$22,000 Total—$5,760,000	Capital—$0 Operating—$48,400,000 Long-term—$2,120,000 Total—$50,500,000	Capital—$4,410,000 Operating—$6,340,000 Long-term—$92,000 Total—$10,800,000	Capital—$17,500,000 Operating—$14,100,000 Long-term—$0 TOTAL—$31,600,000
Summary	Retained: Contaminated soil contained	Retained: Contaminated soil contained in place although high cost	Not Retained: High cost for treatment without reducing long-term risk compared to landfilling	Not Retained: Not commercially available, high cost compared to landfilling, some long-term risks remain



Prepared for:

U.S. Army Program Manager
for Rocky Mountain Arsenal

October 1995

FIGURE 12.0-1

Site Locations
Secondary Basins Medium Group

Rocky Mountain Arsenal.
Prepared by: Foster Wheeler Envirnmental Corporation

Prepared for:

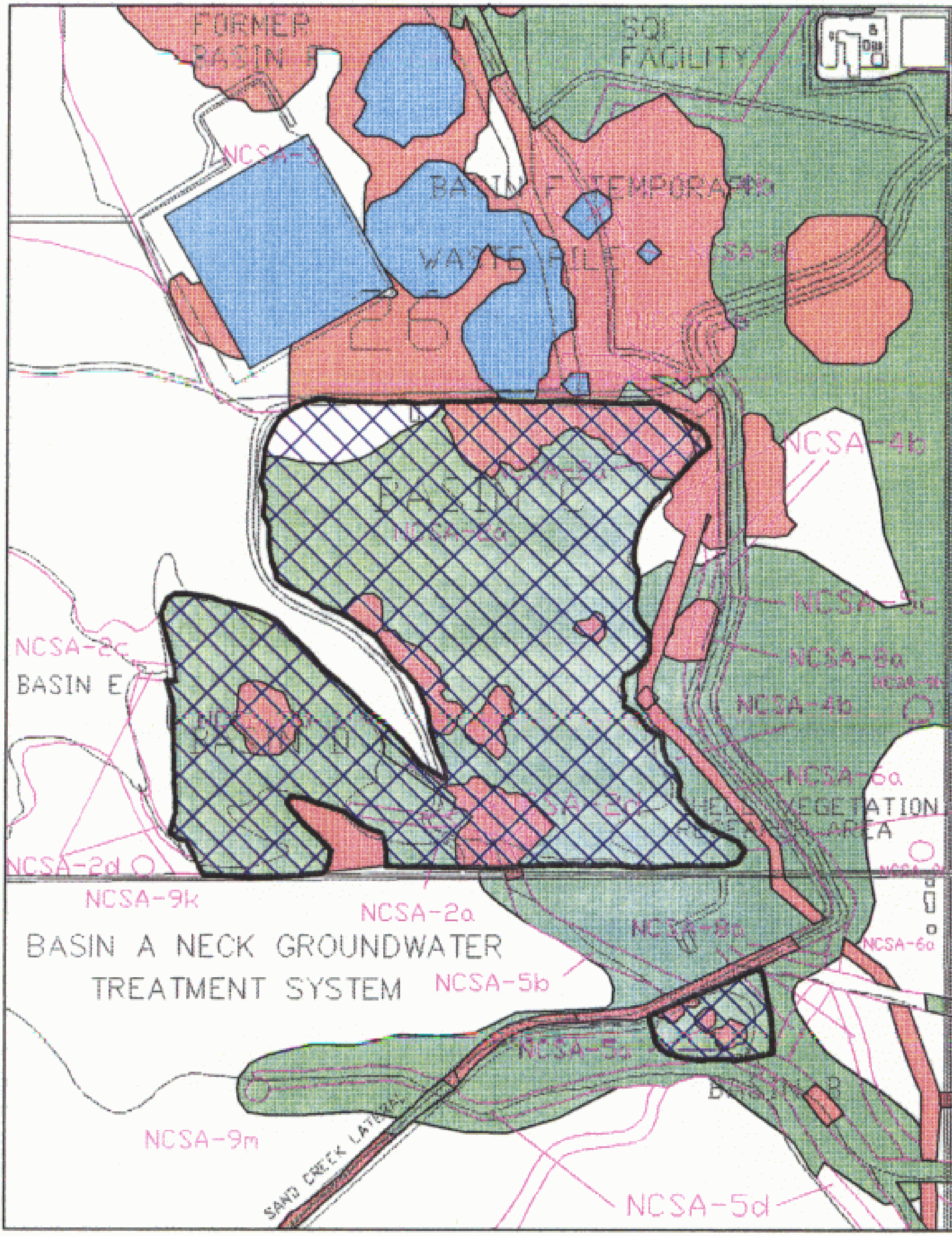
U.S. Army Program Manager
for Rocky Mountain Arsenal

October 1995

FIGURE 12.1-1

Exceedance Areas
Secondary Basins Subgroup

Rocky Mountain Arsenal.
Prepared by: Ebasco Services Incorporated



Legend

Principal Threat Exceedance Area

Human Health Exceedance Area

Excess Biota Risk Area

2 Foot Soil Cover Area

Sites with Soil Cover Remedies

SAR Site and ID

31 Section Number

Section Line

Drainage

Road

Railroad

N

0 400 800
Scale in Feet

C:\PROJECTS\ARSENAL\FS\GRAPHICS\SUPPORT\RISK\SECBAS.DWG

Prepared for:
U.S. Army Program Manager
for Rocky Mountain Arsenal

Prepared October 1995

Figure 12.2–1
Soil Cover Areas
Secondary Basins Medium Group

Rocky Mountain Arsenal
Prepared by: Foster Wheeler Environmental Corp.